SEBU9165-01
July 2013

Operation and Maintenance Manual

C13 Generator Set

NH3 1-Up (Generator Set)

Important Safety Information

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

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

Do not operate or perform any lubrication, maintenance or repair on this product, until you verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.

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

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

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts.

Failure to follow this warning may lead to premature failures, product damage, personal injury or death.

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

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Foreword

Literature Information

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

English is the primary language for all Cat 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 Cat 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 Cat 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 Cat dealer. Your Cat 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 Cat 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. 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 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.

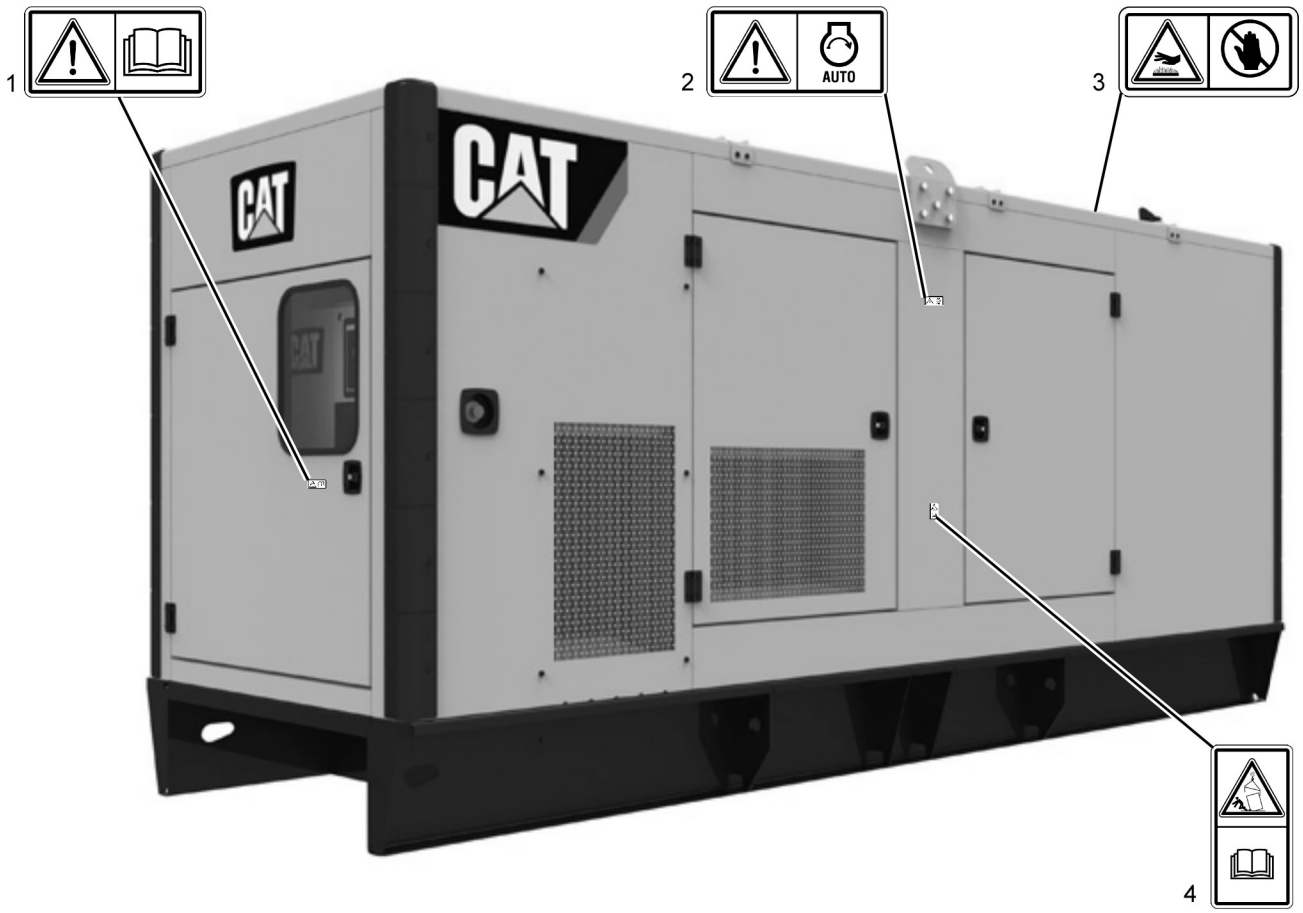

Illustration 1 g02918420

Right side view of the enclosure

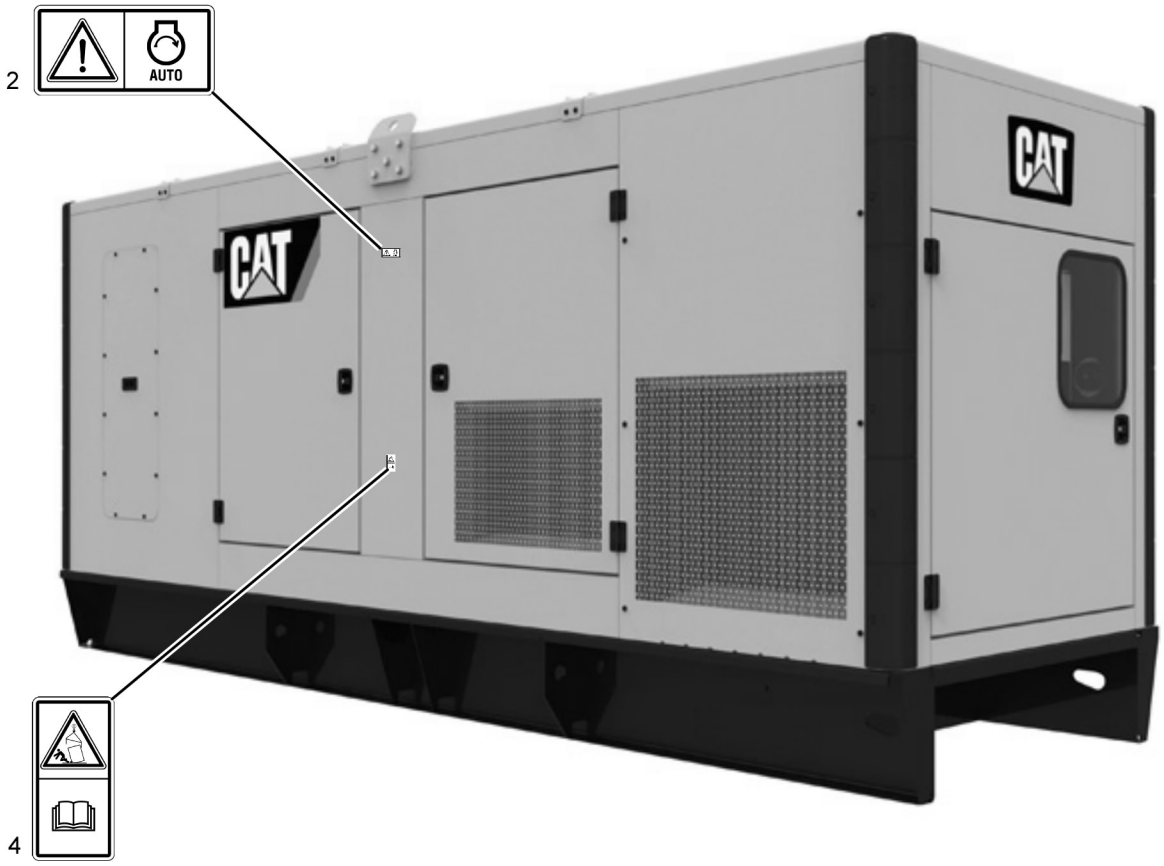

Illustration 2 g02918358

Left side view of the generator set enclosure

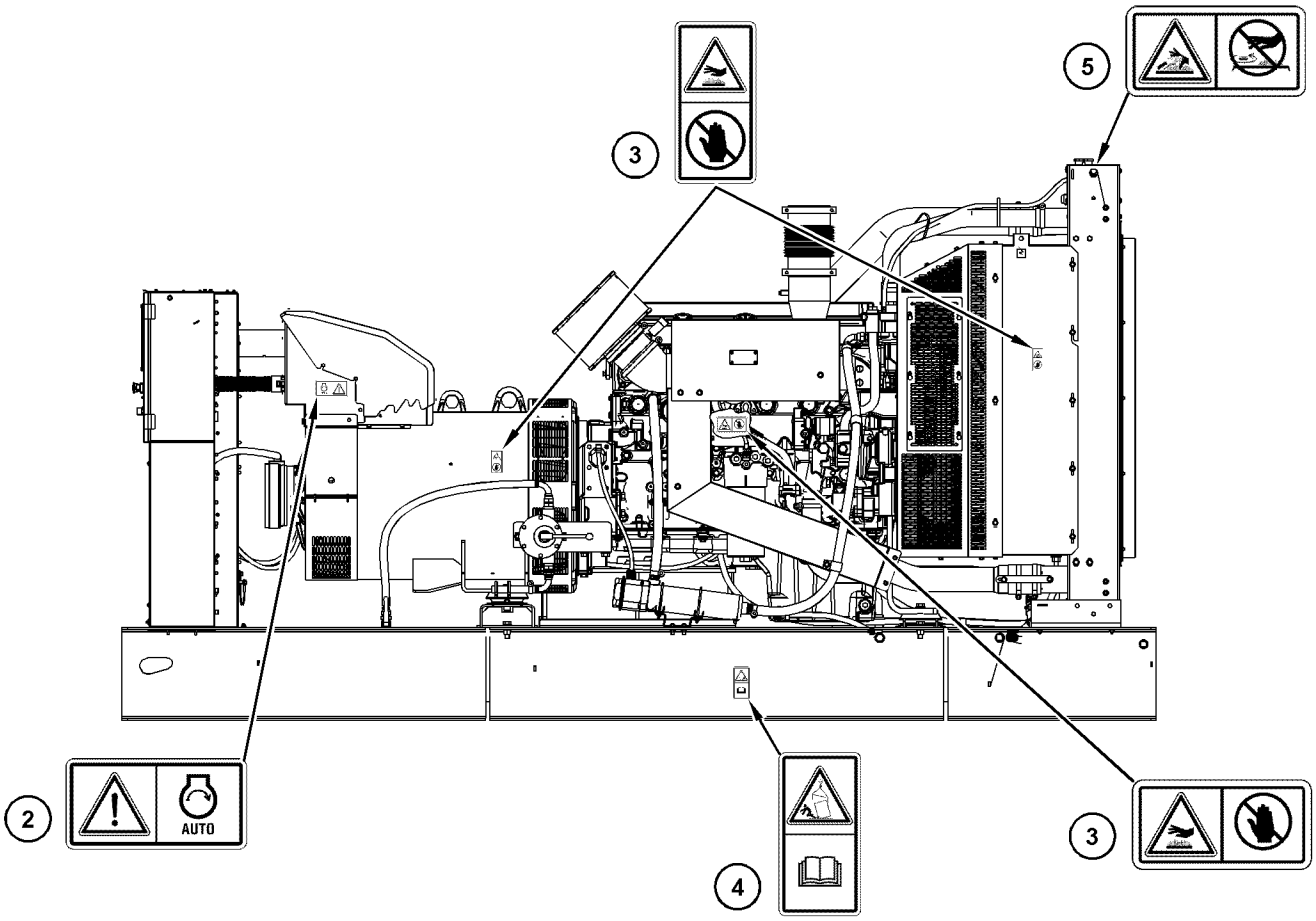

Illustration 3 g03403574

Right side view of the open generator set

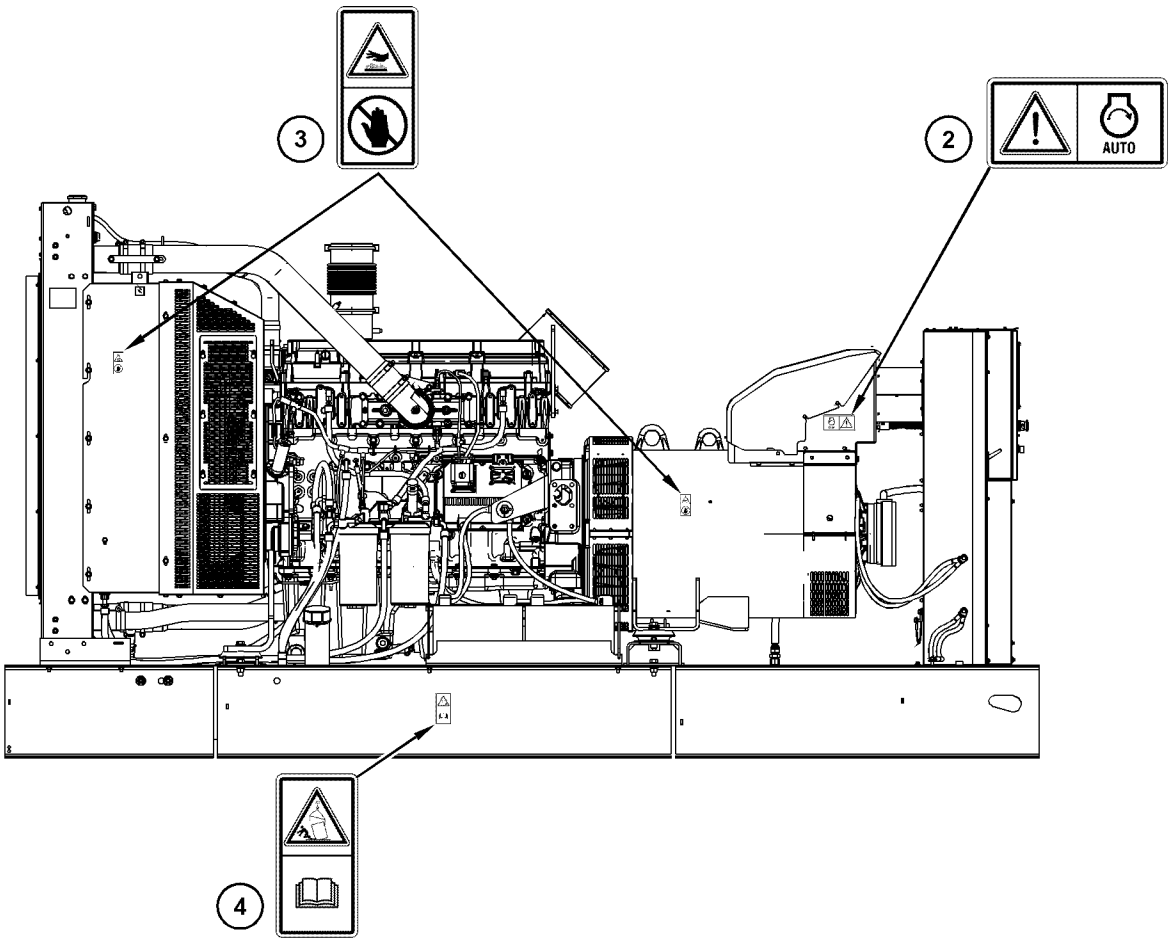

Illustration 4 g03403538

Left side view of open generator set

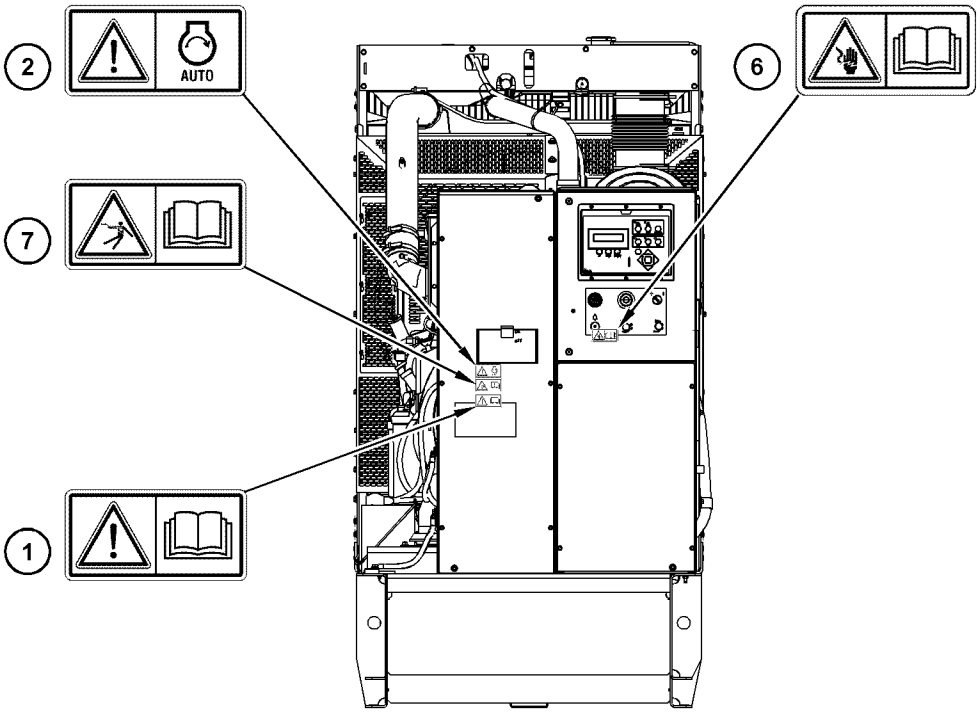

Illustration 5 g03403651

Rear view of the open generator set

Universal Warning (1)

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

Illustration 6 g01370904

WARNING

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

Automatic Starting (2)

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

Illustration 7 g01392484

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.

Hot Surface (3)

This safety message is located on the top and sides of the enclosure, as well as near the exhaust, and on the aftercooler.

Illustration 8 g01384734

WARNING

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

Crush (4)

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

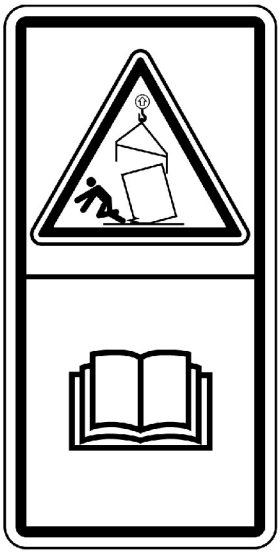

Illustration 9 g01433231

WARNING

Crushing hazard! Read and understand the instructions and warnings in the Operation and Maintenance manual. Failure to follow the instructions or heed the warnings could cause serious injury or death.

Hot Fluid Under Pressure (5)

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

Illustration 10 g01371640

WARNING

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

Electrical Shock (6)

The safety message for electrical shock is located on the enclosure for the control panel.

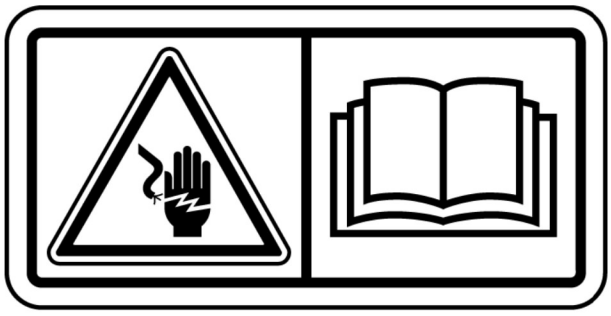

Illustration 11 g01372247

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 (7)

This safety message is located on the enclosure for the circuit breaker.

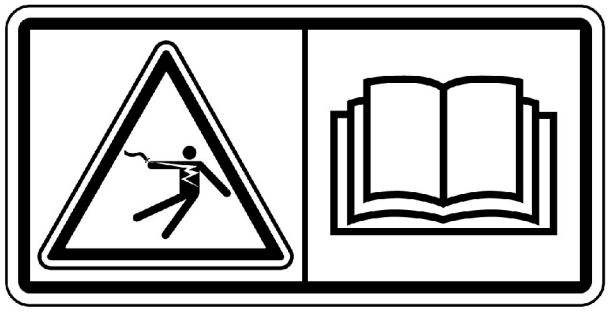

Illustration 12 g01392482

DANGER

DANGER: Shock/Electrocution Hazard-Do not operate this equipment or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings will result in serious injury or death.

WARNING

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

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

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Additional Messages

SMCS Code: 1000; 7405

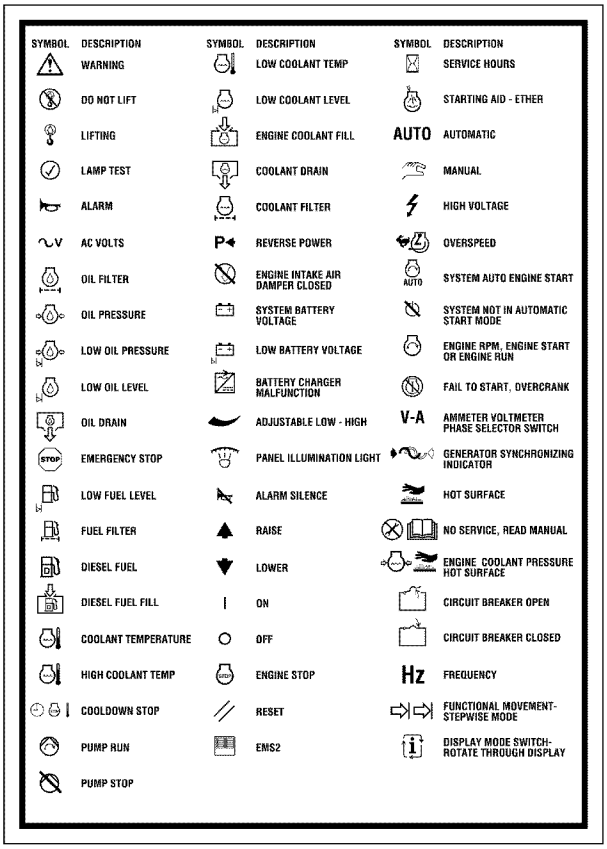

Illustration 13 g03400665

This message is found on the rear of the enclosure. This message defines the symbols used in other messages.

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General Hazard Information

SMCS Code: 1000; 4450; 7405

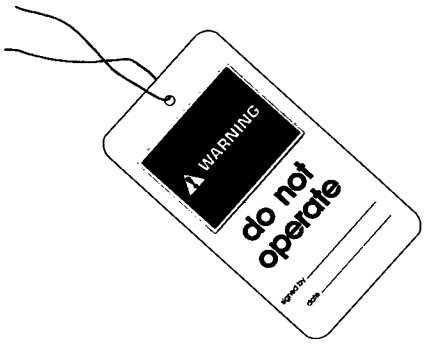

Illustration 14 g00104545

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

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

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

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

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

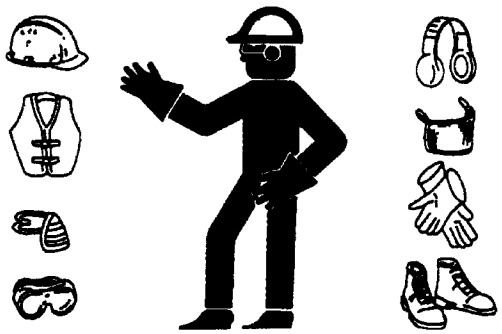

Illustration 15 g00702020

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

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

- The engine is stopped. Ensure that the engine cannot be started.
- The protective locks or the controls are in the applied position.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- When starting a new engine, make provisions to stop the engine if an overspeed occurs. If an engine has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

Pressurized Air and Water

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

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

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. Always wear eye protection for cleaning the cooling system.

Avoid direct spraying of water on electrical connectors, connections, and components. When using air for cleaning, allow the machine to cool to reduce the possibility of fine debris igniting when redeposited on hot surfaces.

Fluid Penetration

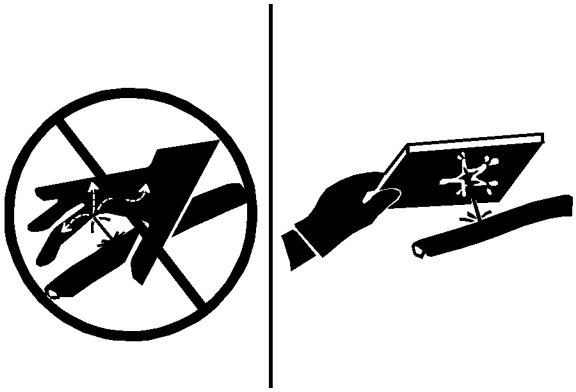

Illustration 16 g00687600

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

Containing Fluid Spillage

NOTICE

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

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

Dispose of all fluids according to local regulations and mandates.

Static Electricity Hazard when Fueling with Ultra-low Sulfur Diesel Fuel

The removal of sulfur and other compounds in ultra-low sulfur diesel fuel (ULSD fuel) decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fueling standards for proper grounding and bonding.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

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. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts and excessive heat during operation.

Inhalation

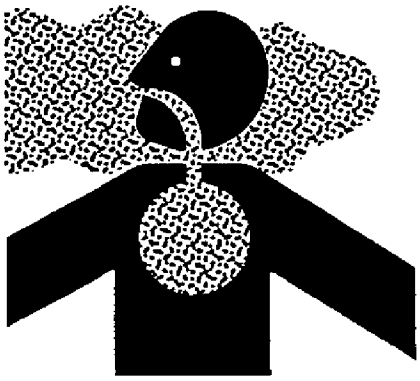

Illustration 17 g02159053

Exhaust

Use caution. Exhaust fumes can be hazardous to your health. If you operate the equipment in an enclosed area, adequate ventilation is necessary.

Asbestos Information

Cat equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Cat 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 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.

Softwrap

Keep the engine room ventilation operating at full capacity. Wear a particulate respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH) . Wear appropriate protective clothing in order to minimize direct contact. Use good hygiene practices and wash hands thoroughly after handling Softwrap material. Do not smoke until washing hands thoroughly after handling Softwrap material. Clean up debris with a vacuum or by wet sweeping. Do not use pressurized air to clean up debris.

Reference: The applicable material safety data sheets can be found at the following web site by searching using part number or the name:

http://dsf2ws.cat.com/msds/servlet/cat.cis.ecs.msdsSearch.controller.UserIdentificationDisplayServlet

Dispose of Waste Properly

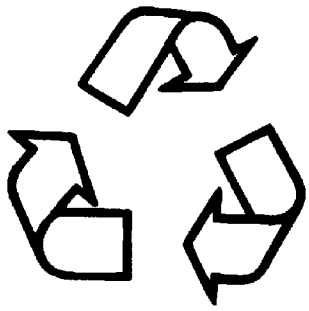

Illustration 18 g00706404

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

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

i01480768

Burn Prevention

SMCS Code: 1000; 4450; 7405

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

Coolant

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

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

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

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

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

Oils

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

Batteries

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

i05374808

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405

Illustration 19 g00704000

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

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

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

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

A flash fire may result if the covers for the engine crankcase are removed within 15 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 Cat dealer for additional information about suitable protection devices.

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

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

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

Do not expose the engine to any flame.

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

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

Wiring must be kept in good condition. Properly route and attach all electrical wires. 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. Properly route all hoses. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Properly install all oil filters and fuel filters. The filter housings must be tightened to the proper torque.

Illustration 20 g00704059

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

Avoid static electricity risk when fueling. Ultra Low Sulfur Diesel (ULSD) poses a greater static ignition hazard than earlier diesel formulations with a higher Sulfur content. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

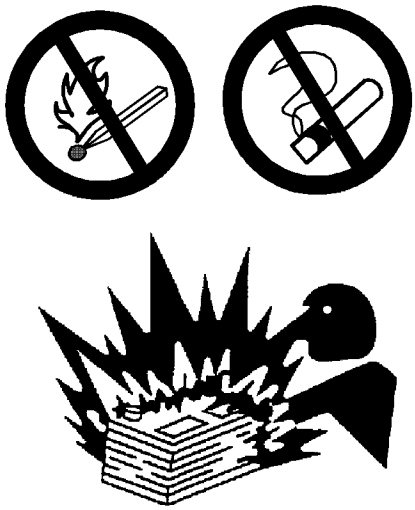

Illustration 21 g02298225

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. Charging a frozen battery may result in an explosion.

