



Operation and Maintenance Manual

C6.6 Generator Set

SDA1-Up (C6.6 Generator Set)
N6D1-Up (C6.6 Generator Set)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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



When replacement parts are required for this product Caterpillar recommends using Cat replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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

Table of Contents

Foreword	4
----------------	---

Safety Section

Safety Messages	6
Additional Messages	18
General Hazard Information	25
Burn Prevention	28
Fire Prevention and Explosion Prevention	28
Crushing Prevention and Cutting Prevention	31
Before Starting Engine	31
Engine Starting	31
Engine Stopping	32
Electrical System	32
Generator Isolating for Maintenance	33

Product Information Section

General Information	35
Product Identification Information	38

Operation Section

Lifting and Storage	41
Features and Controls	43
Engine Starting	48
Engine Operation	50
Generator Operation	51
Cold Weather Operation	77
Engine Stopping	80

Maintenance Section

Refill Capacities	81
Maintenance Recommendations	90
Maintenance Interval Schedule (Standby Generator Sets)	92

Maintenance Interval Schedule (Prime Power Generator Sets)	93
--	----

Warranty Section

Warranty Information	130
----------------------------	-----

Reference Information Section

Engine Ratings	131
Customer Service	133
Reference Materials	135

Index Section

Index	138
-------------	-----

Foreword

Literature Information

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

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

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

Safety

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

Operation

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

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

Maintenance

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

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

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

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

Maintenance Intervals

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

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

Overhaul

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

California Proposition 65 Warning

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

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

Safety Section

i02439277

Safety Messages

SMCS Code: 1000; 7405

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

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

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

WARNING

Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.

Illustrations 1 through 4 show one type of enclosed generator set.

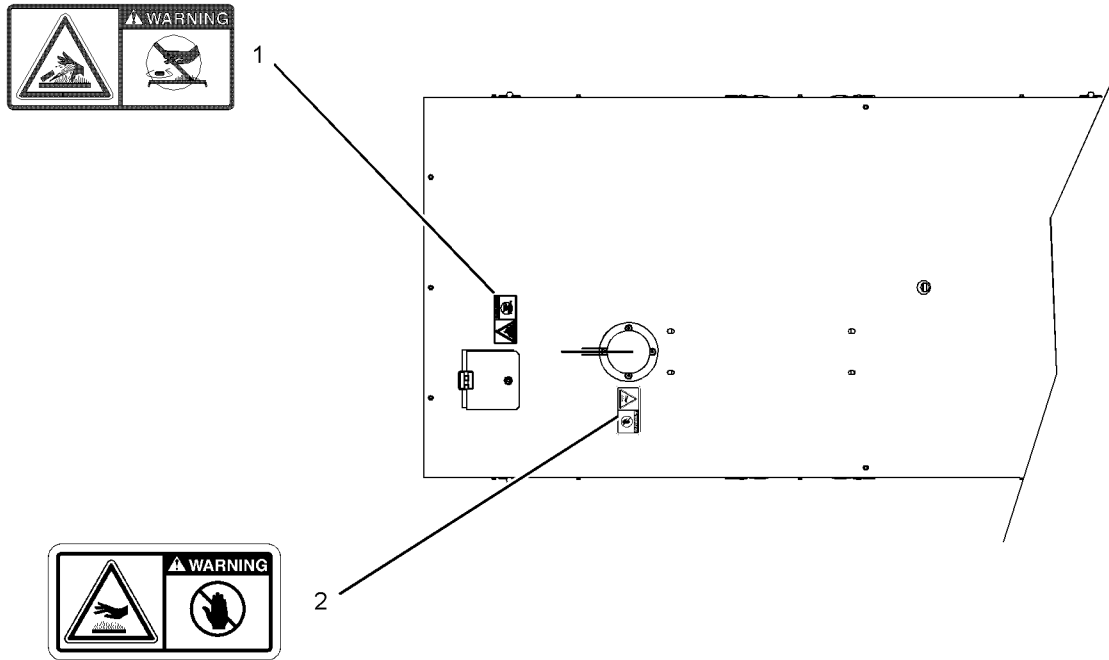


Illustration 1

g01218859

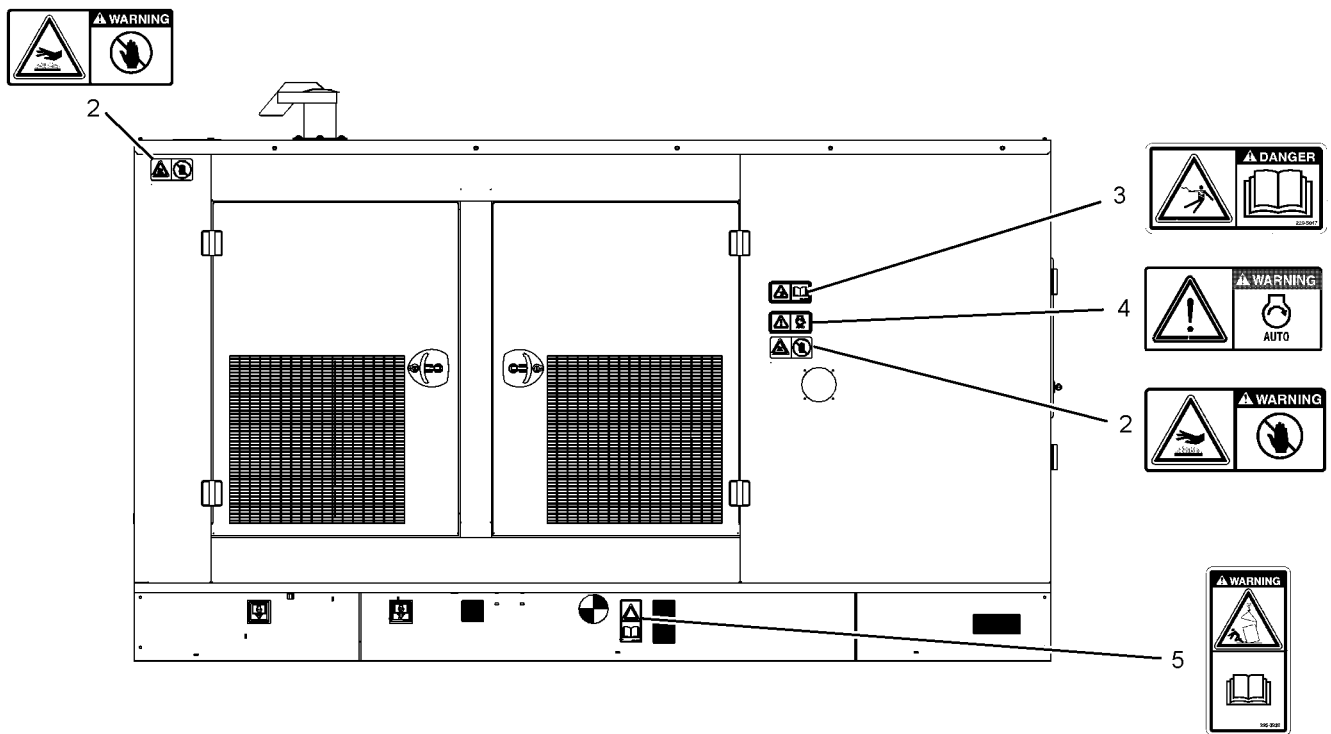


Illustration 2

g01219063

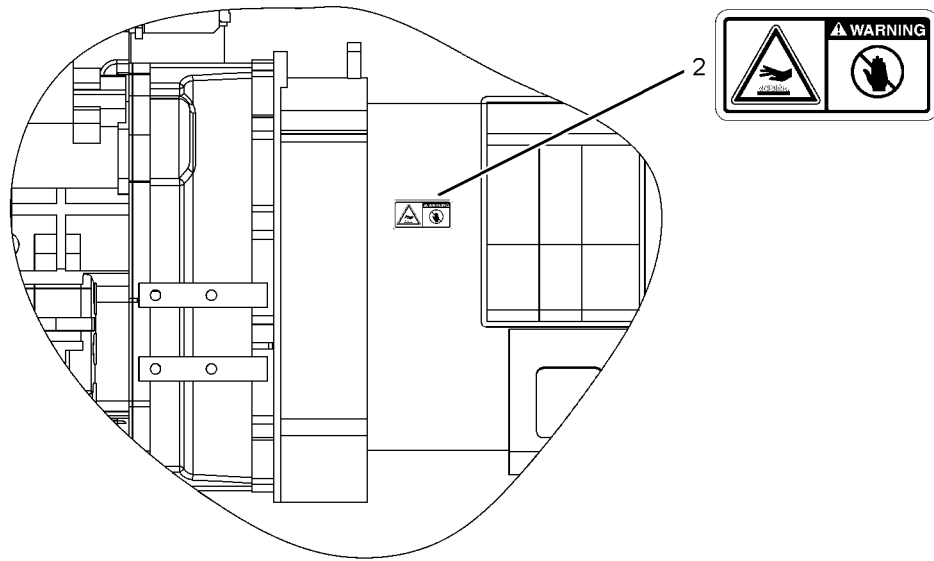


Illustration 3
View of the inside of the enclosure

g01232868

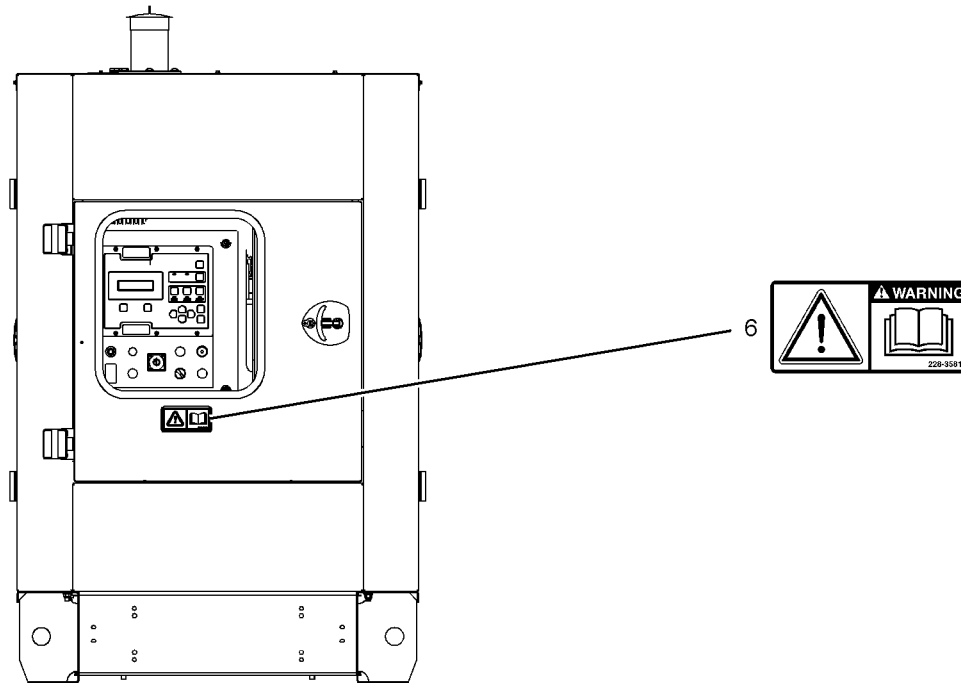


Illustration 4

g01222980

Illustrations 5 through 7 show another type of enclosed generator set.