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

Fire Extinguisher

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

Ether

Ether is flammable and poisonous.

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

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

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

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

Lines, Tubes, and Hoses

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

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Cat 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 parts 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 in order to prevent vibration, rubbing against other parts, and excessive heat.

i01359666

Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 4450; 7405

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

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

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

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

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

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

i04597969

Mounting and Dismounting

SMCS Code: 1000; 4450; 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 2 feet and one hand or use 1 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.

i04808048

Sound Information

SMCS Code: 1000

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

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

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

Refer to the following for sound levels:

- The sound pressure level of a complete generator set (including the radiator) at 1 meter is 98 dB(A) for the noisiest configuration when ISO 8528-10:1998(E) clause 14 is used at 75 percent of the rated power.
- The sound power level of a complete generator set (including the radiator) that is not covered by the European Union Directive 2000/14/EC is 99 dB(A) for the noisiest configuration when ISO 8528-10:1998(E) clause 13 is used at 75 per cent of the rated power.

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

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

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

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

i03560601

Before Starting Engine

SMCS Code: 1000

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

⚠ WARNING

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

Inspect the engine for potential hazards.

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

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

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

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

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

See the Service Manual for repairs and for adjustments.

i01103904

Engine Starting

SMCS Code: 1000

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

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

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

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

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

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

Ether

Ether is poisonous and flammable.

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

Do not smoke while ether cylinders are changed.

Use ether in well ventilated areas.

Use ether with care in order to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

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

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

i01462046

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.

i04598035

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.

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

Grounding Practices

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

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

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

For engines with an alternator that is grounded to an engine component, a ground strap MUST connect that component to the negative “−” battery terminal. The component MUST also be electrically isolated from the engine.

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

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

i02784356

Engine Electronics

SMCS Code: 1000; 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 Troubleshooting Manual for more information.

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.

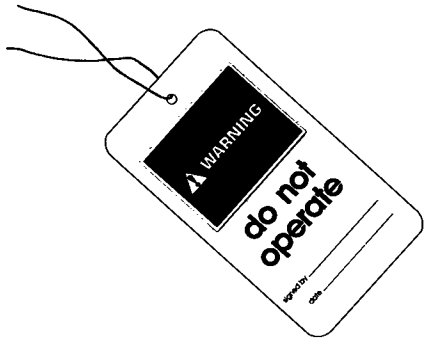

Illustration 22 g00104545

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

i05378829

Model View Illustrations

SMCS Code: 1000

The following engine model views show typical C13 Generator Set features. The operator should become familiar with the locations of these items. Due to individual applications, your engine may appear different from the illustrations.

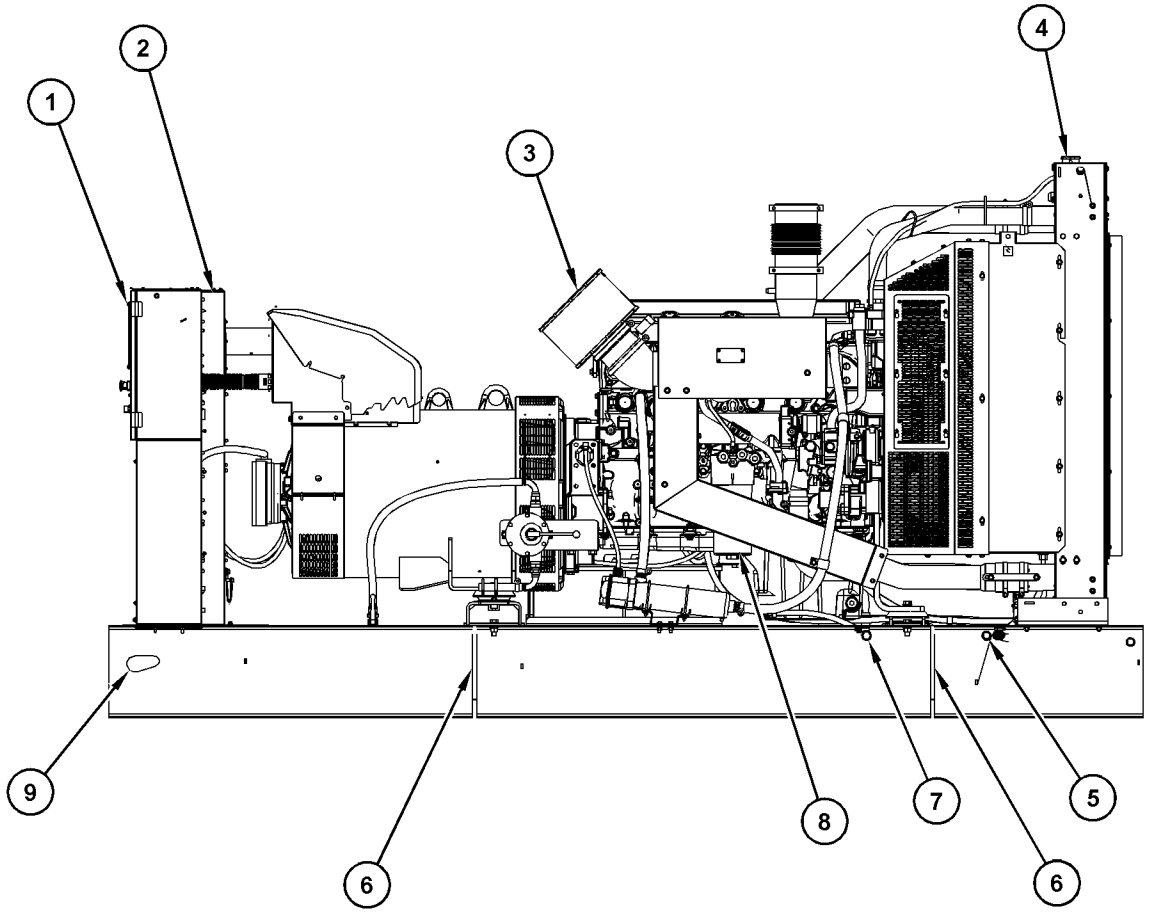

Illustration 23 g03403663

Right Hand Side View

(1) Control panel
(2) Breaker box
(3) Air cleaner
(4) Radiator cap
(5) Engine coolant drain
(6) Generator set lift point
(7) Engine oil drain
(8) Engine oil filter
(9) Rear drag point

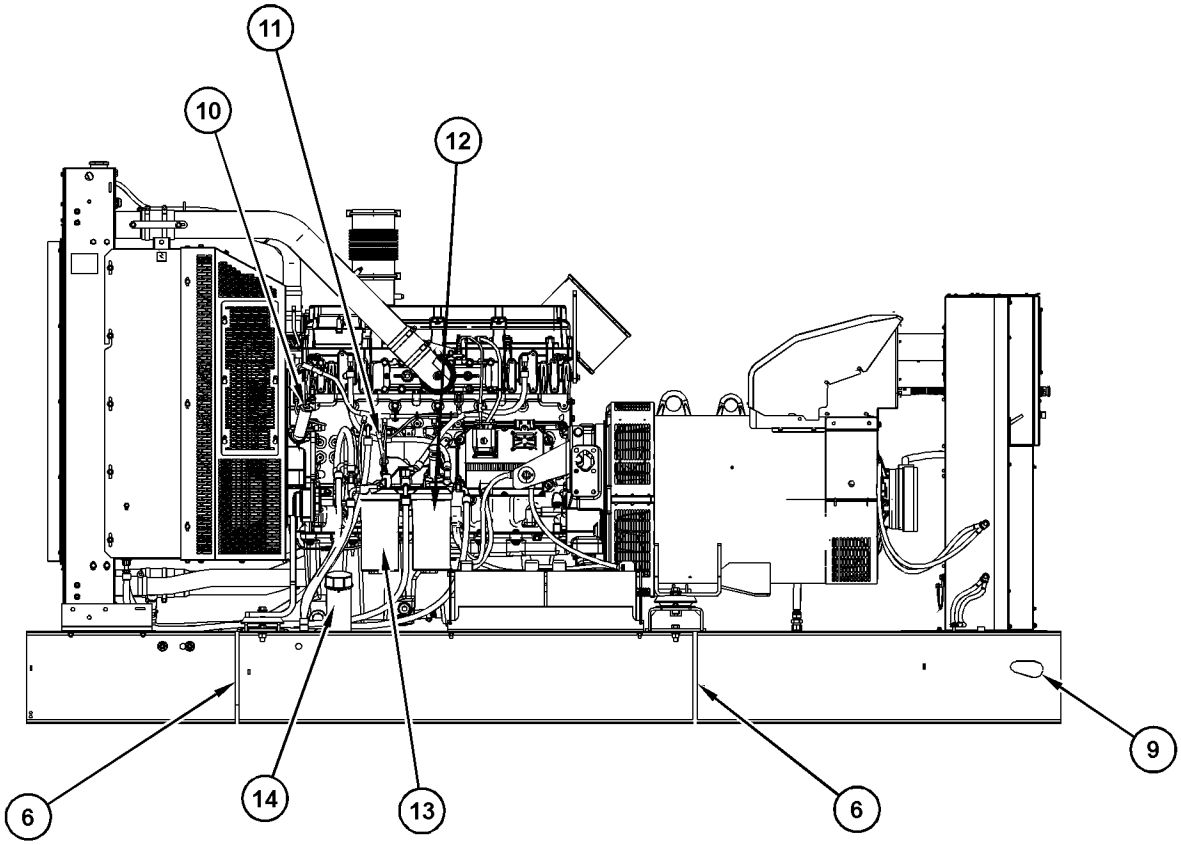

Illustration 24 g03403668

Left Hand Side View

(10) Oil filler
(11) Engine oil level gauge (dipstick)
(12) Secondary fuel filter
(13) Fuel filter/water separator
(14) Fuel fill pipe

i05367459

Product Description

SMCS Code: 1000; 4450; 4491

Intended Use

This Power Generator is intended for use in the generation of electrical power.

Engine Information

These Caterpillar Engines provide the following features:

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

Engine Specifications

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

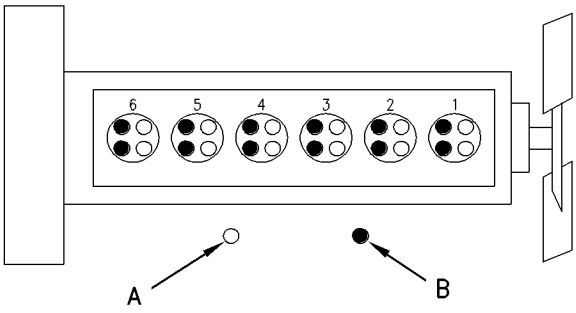

Illustration 25 g00284836

Cylinder and valve locations

(A) Inlet valves
(B) Exhaust valves

Table 1

C13 Engine Specifications	
Cylinders and Arrangement	In-line six cylinder
Bore	130 mm (5.1 inch)
Stroke	157 mm (6.2 inch)
Displacement	12.5 L (759.9 cubic inch)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

Electronic Engine Features

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

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

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

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

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

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

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

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

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

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

Engine Cooling and Lubrication

The cooling system consists of the following components:

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

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

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

Engine Service Life

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

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

Generator Description

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

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

The generators have four poles. The generators have six or12 lead configurations. The configuration depends on the frame size. The generators can produce electrical power in either 50 Hz or 60 Hz applications.

Aftermarket Products and Caterpillar Engines

NOTICE

Caterpillar requires the use of a 4 micron(c) secondary fuel filter for the following reasons: to maximize fuel system life and to prevent premature wear out from abrasive particles in the fuel. Cat high efficiency fuel filters meet these requirements. Consult your Cat dealer for the proper part numbers.

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

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

Product Identification Information

i03671899

Plate Locations and Film Locations

SMCS Code: 1000; 4450

Generator Set Identification

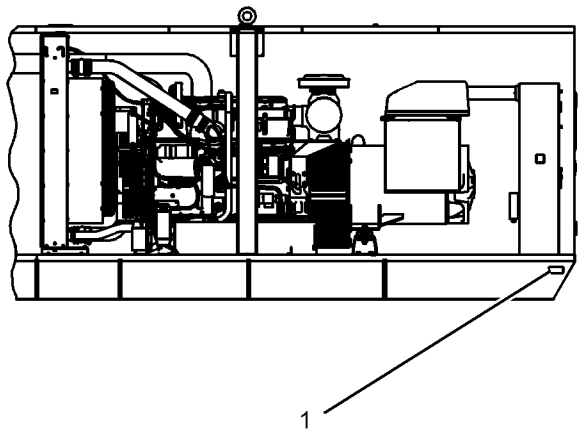

Illustration 26 g01185578

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

The generator set consists of the generator and the engine. The location of the identification plate for the generator set is shown in illustration 27 .

Serial Number Plate

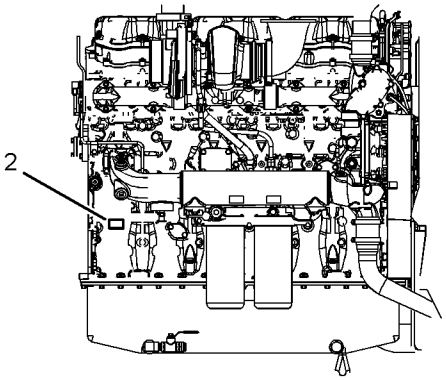

Illustration 27 g01185411

Right Side View of Engine Only

(2) Location of serial number plate

The Engine Serial Number Plate contains the following information:

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

Engine Information Plate

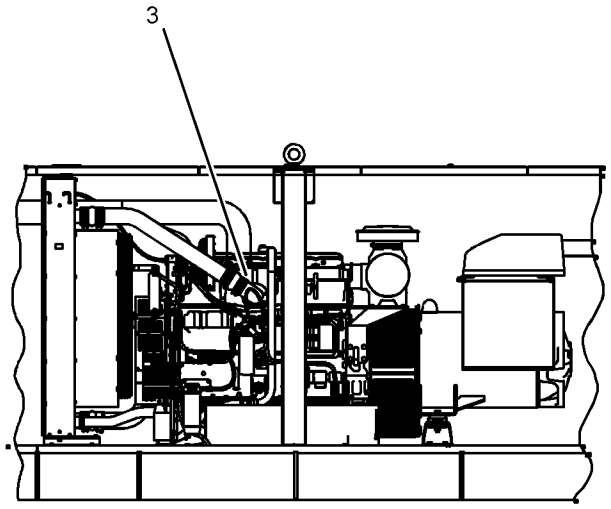

Illustration 28 g01185515

(3) Location of the engine information plate

The Engine Information Plate contains the following information:

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

Generator Identification Plate

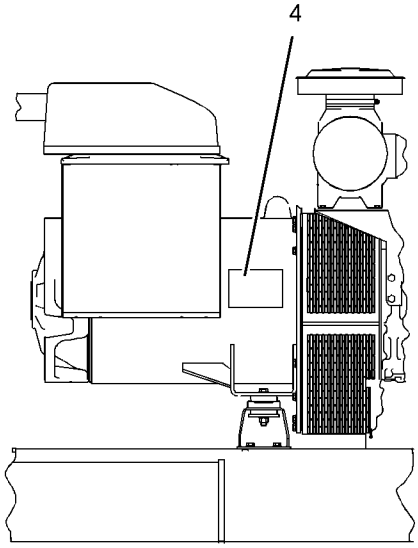

Illustration 29 g01185532

Location of the generator identification plate

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

The generator identification film includes the following information:

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

European Union

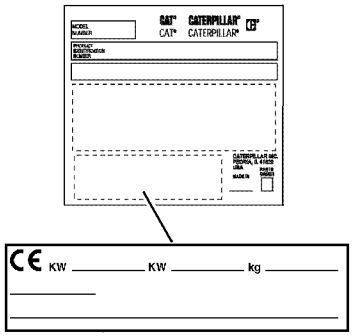

Illustration 30 g01880193

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

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

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

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

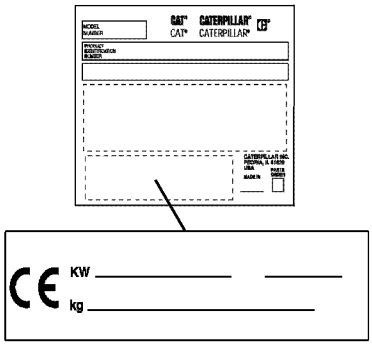

Illustration 31 g01120192

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

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

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

- Engine Power Primary Engine (kW)_____
- Typical Machine Operating Weight for European Market (kg)_____
- Year_____

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

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

i05374776

Declaration of Conformity

SMCS Code: 1000

Table 2

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

EC DECLARATION OF CONFORMITY OF PRODUCTS

Manufacturer:CATERPILLAR INC . 100 N.E. ADAMS STREET PEORIA, IL 61629 USA

Person authorized to compile the Technical File and to communicate relevant part (s) of the Technical File to the Authorities of European Union Member States on request:

Standards & Regulations Manager,Caterpillar France S.A.S 40 ,
Avenue Leon-Blum, B.P. 55, 38041 Grenoble Cedex 9, France

I, the undersigned, _____, hereby certify that the construction equipment specified hereunder

Description:	Generic Denomination:	Power Generation Equipment
	Function:	Power Generator
	Model/Type:	C13
	Serial Number:	
	Commercial Name:	Caterpillar

Fulfils all the relevant provisions of the following Directives

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

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

Note (2) Notified body name and address

Done at: **Signature**

Date: **Name/Position**

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

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.

i04019095

Emissions Certification Film

SMCS Code: 1000; 7405

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

Consult your Cat dealer for an Emission Control Warranty Statement.

This label is located on the engine.

i04397923

Reference Information

SMCS Code: 1000; 4450

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

Record for Reference

Engine Model _____

Engine Serial Number _____

Engine Arrangement Number _____

Modification Number _____

Engine Low Idle Speed _____

Engine Full Load Speed _____

Performance Specification Number _____

Primary Fuel Filter Element _____

Secondary Fuel Filter Element _____

Engine Oil Filter Element _____

Auxiliary Oil Filter Element _____

Supplemental Coolant Additive Maintenance Element _____

Engine Oil Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element _____

Fan Drive Belt _____

Alternator Belt _____

Generator Arrangement Number _____

Generator Set Serial Number _____

Generator Frame Size _____

Voltage Rating _____

kW Rating _____

Excitation System

AREP _____

Self-Excited _____

Permanent Magnet _____

Operation Section

Lifting and Storage

i05373685

Product Lifting

SMCS Code: 7000; 7002

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

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

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

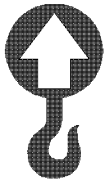

Illustration 32 g01034418

Label for lifting eye

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

On some enclosed generator sets, removal of a top cover/platel of the enclosure may be necessary in order to access the lifting eye.

Note: Never lift a generator set that has fuel on board.

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

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

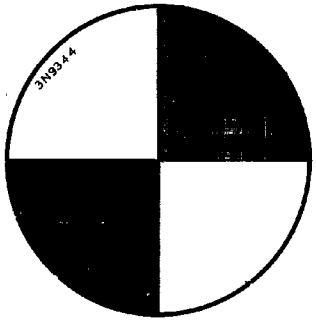

Illustration 33 g01187534

Label for the Center of Gravity

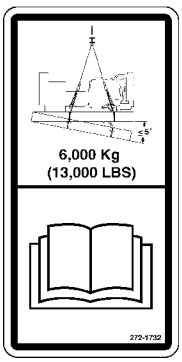

Illustration 34 g01187465

Safety Message for lifting the 6000Kg generator set by four points

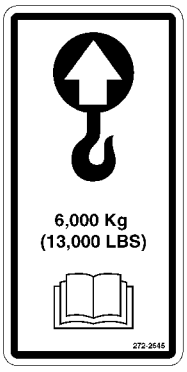

Illustration 35 g01187466

Safety Message for 6000Kg lifting point lifting

Engine Lifting with a Generator

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

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

During lifting a generator set package it may not be level if the unit is lifted with a lifting arch which has one or two lifting eyes depending on selected options. 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 lifting arch which has one or two lifting eyes 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 standing at the side of the enclosure. The lifting eye may stretch when the package is lifted. Incorrect lifting practices may cause the locking nuts to loosen. Incorrect lifting practices could cause the single lifting eye to swivel. Ensure that the lifting eye is correctly oriented on the packaged generator set. Ensure that the lifting arch and lifting eyes are 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.

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Product Storage

SMCS Code: 7002

Note: If storage for more than 1 yr is necessary, contact your local Cat dealer for the preferred storage procedure.

Engine

Storage (Less Than One Year)

If an engine is not used, oil can run off the following parts that normally receive lubrication: cylinder walls, piston rings, main bearings, connecting rod bearings, crankshaft and gears.

This lack of lubricant allows corrosion to begin to appear on the metal. This condition is worse in areas of high humidity.

When the engine is started again, metal to metal contact will cause wear before the surfaces receive oil. To minimize this wear, use the starter to turn the engine with the throttle in the FUEL OFF position. When oil pressure is shown on the pressure gauge, start the engine.

1. Clean the engine of any dirt, rust, grease, and oil. Inspect the exterior. Paint areas that contain paint damage with a good quality paint.
2. Remove dirt from the air cleaners. Check all seals, gaskets, and the filter element for damage.
3. Apply lubricant to all points in this Operation and Maintenance Manual, “Maintenance Interval Schedule”.
4. Drain the crankcase oil. Replace the crankcase oil and change the oil filters. For the proper procedure, refer to this Operation and Maintenance Manual.
5. If the engine is equipped with an air starting motor, fill the reservoir with the following mixture: 50 percent volatile corrosion inhibitor oil (<nomen>VCI oil</nomen>) and 50 percent engine oil.
6. Add VCI oil to the crankcase oil. The volume of VCI oil in the crankcase oil should be 3 to 4 percent.

Note: If the engine crankcase is full, drain enough engine oil so the mixture can be added.

7. Remove the air filter elements. Turn the engine at cranking speed with the throttle control in FUEL OFF position. Use a sprayer to add a mixture of 50 percent VCI oil and 50 percent engine oil into the air inlet or turbocharger inlet.

Note: The mixture of VCI oil can be added to the inlet by removing the plug for checking turbocharger boost pressure. The minimum application rate for the VCI oil mixture is 5.5 mL per L (3 oz per 1000 cu in) of engine displacement.

8. Use a sprayer to apply a mixture of 50 percent VCI oil and 50 percent crankcase oil into the exhaust openings. The minimum application rate for the oil mixture is 5.5 mL per L (3 oz per 1000 cu in) of engine displacement. Seal the exhaust pipe and seal any drain holes in the muffler.

9. Remove the fuel from the secondary fuel filter housing. Alternately, empty and reinstall the spin-on fuel filter element in order to remove any dirt and water. Drain any sleeve metering fuel pump.

Clean the primary fuel filter. Fill with calibration fluid or kerosene. Install the primary fuel filter and operate the priming pump. This procedure will send clean oil to the secondary filter and the engine.

Open the fuel tank drain valve in order to drain any water and dirt from the fuel tank. Apply a spray of calibration fluid or kerosene at the rate of 30 mL per 30 L (1 oz per 7.50 gal US) of fuel tank capacity in order to prevent rust in the fuel tank. Add 0.15 mL per L (.02 oz per 1 gal US) of commercial biocide such as Biobor JF to the fuel.

Apply a small amount of oil to the threads on the fuel tank filler neck and install the cap. Seal all openings to the tank in order to prevent evaporation of the fuel and as a preservative.

10. Remove the fuel nozzles or spark plugs. Apply 30 mL (1 oz) of the mixture of oils (50 percent VCI oil and 50 percent engine oil) into each cylinder.

Use a bar or a turning tool in order to turn over the engine slowly. This procedure puts the oil on the cylinder walls. Install all fuel nozzles or spark plugs and tighten to the correct torque.

11. Spray a thin amount of a mixture of 50 percent VCI oil and 50 percent engine oil onto the following components: flywheel, ring gear teeth and starter pinion. Install the covers in order to prevent evaporation of the vapors from the VCI oil.

12. Apply a heavy amount of Cat Multipurpose Grease (MPGM) to all outside parts that move, such as rod threads, ball joints, linkage.

Note: Install all covers. Ensure that tape has been installed over all openings, air inlets, exhaust openings, the flywheel housing, the crankcase breathers, the dipstick tubes.

Ensure that all covers are airtight and weatherproof. Use a waterproof weather resistant tape such as Kendall No. 231 or an equivalent. Do not use duct tape. Duct tape will only seal for a short time.

13. Under most conditions, removing the batteries is the best procedure. As an alternative, place the batteries in storage. As needed, periodically charge the batteries while the batteries are in storage.

If the batteries are not removed, wash the tops of the batteries until the tops are clean. Apply an electrical charge to the batteries in order to obtain a specific gravity of 1.225.

Disconnect the battery terminals. Place a plastic cover over the batteries.

Note: For additional information, refer to Special Instruction, SEHS7633, “Battery Test Procedure”.

14. Loosen all belts.

15. Place a waterproof cover over the engine. Ensure that the engine cover is secure. The cover should be loose enough to allow air to circulate around the engine in order to prevent damage from condensation.

16. Attach a tag with the storage date to the engine.

17. Remove the waterproof cover at 2 month or 3 month intervals in order to check the engine for corrosion. If the engine has signs of corrosion, repeat the protection procedure.

Coolant System

Completely fill the cooling system before storage.

Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information about coolants.

Removal from Storage

1. Remove all outside protective covers.

2. Change the oil and filters.

3. Check the condition of the fan and alternator belts. Replace the belts, if necessary. Refer to this Operation and Maintenance Manual, “Belts - Inspect/Adjust/Replace” for the correct procedure.

4. Replace the fuel filter elements.

5. Remove the plastic covers from the air cleaner elements.

6. Use a bar or a turning tool in order to turn the engine in the normal direction of rotation. The procedure ensures that no hydraulic locks or resistance exist.

7. Before starting the engine, remove the valve cover or covers. Put a large amount of engine oil on the camshaft, cam followers, and valve mechanism in order to prevent damage to the mechanism.

8. Pressure lubricate the engine before starting the engine. Pressure lubricating the engine ensures immediate lubrication and prevents damage to the engine during the first few minutes of engine operation. If the engine is not equipped with a prelube pump, contact your Cat dealer for information about lubrication of the engine before starting the engine.

9. Check the condition of all rubber hoses. Replace any worn hoses. Replace any damaged hoses.

10. Before start-up, test the cooling system for a 3 percent ro a 6 percent concentration of coolant conditioner. Add liquid coolant conditioner or a coolant conditioner element, if equipped.

Test the coolant mixture for proper nitrite level. If necessary, adjust the coolant mixture.

Prime the engine with clean diesel fuel before starting.

11. Ensure that the cooling system is clean. Ensure that the system is full. Ensure that the system has the correct amount of supplemental cooling system conditioner.

12. On the first day of operation, check the entire engine several times for leaks and correct operation.

13. If the engine was removed from storage in which temperatures of less than -12°C (10°F) were encountered, refer to Service Manual, SEBU5898, “Cold Weather Recommendations Operation and Maintenance”.

Generator

Storage (Less Than One Year)

When a generator is in storage, moisture condenses in the windings. To minimize condensation, always place the generator in a dry storage area. Seal all openings with tape.