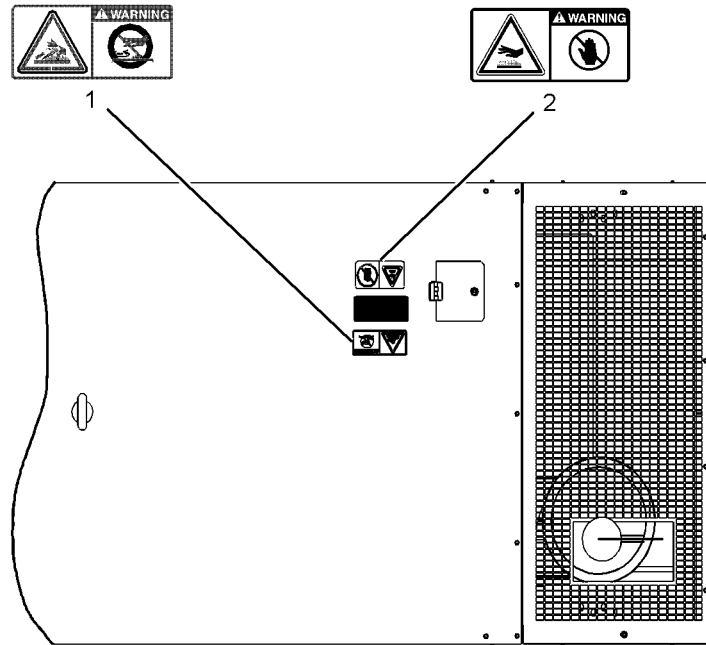


Illustration 5

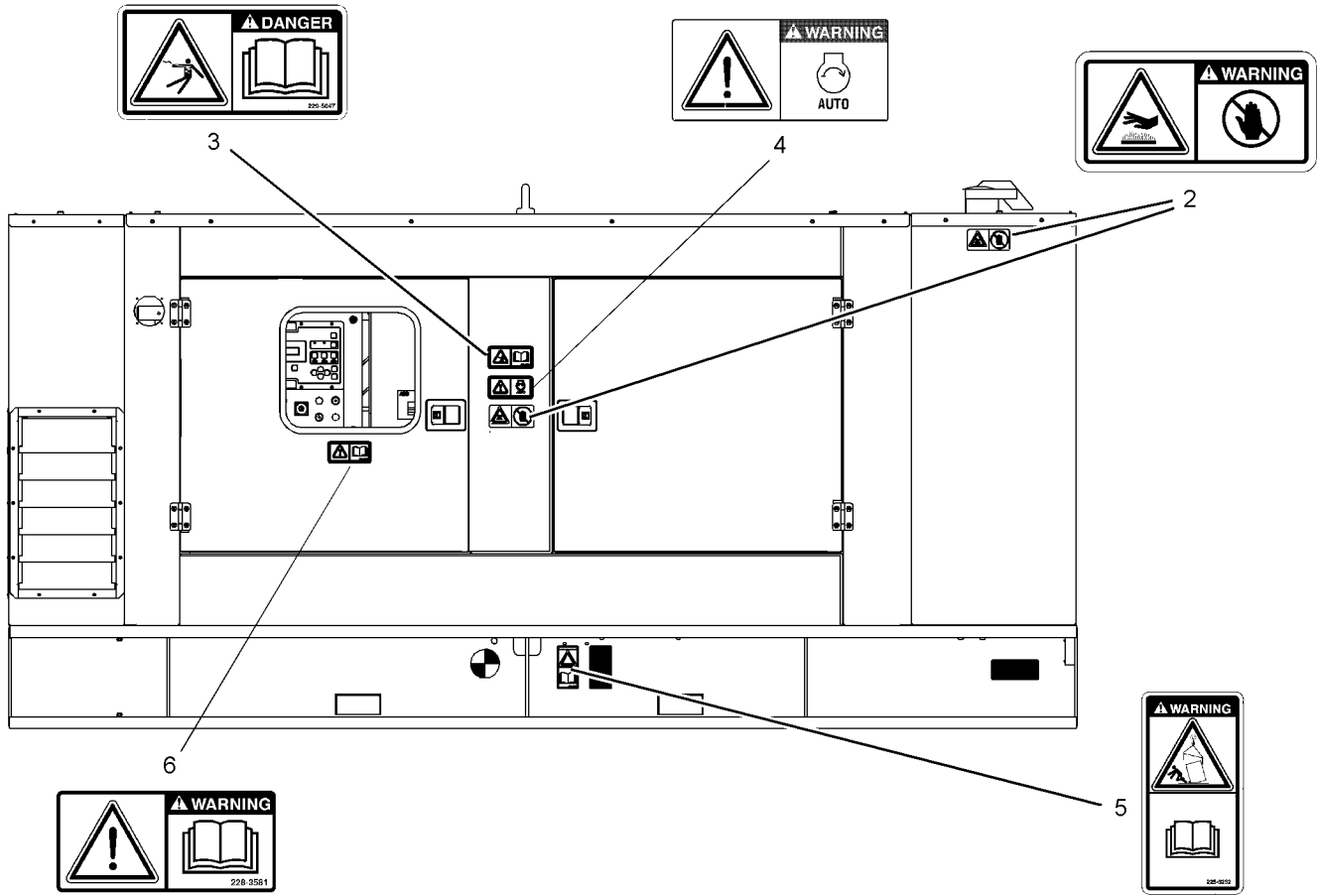


Illustration 6

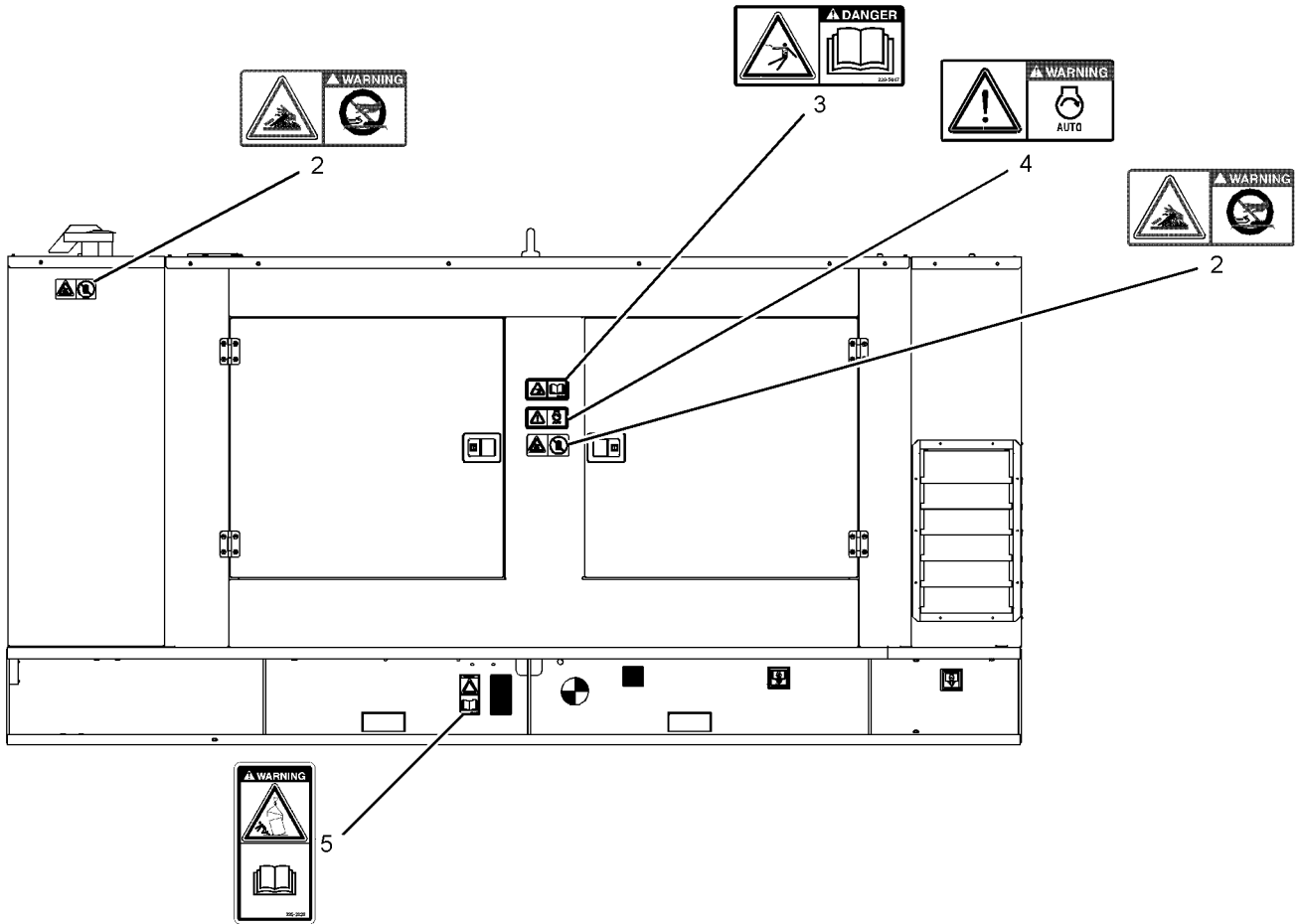


Illustration 7

g01222036

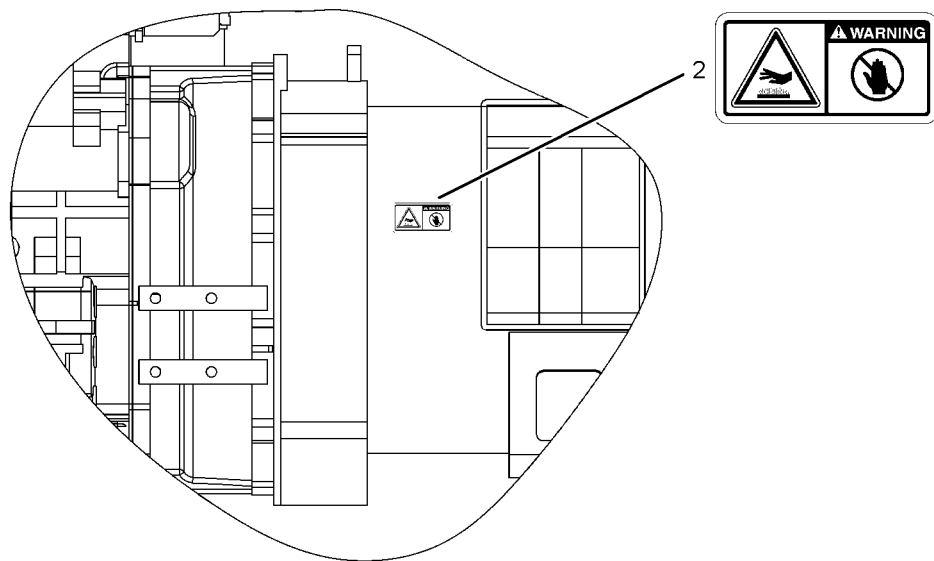


Illustration 8

g01232868

View of the inside of the enclosure

Illustrations 9 and 10 show an open generator set.

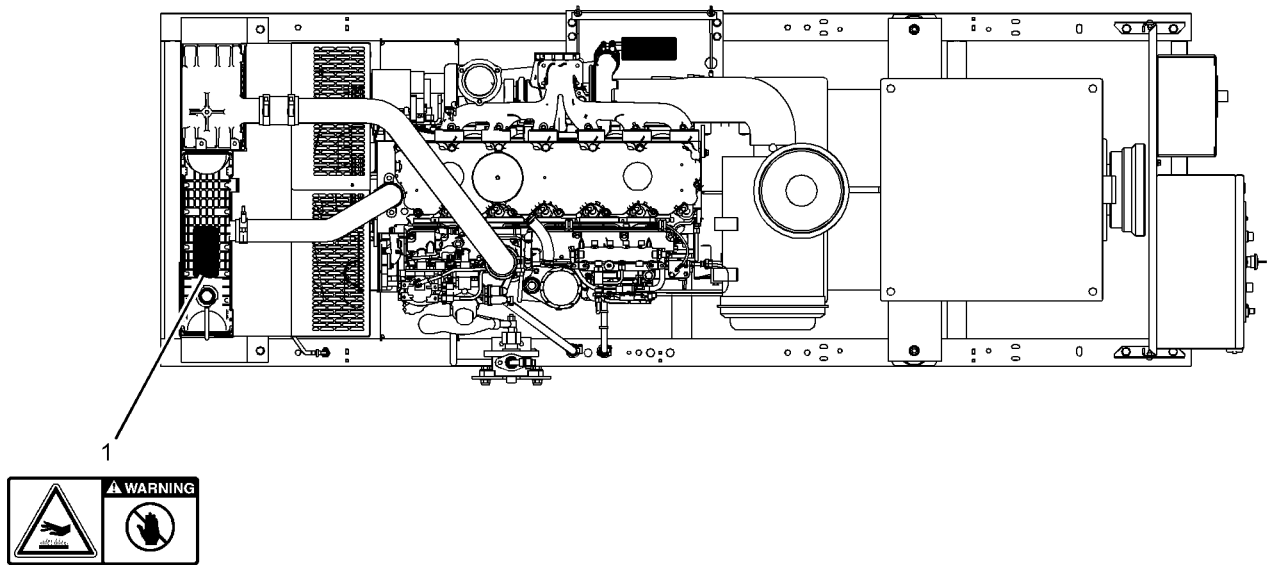


Illustration 9

g01222927

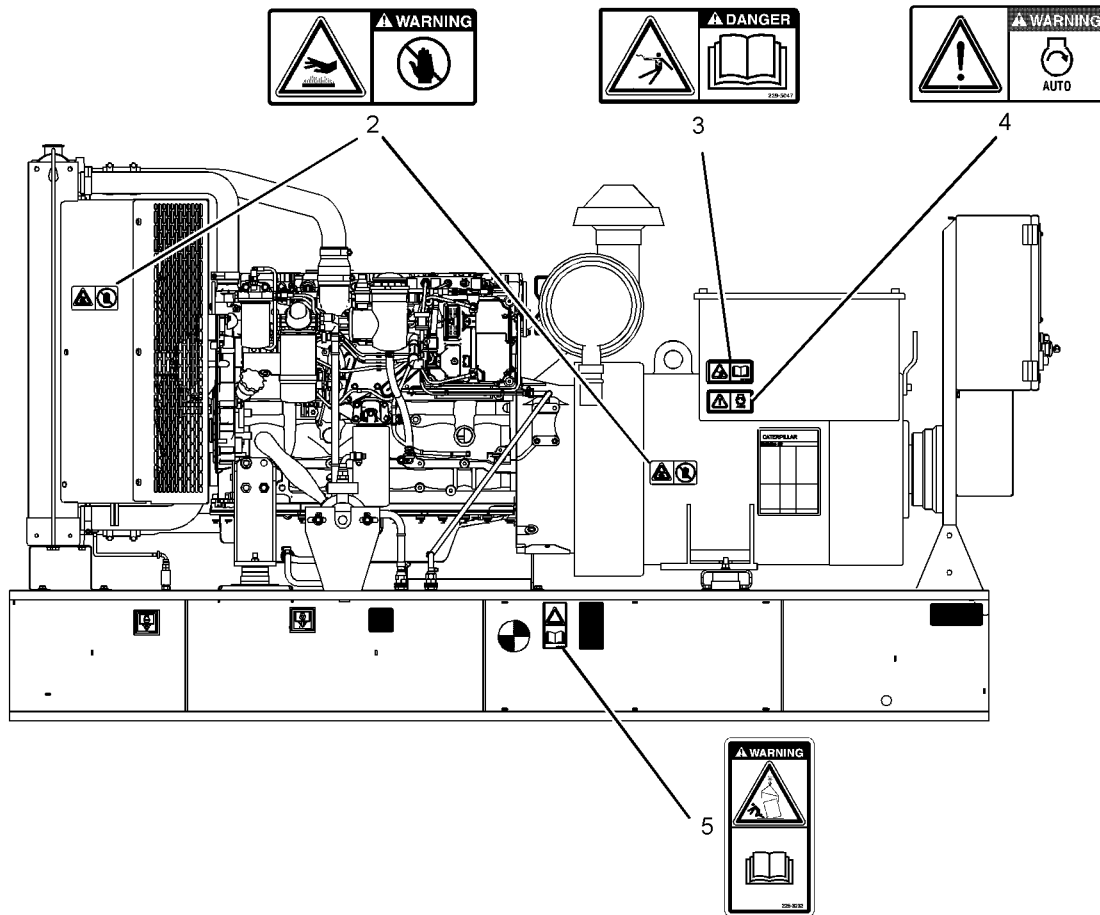


Illustration 10

g01222960

Illustration 11 shows the control panel and the distribution panel.