If a brush-type generator (SRCR) is being stored, lift the brushes off the slip ring to prevent chemical damage to the slip ring. Attach a tag to the generator which states that the brushes have been lifted.

Perform a resistance check of the windings. Record this reading. This check is done in order to provide a base line for determining whether moisture or winding deterioration occurs during storage.

Removal From Storage

Remove all protective covers. Reseat the brushes on the slip ring for SRCR generators.

Before start-up of a generator, use a megohmmeter to check insulation resistance for moisture and/or foreign material. Refer to this Operation and Maintenance Manual, “Generator Start-up Check List” for the procedure. A resistance reading of 1 megohm or less indicates that the winding has absorbed too much moisture.

Use one of the following methods for drying the generator in order to remove moisture which is caused by high humidity or dampness:

1. Place the generator in an oven which is no hotter than 85°C (185°F) for 4 hours.

2. Use a canvas enclosure around the generator and heating lamps to increase the ambient temperature. Provide an opening in the top of the canvas in order to release the moisture.

3. Send a low voltage current through the windings in order to increase the temperature of the windings to 85°C (185°F).

Megohmmeter Checks

Test the main stator windings with a megohmmeter in the following situations:

1. Before the initial start-up of the generator set

2. Every 3 months if the generator operates in a humid environment

3. If the generator has not been run under load for3 months or more

These intervals are only recommendations. Perform a megohmmeter test more frequently if the following conditions exist: extreme humidity, salty environment and the last megohmmeter test was close to 1 megohm.

Additional Information

For additional information about storage procedures, refer to Special Instruction, SEHS9031, Storage Procedure for Cat Products.

Installation

i03661199

Product Installation

SMCS Code: 1000; 1404; 4450; 7002

Receiving Inspection

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

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

Unpacking

Moving the Generator

⚠ WARNING

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

NOTICE

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

Unpack the equipment with care in order to avoid scratching painted surfaces. Move the unit to the mounting location. Follow the instructions under the Product Lifting topic. The hoist and the hoist cables should have a rating that is greater than the weight of the generator.

Location

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

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

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

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

Protective Devices

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

Storage

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

Features and Controls

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Alarms and Shutoffs

SMCS Code: 7400

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

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Battery Disconnect Switch (If Equipped)

SMCS Code: 1411

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

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

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

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

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

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

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

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Cold Start Strategy

SMCS Code: 1450; 1456; 1900

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

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

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

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

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Electronic Modular Control Panel 4 (EMCP 4)
(EMCP 4.1/4.2 If equipped)

SMCS Code: 4490

Electronic Control Module (Generator Set)

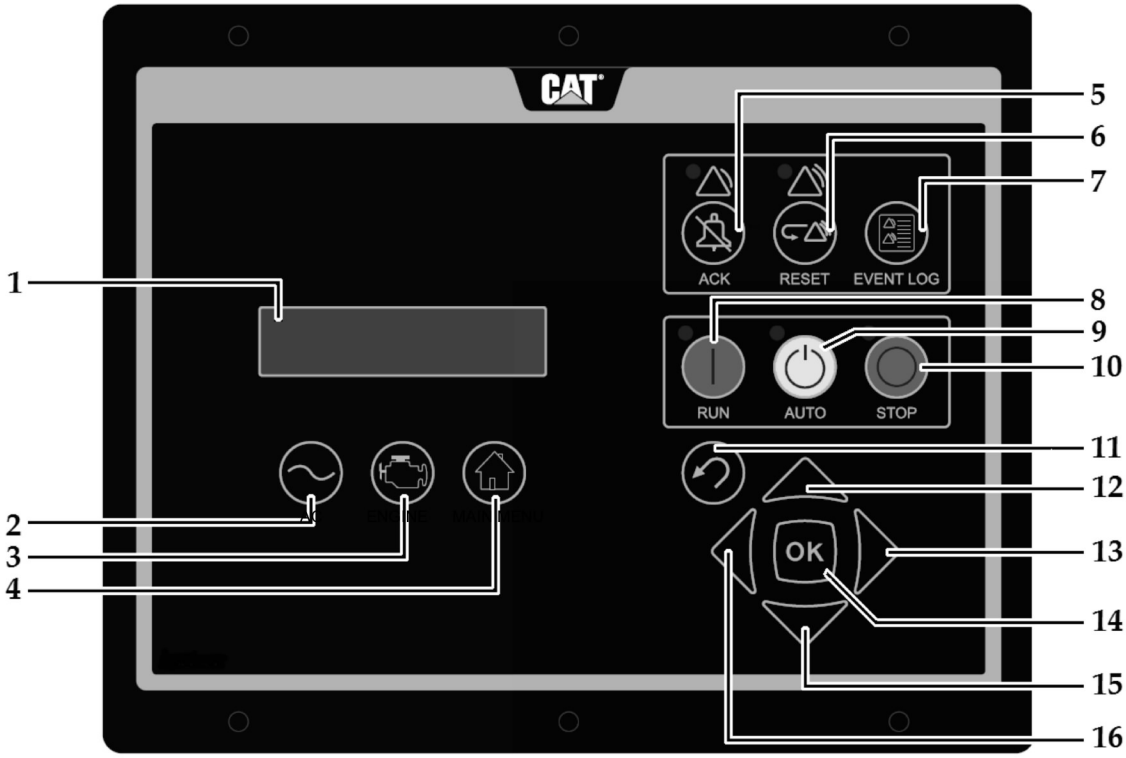

Illustration 36 g02082653

EMCP 4 Control System Panel

(1) Display screen
(2) AC overview key
(3) Engine overview key
(4) Main menu key
(5) Alarms acknowledge key
(6) Reset shut down Key
(7) Event log
(8) Run key
(9) Auto key
(10) Stop key
(11) Escape key
(12) Up key
(13) Right key
(14) OK 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.

Main Menu Key (4) – The "MAIN MENU" key will navigate the display to the main menu directly without having to navigate out of menus.

Acknowledge Key(5) – Pressing the "ACKNOWLEDGE" key will cause the horn relay to turn off. The horn relay being turned off will silence the horn. Pressing the "ACKNOWLEDGE" key will also cause any red or yellow flashing lights to either turn off or to come on continuously. The "ACKNOWLEDGE" key may also be configured to send out a global alarm silence signal on the J1939 Data Link. Sending out a global alarm silence signal on the J1939 Data Link will silence the horns on the annunciators.

Reset Key (6) – Pressing the "RESET" key will reset various events.

Event Log Key (7) – Pressing the "EVENT LOG" key will navigate the display to the event log.

RUN Key (8) – Pressing the "RUN" key will start the engine.

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

STOP Key (10) – Pressing the "STOP" key will stop the engine.

Escape Key (11) – The "ESCAPE" key is used in order to navigate through the menus. When the key is pressed, the user moves backward or the user moves upward through the menus. The "ESCAPE" key is also used to exit out of entering data when the user is programming the setpoints. If the "ESCAPE" key is pressed while the user is programming the setpoints, changes made on the screen will not be saved to memory.

Up Key (12) – 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.

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 "OK" 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 yellow warning lamp is located above the "ACKNOWLEDGE" key. 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 red shutdown lamp is located above the "RESET" key. 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

There are several digital inputs and outputs on “EMCP 4.1” and “EMCP 4.2” . For detailed information about the inputs on this electronic control module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, EMCP4.1/4.2.

Control Panel

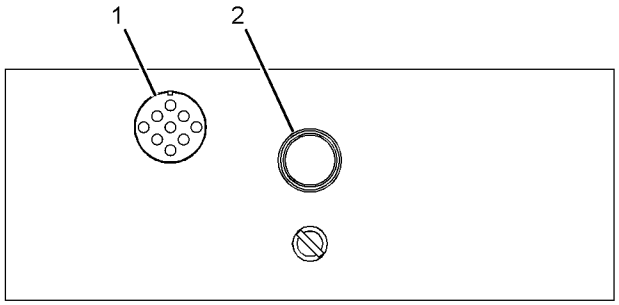

Illustration 37 g02931456

(1) Customer connection (if equipped)
(2) Emergency stop push button

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

Emergency Stop Push Button (3) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

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Overspeed

SMCS Code: 1900; 1907; 1912; 7427

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

This generator set application is equipped with an EMCP 4 that is used to provide engine control. The EMCP 4 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 4 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 4 before the engine is restarted.

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

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Sensors and Electrical Components

SMCS Code: 1900; 7400

Sensor Locations

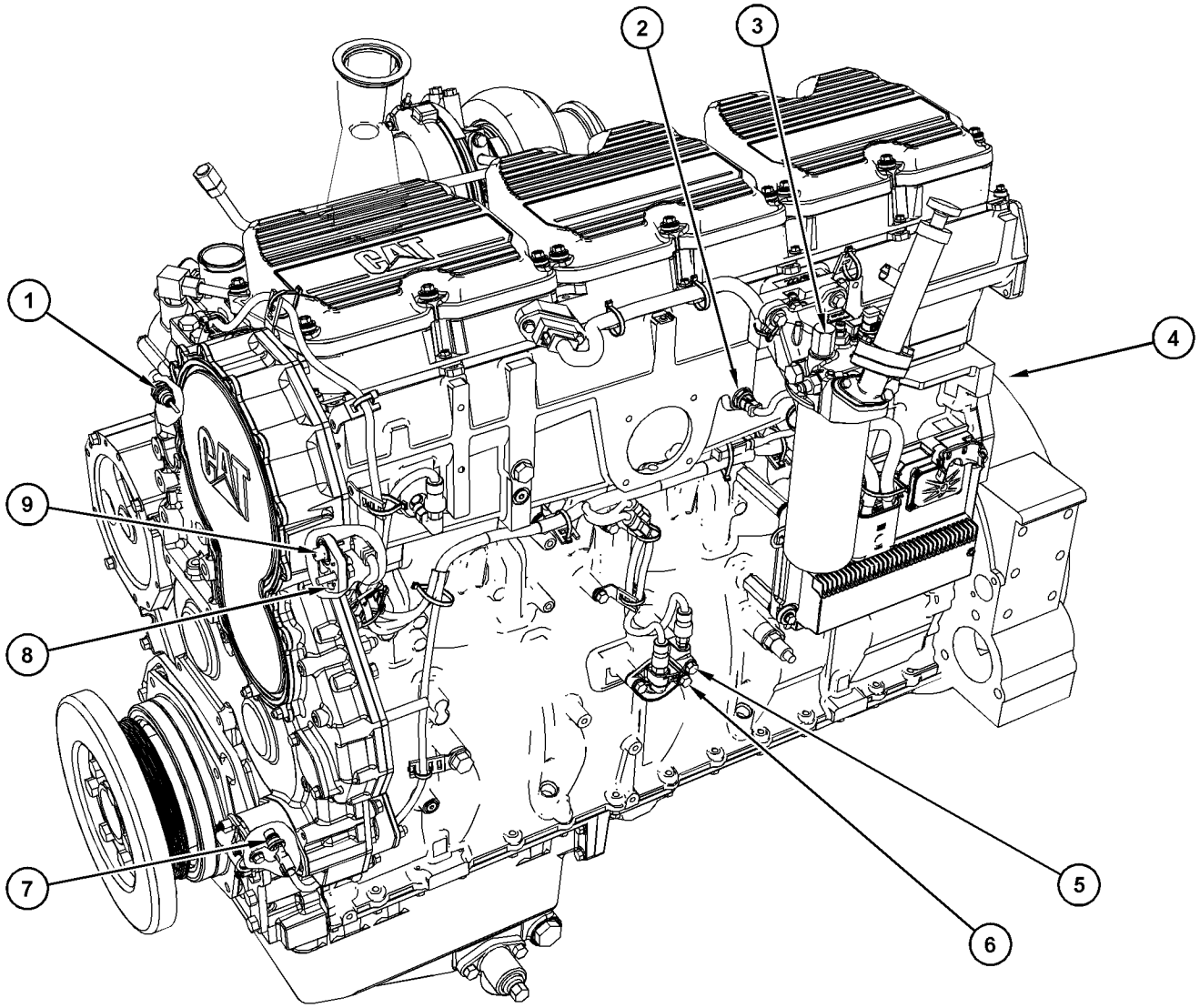

Illustration 38 g03403466

(1) Coolant Temperature Sensor

(2) Temperature Sensor for the Air Intake Manifold

(3) Fuel Pressure and Fuel Temperature Sensor

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

(5) Oil Pressure Sensor

(6) Atmospheric Pressure Sensor

(7) Primary Speed/Timing Sensor

(8) Secondary Speed/Timing Sensor

(9) Air Inlet Manifold Pressure Sensor

Failure of Sensors

All Sensors

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

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

Inlet Air Temperature Sensor

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

Engine Speed/Timing Sensors

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

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

Intermittent failure of the sensors will cause erratic engine control.

Coolant Temperature Sensor

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

Failure of the Coolant Temperature Sensor

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

Engine Diagnostics

i03840813

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 cannot 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.

i03150946

Configuration Parameters

SMCS Code: 1000; 1900; 1901; 1902

Customer specified parameters that will enhance the fuel efficiency and the operator's convenience can be programmed into the Electronic Control Module (ECM). Some parameters may affect engine operation. This may lead to complaints from the operator about power or about performance. The following engine related parameters may be programmed by the customer by using Caterpillar electronic service tools in order to influence the operation of the engine:

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_____

The customer specified parameters can be changed as often as needed. Password protection is provided so that the customer can change the parameters. The customer can authorize someone else to change the parameters. Ensure that a record of the parameters is kept in the Operation and Maintenance Manual. For detailed instructions on programming the engine for optimum performance and for optimum fuel economy, consult your Caterpillar dealer.

Engine Starting

i02354640

Before Starting Engine

SMCS Code: 1000; 1400; 1450

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

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

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

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

⚠ WARNING

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

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

i02351727

Cold Weather Starting

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

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

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

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

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

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

Extra battery capacity may be necessary for very cold temperatures.

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

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

Starting With the Starting Aid Switch (If Equipped)

⚠ WARNING

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

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

NOTICE

Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

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

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

1. Perform the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine”.

2. Press the “RUN” key.

3. Ether will automatically be injected if the following conditions are met:

a. The Starting Aid switch is in the AUTOMATIC position.

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

4. Additional injections may be necessary in order to start the engine. Additional injections may also be necessary in order to achieve low idle. If additional injections are necessary, toggle the Starting Aid switch to the MANUAL position. For additional injections, the jacket water coolant temperature must be less than 10 °C (50 °F).

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

i03798590

Starting the Engine (EMCP 4)

SMCS Code: 1000; 1450

⚠ WARNING

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

⚠ WARNING

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

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

NOTICE

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

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

NOTICE

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

1. Start the engine by one of these three methods.

- The operator presses the "RUN" Key.
- The control is in "AUTO" and the remote initiate contact (IC) becomes active.
- The operator presses the "AUTO" Key and a start command is sent via the RS-485 SCADA Data Link.

2. The EMCP 4 checks the system before the crank cycle begins. The EMCP 4 checks that no system faults are present. The EMCP 4 checks that all previous shutdown faults have been reset. The EMCP 4 also checks that the engine is not already running. If the engine is equipped with prelube, the EMCP 4 checks the status of the prelube. If the prelube is not complete, the EMCP 4 will not crank the engine.

3. The EMCP 4 begins the crank cycle.

4. The EMCP 4 cranks the engine until the crank cycle time reaches the setpoint for total crank time or until the engine starts.

5. The EMCP 4 deactivates the starting motor relay (SMR) when the engine speed reaches the setpoint for crank terminate speed.

i03640789

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

Use a battery that is sourced 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 the negative battery cable last and remove the negative battery cable first.

When an external electrical source is used to start the engine, turn the control switch on the generator set 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 jump start cables are attached to the engine that is 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 charging or starting source.

3. Connect one negative end of the jump start cable to the negative cable terminal of the charging or starting source. Connect the other negative end of the jump start cable to the stalled engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting combustible gases that are produced by some batteries.

4. Charge the batteries. The engine will not continue to run after starting if the batteries have not been charged.

5. Start the engine.

6. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

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

i02369353

After Starting Engine

SMCS Code: 1000

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

Warm-up

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

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

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

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

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

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

Engaging the Generator

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

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

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

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

5. Continue to check the indicators and the generator.

Engine Operation

i01646252

Engine Operation

SMCS Code: 1000

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

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

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

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

i04289968

Fuel Conservation Practices

SMCS Code: 1000; 1250

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

- Avoid spilling fuel.

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

- Be aware of the properties of the different fuels. Use only the recommended fuels.
- Avoid unnecessary operation at no load.

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

- Observe the service indicator for the air cleaner frequently, if equipped. Keep the air cleaner elements clean.
- Do not remove the cover for the air cleaner unless the air filter service indicator indicates the need for cleaning of the filter.
- Maintain a good electrical system.

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

- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.
- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the settings must be changed by a Cat dealer. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Cat dealer in order to obtain the rated horsepower.

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 39 . 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.

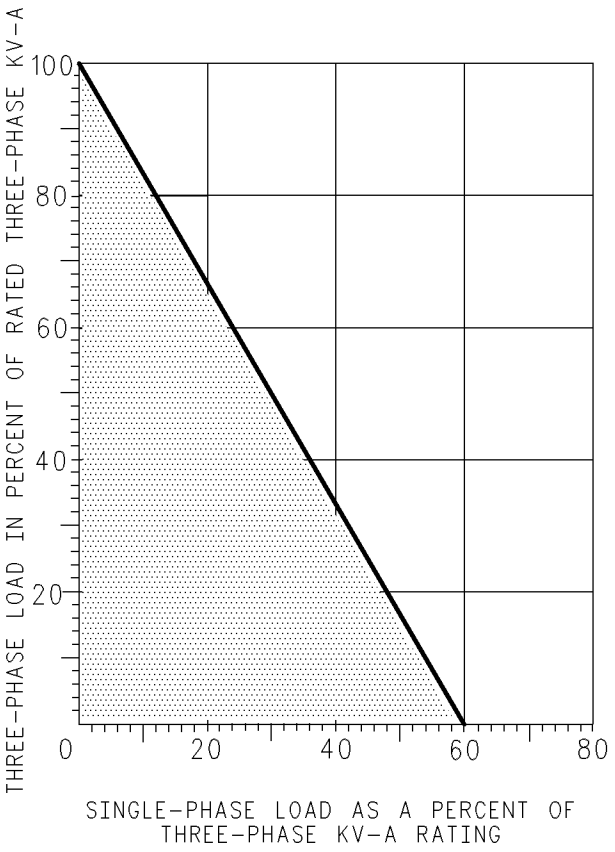

Illustration 39 g00627416

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. RTD temperature detectors are available. Contact your Caterpillar dealer for more information.

Bearing Temperature Detectors

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

i02424120

Single Unit Operation

SMCS Code: 4450

Initial Start-Up

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

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

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

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

Starting

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

Adjust the Voltage

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

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

Stopping

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

i03840814

Parallel Operation

SMCS Code: 4450

Initial Start-Up

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

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

1. Check the phase rotation.

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.

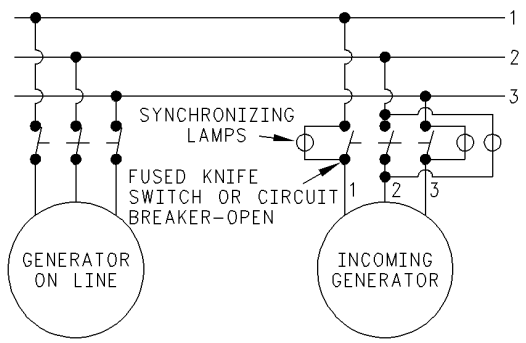

Illustration 40 g00695380

⚠ 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 cannot 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

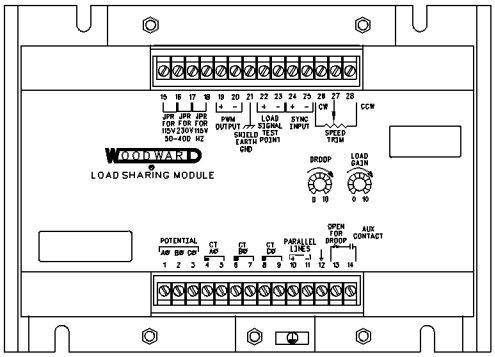

Illustration 41 g00630841

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.

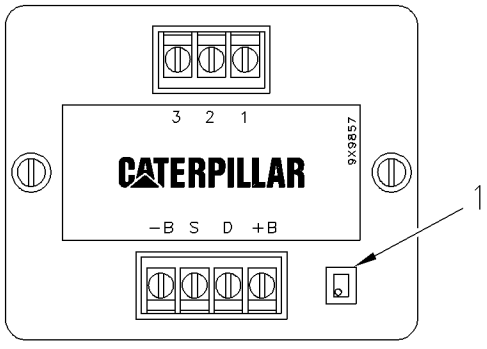

Illustration 42 g00637397

(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.

i05264083

Voltage Regulators

SMCS Code: 4467

Cat Digital Voltage Regulator (Cat DVR)

⚠ DANGER

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

Service by trained personnel only.

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

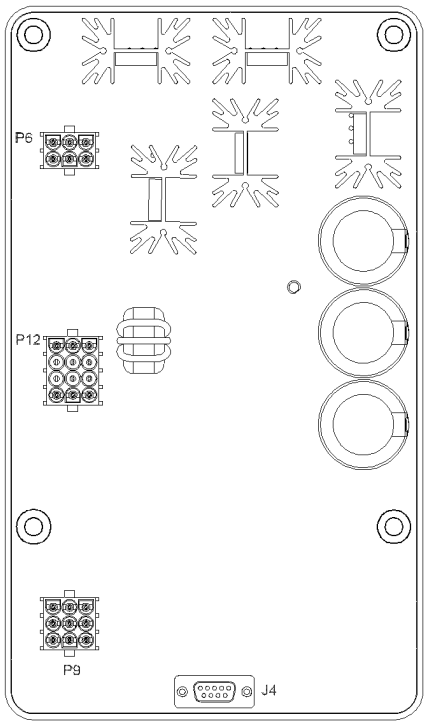

Illustration 43 g01115009

The Cat DVR is a microprocessor-based voltage regulator. Control power for the Cat DVR is supplied from an external source of 24 VDC. The power stage of the Cat DVR is supplied from a multiple pole high frequency permanent magnet generator which is mounted on the end of the generator shaft. Connections to the Cat DVR are made through three connectors. The communication between the Cat DVR and the service tool is accomplished by using a CANBUS protocol.

The Cat DVR has the following features:

- Three control modes:

1. Automatic voltage regulation (AVR)

2. Power factor (PF) regulation

3. Reactive power (VAR) regulation

- Programmable stability settings
- Soft start control with an adjustable time setting in AVR mode
- Dual slope voltage versus frequency (V/Hz) characteristic
- Three-phase or single-phase voltage sensing
- Single-phase current sensing
- Field current sensing and field voltage sensing
- Ten protection functions

Adjusting the Cat DVR

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

Refer to Specifications, Systems Operation, Testing and Adjusting, RENR7941, Cat Digital Voltage Regulator for complete information.

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Voltage Regulators
(R450Automatic Voltage Regulator (AVR))

SMCS Code: 4467

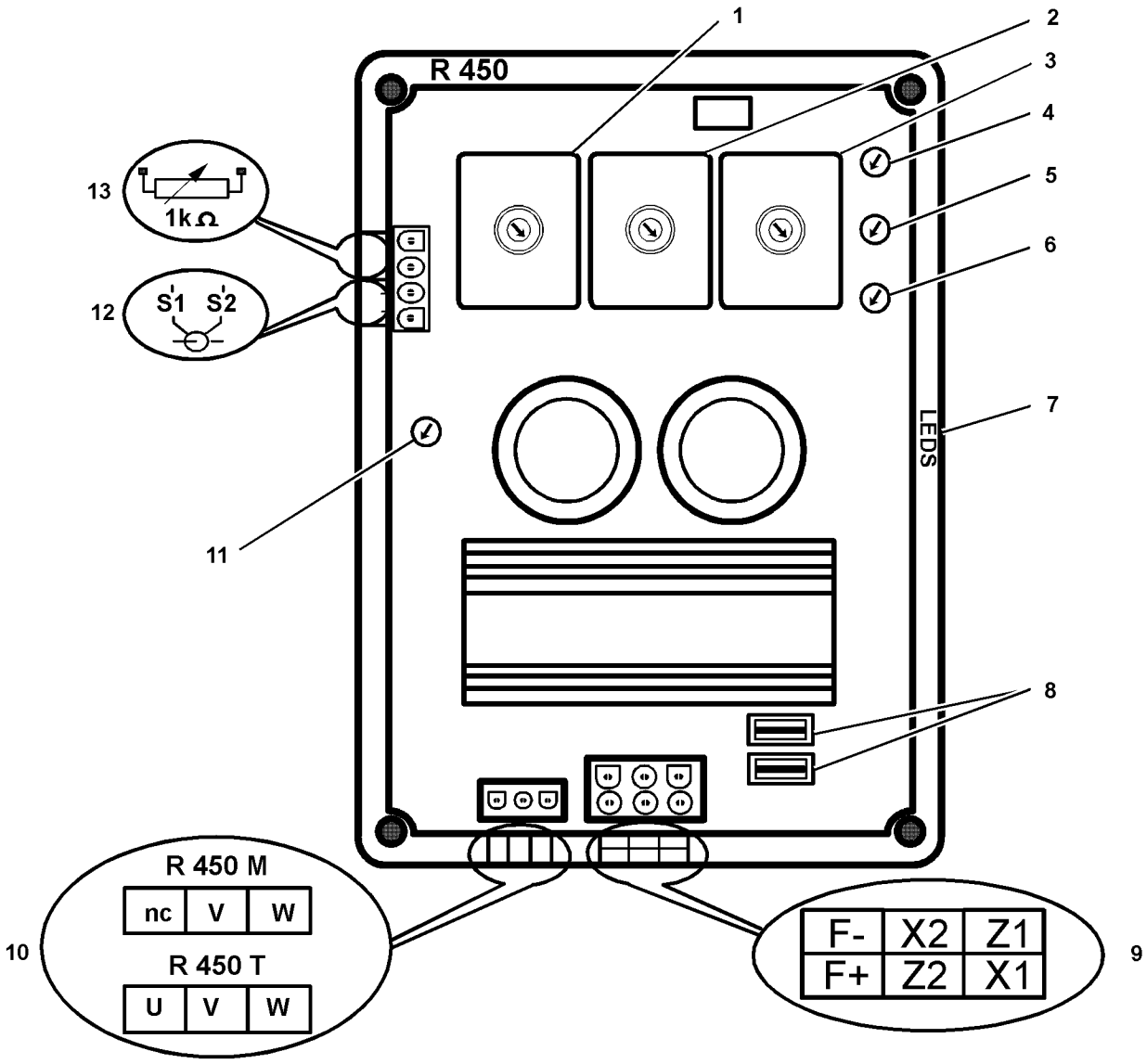

Illustration 44 g02320335

(1) Rotating switch (Excitation type and time response)
(2) Rotating switch (Voltage sensing)
(3) Rotating switch (LAM and U/F)
(4) “P1” Voltage
(5) “P2” Stability
(6) “P3” Excitation
(7) Excitation limiting/overload indicator LEDs
(8) 10 Amp fuses
(9) Field and excitation supply connections
(10) Model designation
(11) “P4” (Quad droop)
(12) Droop current transformer input
(13) Remote voltage adjustment potentiometer input

⚠ 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 R450 AVR may control any of the following excitation systems: AREP, PMG and SHUNT.