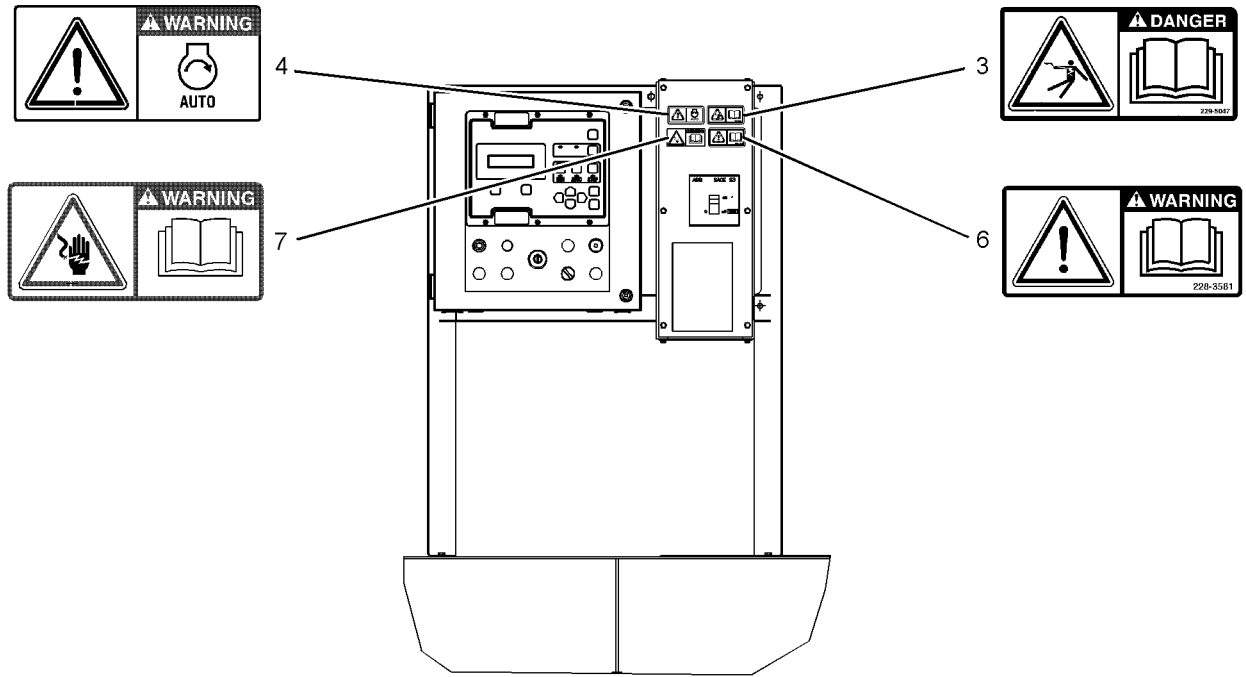


Illustration 11

Hot Fluid Under Pressure (1)

This safety message is located on the top of the enclosure by the radiator cap access cover on enclosed generator sets. This safety message is located toward the top of the radiator by the filler neck on open generator sets.



g00930639

⚠ 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.

Hot Surface (2)

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



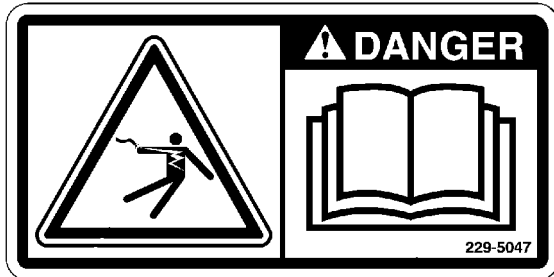
g01085603

⚠ WARNING

Hot surface! Do not touch!

Electrocution (3)

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



g00928349

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.

Automatic Starting (4)

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



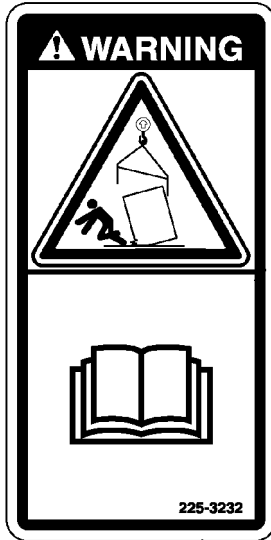
g01154070

WARNING

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

Lifting the Generator Set (5)

This safety message is located on the sides of the enclosure toward the bottom of the enclosure on enclosed generator sets. This safety message is located on the sides of the base on open generator sets.



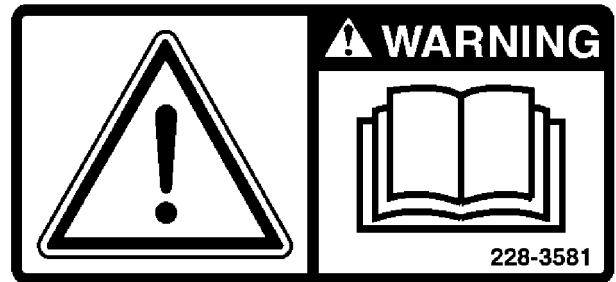
g00928085



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

Universal Warning (6)

This safety message is located on the door for access to the control panel on enclosed generator sets. This safety message is located on the enclosure for the control panel and the distribution panel on open generator sets and enclosed generator sets.



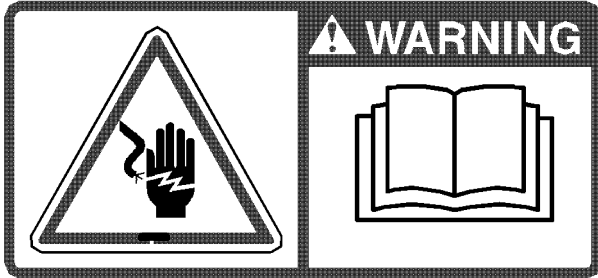
g00934493



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

Electrical Shock (7)

The safety message for electrical shock is located on the enclosure for the control panel and the distribution panel on open generator sets and enclosed generator sets.



g01120247

WARNING

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

i02482102

Additional Messages

SMCS Code: 1000; 7405

There are several specific messages on these machines. The exact location of the messages and the description of the messages are reviewed in this section. Please become familiarized with all messages.

Make sure that all of the messages are legible. Clean the messages or replace the messages if the words or images are unreadable. When you clean the messages, use a cloth, water and soap. Do not use solvent, gasoline, or other harsh chemicals to clean the messages. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the messages. Loose adhesive will allow the messages to fall.

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

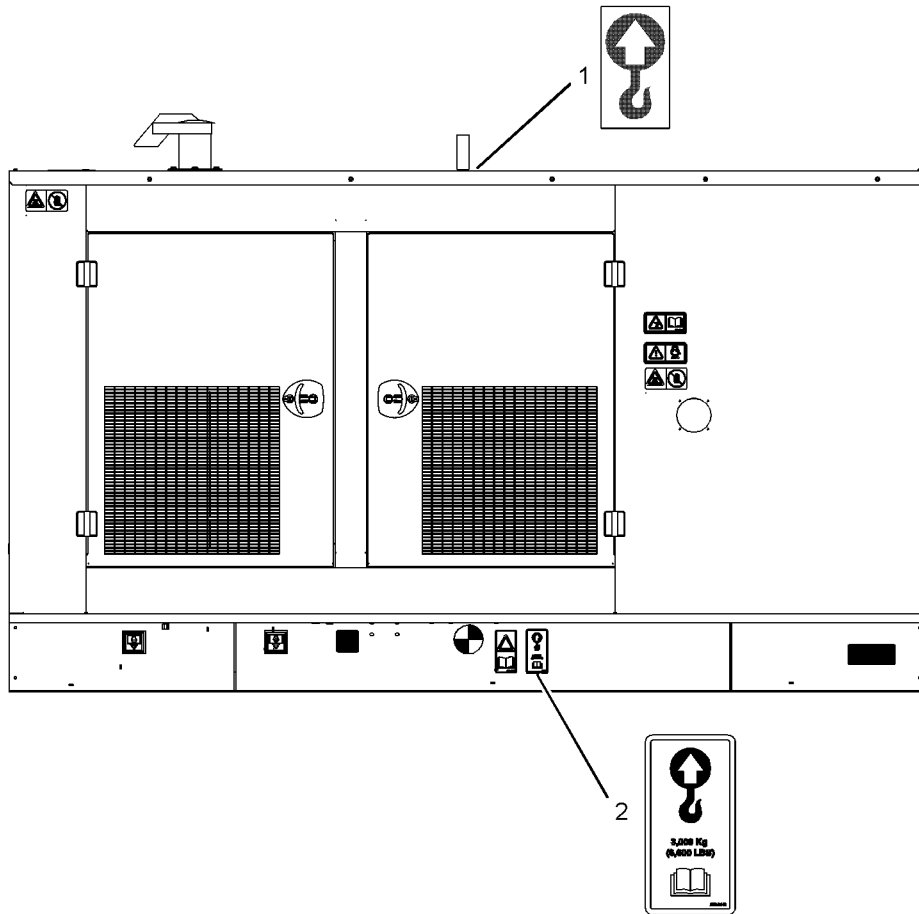


Illustration 12
This illustration shows one type of enclosed generator set.