Excitation Type and Time Response Rotating Switch

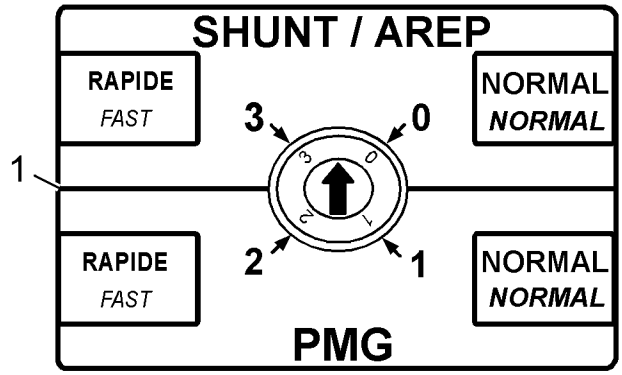

Illustration 45 g02352788

0 – "AREP" excitation and normal time response

1 – "PMG" excitation and normal time response

2 – "PMG" excitation and fast time response. For "SHUNT" applications, "AREP" excitation must be selected.

3 – "AREP" excitation and fast time response.

Voltage Sensing Rotating Switch

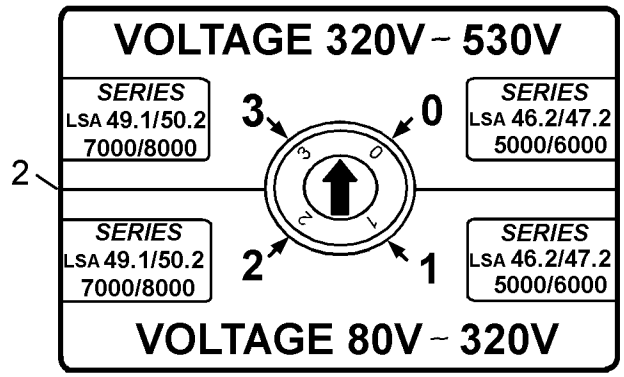

Illustration 46 g02352789

0 – Voltage from 320V to 530V (5000/6000 series)

1 – Voltage from 80V to 320V (5000/6000 series)

2 – Voltage from 80V to 320V (7000/8000 series)

3 – Voltage from 320V to 530V (7000/8000 series)

LAM and U/F Rotating Switch

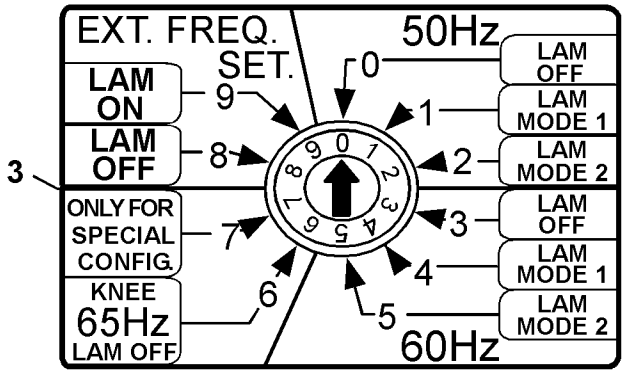

Illustration 47 g02352790

0 – Change in the voltage according to the U/F ratio. Knee point position at 48 Hz.

1 – Change in the voltage according to the 2 U/F. Knee point position at 48 Hz.

2 – Change in the voltage according to the self auto-adaptive LAM combined with 2 U/F. Knee point position at 48 Hz.

3 – Change in the voltage according to the U/F ratio. Knee point position at 58 Hz.

4 – Change in the voltage according to the 2 U/F. Knee point position at 58 Hz.

5 – Change in the voltage according to Change in the voltage according to the self auto-adaptive LAM combined with 2 U/F. Knee point position at 58 Hz.

6 – Change in the voltage according to the U/F ratio. Knee point position at 65 Hz.

7 – Special (not used)

8 – Change in the voltage according to the U/F ratio. Knee point position at 48 Hz or 58 Hz according to the selection of the frequency by an external contact.

9 – Change in the voltage according to LAM 1. Knee point position at 48 Hz or 58 Hz according to the selection of the frequency by an external contact.

Excitation Systems

“SHUNT” R 450 AVR

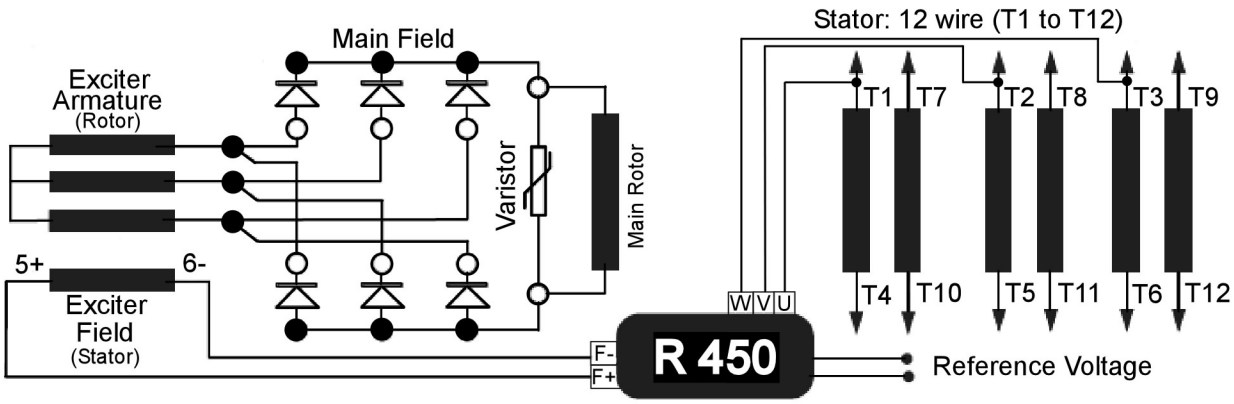

Illustration 48 g02173876

With “SHUNT” excitation, the AVR is powered by the main winding (100V to 140V) by using “X1, X2” on the AVR. The rotating switch should be in the “SHUNT/AREP” position.

“AREP” R 450 AVR

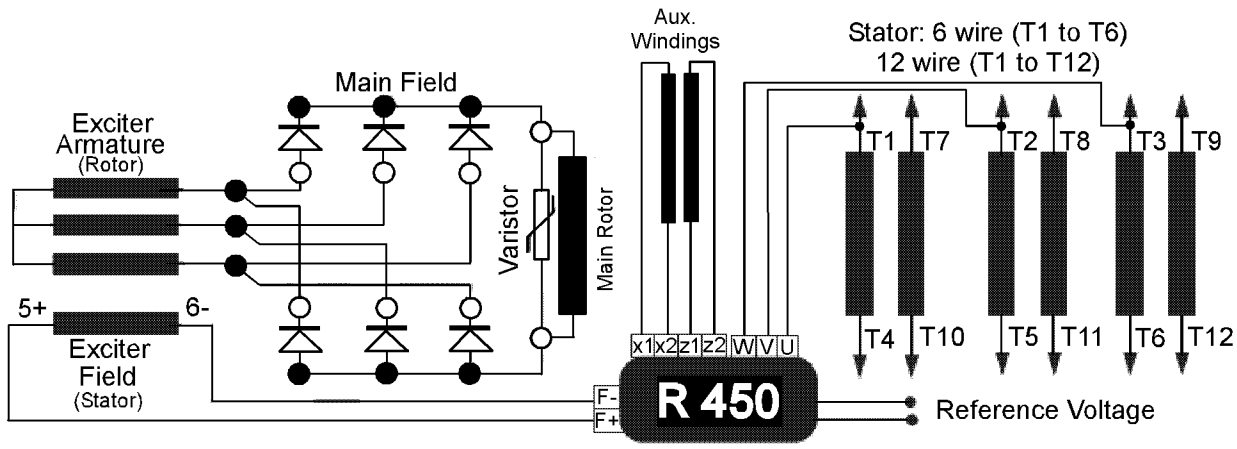

Illustration 49 g02173878

“AREP” Excitation System

The electronic AVR is powered by two auxiliary windings which are independent of the voltage sensing circuit.

The first winding has a voltage proportional to the alternator main voltage (“SHUNT” characteristic). The second winding has a voltage proportional to the stator current (compound characteristic: Booster effect).

The power supply voltage is rectified and filtered before being used by the AVR monitoring transistor. The excitation principle provides the generator set with a short circuit current overload capacity of 3 IN for 10s. The rotating switch should be in the “SHUNT/AREP” position.

“PMG” R 450 AVR

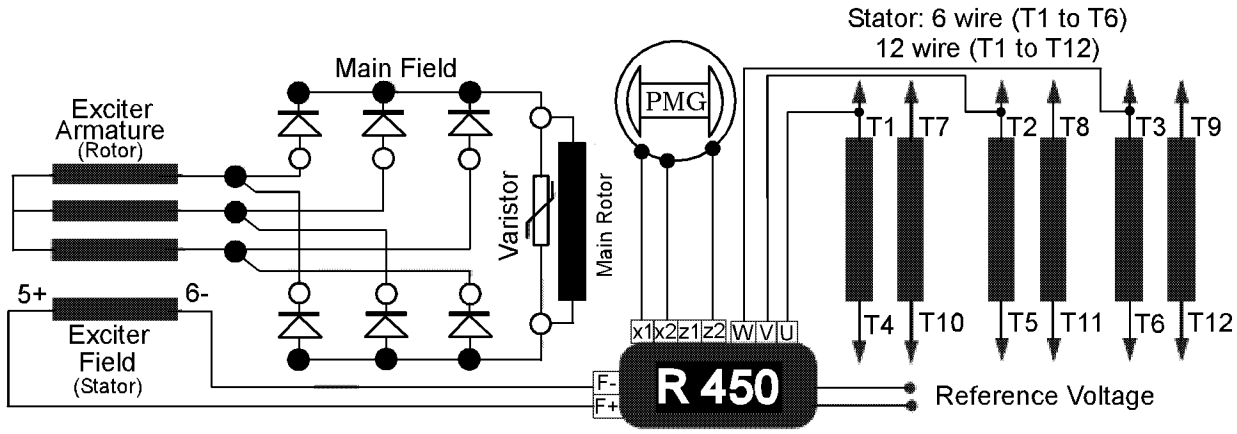

Illustration 50 g02173879

“PMG” Excitation System

With PMG excitation, a PMG added to the alternator supplies the AVR with voltage which is independent of the main alternator winding. The AVR monitors the alternator output voltage by adjusting the excitation current. Excitation principle provides the machine with a short circuit current overload capacity of 3 IN for 10s.

The rotating switch should be in the PMG position.

Set-up

A qualified engineer must make adjustments during tests of the AVR. The drive speed specified on the nameplate must be reached before starting the adjustment. After operational testing is completed, replace all access panels and covers.

The AVR adjusts the equipment.

NOTICE
Before using the AVR, correctly configure the rotating switches with AREP/SHUNT or PMG excitation.

Initial Potentiometer Settings

“P1” – Voltage minimum fully anti-clockwise (Factory setting 400V - 50 Hz)

“P2” – Stability (Not set)

“P3” – Excitation ceiling (Factory-sealed) 10 Amp maximum

“P4” – Voltage quadrature droop (Operation with current transformer) 0 quadrature droop fully anti-clockwise (Not set (fully anti-clockwise))

Stability Adjustments (Stand Alone Operation)

1. Install a DC analogue voltmeter (needle dial) calibrated 100 V on terminals “F+” , “F-” and an AC voltmeter calibrated 300 to 500 V or 1000 V on the alternator output terminals.

2. Check the rotating switch selection.

3. Voltage potentiometer “P1” at minimum, fully anti-clockwise.

4. Stability potentiometer “P2” around 120° from the anti-clockwise stop.

5. Start the engine. Set the speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.

6. Set the output voltage to the desired value using “P1” .

a. Rated voltage for solo operation (such as 400 V)

b. Or rated voltage (such as 410 V−)

7. If the voltage oscillates, use “P2” to make adjustments. Adjustments may be made in both directions. Observe the voltage between “F+” and “F−” , which is approximately 10 VDC. The best response time is obtained at the limit of the instability. If no stable position can be obtained. select the fast position.

8. Check the LAM operation depending on the rotating switch selection.

9. Vary the frequency below 48Hz or 58 Hz according to the operating frequency. Check the change in voltage from the voltage observed previously.

10. Readjust the speed of the generator set to the rated no-load value.

Stability Adjustments (Parallel Operation)

Note: Make sure that the speed droop is identical for all engines before working with the alternator.

1. Preset for parallel operation with the current transformer connected to “S1” , “S2” .

Note: Potentiometer “P4” (quadrature droop) in 1/4 position in the case of 5A CT and at 1/2 position in the case of 1A CT.

Apply the rated load (PF = 0.8 inductive). The voltage should drop by 2% to 3% (400V). If the voltage increases, check to make sure that one of the following have been reversed: “V” , “W” , “S1” and “S2”

2. The no-load voltages should be identical for all the alternators which run in parallel.

a. Couple the machines in parallel.

b. Attempt to obtain 0 kW power exchange by adjusting the speed.

c. Attempt to cancel or minimize the current circulating between the generator sets by alternating the voltage setting “P1” on one of the generator sets.

d. Do not adjust the voltage settings after the above procedure is completed.

3. Apply the available load by one of the following methods. The setting is only correct if a reactive load is available.

a. Alter the speed. Match the kW or divide the rated power of the units proportionally.

b. Alter the quadrature droop potentiometer "P4" . Match or divide the currents.

Maximum excitation adjustment

In the standard setting, the potentiometer "P3" is in maximum position. For applications requiring an overload protection, use the following procedure to adjust the excitation ceiling in AREP and PMG.

Method 1

1. Connect the AVR to the alternator.

2. Apply the load to 100% of rated generator set rated at power factor =0.8. The greed lamp is illuminated and the red lamp is off.

3. Adjust "P3" until the red lamp is flashing and the green lamp is illuminated.

4. Decrease the load to 100% and make sure that the red lamp is not illuminated.

5. Increase the load to 115%. Make sure that the red lamp flashes for 90 seconds. Make sure that the excitation current is brought back to the above adjusted value (I ex adjusted)

Method 2

Multiply the rated excitation current by 1.1. Use the obtained value to set the potentiometer P3. Use the following table.

Position of P3	1 Exc (A)
8h	1
9h	1.55
10h	1.95
11h	2.5
12h	3.15
13h	3.65
14h	4.25
15h	4.7
16h	5.15

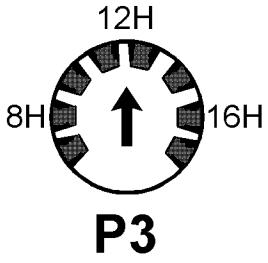

Illustration 51 g02355098

In the case of a permanent short-circuit, the excitation current must reach 2.9 × hex adjusted (clamped to 9.5 A) during 1 second in AREP or 10 seconds in PMG. The current must shut down to a value less than 1 Amp.

Note: When the excitation current is set to the rated value, a voltage dip is observed in the excitation current limit when the limitation is activated and the current limit is reached.

For information about electrical faults, refer to the Systems Operation/Testing and Adjusting, "Troubleshooting" information for the generator set.

i04672852

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 is 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

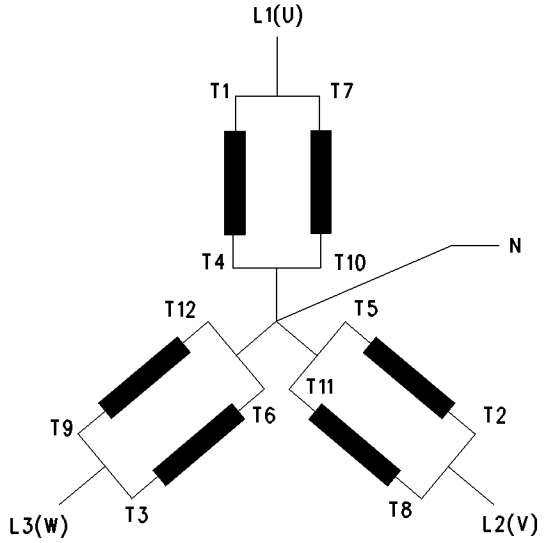

Illustration 52 g00952030

5000 12 wire factory connection for A wiring code

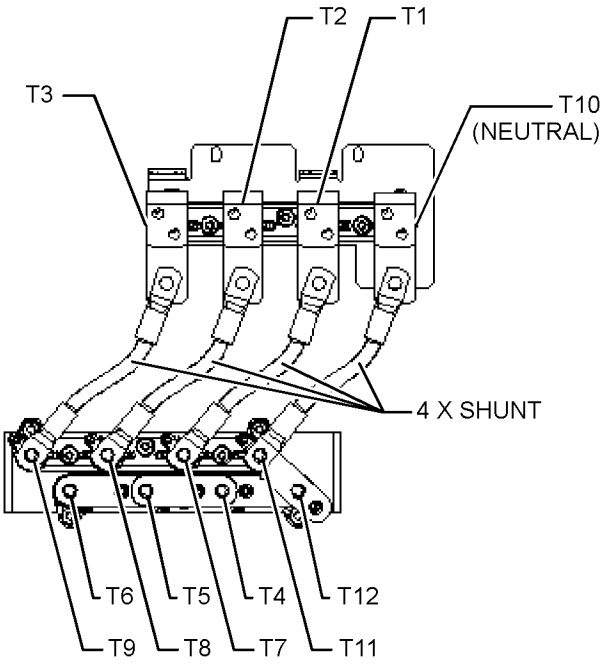

Illustration 53 g02792206

Table 3

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

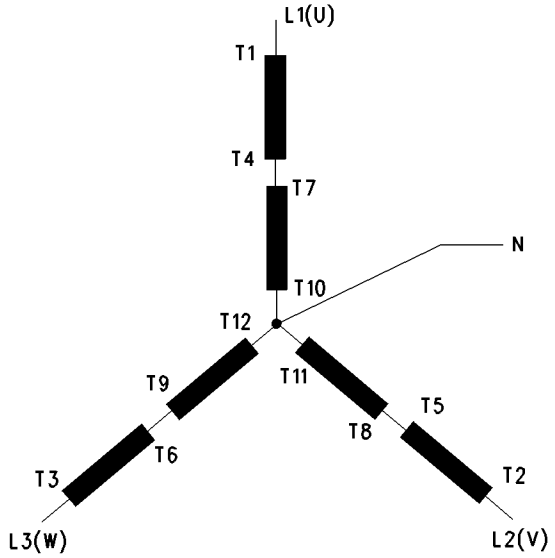

Illustration 54 g00952201

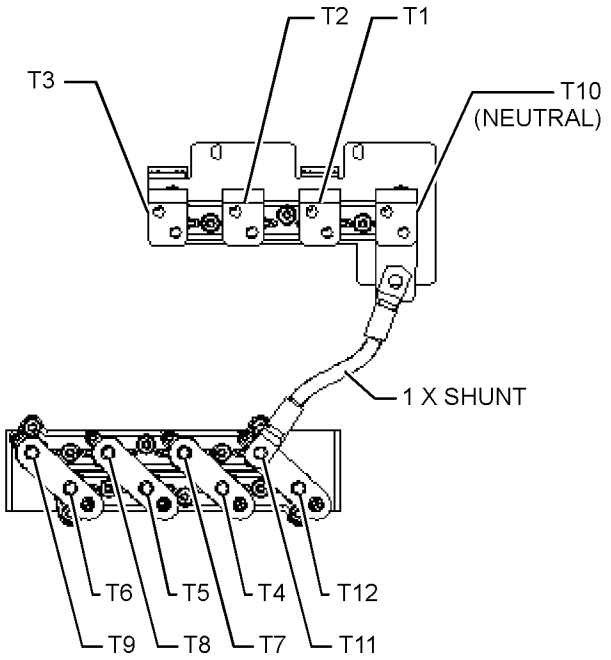

Illustration 55 g02792219

5000 12 wire factory connection for wiring code D

Table 4

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 5

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

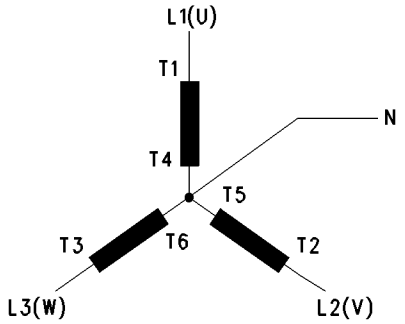

Illustration 56 g00996408

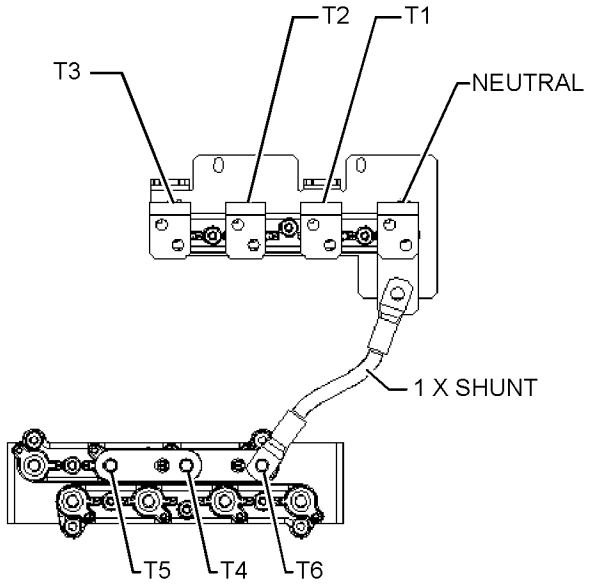

Illustration 57 g02792625

5000 6 wire factory connection for wiring code D

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

Table 6

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.

Cold Weather Operation

i05264084

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

The following fuels are the grades that are available for Cat 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”.

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Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250; 1280

Fuel Tanks

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

Fuel tanks should 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.

Draining the fuel tank will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank. Drain the water and sediment from any fuel storage tank at the following intervals:

- Weekly
- Oil changes
- Refueling of the fuel tank

Fuel Filters

NOTICE

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

NOTICE

Caterpillar requires the use of a 4 micron(c) secondary fuel filter for the following reasons: to maximize fuel system life and to prevent premature wear out from abrasive particles in the fuel. Cat high efficiency fuel filters meet these requirements. Consult your Cat dealer for the proper part numbers.

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

Fuel Heaters

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

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

Disconnect the fuel heater in warm weather.

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

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

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

Engine Stopping

i02237582

Emergency Stopping

SMCS Code: 1000; 7418

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

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

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

Emergency Stop Button

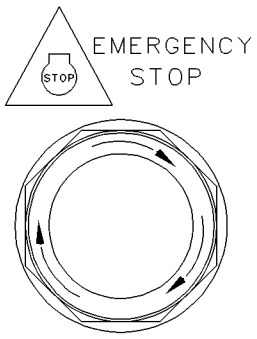

Illustration 58 g00104303
Typical emergency stop button

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.

i03907397

Manual Stop Procedure

SMCS Code: 1000; 7418

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

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

Allow the engine to gradually cool before stopping the engine

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

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

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

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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.

Maintenance Section

Refill Capacities

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Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

NOTICE
Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.

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

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

Refer to this Operation and Maintenance Manual, “Severe Service Application – Check” for information about operating an engine in a severe service application.

Note: Instructions for the installation of the filter are printed on the side of each Caterpillar spin-on filter. For filters that are not Caterpillar filters, refer to the installation instructions that are provided by the supplier of the filter.

Diesel Engine Oil

Cat DEO (Diesel Engine Oil)

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

- **Cat DEO-ULS (Diesel Engine Oil Ultra Low Sulfur) (SAE 5W-40)**
- **Cat DEO-ULS (Diesel Engine Oil Ultra Low Sulfur) (SAE 10W-30)**
- **Cat DEO-ULS (Diesel Engine Oil Ultra Low Sulfur) (SAE 15W-40)**

Engine Oil

Cat oils have been developed and tested in order to provide the full performance and life that has been designed and built into Cat engines.

Cat DEO-ULS or oils that meet the Cat ECF-3 specification and the API CJ-4 are required for use in the applications listed below. Cat DEO-ULS and oils meeting Cat ECF-3 specification and the API CJ-4 and ACEA E9 oil categories have been developed with limited sulfated ash, phosphorus, and sulfur. These chemical limits are designed to maintain the expected aftertreatment devices life, performance, and service interval. If oils meeting the Cat ECF-3 specification and the API CJ-4 specifications are not available, oils meeting ACEA E9 may be used. ACEA E9 oils meet the chemical limits designed to maintain aftertreatment device life. ACEA E9 oils are validated using some but not all ECF-3 and API CJ-4 standard engine performance tests. Consult your oil supplier when considering use of an oil that is not Cat ECF-3 or API CJ-4 qualified.

Failure to meet the listed requirements will damage aftertreatment-equipped engines and can negatively impact the performance of the aftertreatment devices. The Diesel Particulate Filter (DPF) will plug sooner and require more frequent DPF ash service intervals.

Typical aftertreatment systems include the following:

- Diesel Particulate Filters (DPF)
- Diesel Oxidation Catalysts (DOC)
- Selective Catalytic Reduction (SCR)
- Lean NOx Traps (LNT)

Other systems may apply.

Table 7

Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Engine Crankcase	Cat DEO-ULS Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−30	50	−22	122
	Cat DEO-ULS	SAE 10W-30	−18	40	0	104
	Cat DEO-ULS	SAE 15W-40	−9.5	50	15	122

NOTICE
Oil Renewal systems should not be used in engines equipped with aftertreatment systems. Reduced life or damage to the aftertreatment may occur.

S·O·S Services Oil Analysis

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

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

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered S·O·S Oil Analysis program will reduce repair costs and the program will lessen the impact of downtime.

The S·O·S Oil Analysis program uses a wide range of tests to determine the condition of the oil and the condition of the lubricated compartment. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Caterpillar dealership should make the final analysis.

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

Refer to Special Publication, SEBU6251, Caterpillar Commercial Engine Fluids Recommendations in order to obtain additional information about S·O·S Services oil analysis. You can also contact your local Caterpillar dealer in order to obtain additional information about the S·O·S Services Oil Analysis program.

Refill Capacities (Engine Oil)

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

Table 8

C13 Industrial Engine Approximate Refill Capacities		
System	Liters	Quarts
Oil Sump(1)	40	42.2

(1) These values are approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

Diesel Fuel Recommendations

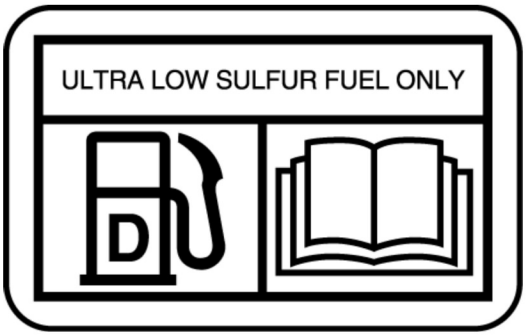

Illustration 59 g02157153
NACD Film

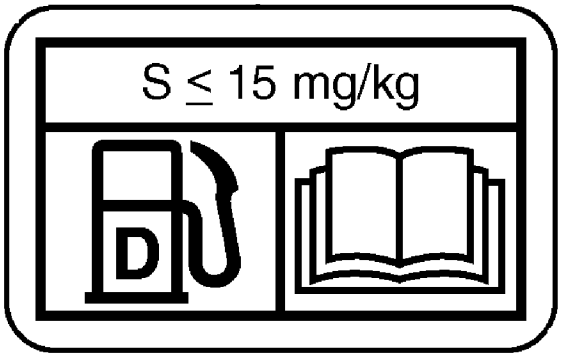

Illustration 60 g02052934
EAME Film

Diesel fuel must meet “Cat Specification for Distillate Fuel” and the latest versions of ASTM D975 or EN 590 in order to ensure optimum engine performance. Refer to Special Publication, SEBU6250, Caterpillar Machine Fluids Recommendations for the latest fuel information and for Cat fuel specification. This manual may be found on the Web at Safety.Cat.com.

NOTICE
Ultra Low Sulfur Diesel (ULSD) fuel 0.0015 percent (≤15 ppm (mg/kg)) sulfur is required by regulation for use in engines certified to nonroad Tier 4 standards (U.S. EPA Tier 4 certified) and that are equipped with exhaust aftertreatment systems.

European ULSD 0.0010 percent (≤10ppm (mg/kg)) sulfur fuel is required by regulation for use in engines certified to European nonroad Stage IIIB and newer standards and are equipped with exhaust aftertreatment systems.

Misfueling with fuels of higher sulfur level can have the following negative effects:

- **Shorten the time interval between aftertreatment device service intervals (cause the need for more frequent service intervals)**
- **Adversely impact the performance and life of aftertreatment devices (cause loss of performance)**
- **Reduce regeneration intervals of aftertreatment devices**
- Reduce engine efficiency and durability.
- Increase the wear.
- Increase the corrosion.
- Increase the deposits.
- Lower fuel economy
- Shorten the time period between oil drain intervals (more frequent oil drain intervals).
- Increase overall operating costs.

Failures that result from the use of improper fuels are not Cat factory defects. Therefore the cost of repairs would not be covered by a Cat warranty.

Caterpillar does not require the use of ULSD in off road and machine applications that are not Tier 4/ Stage IIIB certified engines. ULSD is not required in engines that are not equipped with after treatment devices. For Tier 4/Stage IIIB/Stage IV certified engines always follow operating instructions. Fuel tank inlet labels are installed in order to ensure that the correct fuels are used.

Refer to Special Publication, SEBU6250, Caterpillar Machine Fluids Recommendations for more details about fuels, lubricants, and Tier 4 requirements. This manual may be found on the Web at Safety.Cat.com.

Refill Capacities (Fuel System)

Refer to the manual that is provided by the OEM for capacities of the fuel system.

Lubricating Grease

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

Caterpillar provides various greases that vary in performance from a moderate performance to an high performance. These greases service the entire line of Caterpillar products in the wide variety of climates throughout the world. From this variety of Caterpillar grease products, you can find a Caterpillar grease that will meet or exceed the performance requirements of most engines.

The performance requirements of your engine must be determined before you select any Caterpillar grease. Consult the recommendations for greases that are made by the OEM for the equipment. Then, consult with your Caterpillar dealer for a list of greases that have the performance specifications and the available sizes of containers.

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

If it is necessary to choose a single grease to use for all of the equipment at one site, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which barely meet the minimum performance requirements can be expected to produce the minimum lives of your parts. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. This cost should be based on an analysis that includes the costs of parts, labor, downtime, and the cost of the amount of grease that is required.

Note: Purge all of the old grease from a joint before you change from one type of grease to another type of grease. Some greases are not chemically compatible with other greases. Consult your supplier in order to determine if the greases are compatible.

If you are not certain that the old grease is compatible with the new grease, purge the old grease from the system before applying the new grease.

Note: All Caterpillar greases are compatible with each other.

Coolant

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

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

NOTICE
Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

The following two coolants are used in Caterpillar Diesel Engines :

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

Note: Cat generator sets using certain engines and radiators require dosing of the ELC with a measured volume of liquid phosphate solution. The phosphate solution alters aluminum components from chemically active to chemically passive. The major aluminum component is the radiator core.

Note: All Cat generator sets built using an aluminum radiator core leave the factory already dosed. NO further dosing is required throughout the life of the generator set except were the radiator is replaced with new.

Note: When a new radiator is installed, failure to add the proper volume of liquid phosphate solution may cause undesirable effects such as:

- Depletion of nitrites in the coolant, causing cavitation erosion of wet cylinder liners
- Loss of coolant color, reducing the ease of coolant level checking in the radiator top tank

Note: Radiators with copper cores should never be dosed with phosphate solution, which would cause severe scaling and reduced efficiency of the coolant system.

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

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

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

Table 9

Service Life Before Flushing and Before Refilling	
Coolant	**Service Life(1)**
Cat ELC	12,000 hours, or 6 years
Commercial coolant that meets the Caterpillar EC-1 specification	6000 hours, or 6 years
Cat DEAC	3000 hours, or 3 years
Commercial Heavy-Duty Coolant that meets ASTM D4985 or ASTM D6210	3000 hours, or 1 year

(1) Use the interval that occurs first.

Note: Add the Cat ELC Extender at the halfway point of the coolant change interval.

Note: These coolant change intervals are only possible with annual S·O·S Services Level 2 coolant sampling and analysis.

S·O·S Services Coolant Analysis

Table 10

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
DEAC	Every 250 Hours(1) (2)	Every 2000 Hours or Yearly(1) (3)
ELC	Optional(3)	Yearly(3)

(1) This interval is recommended for the sampling of all conventional heavy-duty coolant.
(2) This interval is also recommended the for the sampling of a commercial coolant that meets the Cat (Engine Coolant specification - 1) requirement.
(3) The Level 2 coolant analysis should be performed sooner if a problem is suspected or identified.

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

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.

Refill Capacity (Coolant System)

To maintain the cooling system, the total cooling system capacity must be known. The capacity of the total cooling system will vary. The capacity will depend on the size of the radiator (capacity). Table 11 should be completed by the customer for the maintenance of the cooling system.

Table 11

Approximate Capacity of the Cooling System		
Compartment or System	Liters	Quarts
Total Cooling System (1)	38	40.2

(1) The total cooling system capacity includes the following components:the engine block, the radiator and all coolant hoses and lines.

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

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Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Refer to this Operation and Maintenance Manual, “Severe Service Application” for information about operating an engine in a severe service application.

Note: The interval for changing the coolant varies depending on the type of coolant being replaced. Refer to this article, “Coolant Recommendations”, for the intervals for changing the coolant.

Diesel Engine Oil

For more information, refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations.

Cat Diesel Engine Oil (Cat DEO)

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

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

Table 12

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat Cold Weather DEO-ULS	SAE 0W-40
Diesel Engine Oil	Cat DEO	SAE 15W-40
		SAE 10W-30
	Cat DEO SYN	SAE 5W-40

Note: Cat DEO and Cat DEO-ULS multigrade oils are the preferred oils for use in this Cat Diesel Engine.

Commercial Oil

Note: Non-Cat commercial oils are second choice oils for your engine.

NOTICE
Caterpillar does not warrant the quality or performance of non-Cat fluids.

The three current Caterpillar ECF specifications are: Cat ECF-1-a, Cat ECF-2 and Cat ECF-3. Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications.

A commercial oil must meet the following standards to be considered an equivalent of a Cat Diesel Engine Oil :

Table 13

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Performance Requirement	Cat ECF Specifications Requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements

(continued)

(Table 13, contd)

Cat ECF-2	API CI-4 / CI-4 PLUS Oil Category performance requirements
	Passing standard Cat C13 engine test per API requirements
	Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	API CH-4 Oil Category performance requirements
	For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one additional Cat 1P SCOTE test (ASTM D6681) is required
	Oils of sulfated ash > 1.50 percent are not allowed

In selecting oil for any engine application, both of the following must be satisfied: the oil viscosity and the category of oil performance or the specification for oil performance . Using only one of these parameters will not sufficiently define oil for an engine application.

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

Refer to Table 14 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 14 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

Table 14

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines					
Oil Type and Performance Requirements	Viscosity Grade	°C		°F	
		Min	Max	Min	Max
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-30	−40	30	−40	86
Cat Cold Weather DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-40	−40	40	−40	104

(continued)

(Table 14, contd)

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines					
Cat DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-30	−30	30	−22	86
Cat DEO-ULS SYN **Cat DEO** Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-40	−30	50	−22	122
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 10W-30	−18	40	0	104
Cat DEO-ULS **Cat DEO**	SAE 10W-40	−18	50	0	122
	SAE 15W-40	−9.5	50	15	122

Note: A cold soaked start occurs when the engine has not been operated recently, allowing the oil to become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be necessary for cold soaked starts that are above the minimum temperature depending on factors such as parasitic load.

Total Base Number (TBN) and Fuel Sulfur Levels

The use of Cat S·O·S Services oil analysis is recommended strongly for determining oil life.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the ASTM D2896 procedure. For direct injection engines that use distillate fuel, the following guidelines apply:

Table 15

TBN recommendations for applications in Cat engines (1)		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils	TBN of Commercial Engine Oils
≤0.05 percent (≤500 ppm)	Cat DEO-ULS Cat DEO	Min 7
0. 1- 0.05 percent (1000-500 ppm)	Cat DEO-ULS Cat DEO	Min 7
Above 0.1 percent (above 1000 ppm)(2)	Cat DEO(3)	Min 10

(continued)

(Table 15, contd)

(1) When using fuel with 0.10% sulfur (1000 ppm) or higher, refer to this Operation and Maintenance Manual, “Severe Service Application” for more information.

(2) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.

(3) Cat DEO-ULS may be used if an oil analysis program is followed. Base the oil change interval on the analysis.

S·O·S Services Oil Analysis

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

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered S·O·S oil analysis program will reduce repair costs and the program will lessen the impact of downtime.

The S·O·S Oil Analysis program uses a wide range of tests to determine the condition of the oil and the crankcase. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Cat dealership should make the final analysis.

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

Refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations in order to obtain additional information about S·O·S Services oil analysis. You can also contact your local Cat dealer.

Fuel

Note: Caterpillar strongly recommends the filtration of fuel through a fuel filter with a rating of four microns (c) absolute or less. This filtration should be located on the device that dispenses the fuel to the fuel tank for the engine. This filtration should also be located on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

NOTICE
In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat Diesel Engines that are equipped with unit injected fuel systems. All current Cat Diesel Engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.

Caterpillar does not warrant the quality or performance of non-Cat fluids and filters.

Diesel engines can burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. These fuels are not suitable for use in all engine applications. The acceptability of these fuels for use is determined on an individual basis. A complete fuel analysis is required.

For more information, refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations or consult your Cat dealer for further information.

Diesel Distillate Fuel

Diesel engines may burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene. These fuels must meet the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel” article.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. **These fuels are not suitable for use in all engine applications.** The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Cat dealer for further information.

NOTICE
The footnotes are a key part of the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table. Read ALL of the footnotes.

Table 16

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35% maximum	D1319	ISO 3837
Ash	0.01% maximum (weight)	D482	ISO 6245
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	D524	ISO 4262
Cetane Number (1)	40 minimum (DI engines)	D613 or D6890	ISO 5165
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	D2500	ISO 3015
Copper Strip Corrosion	No. 3 maximum	D130	ISO 2160
Distillation	10% at 282 °C (540 °F) maximum	D86	ISO 3405
	90% at 360 °C (680 °F) maximum		
Flash Point	legal limit	D93	ISO 2719
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	D6468	No equivalent test
API Gravity (2)	30 minimum	D287	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	D97	ISO 3016
Sulfur	(3) (4) (5)	D5453 or D2622	ISO 20846 or ISO 20884

(continued)

(Table 16, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	D1796 or D2709	ISO 3734
Water	0.05% maximum	D6304	No equivalent test
Sediment	0.05% maximum (weight)	D473	ISO 3735
Gums and Resins (6)	10 mg per 100 mL maximum	D381	ISO 6246
Lubricity	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	D6079	No equivalent test

(1) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index of 37.5 (PC engines), and 44.2 (DI engines) when the ASTM D4737-96a test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.

(2) Via standards tables, the equivalent kg/m^3 (kilograms per cubic meter) using the ASTM D287 test method temperature of 15.56° C (60° F) for the minimum API gravity of 30 is 875.7 kg/m^3, and for the maximum API gravity of 45 is 801.3 kg/m^3.

(3) ULSD 0.0015% (<15 ppm S) is required by law for Tier 4 engines and engines with aftertreatment devices.

(4) Certain Cat fuel systems and engine components can operate on fuel with a maximum sulfur content of 3%. Contact your Cat dealer for guidance about appropriate maintenance intervals and fluids for engines operating on fuel with sulfur levels between 0.1% and 3%.

(5) An engine which operates on fuel with 0.1% (1000 ppm) of sulfur or more is operating in a severe service application. Refer to this Operation and Maintenance Manual, “Severe Service Application” for information about operating an engine in a severe service application.

(6) Follow the test conditions and procedures for gasoline (motor).

Biodiesel

A biodiesel blend of up to 20 percent may be used in the engine when the fuel blend meets the recommendations in table 17 and meets the recommendations in Special Publication, SEBU6251, “Biodiesel”.

Note: A complete Cat S·O·S Services oil analysis program is **recommended strongly** when using biodiesel blends above 5 percent.

Table 17

Biodiesel Blends for Cat Commercial Diesel Engines		
Biodiesel blend stock	Final blend	Distillate diesel fuel used for blend
Caterpillar biodiesel specification, ASTM D6751 or EN14214	B20: ASTM D7467 and API gravity 30-45	Caterpillar distillate diesel fuel specification, ASTM D975 or EN590

Fuel Additives

Cat Diesel Fuel Conditioner

Cat Diesel Fuel Conditioner is a proprietary formulation that has been extensively tested for use with distillate diesel fuels for use in Cat Diesel Engines. Cat Diesel Fuel Conditioner is a high performance diesel fuel conditioner for use with lower quality fuels that do not meet the minimum requirements of any of the following:

- “Caterpillar Specification for Distillate Diesel Fuel”
- National Conference on Weights and Measures (NCWM) Premium Diesel definition (refer to the 2004 or newer National Institute of Standards & Technology (NIST) Handbook).
- EN590 (non-arctic)
- ASTM D975

Cat Diesel Fuel Conditioner is the only fuel conditioner/additive available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations for information about the use of Cat Diesel Fuel Conditioner.

Cat Diesel Fuel System Cleaner

Note: Cat Diesel Fuel System Cleaner is the only fuel system cleaner available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Cat Diesel Fuel System Cleaner is a proven high performance detergent product designed specifically for cleaning deposits that form in the fuel system. Deposits in the fuel system reduce system performance and can increase fuel consumption. Cat Diesel Fuel System Cleaner addresses the deposits formed due to the use of degraded diesel fuel, poor quality diesel fuel, and diesel fuel containing high quantities of high molecular weight compounds. Cat Diesel Fuel System Cleaner addresses deposits formed due to the use of biodiesel, biodiesel blends, and biodiesel that does not meet the appropriate quality specifications. Continued use of Cat Diesel Fuel System Cleaner is proven to inhibit the growth of new deposits.

Caterpillar strongly recommends that Cat Diesel Fuel System Cleaner be used with biodiesel and biodiesel blends. Cat Diesel Fuel System Cleaner is suitable for use with biodiesel/biodiesel blends that meet Caterpillar biodiesel recommendations and requirements. Not all fuel cleaners are suitable for use with biodiesel/biodiesel blends. Read and follow all applicable label usage instructions. Also, refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations, “Distillate Diesel Fuel”, article and also refer to the “Biodiesel” article, which includes Caterpillar biodiesel recommendations and requirements.

Aftermarket Fuel Additives

There are many different types of fuel additives that are available to use. Caterpillar does not generally recommend the use of fuel additives.

In special circumstances, Caterpillar recognizes the need for fuel additives. Use fuel additives with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum levels that are allowed by the following agencies: EPA and other regulatory agencies. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: For best results, your fuel supplier should treat the fuel when additives are needed.

Cooling System

Note: Refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations for complete information about the proper fluids for use in the cooling system.

⚠ WARNING

The cooling system operates under pressure which is controlled by the radiator pressure cap. Removing the cap while the system is hot may allow the escape of hot coolant and steam, causing serious burns.

Before you remove the radiator cap, allow the system to cool. Use a thick cloth and turn the radiator cap slowly to the first stop to allow pressure to escape before fully removing the cap.

Avoid contact with coolant.

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

NOTICE
If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely in order to prevent damage caused by freezing coolant.

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

Coolant Recommendations

Note: A Cat Diesel Engine equipped with air-to-air aftercooling (ATAAC) requires a minimum of 30 percent glycol to help prevent water pump cavitation.

Table 18

Coolant Recommendations for use in Cat Diesel Engines			
Recommendations	**Product**	**Service Hours** (1) (2) (3)	**Required Maintenance**
Preferred	Cat ELC (Cat Extended Life Coolant)	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
	Cat ELI (Cat Extended Life Inhibitor)	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
Min requirements	Cat EC-1 specification and ASTM D6210 and Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid Phosphate, borate, and silicate free Tolyltriazole: minimum typical concnetration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or 6 years	Add Extender at 3000 service hours or one half of service life
Acceptable	Cat DEAC (Cat Diesel Engine Antifreeze/Coolant)	3000 hours or 3 years	SCA (Supplemental coolant additive) at maintenance intervals
Min requirements for fully formulated Heavy Duty Commercial coolants	ASTM D6210 and Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for Commercial coolants requiring SCA precharge	ASTM D4985 and(1) Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	SCA at initial fill and SCA at maintenance intervals

(1) New Coolants at 50 volume percent diluted. Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 ASTM D1193 requirements.
(2) Maintain the in-service coolant at the given limits.
(3) When referring to the service hours, use the interval that occurs first. These coolant change intervals are only achievable with annual S·O·S Services Level 2 coolant sampling analysis.

Table 19

Special Requirements	
Cat C7-C32 Marine Engines with heat exchangers	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is NOT allowed.
Cat diesel engines equipped with air-to-air aftercooling (ATAAC)	

NOTICE

Use Only Approved SCAs and Extenders

Conventional coolants require the maintenance addition of SCA throughout the expected life of the coolants. Do NOT use an SCA with a coolant unless approved specifically by the coolant supplier. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

To help ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do not use an extender with a coolant unless the extender has been approved specifically for use by the coolant manufacturer. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC can be recycled into conventional coolants.

For more information, refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations.

S·O·S Services Coolant Analysis

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

Table 20

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional	Yearly(1)

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

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

S·O·S Services Coolant Analysis (Level 1)

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

The following properties of the coolant are tested:

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

The results are reported, and appropriate recommendations are made.

S·O·S Services Coolant Analysis (Level 2)

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

The S·O·S coolant analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Identification of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported, and appropriate recommendations are made.

For more information on S·O·S coolant analysis, consult your Cat dealer.

Greases

If it is necessary to choose a single grease, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which barely meet the minimum performance requirements can be expected to barely produce the minimum lives of your parts. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. The cost should be based on an analysis that includes the costs of parts, labor, downtime, and the cost of the amount of grease that is required.

For more information, refer to Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations.

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 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
- experience level of the operator
- philosophy of the operator

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 Cat dealer.

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System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

⚠ WARNING

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

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

Fuel System

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

High Pressure Fuel Lines (If Equipped)

⚠ WARNING

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

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

This is because of the following differences:

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

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

1. Stop the engine.

2. Wait for ten minutes.

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

Engine Oil

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

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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 Cat dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine 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 Cat Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

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

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

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

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

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to move back accidentally, and contact any of the ECM pins.

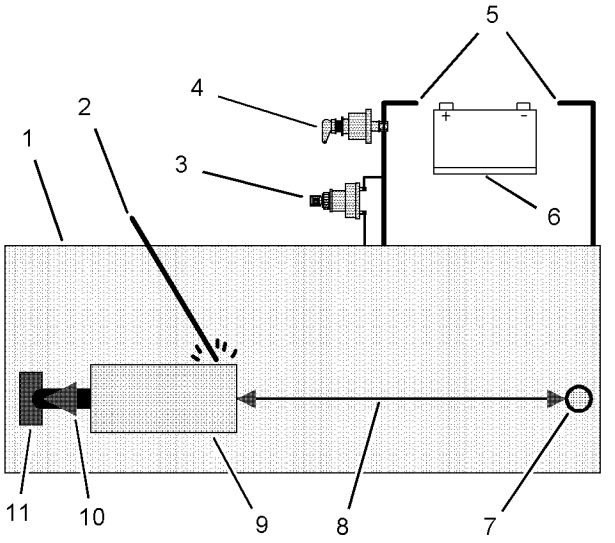

Illustration 61 g01075639

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

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Generator Start-up Checklist

SMCS Code: 4450

Table 21

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						
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					

(continued)

(Table 21, contd)

GENERATOR START-UP CHECKLIST				
	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 22

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 (Emergency Standby Power)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of all maintenance including the following procedures: all adjustments, the use of proper lubricants, fluids, filters and the installation of new components due to normal wear and aging . The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Note: Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, service hours and calendar time . Before each consecutive interval is performed, all maintenance from the previous intervals must be performed.

Products that operate in severe operating conditions may require more frequent maintenance.

The engine aftertreatment system can be expected to function properly for the useful life of the engine (emissions durability period), as defined by regulation. All prescribed maintenance requirements must be followed.

When Required

"Battery - Recycle" 102
"Battery - Replace" 103
"Battery or Battery Cable - Disconnect" 104
"Circuit Breakers - Reset" 106
"Coolant Extender (ELC) - Add" 109
"Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace" 118
"Engine Air Cleaner Element (Single Element) - Replace" 120
"Fuel System - Prime" 127
"Generator - Dry" 131
"Generator Load - Check" 140
"Generator Set - Test" 140

Every Week

"Battery Electrolyte Level - Check" 104
"Coolant Level - Check" 110
"Electrical Connections - Check" 115
"Engine Air Cleaner Service Indicator - Inspect" .. 120
"Engine Oil Level - Check" 122
"Fuel System Primary Filter/Water Separator - Drain" 129
"Fuel Tank Water and Sediment - Drain" 130
"Generator - Inspect" 133
"Generator Bearing Temperature - Test/Record" .. 139
"Generator Lead (Flat Braided Cable) - Check" ... 139
"Jacket Water Heater - Check" 145
"Power Factor - Check" 151
"Voltage and Frequency - Check" 155
"Walk-Around Inspection" 155

Every 200 Service Hours or 1 Year

"Engine Oil and Filter - Change" 123

Every 6 Months

"Coolant Sample (Level 1) - Obtain" 111
"Generator Lead (Round Cable) - Check" 139

Every Year

"Alternator - Inspect" 102
"Belts - Inspect/Adjust/Replace" 105
"Coolant Sample (Level 2) - Obtain" 112
"Cooling System Supplemental Coolant Additive (SCA) - Test/Add" 113
"Crankshaft Vibration Damper - Inspect" 114
"Engine - Clean" 115
"Engine Air Cleaner Element (Dual Element) - Inspect/Clean/Replace" 115
"Engine Crankcase Breather - Clean" 121
"Engine Mounts - Inspect" 122
"Engine Oil Sample - Obtain" 122
"Engine Protective Devices - Check" 125
"Engine Speed/Timing Sensor - Clean/Inspect" ... 126
"Engine Valve Lash - Check" 126
"Engine Valve Rotators - Inspect" 126

“Fuel System Primary Filter (Water Separator) Element - Replace” 128
“Fuel System Secondary Filter - Replace” 129
“Generator Bearing - Lubricate”..... 134
“Generator Set Vibration - Inspect”..... 142
“Grounding Stud - Inspect/Clean/Tighten”..... 142
“Hoses and Clamps - Inspect/Replace”..... 143
“Rotating Rectifier - Check” 152
“Starting Motor - Inspect”..... 154
“Stator Lead - Check” 154
“Water Pump - Inspect”..... 157

Every 3 Years

“Coolant (DEAC) - Change”..... 106
“Coolant Temperature Regulator - Replace” 112
“Ether Starting Aid Cylinder - Replace” 127
“Turbocharger - Inspect”..... 154

Every 6 Years

“Coolant (ELC) - Change”..... 108

Overhaul

“Overhaul Considerations” 149

Commissioning

“Generator Set Alignment - Check” 141

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Maintenance Interval Schedule (Standby Generator Sets)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of all maintenance including the following procedures: all adjustments, the use of proper lubricants, fluids, filters and the installation of new components due to normal wear and aging . The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Note: Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, service hours and calendar time . Before each consecutive interval is performed, all maintenance from the previous intervals must be performed.

Products that operate in severe operating conditions may require more frequent maintenance.

The engine aftertreatment system can be expected to function properly for the useful life of the engine (emissions durability period), as defined by regulation. All prescribed maintenance requirements must be followed.

When Required

“Battery - Recycle”..... 102
“Battery - Replace”..... 103
“Battery or Battery Cable - Disconnect”..... 104
“Circuit Breakers - Reset” 106
“Coolant Extender (ELC) - Add” 109
“Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace” 118
“Engine Air Cleaner Element (Single Element) - Replace” 120
“Fuel System - Prime”..... 127
“Generator - Dry”..... 131
“Generator Load - Check”..... 140
“Generator Set - Test” 140

Every Week

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“Battery Charger - Check”..... 103
“Battery Electrolyte Level - Check”..... 104
“Coolant Level - Check”..... 110
“Electrical Connections - Check” 115
“Engine Air Cleaner Service Indicator - Inspect” .. 120
“Engine Oil Level - Check”..... 122
“Fuel System Primary Filter/Water Separator - Drain” 129
“Fuel Tank Water and Sediment - Drain” 130
“Generator - Inspect” 133
“Generator Bearing Temperature - Test/Record”.. 139
“Generator Lead (Flat Braided Cable) - Check” ... 139

"Jacket Water Heater - Check" 145
"Power Factor - Check" 151
"Standby Generator Set Maintenance Recommendations" 153
"Voltage and Frequency - Check" 155
"Walk-Around Inspection" 155

Every 6 Months

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"Belts - Inspect/Adjust/Replace" 105
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"Cooling System Supplemental Coolant Additive (SCA) - Test/Add" 113
"Crankshaft Vibration Damper - Inspect" 114
"Engine - Clean" 115
"Engine Air Cleaner Element (Dual Element) - Inspect/Clean/Replace" 115
"Engine Crankcase Breather - Clean" 121
"Engine Mounts - Inspect" 122
"Engine Oil Sample - Obtain" 122
"Engine Oil and Filter - Change" 123
"Engine Performance - Test" 124
"Engine Protective Devices - Check" 125
"Engine Speed/Timing Sensor - Clean/Inspect" ... 126
"Engine Valve Lash - Check" 126
"Engine Valve Rotators - Inspect" 126
"Fuel System Primary Filter (Water Separator) Element - Replace" 128
"Fuel System Secondary Filter - Replace" 129
"Generator Bearing - Lubricate" 134
"Generator Set Vibration - Inspect" 142
"Grounding Stud - Inspect/Clean/Tighten" 142
"Hoses and Clamps - Inspect/Replace" 143
"Rotating Rectifier - Check" 152
"Starting Motor - Inspect" 154
"Stator Lead - Check" 154
"Water Pump - Inspect" 157

Every 3 Years

"Coolant (DEAC) - Change" 106
"Coolant Temperature Regulator - Replace" 112
"Ether Starting Aid Cylinder - Replace" 127
"Turbocharger - Inspect" 154

Every 6 Years

"Coolant (ELC) - Change" 108

Overhaul

"Overhaul Considerations" 149

Commissioning

"Generator Set Alignment - Check" 141

i05378296

Maintenance Interval Schedule (Prime Power Generator Sets)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of all maintenance including the following procedures: all adjustments, the use of proper lubricants, fluids, filters and the installation of new components due to normal wear and aging . The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Note: Use whichever of the following that occurs first in order to determine the maintenance intervals: fuel consumption, service hours and calendar time . Before each consecutive interval is performed, all maintenance from the previous intervals must be performed.