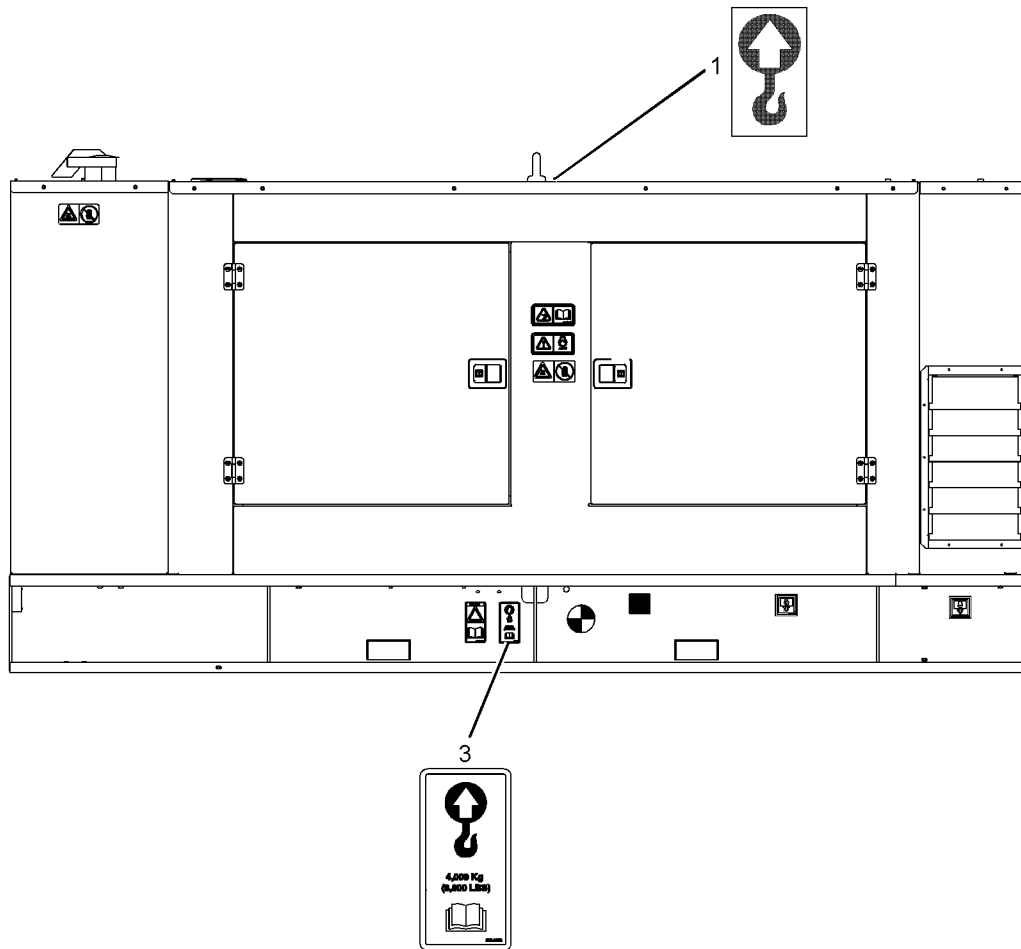


Illustration 13
This illustration shows another type of enclosed generator set.

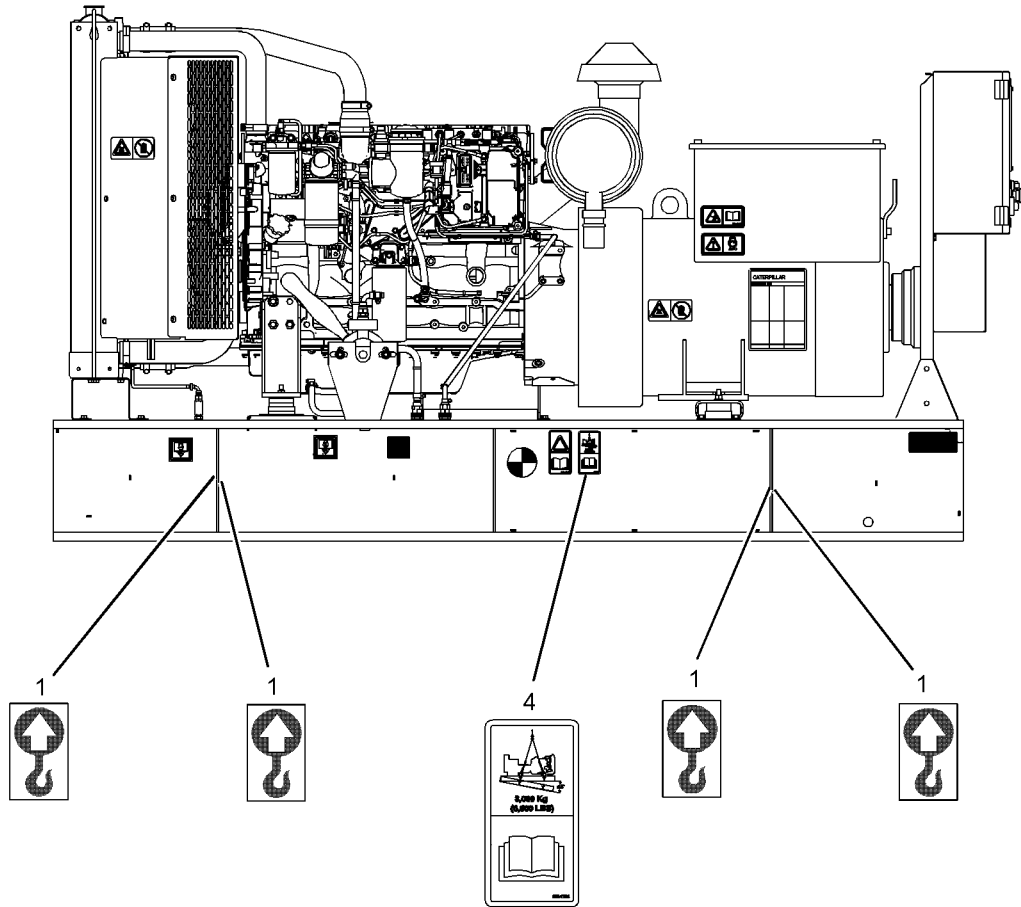


Illustration 14

g01233028

This illustration shows an open generator set.

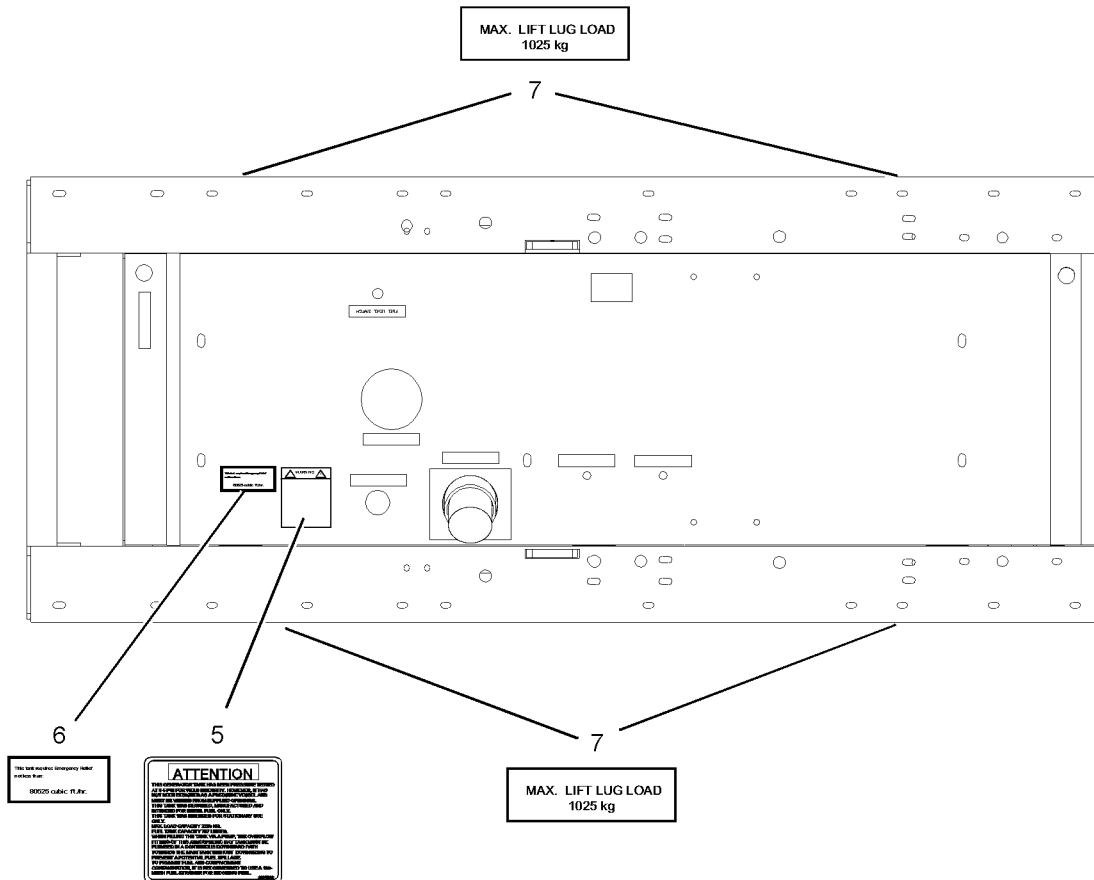


Illustration 15
 Typical example of a fuel tank

g01239864

Lifting point (1)



Illustration 16 g01034418

Lift the package from this point. Refer to the following topic:

- Operation and Maintenance Manual, “Product Lifting”

Rating for lifting equipment (2)

This message is located on the side of the enclosure near the bottom of the enclosure.

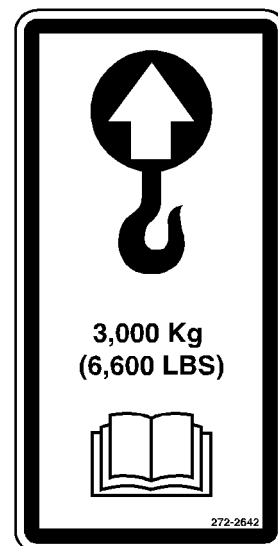


Illustration 17

g01233472

The lifting equipment that is used for lifting this type of generator set must be rated for a total weight of 3000 kg (6,600 lb).

Rating for lifting equipment (3)

This message is located on the side of the enclosure near the bottom of the enclosure.

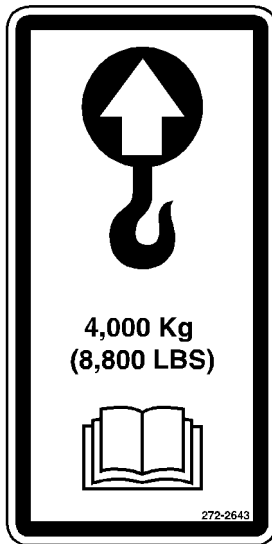


Illustration 18

g01233040

The lifting equipment that is used for lifting this type of generator set must be rated for a total weight of 4000 kg (8,800 lb).

Rating for lifting equipment (4)

This message is located on the side of open generator sets on the base.

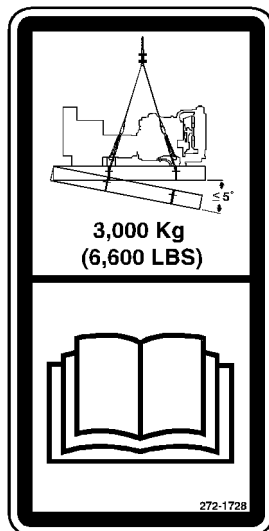


Illustration 19

g01233043

The lifting equipment that is used for lifting this type of generator set must be rated for a total weight of 3000 kg (6,600 lb).

Fuel tank vent (5)

This message is located on the fuel tank by the vent.

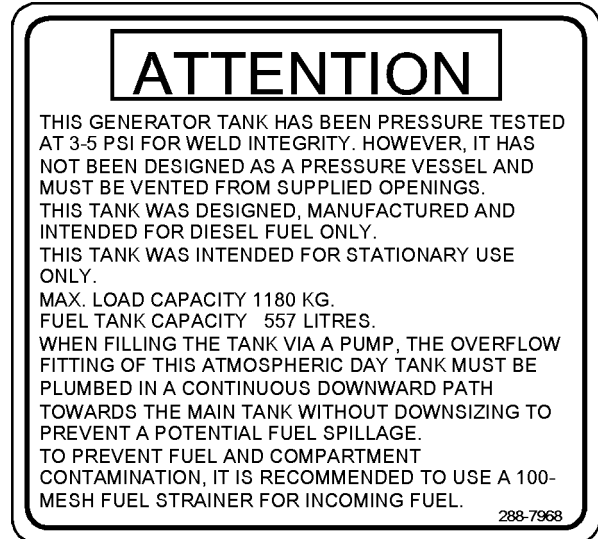


Illustration 20

g01239683

This generator tank has been pressure tested at 20.6 kPa (3 psi) to 34.5 kPa (5 psi) for weld integrity. However, it has not been designed as a pressure vessel and must be vented from supplied openings. This tank was designed, manufactured and intended for diesel fuel only. This tank was intended for stationary use only. Maximum load capacity 1180 kg (2601 lb) Fuel tank capacity 557 L (147 US gal). When filling the via a pump, the overflow fitting of this atmospheric day tank must be plumbed in a continuous downward path toward the main fuel tank without downsizing to prevent a potential fuel spillage. To prevent fuel and compartment contamination, it is recommended to use a 100 mesh fuel strainer for incoming fuel.

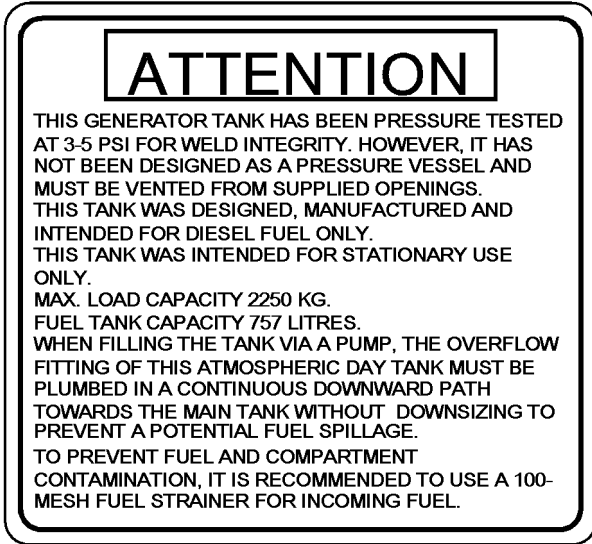


Illustration 21

g01239658

This generator tank has been pressure tested at 20.6 kPa (3 psi) to 34.5 kPa (5 psi) for weld integrity. However, it has not been designed as a pressure vessel and must be vented from supplied openings. This tank was designed, manufactured and intended for diesel fuel only. This tank was intended for stationary use only. Maximum load capacity 2250 kg (4960 lb). Fuel tank capacity 757 L (200 US gal). When filling the via a pump, the overflow fitting of this atmospheric day tank must be plumbed in a continuous downward path toward the main fuel tank without downsizing to prevent a potential fuel spillage. To prevent fuel and compartment contamination, it is recommended to use a 100 mesh fuel strainer for incoming fuel.

This generator tank has been pressure tested at 20.6 kPa (3 psi) to 34.5 kPa (5 psi) for weld integrity. However, it has not been designed as a pressure vessel and must be vented from supplied openings. This tank was designed, manufactured and intended for diesel fuel only. This tank was intended for stationary use only. Maximum load capacity 2250 kg (4960 lb). Fuel tank capacity 1485 L (392 US gal). When filling the via a pump, the overflow fitting of this atmospheric day tank must be plumbed in a continuous downward path toward the main fuel tank without downsizing to prevent a potential fuel spillage. To prevent fuel and compartment contamination, it is recommended to use a 100 mesh fuel strainer for incoming fuel.

Size of fuel tank vent (6)

This message is located on the fuel tank by the vent.

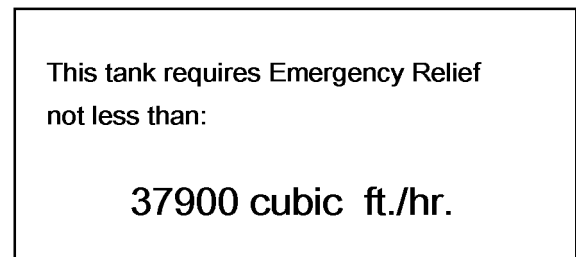


Illustration 23

g01239936

This tank requires emergency relief not less than 37900 cubic feet per hour.

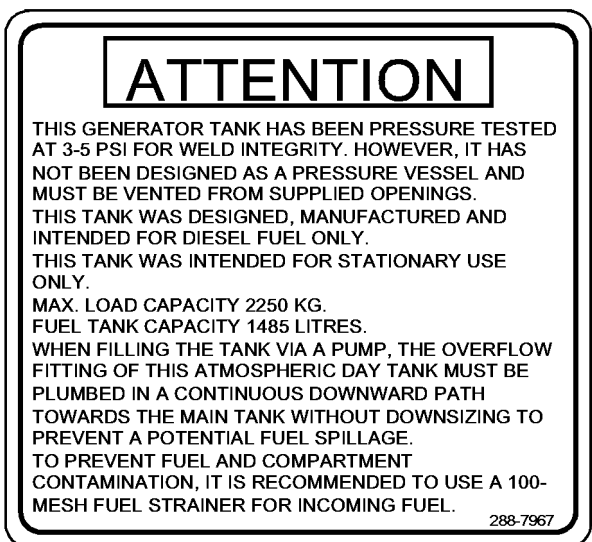


Illustration 22

g01239678

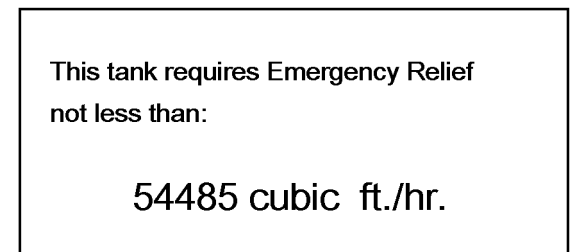


Illustration 24

g01239912

This tank requires emergency relief not less than 54485 cubic feet per hour.

This tank requires Emergency Relief
not less than:

80525 cubic ft./hr.

Illustration 25

g01239873

This tank requires emergency relief not less than
80525 cubic feet per hour.

Maximum Lift Lug Load (7)

This message is located on the fuel tank by the lifting
points.