Products that operate in severe operating conditions may require more frequent maintenance.

The engine aftertreatment system can be expected to function properly for the useful life of the engine (emissions durability period), as defined by regulation. All prescribed maintenance requirements must be followed.

When Required

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"Battery - Replace" 103
"Battery or Battery Cable - Disconnect" 104
"Circuit Breakers - Reset" 106
"Coolant Extender (ELC) - Add" 109
"Engine - Clean" 115
"Engine Air Cleaner Element (Dual Element) - Inspect/Clean/Replace" 115
"Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace" 118
"Engine Air Cleaner Element (Single Element) - Replace" 120
"Ether Starting Aid Cylinder - Replace" 127
"Fuel System - Prime" 127
"Generator - Dry" 131
"Generator Set - Test" 140
"Generator Set Alignment - Check" 141

Daily

"Coolant Level - Check" 110
"Electrical Connections - Check" 115
"Engine Air Cleaner Service Indicator - Inspect" .. 120
"Engine Oil Level - Check" 122
"Fuel System Primary Filter/Water Separator - Drain" 129
"Generator Load - Check" 140
"Jacket Water Heater - Check" 145
"Power Factor - Check" 151
"Voltage and Frequency - Check" 155
"Walk-Around Inspection" 155

Initial 20 to 40 Service Hours

"Belts - Inspect/Adjust/Replace" 105

Every Week

"Automatic Start/Stop - Inspect" 102
"Generator - Inspect" 133
"Generator Bearing Temperature - Test/Record".. 139
"Generator Lead (Flat Braided Cable) - Check" ... 139

Initial 250 Service Hours

"Engine Valve Lash - Check" 126
"Engine Valve Rotators - Inspect" 126

Every 250 Service Hours

"Coolant Sample (Level 1) - Obtain" 111

Every 250 Service Hours or 6 Months

"Battery Electrolyte Level - Check" 104
"Engine Oil Sample - Obtain" 122
"Fuel Tank Water and Sediment - Drain" 130
"Hoses and Clamps - Inspect/Replace" 143

Every 500 Service Hours or 1 Year

"Belts - Inspect/Adjust/Replace" 105
"Cooling System Supplemental Coolant Additive (SCA) - Test/Add" 113
"Engine Oil and Filter - Change" 123
"Engine Protective Devices - Check" 125
"Fuel System Primary Filter (Water Separator) Element - Replace" 128
"Fuel System Secondary Filter - Replace" 129
"Grounding Stud - Inspect/Clean/Tighten" 142

Every 2000 Service Hours or 1 Year

"Engine Crankcase Breather - Clean" 121
"Generator Lead (Round Cable) - Check" 139
"Generator Set Vibration - Inspect" 142
"Stator Lead - Check" 154

Every Year

"Coolant Sample (Level 2) - Obtain" 112
"Radiator - Clean" 152
"Rotating Rectifier - Check" 152

Every 3000 Service Hours or 3 Years

"Alternator - Inspect" 102
"Coolant Temperature Regulator - Replace" 112
"Crankshaft Vibration Damper - Inspect" 114

“Engine Mounts - Inspect” 122
“Engine Speed/Timing Sensor - Clean/Inspect”... 126
“Engine Valve Rotators - Inspect” 126
“Starting Motor - Inspect” 154
“Turbocharger - Inspect” 154
“Water Pump - Inspect” 157

Every 4000 Service Hours or 2 Years

“Coolant (DEAC) - Change” 106

Every 4500 Service Hours

“Generator Bearing - Lubricate” 134

Every 12 000 Service Hours or 6 Years

“Coolant (ELC) - Change” 108

Every 600 000 L (158 500 US gal) of Fuel

“Overhaul (Top End)” 148

Every 1 200 000 L (317 000 US gal) of Fuel

“Overhaul (Major)” 145

Overhaul

“Overhaul Considerations” 149

i02676048

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.

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.

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.

i02039199

Battery - Recycle

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

Always recycle a battery. Never discard a battery. Return used batteries to one of the following locations:

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

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

Table 23

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.

i02601752

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

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

⚠ 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: 1401; 1402-029

⚠ WARNING

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

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

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

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

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

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

i02667833

Belts - Inspect/Adjust/Replace

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

Inspection

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

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

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

- Belts
- Pulleys
- Bearings

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

Adjusting the Alternator Belt

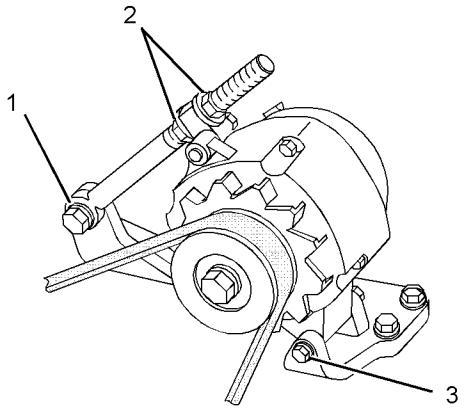

Illustration 62 g01092641

Typical alternator

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

1. Remove the drive belt guard.

2. Loosen mounting bolt (1), adjusting nuts (2) and mounting bolt (3).

3. Turn adjusting nuts (2) in order to increase or decrease the drive belt tension.

4. Tighten adjusting nuts (2). Tighten mounting bolt (3). Tighten mounting bolt (1). For the proper torque, see the Service Manual, “Specifications” module.

5. Reinstall the drive belt guard.

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

Adjusting the Fan Drive Belt

1. Loosen the mounting bolt for the pulley.

2. Loosen the adjusting nut for the pulley.

3. Move the pulley in order to adjust the belt tension.

4. Tighten the adjusting nut to the proper torque.

5. Tighten the mounting bolt to the proper torque.

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

Replacement

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

i04663490

Circuit Breakers - Reset

SMCS Code: 1417-529; 1420-529

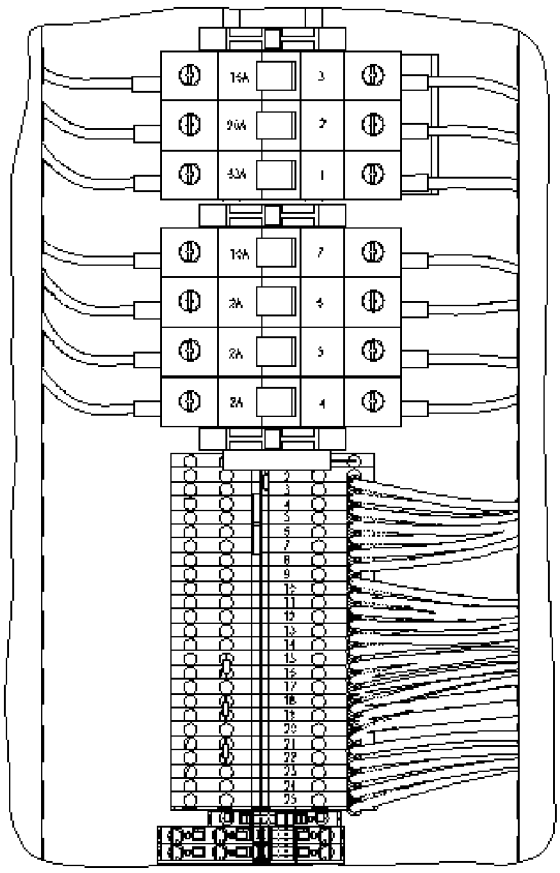

Illustration 63 g02792806

Push in on the circuit breaker in order to reset the circuit breaker.

i03841934

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 an antifreeze/coolant solution. 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.

i04239711

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.

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 :

InsideUSA 1-800-542-TOOL
Inside Illinois 1-800-541-TOOL
Canada 1-800-523-TOOL
International1-309-578-7372

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 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. 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 Extended Life Coolant (ELC). Refer to this Operation and Maintenance Manual, “Fluid Recommendations”for more information on cooling system specifications Refer to this Operation and Maintenance Manual, “Refill Capacities” for information about the capacity of the cooling system. 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 1 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. Only install the used filler cap if the gasket is not damaged. Use a 9S-8140 Pressurizing Pump to pressure test a reinstalled 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.

i04862631

Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Note: Refer to this Operation and Maintenance Manual, “Fluid Recommendations” (Cooling System) for the maintenance interval for the addition of the coolant extender.

Cat ELC (Extended Life Coolant) and Cat ELI (Extended Life Inhibitor) do not require the frequent additions of any supplemental cooling additives. The Cat ELC Extender will only be added one time.

Note: Do not use conventional supplemental coolant additive (SCA) with Cat ELC or with Cat ELI.

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat 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. If necessary, 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 the cooling system capacity. Refer to this Operation and Maintenance Manual, “Refill Capacities” for the coolant capacity.

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.

For further information, refer to this Operation and Maintenance Manual, , Fluid Recommendations.

i03842450

Coolant Level - Check

SMCS Code: 1395-082

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

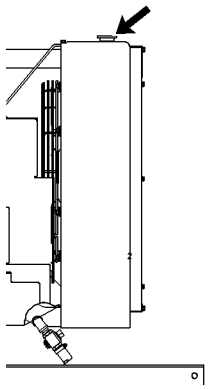

Illustration 64 g00285520

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.

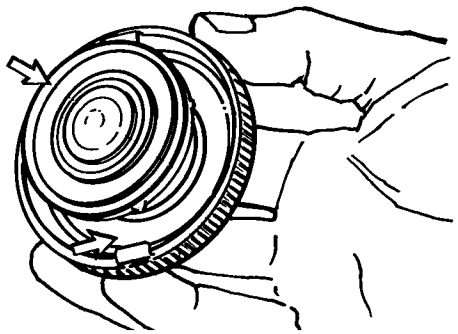

Illustration 65 g00103639
Typical filler cap gaskets

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.

i04333559

Coolant Sample (Level 1) - Obtain

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

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

Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with one of the following coolants: Cat ELC (Extended Life Coolant)., Cat ELI (Extended Life Inhibitor) and Conventional Heavy-Duty Coolant.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any of the following coolants: Cat DEAC, Cat SCA and Conventional Heavy-Duty Coolants.

For additional information about coolant analysis and about other coolants, see this Operation and Maintenance Manual, “Fluid Recommendations” or consult your Cat dealer.

Sampling Conditions

If the engine is equipped with a sampling port, the engine should be running at operating temperature when the sample is obtained.

If the engine is not equipped with a sampling port, the coolant should be warm.

Use the following guidelines for proper sampling of the coolant:

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

Timing of the Sampling

Table 24

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Cat SCA Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional(1)	Yearly(1)

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

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

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

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.

Submit the sample for Level 1 analysis.

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

i05378320

Coolant Sample (Level 2) - Obtain

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

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

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

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

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU7003, “Cat 3600 Series and C280 Series Diesel Engine Fluids Recommendations” or consult your Cat dealer.

i04139169

Coolant Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. Replacing the water temperature regulator is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the proper maintenance interval.

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

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

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

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

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

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

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

Refer to two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

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

i02378612

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

SMCS Code: 1352-045; 1395-081

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

⚠ WARNING

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

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

Test the Concentration of the SCA

Coolant/Antifreeze and SCA

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

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

Water and SCA

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

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

1. Fill the syringe to the “1.0 ml” mark with the coolant.
2. Dispense the 1.0 mL coolant sample from the syringe into the empty mixing bottle.
3. Add tap water to the mixing bottle in order to bring the level up to the “10 ml” mark. Place the cap on the bottle and shake the bottle.
4. Add 2 to 3 drops of the “NITRITE INDICATOR SOLUTION B” to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
5. Add 1 drop of “NITRITE TEST SOLUTION A” to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
6. Repeat 5 until the solution changes color from red to light gray, green, or blue. Record the number of drops of “NITRITE TEST SOLUTION A” that were required to cause the color change.
7. Use Table 25 to interpret the results.

Table 25

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

Add the SCA, If Necessary

⚠ WARNING

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

1. Remove the cooling system filler cap slowly.

Note: Always dispose of fluids according to local regulations.

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

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

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

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

3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic. The proper concentration of SCA depends on the type of coolant that is used.

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

i03175962

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.

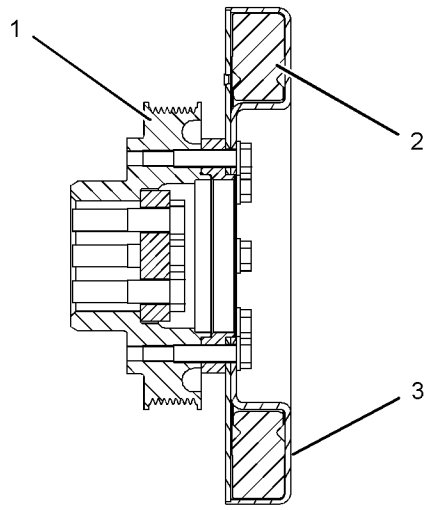

Illustration 66 g01134779
Viscous vibration damper
Typical example
(1) Crankshaft pulley
(2) Weight
(3) Case

Inspection

Inspect the damper for the following conditions:

- The damper is dented, cracked, or fluid is leaking from the damper.
- The paint on the damper is discolored from excessive heat.
- The damper is bent.
- The bolt holes are worn or there is a loose fit for the bolts.
- The engine has had a crankshaft failure due to torsional forces.

Replace the damper if any of these conditions exist.

Removal and Installation

Refer to this Operation and Maintenance Manual, “Belts - Inspect/Adjust/Replace” for information on removing and on installing the belt. Refer to the Disassembly and Assembly Manual, “Vibration Damper and Pulley - Remove and Install” for information on removing and installing the damper.

i01595880

Electrical Connections - Check

SMCS Code: 4459-535

Check all exposed electrical connections for tightness.

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

- transformers
- fuses
- capacitors
- lightning arrestors

Check all lead wires and electrical connections for proper clearance.

i01664717

Engine - Clean

SMCS Code: 1000-070

⚠ WARNING

Personal injury or death can result from high voltage.

Moisture could create paths of electrical conductivity.

Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".

NOTICE
Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

NOTICE
Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: For more information on cleaning and drying electric generators, refer to Special Instruction, SEHS9124, Cleaning and Drying of Electric Set Generators.

i04659829

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

SMCS Code: 1051; 1054-040; 1054-070; 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, thoroughly check the air cleaner elements for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Dual Element Air Cleaners

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

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

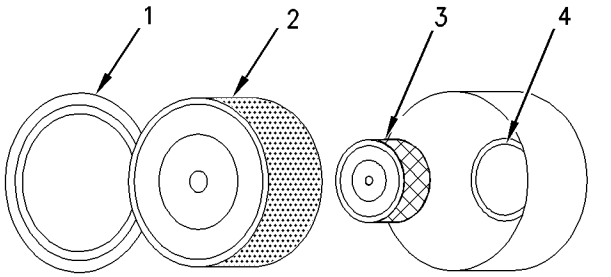

Illustration 67 g00736431

(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 out dirt.

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

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

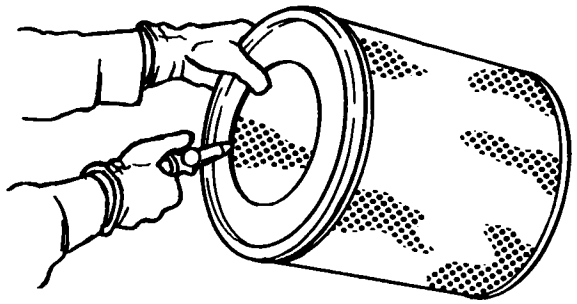

Illustration 68 g00281692

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

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

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

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

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

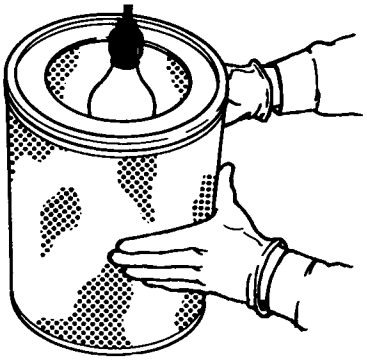

Illustration 69 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 W 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.

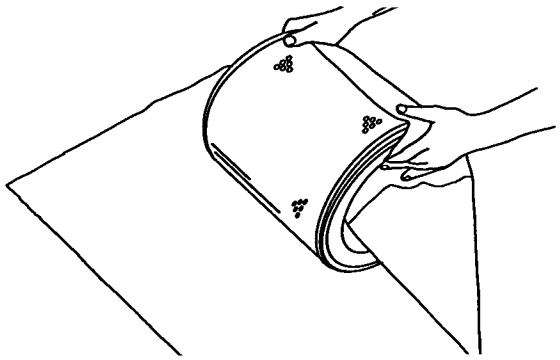

Illustration 70 g00281694

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.

i05374643

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

SMCS Code: 1051; 1054-040; 1054-070; 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 Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

Locomotives can be fitted with a clean room of filtered air. Engine combustion air is pulled from this clean room.

- 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 three 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 shall be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

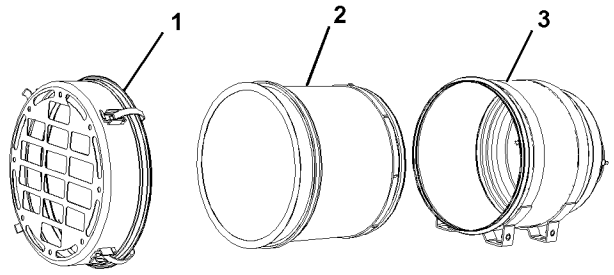

Illustration 71 g01245584
Typical example
(1) Cover
(2) Air cleaner element
(3) Turbocharger inlet

1. Remove the air cleaner cover (1). Remove the air cleaner element (2).

Note: Refer to “Cleaning the Air Cleaner Elements”.

2. Cover the air inlet with tape in order to keep out dirt.

3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

4. Remove the tape from the air inlet. Install an air cleaner element that is new or cleaned.

5. Install the air cleaner cover.

6. Install and latch the clamp.

7. Reset the air cleaner service indicator.

Cleaning the Air Cleaner Elements

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

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

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

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 620 kPa (90 psi). Direct the air flow into the outlet end of the filter element, keeping the nozzle at least 50 mm (2 inches) away from the outlet face of the filter element.

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

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

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

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

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

Pressurized Air

Pressurized air can be used to clean air cleaner elements up to three times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 620 kPa (90 psi). Keep the air nozzle at least 50 mm (2 inch) away from the face of the filter element.

Note: When the air cleaner elements are cleaned, always apply air pressure to the outlet side of the filter element.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Inspecting the Air Cleaner Elements

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

Storing Air Cleaner Elements

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

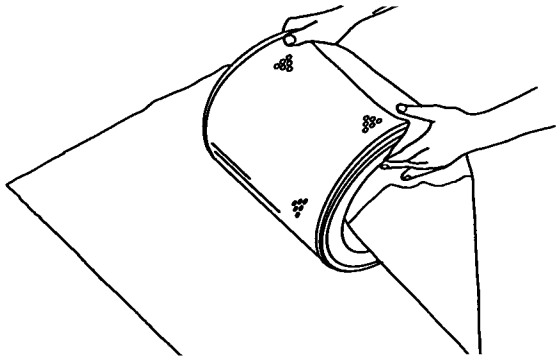

Illustration 72 g00281694

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

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

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i05374615

Engine Air Cleaner Element (Single Element) - Replace
(If Equipped)

SMCS Code: 1051; 1054-510; 1054

Note: Do not operate the engine when one or more of the engine air filters is not attached to the housing. Operating the engine without an engine air filter may damage the engine.

1. Remove the hose clamps that attach the air filter element to the housing.

2. Replace the used air filter element with a new air filter element.

3. Replace the hose clamps and tighten. Refer to Specifications, SENR3130, “Torque Specifications” for the proper torque of the clamps.

i04664129

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

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

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

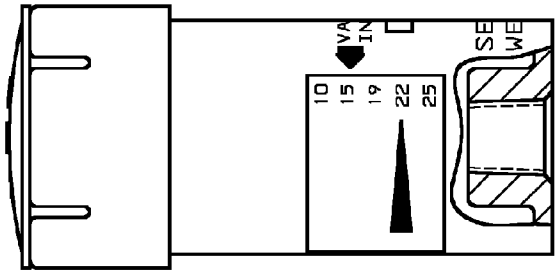

Illustration 73 g02792941
Typical service indicator

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).

i02375134

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

NOTICE
Perform this maintenance with the engine stopped.

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

The crankcase breather consists of two components:

1. A breather assembly that is located underneath the valve cover that is at the rear of the engine

2. A breather hose that connects the breather assembly to the outside air beneath the engine

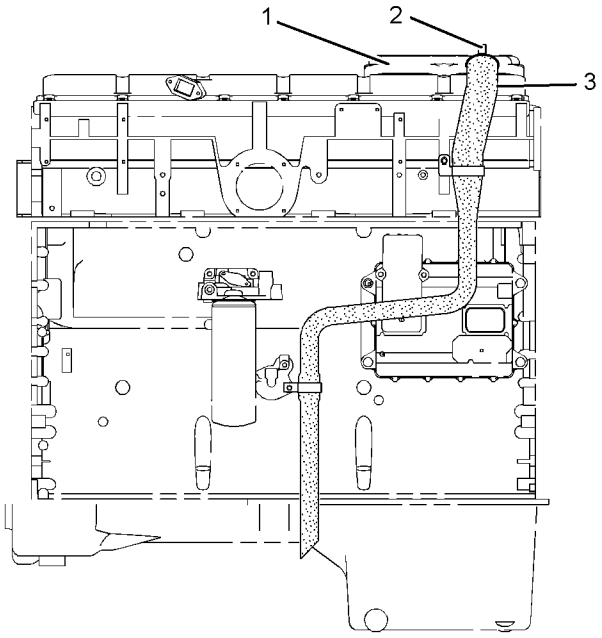

Illustration 74 g01185485

Typical Routing of Breather Hose

(1) Rear Valve Cover

(2) Hose Clamp

(3) Breather Hose

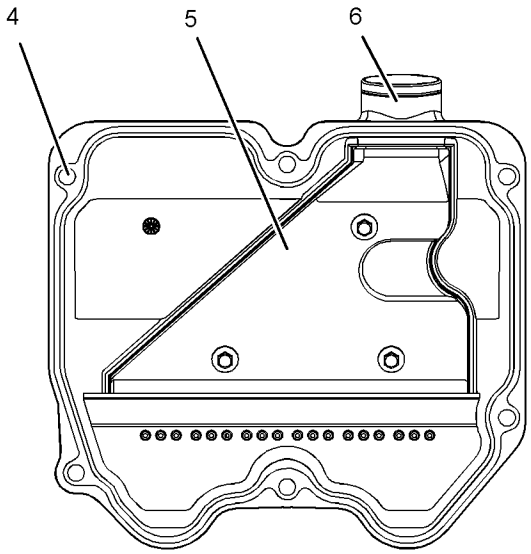

Illustration 75 g01185489

Top View After Removal of Valve Cover

(4) Bolt Hole

(5) Breather Assembly

(6) Access to Hose

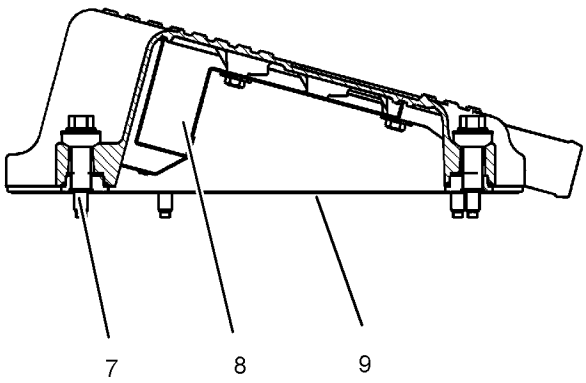

Illustration 76 g01185487

Side View of Valve Cover and Breather Elements

(7) Bolt

(8) Breather Elements

(9) Seal

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

1. Remove the six bolts that attach the valve cover to the engine. Remove the valve cover.

2. Loosen the clamp that attaches the breather hose to the breather assembly and remove the breather assembly.

3. Check the condition of the seal. Replace the seal if the seal is damaged.

4. Remove both of the breather elements. Wash the breather elements and the breather in clean nonflammable solvent.

5. Shake the breather elements until the breather elements are dry. You may also use pressurized air in order to dry the breather elements.

6. Install the elements into the breather and install the breather assembly onto the engine.

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

i02139969

Engine Mounts - Inspect

SMCS Code: 1152-040; 1152

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.

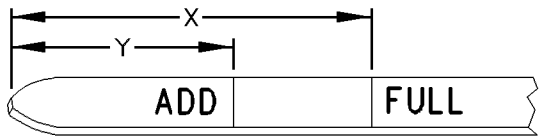

Illustration 77 g00110310

(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.

i04798777

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

⚠ WARNING

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

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

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

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

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

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

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGJ0047, “How To Take A Good Oil Sample”. Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02354905

Engine Oil and Filter - Change

SMCS Code: 1318-510

⚠ WARNING

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

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the engine oil from the crankcase while the engine oil is warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

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

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

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

Replace the Oil Filter

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

1. Remove the oil filter with a 1U-8760 Chain Wrench.

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

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

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

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

Illustration 78 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. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information on lubricant specifications and refill capacities.

NOTICE

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

NOTICE

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

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

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

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

i02366807

Engine Performance - Test
(Standby Generator Sets)

SMCS Code: 1000-081

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

Frequently monitor the following parameters duringengine operation:

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

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

Table 26 is offered as an example of an 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 regular basis. This will help to reveal the trends of the engine performance. Records of engine performance will also provide a baseline for evaluating the mechanical condition of the engine.

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

Table 26

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

i05264151

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. Determining if the engine protective devices are in good working order during normal operation is impossible. 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 Cat 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.

i04801657

Engine Speed/Timing Sensor - Clean/Inspect

SMCS Code: 1905-040; 1905-070; 1907-040; 1907-070

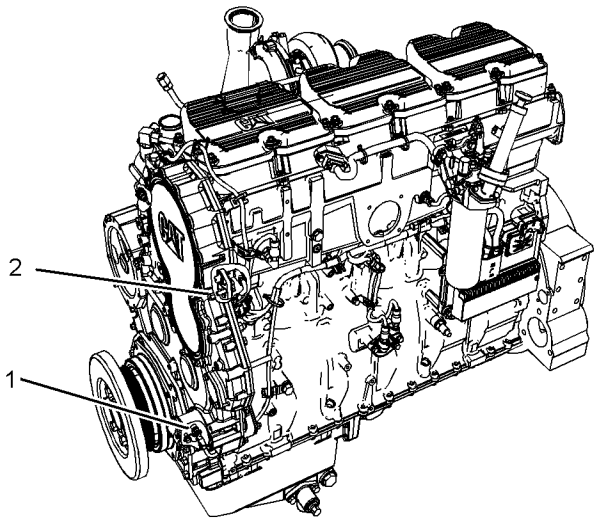

Illustration 79 g01184108

(1) Primary Speed/Timing Sensor

(2) Secondary Speed/Timing Sensor

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

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

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

i04801771

Engine Valve Lash - Check

SMCS Code: 1105-535

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

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

NOTICE
Only qualified service personnel should perform this maintenance. Refer to the Systems Operation/Testing and Adjusting Manual, “Valve Lash and Valve Bridge Adjustment” article or consult your Caterpillar dealer for the complete valve lash adjustment procedure.