MAX. LIFT LUG LOAD
623 kg

Illustration 26

g01239953

Maximum lift lug load 623 kg (1373 lb)

MAX. LIFT LUG LOAD
1000 kg

Illustration 27

g01239955

Maximum lift lug load 1000 kg (2205 lb)

MAX. LIFT LUG LOAD
1025 kg

Illustration 28

g01239958

Maximum lift lug load 1025 kg (2260 lb)

i02344741

General Hazard Information

SMCS Code: 1000; 4450; 7405

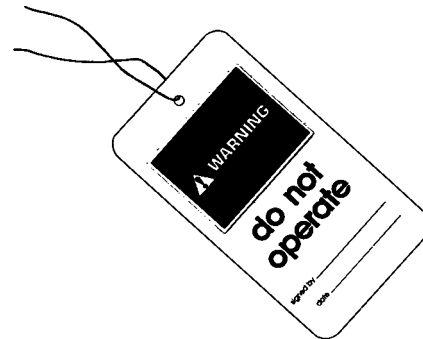


Illustration 29

g00104545

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

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

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

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

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

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

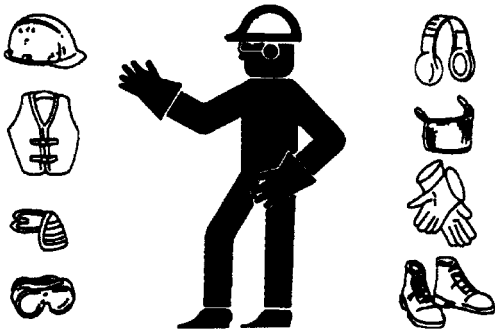


Illustration 30

g00702020

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

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

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

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

Pressurized Air and Water

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

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

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

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly.

Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.

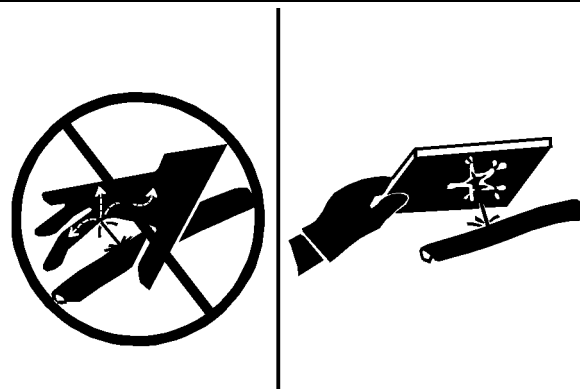


Illustration 31

g00687600

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

Containing Fluid Spillage

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

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

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

Obey all local regulations for the disposal of liquids.

Asbestos Information

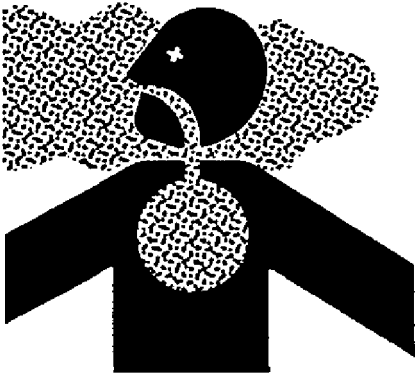


Illustration 32

g00702022

Caterpillar equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

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

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

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Dispose of Waste Properly

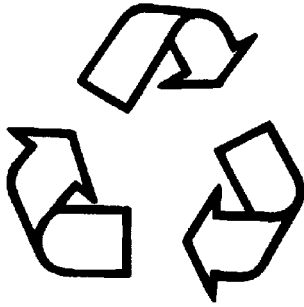


Illustration 33

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.

i02344742

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.

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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

Allow the pressure to be purged in the air system, in the hydraulic system, in the lubrication 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.

i02328452

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405



Illustration 34

g00704000

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

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

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

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

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

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

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

Do not expose the engine to any flame.

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

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

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

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

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

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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

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

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



Illustration 35

g00704059

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

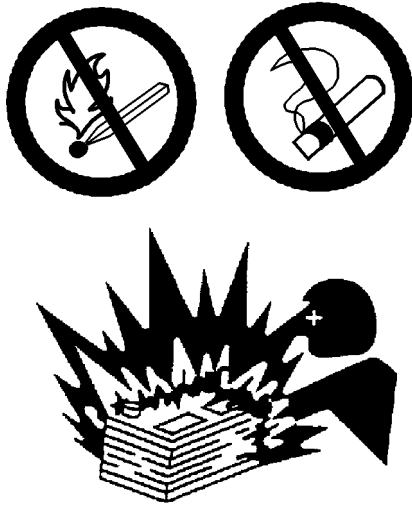


Illustration 36

g00704135

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

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

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

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

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

Fire Extinguisher

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

Ether

Ether is flammable and poisonous.

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

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

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

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

Lines, Tubes and Hoses

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

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

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

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

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

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

i01359666

Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 4450; 7405

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

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

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

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

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

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

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.

i02344744

Engine Starting

SMCS Code: 1000

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

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 the Operation and Maintenance Manual, "Engine Starting" topic in the 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 correctly, check the water temperature gauge and/or the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion which 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.

Note: The engine is equipped with a device for cold starting. If the engine will be operated in very cold conditions, then an extra cold starting aid may be required. Normally, the engine will be equipped with the correct type of starting aid for your region of operation.

These engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting.

i02328530

Engine Stopping

SMCS Code: 1000

To avoid overheating of the engine and accelerated wear of the engine components, stop the engine according to this Operation and Maintenance Manual, "Engine Stopping" topic (Operation Section).

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

On the initial start-up of a new engine or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs.

To stop an electronic controlled engine, cut the power to the engine and/or the air supply to the engine.

i02234878

Electrical System

SMCS Code: 1000; 1400

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

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative "-" 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 cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical connections before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

Grounding Practices

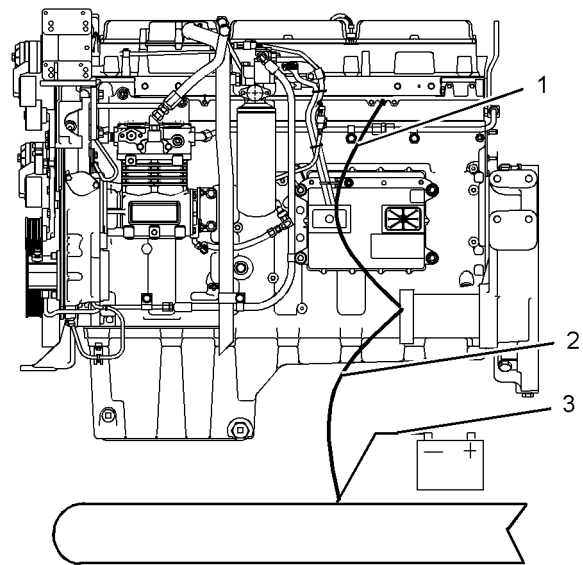


Illustration 37

g01162916

Typical example

- (1) Starting motor to engine block
- (2) Ground to starting motor
- (3) Ground to battery

i01489970

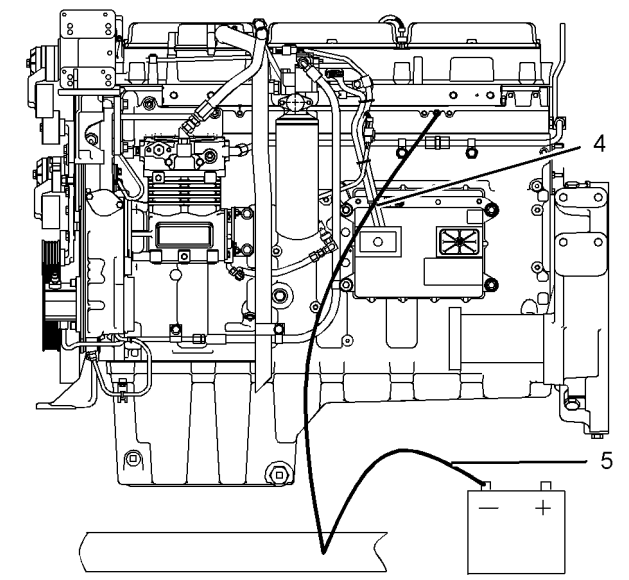


Illustration 38

g01162918

Typical example

- (4) Ground to engine
- (5) Ground to battery

Correct grounding for the engine electrical system is necessary for optimum engine performance and reliability. Incorrect grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to the crankshaft bearing journal surfaces and to aluminum components.

Engines that are installed without engine-to-frame ground straps can be damaged by electrical discharge.

To ensure that the engine and the engine electrical systems function correctly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a direct engine ground to the frame.

The connections for the grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative “-” battery terminal with a wire that is adequate to handle the full charging current of the alternator.

The power supply connections and the ground connections for the engine electronics should always be from the isolator to the battery.

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.

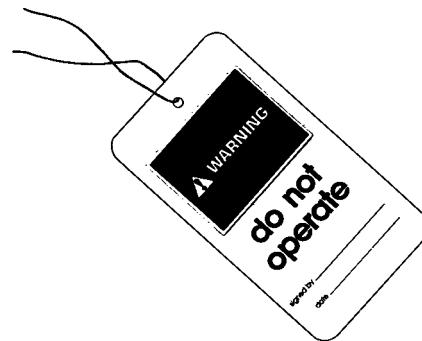


Illustration 39

g00104545

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

9. Determine that the generator is in a de-energized condition. Add ground straps to the conductors or terminals. During the entire work period, these ground straps must remain connected to the conductors and to the terminals.