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

⚠ WARNING

Ensure that the engine cannot be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

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

Refer to the Service Manual for more information.

i01597115

Engine Valve Rotators - Inspect

SMCS Code: 1109-040

⚠ WARNING

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

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

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

1. Start the engine according to Operation and Maintenance Manual, “Engine Starting” (Operation Section) for the procedure.

2. Operate the engine at low idle.

3. Observe the top surface of each valve rotator. The valve rotators should turn slightly when the valves close.

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

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

i00805059

Ether Starting Aid Cylinder - Replace
(If Equipped)

SMCS Code: 1456-510-CD

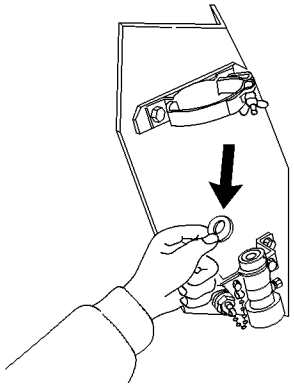

Illustration 80 g00104888
Typical example

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.

i04648529

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

⚠ WARNING

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

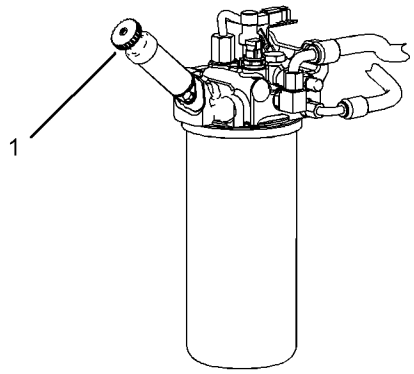

Illustration 81 g01182169

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.

i02544226

Fuel System Primary Filter (Water Separator) Element - Replace

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

⚠ WARNING

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

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

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

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

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

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

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

Dispose of all fluids according to local regulations and mandates.

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

2. Shut off the fuel supply.

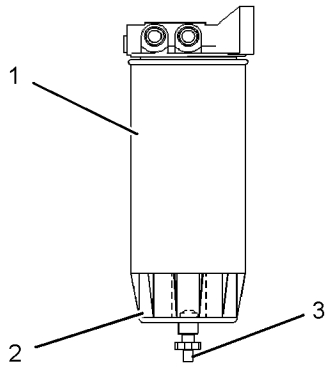

Illustration 82 g01274118

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

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

3. Turn drain valve (3) counterclockwise in order to open. The drain valve is located on the bottom of the water separator.

4. Drain the water and sediment into a suitable container. Dispose of the drained fluids and used filters according to local regulations.

5. Close the drain valve.

6. Hold the bottom of the filter while you loosen the bowl. Remove the bowl.

7. Turn the filter counterclockwise in order to loosen the filter. If the filter will not turn, use a strap wrench to loosen the filter.

8. Remove the filter and discard the filter. Clean the bottom of the filter mounting base. Make sure that all of the old filter seal is removed from the bottom groove of the opening in the base.

9. Clean the water separator bowl and clean the groove for the seal. Inspect the seal. If the seal is worn or damaged, replace the seal.

10. Lubricate the seal with clean diesel fuel or lubricate the seal with clean motor oil. Place the seal in the groove on the water separator bowl.

11. Install the water separator bowl onto the new fuel filter by hand. Tighten the bowl assembly to 15 15 N·m (11 lb ft).

12. Apply clean diesel fuel to the seal of the new filter.

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

14. Open the fuel shutoff valve.

15. Reconnect the battery, if necessary.

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

17. Stop the engine and check for leaks.

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

i02546060

Fuel System Primary Filter/ Water Separator - Drain

SMCS Code: 1260-543; 1263-543

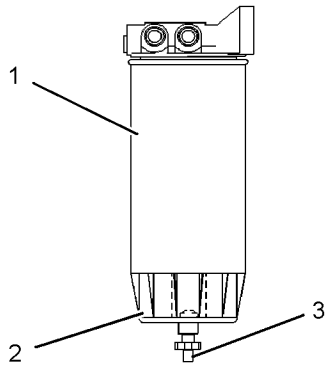

Illustration 83 g01274154

(1) element
(2) bowl
(3) drain valve

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

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

2. Close drain valve(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.

i02326422

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

⚠ WARNING

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

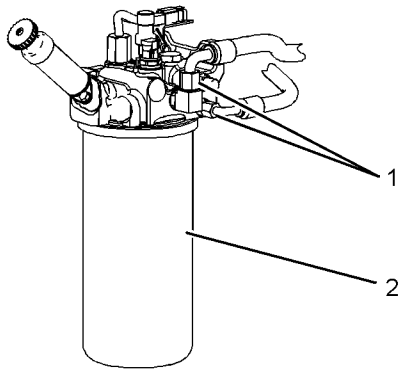

Illustration 84 g01162207

(1) Fuel supply connections
(2) Fuel filter

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

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

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

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

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

2. Remove the used fuel filter.

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

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

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

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

i05111531

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Note: Failure to close the drain can allow air into the system, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine. Drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow 5 to 10 minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This procedure 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 procedure will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

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.

i03997990

Generator - Dry

SMCS Code: 4450-569

⚠ WARNING

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

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

Refer to this Operation and Maintenance Manual, “Generator Isolating for Maintenance” for information regarding the procedure to isolate the generator in a safe manner.

Refer to Special Instruction, REHS9124, Cleaning and Drying of the Generator for further necessary information.

Of the following methods for drying the generator, the use of external heat is preferred.

- External heat
- Internal heat
- Combination of external and internal heat
- Circulating current

External heat is the most preferable method. Insulation drying time can vary from a few hours to several days. The drying time depends on the moisture content and the process for drying that is used.

Note: Drying sometimes does not produce the required results. The use of a qualified rebuild shop may be necessary for dipping and drying the generator.

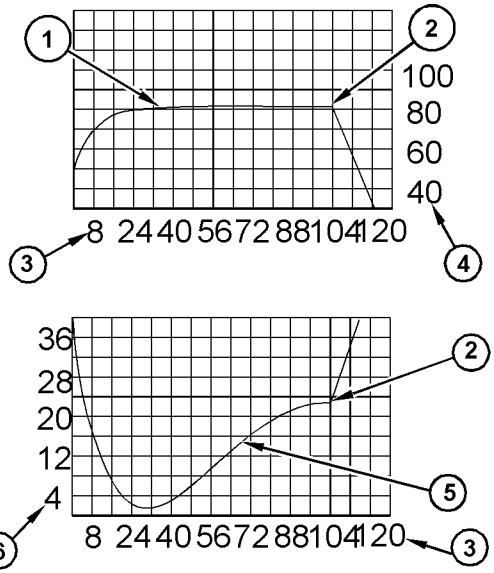

Illustration 85 g02175752

Typical curves of the resistance in the insulation that is drying

(1) Curve of the temperature in the windings
(2) Heat turned off.
(3) Drying time in hours
(4) Temperature in degrees celsius
(5) Curve of insulation resistance during drying process
(6) Insulation resistance in megohms

Note: When new insulation or very damp insulation is being dried, the resistance will probably fall rapidly. The rapid fall in resistance is the result of the temperature being raised to a value for drying. After reaching a minimum for a given temperature, the resistance will again rise as moisture is driven out of the insulation. The actual values will vary with each situation. Refer to Illustration 86 .

If the windings or insulation are wet during the resistance measurement, use a 5 megohm resistor for protection in series with red positive lead. This procedure limits the voltage across the circuit under the test. Use this method until drying is well in progress and the resistance has reached an acceptable level.

Check the windings after every 4 hours when either external or internal heat is used to dry the generator. Check the windings very hour when circulating current is used to dry the generator. Refer to Special Instruction, REHS9124, Cleaning and Drying of the Generator for more information.

Drying is complete when the tests show no increase in resistance and the resistance is above the minimum. Record these readings and compare these readings. Keep these records for future reference.

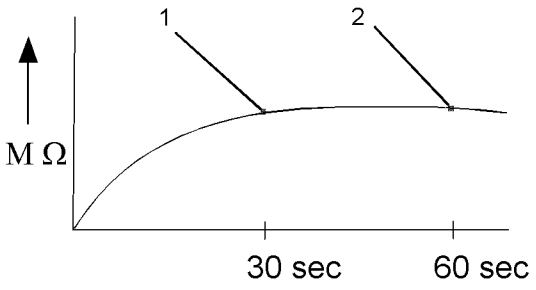

Illustration 86 g01696934

Curve of insulation resistance for windings in good condition

(1) Resistance after 30 seconds
(2) Resistance after 60 seconds

Illustration 86 indicates the curve of the resistance of a normal high resistance in the windings over a period of 60 seconds. The resistance after 60 seconds will be greater than the resistance or equal to the resistance after 30 seconds .

Note: If the insulation resistance after 60 seconds is not higher than the resistance after 30 seconds , the insulation may be weak.

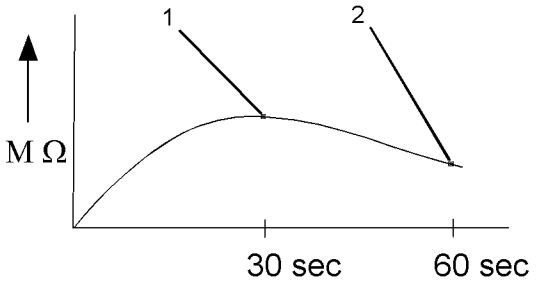

Illustration 87 g01697074

Curve of insulation resistance for windings that are wet or dirty

(1) Resistance after 30 seconds
(2) Resistance after 60 seconds

Illustration 87 indicates the curve of the resistance that is decaying over a period of 60 seconds. If the insulation resistance after 60 seconds is not higher than the resistance after 30 seconds , clean the windings and thoroughly dry the windings. Refer to Special Instruction, REHS9124, Cleaning and Drying of the Generator for more information.

Note: Caterpillar recommends a minimum acceptable insulation resistance of 1 megohm for generators which operate with less than 1000 V of operating or rated voltage. Generators which operate at 1000 V of operating or rated voltage should have a minimum insulation resistance as determined by the following equation:

R = (V/1000) + M

“R” is the minimum insulation resistance.

“V” is the rated voltage.

“M” is 1 megohm.

These values are approximate. It may be possible to operate a generator with less resistance.

External Heat

Ovens

The best oven is a forced air drying oven for drying electrical equipment. Radiant ovens sometimes cause localized overheating.

NOTICE
Do not heat the generator too quickly. Try to limit the rise in temperature of the insulation and windings to 11.11° C (20° F) per hour. Failure to do so may cause equipment damage.

Note: Many electrical shops are equipped with baking ovens.

Heat the generator to approximately 75° C (167° F). Never exceed 75° C (167° F) until the insulation tester tests correctly for insulation resistance (at least 4 hours).

Alternate Method

A tent formed by a tarp or a canvas with heated lamps or a portable space heater may be used as an alternate method.

A hole should be left in the top of the tarp for ensuring proper circulation through the generator and for permitting the moisture to exhaust. Heat the generator to approximately 75° C (167° F). Never exceed 75° C (167° F) until the insulation tester tests correctly for insulation resistance (at least 4 hours).

Internal Heating

If generators operate under one of the following conditions, the electric space heaters should be installed as part of the generator:

- Generators are in damp environments and go for long periods of time without operation.
- Generators operate regularly in an environment with moisture laden air.

Circulating Current

Drying can be accomplished by circulating low voltage current through the windings. Since the voltage is low, the breakdown of the insulation will not occur as the breakdown might have occurred with normal operation and wet insulation. Refer to Special Instruction, REHS9124, Cleaning and Drying of the Generator for this procedure.

i01880220

Generator - Inspect

SMCS Code: 4450-040

⚠ WARNING

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

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

⚠ WARNING

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

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

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

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

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

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

NOTICE

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

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

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

Cleaning (Assembled Generators)

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

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

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

Cleaning (Disassembled Generators)

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

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

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

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

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

i05032881

Generator Bearing - Lubricate

SMCS Code: 4471-086

Procedure for Bearing Service

Perform periodic bearing lubrication at the intervals that are shown in Table 27 . Use the following instructions as the suggested procedure in order to service the bearings of the generator.

Note: If the generator already has a visible grease point, go to Step 4.

1. Stop the generator set. Remove the required external cover plates, grills, and louvers of the generator in order to access the bearings.
2. Remove the top grease pipe plug and the lower grease pipe plug. If no grease pipes can be found, then locate the insert for the grease pipe. The insert is located on the bearing brackets. Remove the inserts. Install the grease pipes.
3. Install a grease fitting in the top grease pipe.
4. Use a Cat ® 8F-9866 Grease Gun or equivalent grease gun to grease the bearings. Use the appropriate type of grease and the quantity that is listed in Table 27 . Avoid the use of alternate types of grease. Usage of alternate types of grease could cause premature bearing failure.

Note: Add only the amount of grease listed in Table 27 . Do not continue to add grease until purging is observed. Purging of grease will not always be observed.

5. If grease fittings are permanently installed, ensure that the protective caps for the grease fittings are installed on the fittings when finished. If a grease fitting was installed in Step 2, remove the top grease fitting and install the plug that was removed. If applicable, do not install the plug on the bottom grease location yet. Wipe off the excess grease.

Note: Do not allow grease to drip on the stator windings of the generator. The stator windings that are exposed to grease could suffer degraded insulation. The degraded insulation would cause a reduction in the life of the windings.

6. Operate the generator set at rated speed for approximately 1 hour. When running the engine more than 30 minutes, the recommended engine load to apply is a minimum of 50%. The procedure will allow the grease to expand. The expanding grease will force the excess grease from the cavity. The internal pressure will be reduced as the excess grease is forced from the cavity. Operate the generator until no grease is forced out of the cavity.

7. Stop the generator set. Inspect the generator windings, grease tubes, and bearing housings. Wipe off any excess grease. If a grease pipe plug was removed in Step 2, install the plug in the bottom grease pipe. Wipe off any excess grease.

Note: Do not allow grease to drip on the stator windings of the generator. The stator windings that are exposed to grease could suffer degraded insulation. The degraded insulation would cause a reduction in the life of the windings.

8. Install all of the external cover plates, grills, and louvers of the generator that were removed in order to access the bearings.

Table 27

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum(1)	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
5P-2448 Ball Bearing	315 BC 160 mm (6.3 inch) OD 75 mm (3 inch) ID	580 590	85° C (185° F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	75 mm (3 inch)
6Y-3955 Ball Bearing	220 BC 180 mm (7.1 inch) OD 100 mm (3.9 inch) ID	450	85° C (185° F)	2S-3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	100 mm (3.9 inch)

(continued)

(Table 27, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum(1)	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
6Y-6488 Ball Bearing	318 BC 190 mm (7.5 inch) OD 90 mm (3.5 inch)	597	85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90 mm (3.5 inch)
108-1760 Ball Bearing	321 BC 225 mm (8.9 inch) OD 105 mm (4.1 inch) ID	680	85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	105 mm (4.1 inch)
108-1761 Ball Bearing	322 BC 240 mm (9.4 inch) OD 110 mm (4.3 inch) ID	690 800	85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	110 mm (4.3 inch)
109-7687 Ball Bearing	316 BC 170 mm (6.7 inch) OD 80 mm (3.15 inch) ID	580	85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	80 mm (3.15 inch)
139-0349 Roller Bearing	Roller	2900 2800	85° C (185° F)	1p0808	Every 250 service hours	2.8 g (0.1 oz)	N/A	127 mm (5 inch)
139-0350 Roller Bearing	Roller	2900 2800	85° C (185° F)	1p0808	Every 250 service hours	2.8 g (0.1 oz)	N/A	127 mm (5 inch)
154-3032 Ball Bearing	326 BC 280 mm (11 inch) OD 130 mm (5.1 inch) ID	820 1800 (2) (3) 2600(3) 2700(3)	85° C (185° F) 95° C (203° F) 85° C (185° F) 85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	130 mm (5.1 inch)
193-4070 Ball Bearing	018 BC 140 mm (5.5 inch) OD 90 mm (3.5 inch) ID	498 499	85° C (185° F)	2S - 3230 Bearing Lubricant	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90 mm (3.5 inch)
241-4644 Bearing	320 BC 215 mm (8.5 inch) OD 100 mm (3.9 inch) ID	LC7	95° C (203° F)	UNIREX N3	Every 4500 service hours or 12 months	60 g (2.1 oz)	N/A	100 mm (3.9 inch)

(continued)

(Table 27, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum[1]	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
243-5220 Bearing	315 BB 160 mm (6.3 inch) OD 75 mm (3.0 inch) ID	LC6100 LC5000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	75 mm (3.0 inch)
253-9789 Bearing	320 BC 215 mm (8.5 inch) OD 100 mm (3.9 inch) ID	1400	85° C (185° F)	UNIREX N3	Grease cannot be added to this bearing.	N/A	N/A	100 mm (3.9 inch)
253-9792 Bearing	226BC 230 mm (9.05 inch) OD 130 mm (5.12 inch) ID	1400	95° C (203° F)	EA6	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	140 mm (5.5 inch)
261-3545 Bearing	307 BB 80 mm (3.1 inch) OD 35 mm (1.4 inch) ID	LC2000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	35 mm (1.4 inch)
262-5921 Bearing	307 BC 80 mm (3.1 inch) OD 35 mm (1.4 inch) ID	LC2000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	35 mm (1.4 inch)
263-0161 Bearing	309 BC 100 mm (3.9 inch) OD 45 mm (1.8 inch) ID	LC3000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	45 mm (1.8 inch)
281-3091 Ball Bearing	328 BC 300 mm (11.8 inch) OD 140 mm (5.5 inch) ID	3010[2] 3020[2] 3042[2] 3044[2] 3045[2]	95° C (203° F)	EA6	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	140 mm (5.5 inch)

(continued)

(Table 27, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum[1]	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
311-0843 Ball Bearing	326 BC 280 mm (11 inch) OD 130 mm (5.1 inch) ID	1800[2]	95° C (203° F)	EA6	Grease cannot be added to this bearing.	N/A	N/A	130 mm (5.1 inch)
311-0844 Ball Bearing	322 BC 240 mm (9.4 inch) OD 110 mm (4.3 inch) ID	1600	95° C (203° F)	EA6	Grease cannot be added to this bearing.	N/A	N/A	110 mm (4.3 inch)
341-7383 Ball Bearing	330 BC 320 mm (12.6 inch) OD 150 mm (5.9 inch) ID	3055 [5] 3066[5] 3068[5]	95° C (203° F)	Exxon Polyrex EM Base material is Polyurea.	Every 1800 service hours or 12 months	51.2 g (1.8 oz)	14.9 mL (0.5 oz)	150 mm (5.9 inch)
375-3715 Ball Bearing	328 BC 300 mm (11.8 inch) OD 140 mm (5.5 inch) ID	3010[2] [3] 3020[2] [3] 3042[2] [3] 3044[2] [3] 3045[2] [3]	95° C (203° F)	2S - 3230 Bearing Lubricant	Every 2400 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	140 mm (5.5 inch)

(1) Indicates the alarm temperature set point that the bearing should be continuously operated at on the specified generator frame size. Shutdown set points are typically 10° C (18° F) higher.

(2) 1800 frame generators and 3000 frame generators shipped before 2012 use double-shielded bearings with EA6 grease. There are no threaded holes in the bearing brackets for the grease tubes that are used to add grease. Therefore, no grease can be added to the bearings. Beginning in 2012, 1800 frame generators and 3000 frame generators that are shipped will use a single-shielded bearing with 2S-3230 grease. The front and rear brackets contain factory installed grease fittings, therefore, single-shielded bearings must be lubricated periodically. Reference the Parts Manual with package serial number to identify the bearing part number and to determine bearing lubrication requirements.

(3) All 2600, 2700, 1800 and 3000 frame generators shipped beginning in 2012, use a single-shielded bearing design. Replacement bearings received from the Parts Division will have a shield on each side of the bearing. The shield facing the outside of the generator must be removed when the new bearing is installed.

(4) Grease cannot be added to this bearing. Refer to the Operation and Maintenance Manual, “Generator Bearing - Replace” article for information concerning the replacement of these bearings.

(5) The generator uses a non-shielded bearing design. Although replacement bearings may have a shield on each side, both shields must be removed when the new bearing is installed. Replacement bearings are shipped as dry bearings and must be packed to 50% grease fill at time of installation.

Bearing Replacement

Refer to the appropriate publication for each specific generator for bearing replacement procedures.

Replace both bearings of a two-bearing generator.

Replace any bearing wear sleeves and lip seals when the bearings are replaced.

Except for the 341 - 7383 Ball Bearing, replacement bearings are pre-lubricated. The pre-lubricated bearings do not require additional grease at time of replacement. The 341 - 7383 Ball Bearing is shipped as a dry bearing. The 341 - 7383 Ball Bearing must be packed to 50% grease fill at time of installation.

Old grease must be removed at the time of bearing replacement from the bearing bracket cavity. After the bearing bracket cavity is cleaned, the bearing bracket cavity must be packed with new grease from one-third to one-half full.

Note: Generator set alignment is required after the bearings are replaced.

Additional Information

Refer to Special Instruction, REHS4892, Generator Bearing Service for further information.

i05264199

Generator Bearing Temperature - Test/Record

SMCS Code: 4471-081-TA

The monitoring of bearing temperature may prevent premature bearing failure. A generator set should never operate above the recommended set points. Keep records in order to monitor the changes in the temperature of the bearing.

Note: Measure the bearing temperature after the generator reaches normal operating temperature.

Resistive Temperature Detectors (RTDs)

Cat Generators may be equipped with resistance temperature detectors for generator bearings. These detectors are 100 ohm resistance temperature detectors. A resistance temperature detector may be monitored by the optional monitor for the EMCP 3.2/3.3 resistance temperature detector. A resistance temperature detector may be monitored by equipment that is provided by the customer. Consult with your Cat dealer about other methods of measuring the bearing temperature.

The EMCP 3.2/3.3 may be configured to "ALARM" or the EMCP 3.2/3.3 may be configured to "SHUTDOWN" . An alarm is activated if the temperature of the bearing reaches 85 °C (185 °F). A shutdown occurs if the temperature of the bearing reaches 95 °C (203 °F).

Infrared Thermometers

Bearing temperatures can also be recorded with the use of an infrared thermometer. Refer to Special Publication, NENG2500, Cat Dealer Service Tools Catalog for various infrared thermometers. Follow the instructions that come with your infrared thermometer.

i04066149

Generator Lead (Flat Braided Cable) - Check
(If Equipped)

SMCS Code: 4450-535

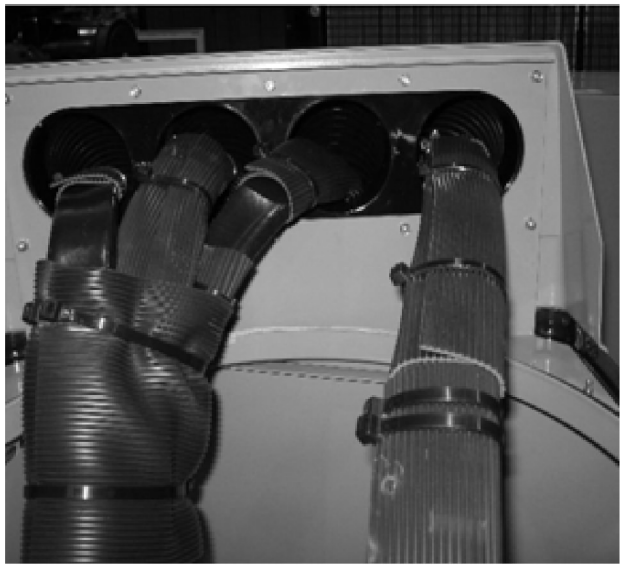

Illustration 88 g02146533

Typical flat braided conductor

The generator set may have braided square conductors or multiple round cables between the generator and the breaker.

Check braided conductors for signs of wear. Pay particular attention to the conductor protective sleeve insulation at the housing for the breaker and in the generator terminal box. Replace the mat immediately if the mat shows signs of wear at a point of contact. Replace the cable immediately if the insulation shows signs of wear at points of contact. If your generator set does not have rubber mats in place, contact your Cat dealer.

i04066150

Generator Lead (Round Cable) - Check
(If Equipped)

SMCS Code: 4450-535

The generator set may have braided square conductors or multiple round cables between the generator and the breaker.

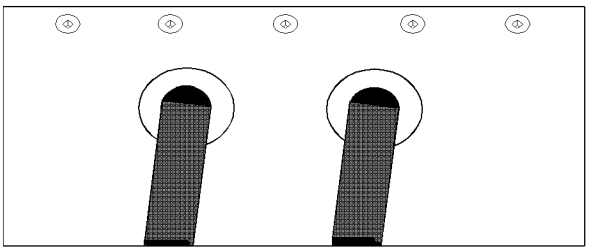

Illustration 89 g02223453

Round generator lead cables

Ensure that the generator output leads are routed out of the generator in a manner that prevents the leads from rubbing against metal objects. Visually inspect the following areas for cracking and physical damage:

- Stator output leads
- Protective sleeving
- Insulation

i01878834

Generator Load - Check

SMCS Code: 4450-535-LA

⚠ WARNING

Personal injury or death can result from high voltage.

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

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

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

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

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

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

i02377583

Generator Set - Test

SMCS Code: 4450-081

⚠ DANGER

DANGER: Shock/Electrocution Hazard-Do not operate this equipment or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings will result in serious injury or death.

⚠ WARNING

Personal injury or death can result from high voltage.

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

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

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

When servicing or repairing electric power generation equipment:

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

Table 28

Tools Needed		
Part Number	**Part**	**Quantity**
237-5130	Digital Multimeter	1
	12 VDC battery	1
	Potential Transformer	1

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

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

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

The generator set functional test consists of the following steps:

1. Stop the generator. Connect the potential transformer's high voltage winding to the generator terminals (T1) and (T2). Connect the voltmeter to the low voltage winding. If two transformers are available, connect the high voltage winding of the second transformer to the generator terminals (T1) and (T3). Connect the secondary terminals that correspond to generator terminal (T2) of both transformers together.
2. Disconnect wires “E+” and “E-” from the voltage regulator. Disconnect the generator from the load.
3. Connect a 12 VDC automotive battery to wires “E +” and “E-” .
4. Measure the AC voltage across the low voltage terminals of the transformer that correspond to the following generator terminals: “T1” and “T2” , “T2” and “T3” and “T3” and “T1” . Record the voltages.

i03956450

Generator Set Alignment - Check
(Generator Sets)

SMCS Code: 7002-024

The genset must be aligned when the genset is installed or moved into a different position. If the generator set is run at the full continuous rating, the alignment of the generator to the engine must be checked annually.

Properly maintain the alignment between the engine and the driven equipment in order to minimize the following problems:

- Bearing problems
- Vibration of the engine crankshaft
- Vibration of the driven equipment

Refer to the following information for more information about the alignment of the generator set:

- Special Instruction, SEHS7654, Alignment - General Instructions
- Special Instruction, SEHS7259, Alignment of Single Bearing Generators
- Special Instruction, REHS0177, Alignment of the Close Coupled Two Bearing Generators

Keep a record of the measurement of the alignment. The record may be used to check the trend of the alignment. The record may be used to analyze the trend of the alignment.

i02291365

Generator Set Vibration - Inspect

SMCS Code: 4450-040-VI

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

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

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

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

The following areas are susceptible to vibration damage:

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

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

i04801129

Grounding Stud - Inspect/ Clean/Tighten

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

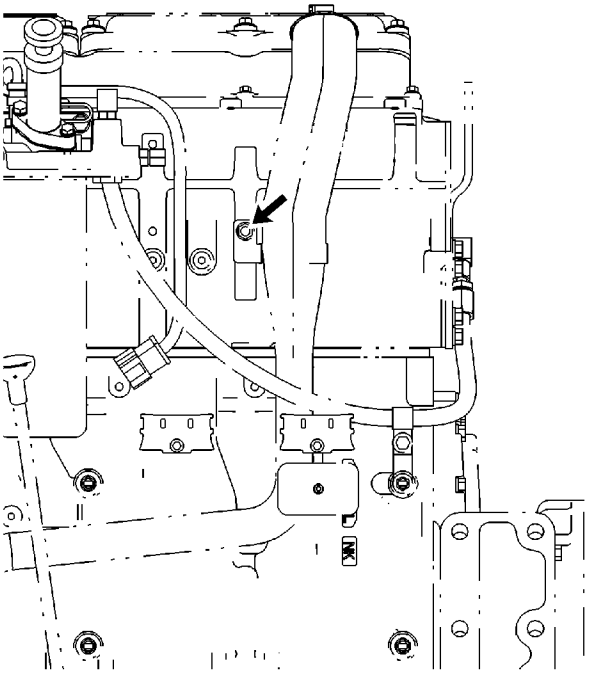

Illustration 90 g02919827

Cylinder head grounding stud

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.

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Hoses and Clamps - Inspect/ Replace

SMCS Code: 7554-040; 7554-510

Hoses and clamps must be inspected periodically and replaced at the recommended interval to ensure safe and continuous operation of the engine. Failure to replace a fuel hose at the recommended change interval may result in a hazardous situation. Take proper safety precautions before inspecting or replacing hoses and clamps.

Note: 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. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, “General Hazard Information” for more information.

Inspect the Hoses and the Clamps

Inspect all hoses for leaks that are caused by the following conditions. Replace any hose which exhibits any of the following conditions. Failure to replace a hose which exhibits any of the following conditions may result in a hazardous situation.

- Hoses which are cracked
- Hoses which are soft
- 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
- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

Inspect all clamps for the following conditions. Replace any clamp which exhibits signs of any of the following conditions.

- Cracking
- Looseness
- Damage

Inspect all couplings for leaks. Replace any coupling which exhibits signs of leaks.

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

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen which can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Replace hoses that are cracked or soft. Replace hoses that show signs of leakage. Replace hoses that show signs of damage. Replace hose clamps that are cracked or damaged. Tighten or replace hose clamps which are loose.

Replace the Hoses and the Clamps

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cooling System

⚠ 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.

⚠ WARNING

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

Failure to relieve pressure can cause personal injury.

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

1. Stop the engine.

2. Allow the engine to cool.

3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system in order to relieve any pressure.

4. Remove the filler cap for the cooling system.

5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.

6. Remove the hose clamps.

7. Disconnect the old hose.

8. Replace the old hose with a new hose.

9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, Torque Specifications, “Hose Clamps” for information about selecting and installing the proper hose clamps.

10. Refill the cooling system.

11. Clean the filler cap for the cooling system. Inspect the gaskets on the filler cap. Replace the filler cap if the gaskets are damaged. Install the filler cap.

12. Start the engine. Inspect the cooling system for leaks.

Fuel System

⚠ WARNING

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

Failure to relieve pressure can cause personal injury.

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

⚠ WARNING

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

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.

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.

Note: High-pressure fuel lines may be installed between the high-pressure fuel pump and the fuel injectors. High-pressure fuel lines are constantly charged with high pressure. Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Wait for 10 minutes after the engine stops before you perform any service or repair on high-pressure fuel lines. Waiting for 10 minutes will to allow the pressure to be purged.

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.

2. Remove the hose clamps.

3. Disconnect the old hose.

4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, Torque Specifications, “Hose Clamps” for information about selecting and installing the proper hose clamps.

6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.

Note: Fuel must be added to the fuel system ahead of the fuel filter.

7. Refill the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” for information about priming the engine with fuel.

8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

WARNING

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

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.
3. Disconnect the old hose.
4. Replace the old hose with a new hose.
5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, Torque Specifications, “Hose Clamps” for information about selecting and installing the proper hose clamps.
6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, “Engine Oil Level - Check” in order to ensure that the lubrication system is filled with the proper amount of engine oil.
7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.
2. Disconnect the old hose.
3. Replace the old hose with a new hose.
4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, Torque Specifications, “Hose Clamps” for information about selecting and installing the proper hose clamps.

Note: The bellows and the V-clamps that are used on the bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

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Jacket Water Heater - Check

SMCS Code: 1383-535

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

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

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Overhaul (Major)

SMCS Code: 7595-020-MJ

Refer to this Operation and Maintenance Manual in order to determine the maintenance interval for a major overhaul.

The need for a major overhaul is determined by several factors.

- An increase of oil consumption
- An increase of crankcase blowby
- The total amount of fuel consumption
- The service hours of the engine
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

A major overhaul includes all of the work that is done for the top end overhaul and the general inspection. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

For the major overhaul, all of the bearings, seals, gaskets, and components that wear are disassembled. The parts are cleaned and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Caterpillar replacement part.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

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

Replacement of Components

Replace the following components during the major overhaul.

- Connecting rod bearings
- Crankshaft seals
- Crankshaft vibration damper
- Electronic fuel injectors
- Main bearings
- Piston rings

Inspection, Reconditioning or Exchanging of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, Index of Publications on Reusability or Salvage of Used Parts.

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Connecting rods
- Cylinder head assembly
- Cylinder liners
- Engine wiring harness
- Exhaust bellows
- Fuel transfer pump
- Oil pump
- Pistons
- Piston pins
- Prelube pump
- Spacer plate
- Turbochargers

Inspection of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, Index of Publications on Reusability or Salvage of Used Parts.

- Camshaft
- Camshaft bearings
- Crankshaft
- Crankshaft thrust washers
- Driven equipment (alignment)
- Engine control module
- Front gear train
- Gear train bushings and bearings
- Rear gear train

Inspect the camshaft for damage to the journals and the lobes. Inspect the following components for signs of wear and/or for signs of fatigue:

- camshaft bearings
- camshaft followers

Inspect the crankshaft for any of the following conditions:

- deflection
- damage to the journals
- bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- rod bearing
- main bearings

Note: If the crankshaft or the camshaft are removed for any reason, use the magnetic particle inspection process to check for cracks.

Replace the crankshaft vibration damper if any of the following conditions occur:

- Engine failure due to a broken crankshaft
- Excessive wear of the front bearing for the crankshaft
- Excessive wear of the gear train that is not caused by a lack of lubrication

Inspect the gears of the gear train and inspect the gear train bushings for the following conditions:

- Worn gear teeth
- Unusual fit
- Unusual wear

In addition to the inspection of components, inspect the alignment of the driven equipment. See the Application and Installation Guide for the engine or see the literature that is provided by the OEM of the driven equipment.

Cleaning of Components

Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores. For instructions on cleaning the cores, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/ Test” topic.

Clean the oil suction screen. Also, remove side covers in order to clean the oil sump. For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.

Obtain a Coolant Analysis

For conventional heavy-duty coolant or antifreeze, check the concentration of supplemental coolant additive (SCA) regularly. The concentration of SCA can be checked with an S·O·S coolant analysis (Level I). A more detailed coolant analysis is recommended periodically.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals which were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis may be obtained from the following sources:

- Caterpillar dealer
- Local water utility company
- Agricultural agent
- Independent laboratory

Caterpillar recommends an S·O·S coolant analysis (Level II). This is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system. The following services are provided:

- Full Level I analysis
- Identification of the source of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of possible electrolysis within the engines' cooling system

A report of the results of the analysis is provided. Maintenance recommendations are based on the results.

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

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Overhaul (Top End)

SMCS Code: 7595-020-TE

The maintenance intervals that are listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule” are expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Refer to this Operation and Maintenance Manual, “Overhaul Considerations” in order to determine the maintenance interval for a top end overhaul.

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. Some additional components are replaced and serviced.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

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

Cylinder Head Assembly

Inspect the cylinder head assembly according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, Index of Publications on Reusability or Salvage of Used Parts.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

The use of out-of-spec parts will cause unscheduled downtime and/or costly repairs.

Fuel Injectors

Replace the fuel injectors. Consult your Caterpillar dealer about exchanging the fuel injectors. Your Caterpillar dealer can provide these services and components.

The wear of fuel injectors is affected by the following considerations:

- Quality of the fuel
- Quality of the filtration of the fuel

The wear of the fuel injectors can result in elevated levels of exhaust emissions and/or poor engine performance. The misfire of a single cylinder is not typically attributed to normal wear. This condition can be repaired by replacing the faulty fuel injector.

The following list of circumstances indicate that the fuel injectors should be inspected more frequently:

- Use of fuels that are not recommended in this Operation and Maintenance Manual, “Refill Capacities and Recommendations”
- Extreme ambient temperatures that reduce the ability of the fuel to provide lubrication
- Frequent plugging of the fuel filters
- Insufficient maintenance of the fuel tank or the fuel storage tank that can allow excessive water, sediment, etc.
- Insufficient maintenance of the fuel filters

Inspection, Reconditioning or Exchanging of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, Index of Publications on Reusability or Salvage of Used Parts.

Recondition the worn components or exchange the components, if necessary. Your Caterpillar dealer can provide these services and components.

- Camshaft followers
- Cylinder head assembly
- Engine wiring harness
- Exhaust manifold seals
- Exhaust manifold bellows
- Inlet manifold seals
- Rocker arms
- Spacer plate
- Software update
- Turbocharger

Inspection of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, Index of Publications on Reusability or Salvage of Used Parts.

- Aftercooler core
- Camshaft
- Driven equipment (alignment)
- Engine control module

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Overhaul Considerations

SMCS Code: 7595-043

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

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

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

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

Oil Consumption as an Overhaul Indicator

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

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

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

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

Overhaul Options

Before Failure Overhaul

A planned overhaul before failure may be the best value for the following reasons:

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

After Failure Overhaul

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

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

This lower cost can be attributed to three aspects:

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

Overhaul Recommendation

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

Note: Overhaul programs vary according to the engine application and according to the dealer that performs the overhaul. Consult your Caterpillar dealer for specific information about the available overhaul programs and about overhaul services for extending the engine life.

If an overhaul is performed without overhaul service from your Caterpillar dealer, be aware of the following maintenance recommendations.

Rebuild or Exchange

Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Fuel Transfer Pump

These components should be inspected according to the instructions that are found in various Caterpillar reusability publications. The Special Publication, SEBF8029 lists the reusability publications that are needed for inspecting the engine parts.

If the parts comply with the established inspection specifications that are expressed in the reusable parts guideline, the parts should be reused.

Parts that are not within the established inspection specifications should be dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

Using out-of-spec parts can result in the following problems:

- Unscheduled downtime
- Costly repairs
- Damage to other engine parts
- Reduced engine efficiency
- Increased fuel consumption

Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar Inc. recommends repairing out-of-spec parts or replacing out-of-spec parts.

Inspection and/or Replacement

Crankshaft Bearings, Valve Rotators, and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings
- Valve rotators
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- Rod bearing
- Main bearings

Note: If the crankshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the crankshaft.

Inspect the camshaft for damage to the journals and to the lobes.

Note: If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Camshaft followers

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

Oil Cooler Core and Aftercooler Core

During an overhaul, Caterpillar Inc. recommends the removal of both the oil cooler core and the aftercooler core. Clean the oil cooler core and the aftercooler core. Then, pressure test both of these cores.

NOTICE
Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

Note: Use this cleaning procedure to clean the oil cooler core and the aftercooler core.

1. Remove the oil cooler core and the aftercooler core.

2. Remove any debris from the oil cooler core and the aftercooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end. To remove debris from the aftercooler core, turn the aftercooler core upside-down.

3. Flush the oil cooler core and the aftercooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core and the aftercooler core.

Note: Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 29 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 29

Hydrosolv Liquid Cleaners[1]		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F).

4. Use steam to clean the oil cooler core and the aftercooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core and the aftercooler core. Remove any other trapped debris.

5. Wash the oil cooler core and the aftercooler core with hot, soapy water. Rinse the oil cooler core and the aftercooler core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

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

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

6. Dry the oil cooler core and the aftercooler core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the components in order to ensure cleanliness. The oil cooler core and the aftercooler core should be pressure tested. Repair the oil cooler core and the aftercooler core, if necessary. Install the oil cooler core and the aftercooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S·O·S Coolant Analysis (Level 1). Further coolant analysis is recommended when the engine is overhauled.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals that were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S·O·S Coolant Analysis (Level 2).

S·O·S Coolant Analysis (Level 2)

An S·O·S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level 2) provides the following information:

- Complete S·O·S Coolant Analysis (Level 1)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S·O·S Coolant Analysis (Level II) provides a report of the results of both the analysis and the maintenance recommendations.

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

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Power Factor - Check

SMCS Code: 4450-535-PWR

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

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Radiator - Clean

SMCS Code: 1353-070

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

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

⚠ WARNING

Personal injury can result from air pressure.

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

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

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

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

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

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

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

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

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Rotating Rectifier - Check

SMCS Code: 4465-535

Check the exciter armature. Ensure that the rotating rectifier is tight. If a failure of a rectifier is suspected, proceed to the Testing a Three-Diode Rectifier Block section.

Testing a Three-Diode Rectifier Block

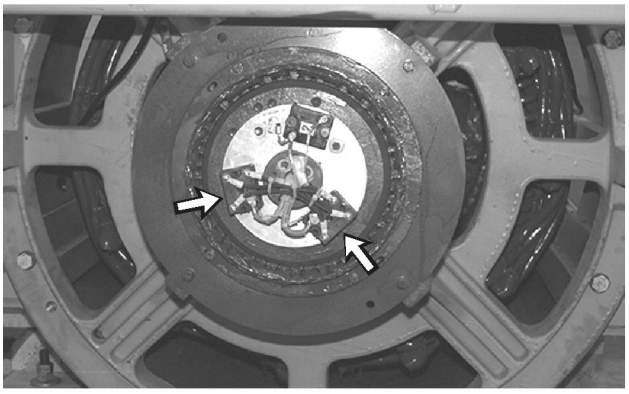

Illustration 91 g00610240

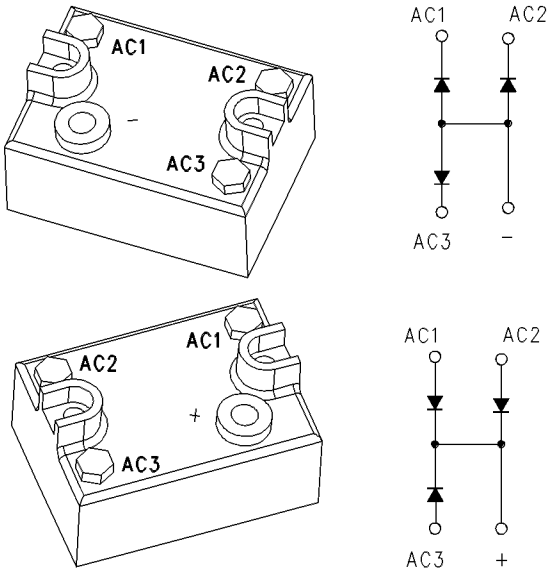

Illustration 92 g00613971

Three-Diode Rectifier Block (two pieces)

The following procedure tests all three diodes within a block. Check the positive rectifier block and the negative rectifier block. If any meter reading does not fall within the given ranges, replace the rectifier block.

1. Set the digital multimeter on the diode range. Remove all leads from the rectifier block.

2. To test the negative rectifier block, follow these steps:

a. Place the red test lead on the negative "-" terminal. Place the black test lead on the following rectifier terminals: "AC1" (3), "AC2" (4) and "AC3" (5). All readings on the meter should be between 0.4 and 1.0.

b. Place the black test lead on the negative "-" terminal. Place the red test lead on the following rectifier terminals: "AC1" (3), "AC2" (4) and "AC3" (5). In all cases, the meter should read "OL" (overload).

3. To test the positive rectifier block, follow these steps:

a. Place the red test lead on the positive "+" rectifier terminal. Place the black test lead on the following rectifier terminals: "AC1" (3), "AC2" (4) and "AC3" (5). In all cases, the meter should read "OL" (overload).

b. Place the black test lead on the positive "+" rectifier terminal. Place the red test lead on the following rectifier terminals: "AC1" (3), "AC2" (4) and "AC3" (5). All readings on the meter should be between 0.4 and 1.0.

Note: A shorted diode can damage the exciter rotor. If a diode is shorted, check the exciter rotor. Refer to the Testing and Adjusting, "Winding - Test" and Testing and Adjusting, "Insulation - Test". Perform these tests.

Note: This rectifier block also contains varistor "CR7" . "CR7" can be checked by measuring the resistance between the positive "+" rectifier terminal and the negative "-" rectifier terminal. The resistance should be a minimum of 15000 ohms.

i04524988

Standby Generator Set Maintenance Recommendations

SMCS Code: 4450-041

A standby generator set may be intermittently used. However, the generator set is needed for operation in an emergency situation. Maintenance of the standby generator set is 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 Cat dealer can help you to establish an effective Preventive Maintenance Program for your generator set. Consult your Cat 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 Cat dealer.

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

- The engine is stopped.
- The starting system is disabled.
- The generator does not pose an electrical shock hazard.
- The generator is disconnected from the load.

Operation

To ensure proper operation, the generator set must be exercised regularly. For instructions on operating the generator set, see the Operation and Maintenance Manual for the generator set control panel.

For these operation procedures, follow the instructions that are provided in this Operation and Maintenance Manual, “Operation Section”: starting the engine, engine operation and stopping the engine.

Record Keeping

Maintain a record in order to document these items: gauge readings, maintenance that is performed, problems and repairs.

Space Heaters

Moisture can damage 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 condition 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.

i03230840

Stator Lead - Check

SMCS Code: 4459-535

Ensure that the stator output leads are routed out of the generator in a manner that prevents the leads from rubbing against metal objects.

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i05264219

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side). Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Cat 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.

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Voltage and Frequency - Check

SMCS Code: 4450-535-EL

Check for proper voltage and frequency setting. Check for stability.

Refer to the generator set Serial Plate for correct voltage and frequency.

i02378188

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

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

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pump and the installation of water pump and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

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

Inspect the Insulation

A visual inspection should be initially directed at the areas that are most prone to damage and deterioration. The most prone areas to damage and deterioration are listed below:

- Ground Insulation. Ground insulation is insulation that is intended to isolate components that are carrying current from components that are not carrying current.
- Support Insulation. Support insulation is usually made from one of the following items: a compressed lamination of fibrous materials, polyester, or felt pads that have been impregnated with various types of bonding agents.

There are many different types of damage that can occur in these areas. Several of the different types of damage are listed below:

Thermal Aging – Thermal aging can cause the degradation of insulation or the deterioration of insulation. An examination of the coils may reveal that the insulation has expanded into the ventilation ducts. This is the result of a loss of bond which will cause the insulation material to separate. The insulation material could also separate from the conductors on the windings.

Abrasion – The surfaces of coils and the surfaces of connectors may be damaged by abrasion. These surfaces may also be damaged by contamination from other sources. An example of these sources would be chemicals or abrasive substances.

Cracking – Cracking of insulation may result from mechanical stress. The structure that is used to brace the stator winding will become loose if the problem is

not corrected. Further mechanical damage or electrical damage may also result.

Erosion – Erosion can be caused when foreign substances rub against the surfaces of the insulation.

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Water Pump - Inspect

SMCS Code: 1361-040

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

A failed water pump might cause severe engine overheating problems. Overheating could result in cracks in the cylinder head, a piston seizure, or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Disassemble and Water Pump - Assemble” for the disassembly and assembly procedure. If necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Remove and Water Pump - Install”.

Inspect the water pump for wear, cracks, pin holes, and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Cat dealer if repair is needed or replacement is needed.

Warranty Section

Warranty Information

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Emissions Warranty Information

SMCS Code: 1000

Caterpillar Inc. (Caterpillar) warrants to the ultimate purchaser and each subsequent purchaser that:

1. New non-road diesel engines and stationary diesel engines less than 10 liters per cylinder operated and serviced in the United States and Canada , including all parts of their emission control systems (“emission related components”), are:

a. Designed, built, and equipped so as to conform, at the time of sale, with applicable emission standards prescribed by the United States Environmental Protection Agency (EPA) by way of regulation.

b. Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.

2. New non-road diesel engines operated and serviced in the state of California , including all parts of their emission control systems (“emission related components”), are:

a. Designed, built, and equipped so as to conform, at the time of sale, to all applicable regulations adopted by the California Air Resources Board (ARB).

b. Free from defects in materials and workmanship which cause the failure of an emission-related component to be identical in all material respects to the component as described in the Caterpillar application for certification for the warranty period.

A detailed explanation of the Emission Control Warranty that is applicable to new non-road and stationary diesel engines, including the components covered and the warranty period, is found in supplement Special Publication, SELF9001, “Federal Emission Control Warranty” and “Emission Control Warranty for California”. Consult your authorized Cat dealer to determine if your engine is subject to an Emission Control 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).

Customer Service

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Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

If a problem arises concerning the operation or service of an engine, the problem will be managed by the dealer in your area.

Your satisfaction is a primary concern to Caterpillar and to Cat 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 without additional assistance, use the phone number 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.
Electric Power North America
Attn: Product Support Manager
AC 6109
Mossville, Illinois 61552

Keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of USA and of Canada

If a problem arises outside of 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
Caterpillar Japan Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i01028392

Ordering Replacement Parts

SMCS Code: 4450; 7567

⚠ WARNING

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

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

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

Reference Materials

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Maintenance Records

SMCS Code: 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is managed. Accurate maintenance records can help your Cat 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 repair costs
- Owner receipts
- Maintenance log

i01176304

Maintenance Log

SMCS Code: 1000; 4450

Table 30

Engine Model	**Customer Identifier**
Serial Number	**Arrangement Number**

Service Hours	**Quantity Of Fuel**	**Service Item**	**Date**	**Authorization**

i05367833

Reference Material

SMCS Code: 1000; 4450

The following literature can be obtained from any Caterpillar dealer.

Note: The information that is found in this publication and the information that is found in the publications that are listed below may be changed without notice.

Operation and Maintenance Manuals are available in other languages. Consult your Caterpillar dealer for information about obtaining these Operation and Maintenance Manuals.

S·O·S Services

- Special Publication, PEDP7036, “S·O·S Fluids Analysis Cornerstone”
- Special Instruction, PEHP7076, “Understanding S·O·S Services Tests”
- Special Publication, PEHP7057, “S·O·S Coolant Analysis”

Coolants

- Special Publication, SEBD0518, “Know Your Cooling System”
- Special Publication, SEBD0970, “Coolant and Your Engine”
- Special Instruction, PEHP9554, Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Special Publication, PELJ0176, “Cat ELC (Extended Life Coolant) ” 223 - 9116 Coolant Test Kit
- Data Sheet, PEHJ0067, “Cat ELC (Worldwide Formulation)”
- Special Instruction, PMEP5027, ELC Coolant/ Antifreeze Label

Fuels

- Special Publication, SEBD0717, “Diesel Fuels and Your Engine”

Lubricants

- Special Publication, PELJ0179, “Caterpillar Engine Crankcase Fluid-1 Specifications”All International Markets
- Special Publication, PEDP7035, Optimizing Oil Change Intervals for Diesel Engines
- Data Sheet, PEHJ0021, “Cat DEO (Diesel Engine Oil) APD, EAME, LACD Only”
- Data Sheet, PEHP7062, “Full Synthetic Diesel Engine Oil Data Sheet”
- Data Sheet, PEHJ0008, “Cat Arctic DEO SYN”
- Special Publication, PEGJ0047, “How to Take a Good Oil Sample”
- Special Publication, SEBD0640, “Oil and Your Engine”
- Data Sheet, PEHJ0059, “Cat DEO (for North America)”
- Data Sheet, PEHJ0072, “Cat DEO (Brazil only)”
- Data Sheet, PEHJ0091, “Cat DEO (Egypt and Saudi Arabia)”

Grease

- Specifications for greases that are recommended by Caterpillar
- Special Instruction, NEHP6010, Cat Ultra 5Moly Grease (NLGI grades 1 and 2)
- Special Instruction, NEHP6011, “Arctic Platinum Grease Spec Sheet”
- Special Publication, NEHP6012, Desert Gold Grease Spec Sheet
- Data Sheet, NEHP6015, “Caterpillar Special Purpose Grease”
- Special Instruction, PEHP0002, “Molybdenum Grease Data Sheet”
- Data Sheet, PEHP0088, “Cat MultiPurpose Grease”
- Special Instruction, PEGJ0035, Grease Selection Special Instruction

Miscellaneous

- Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”
- Special Publication, SEBU5898, “Cold Weather Recommendations”
- Special Instruction, SEHS9031, “Storage Procedure for Caterpillar Products”
- Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog”
- Special Publication, SMBU6981, “Emissions Control Warranty Information for Unites States, Canada, and California”
- Specifications, Systems Operation, Testing and Adjusting, RENR7941, Cat Digital Voltage Regulator
- Specifications, SENR3130, Torque Specifications
- ISO 8528, Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets
- Special Instruction, SEHS7259, Alignment of Single-Bearing Generators
- Special Instruction, SEHS7654, Alignment - General Instructions
- Special Instruction, SEHS9124, Cleaning and Drying of Electric Set Generators
- Systems Operation/Testing and Adjusting, RENR7902, “EMCP III”
- Special Publication, PECP9067, “One Safe Source”
- Special Instruction, SEHS7633, “Battery Test Procedure”
- Special Instruction, REHS0354, “Charging System Troubleshooting for All Engines”
- Special Instruction, SEHS7332, “Do Not Operate Tag”
- Special Publication, SEBF8062, “Procedure to Inspect and Clean Air Filters”
- Special Publication, SEBF8029, “Index to Publications on Reusability of Parts”
- Special Instruction, REHS9124, Cleaning and Drying of the Generator
- Special Instruction, REHS4892, Generator Bearing Service
- Special Instruction, REHS0177, Alignment of the Close Coupled Two Bearing GeneratorsEngine Data Sheet, LEKX4066, Loading Transient Response
- Engine Data Sheet, LEKX4067, Block and Transient Response
- Systems Operation, Troubleshooting, Testing and Adjusting, UENR1209, EMCP4.1/4.2
- Special Publication, PECJ0003, Cat Shop Supplies and Tools Catalog
- Operation and Maintenance Manual, SEBU7902, Overhaul Considerations

Additional Reference Material

ASTM D2896, TBN Measurements This can normally be obtained from your local technological society, from your local library, or from your local college.

SAE J313, Diesel Fuels This can be found in the SAE handbook. Also, this publication can be obtained from your local technological society, from your local library, or from your local college.

SAE J754, Nomenclature This can normally be found in the SAE handbook.

SAE J183, Classification This can normally be found in the SAE handbook.

Engine Manufacturers Association, Engine Fluids Data Book

Engine Manufacturers Association
Two North LaSalle Street, Suite 2200
Chicago, Illinois, USA 60602
E-mail: ema@enginemanufacturers.org
Telephone (312) 827-8700
Facsimile (312) 827-8737

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Decommissioning and Disposal

SMCS Code: 1000

When the generator set is removed from service, local regulations for the generator set decommissioning will vary. Disposal of the generator set will vary with local regulations. Consult the nearest Cat dealer for additional information.

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Product and Dealer Information

Note: For
product identification plate locations, see the section “Product Identification Information” in the Operation and Maintenance Manual.

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission
Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment
Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

_____

_____

	Dealer Contact	Phone Number	Hours
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____