Product Information Section

General Information

i02450263

Model View Illustrations

SMCS Code: 1000

The following model views display typical features of the generator sets that are described in this manual. The operator should become familiar with the locations of these items. Due to individual applications, your generator set may appear different from the illustrations.

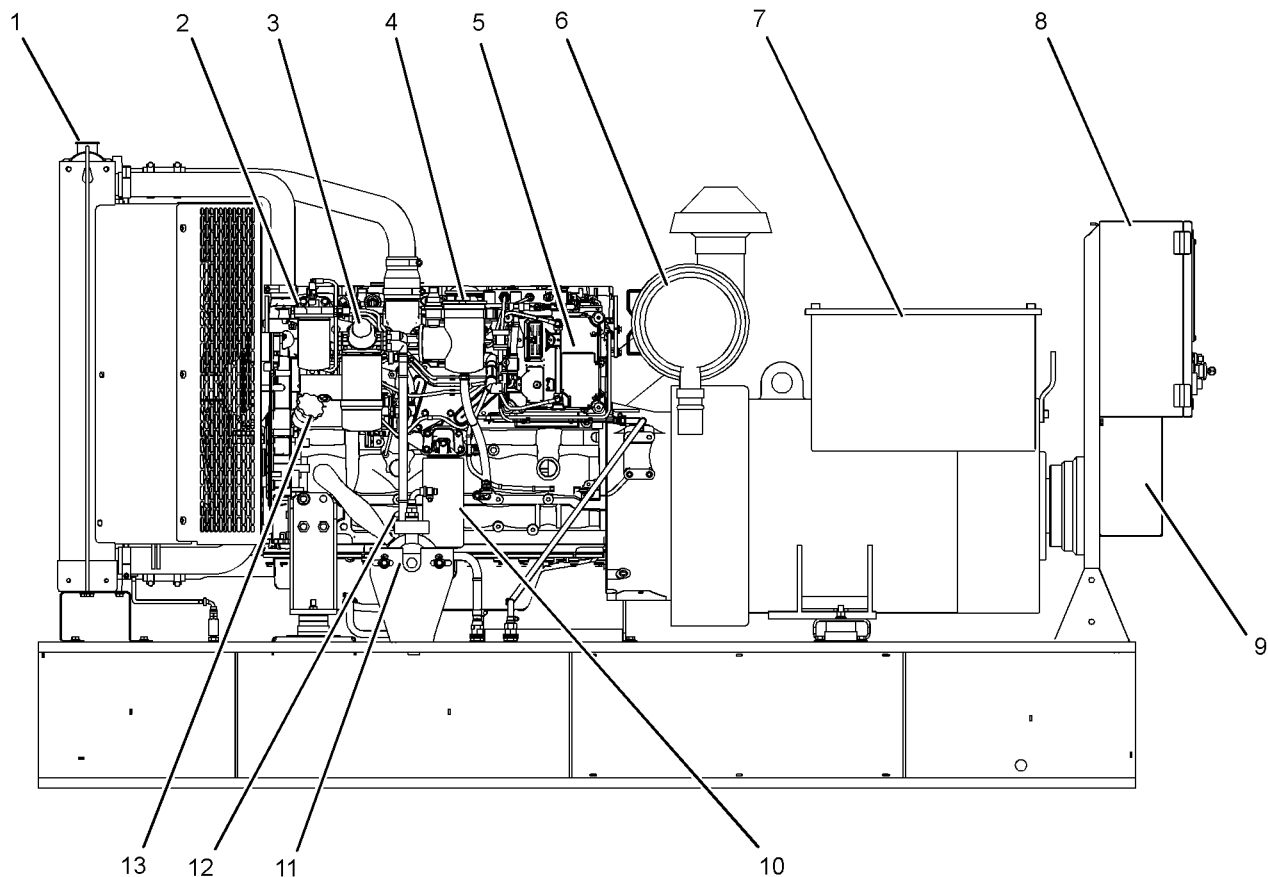


Illustration 40

g01223275

- (1) Radiator filler cap
- (2) Secondary fuel filter
- (3) Primary fuel filter/water separator
- (4) Breather canister
- (5) Engine Control Module (ECM)

- (6) Air Cleaner
- (7) Generator terminal box
- (8) Control panel
- (9) Distribution panel
- (10) Engine oil filter

- (11) Manual sump pump for engine oil drain
- (12) Engine oil level gauge (dipstick)
- (13) Engine oil filler

i04113069

Product Description

SMCS Code: 1000; 4450; 4491

C6.6 Generator Set Engine

The Cat C6.6 Generator Set Engine has the following characteristics.

- In-line six cylinder
- Four stroke cycle
- Turbocharged aftercooled

Engine Specifications

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

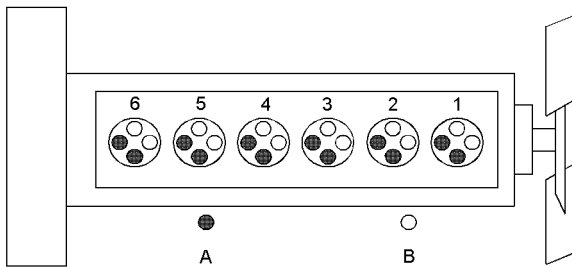


Illustration 41

g01127295

Cylinder and valve location

- (A) Exhaust valves
(B) Inlet valves

Table 1

C6.6 Engine Specifications	
Operating Range (rpm)	900 to 2800 ⁽¹⁾
Number of Cylinders	6 In-Line
Bore	105 mm (4.13 inch)
Stroke	127 mm (5.0 inch)
Aspiration	Turbocharged aftercooled
Compression Ratio	16.2:1
Displacement	6.6 L (403 in ³)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

⁽¹⁾ The operating rpm is dependent on the engine rating, the application, and the configuration of the throttle.

Electronic Engine Features

The engine operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. The electronic engine control system provides the following features:

- Engine monitoring
- Engine speed governing
- Control of the injection pressure
- Cold start strategy
- Automatic air/fuel ratio control
- Torque rise shaping
- Injection timing control
- System diagnostics

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

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be alerted to the condition by a "Stop or Warning" lamp. Under certain conditions, the engine horsepower and the vehicle speed may be limited. The electronic service tool may be used to display the diagnostic codes.

There are three types of diagnostic codes: active, logged, and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Troubleshooting Manual, "Diagnostic Code Cross Reference" topic.

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Engine Cooling and Lubrication

The cooling system consists of the following components:

- Gear-driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature

-
- Gear-driven rotor type oil pump
 - Oil cooler

The engine lubricating oil is supplied by a rotor type oil pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. The bypass valve can provide unrestricted flow of lubrication oil to the engine if the oil filter element should become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

Generator

The Series LC generator has the following characteristics:

- Single phase or three-phase alternating current
- Single bearing
- Brushless type
- Random wound
- Four pole design
- 12 wire generator stator
- Main stator is 2/3 pitch
- Class H insulation
- Interference suppression conforming to standard EN 55011, group 1, class B

Product Identification Information

i02461803

Plate Locations and Film Locations

SMCS Code: 1000; 4450

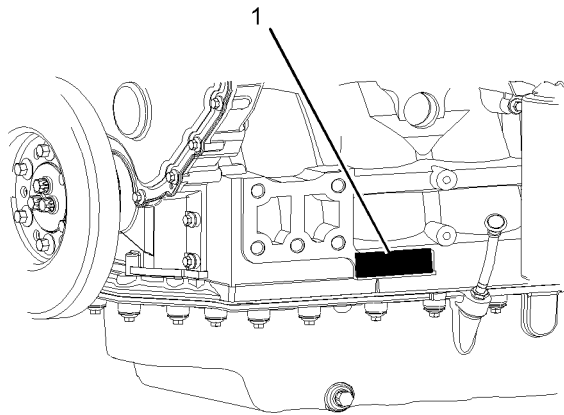


Illustration 42
Location of the serial number plate

g01144128

Serial Number Plate (1)

The engine serial number plate is located on the left side of the cylinder block to the rear of the front engine mounting.

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

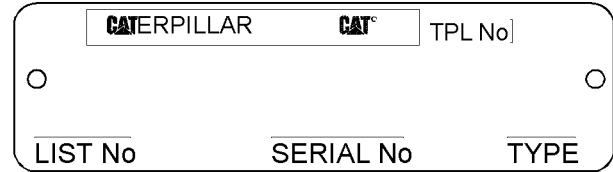


Illustration 43
Serial number plate

g01159926

Emissions Certification Film

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

A typical example is shown.

CATERPILLAR INC.		IMPORTANT ENGINE INFORMATION			2000	JDM00001	
ENGINE MODEL : 3116 - DISPLACEMENT : 6.6L - VALVE LASH : 0.38mm INTAKE 0.64mm EXHAUST							
CAT	ENGINE FAMILY XCPXL06.6MFB	MAXIMUM ADVERTISED kW (HP) 164 (220)	MAXIMUM RATED SPEED (RPM) 2600	MAXIMUM LOW IDLE SPEED (RPM) 875	MAX. FUEL RATE @MAXIMUM (mm³/STROKE) 104	MAXIMUM INITIAL TIMING DEGREES BTDC 11.5	EXHAUST EMISSION CONTROL SYSTEM EM,DI,TC,SPL,CAC
THIS 3116 ENGINE CONFORMS TO DIRECTIVE 97/68/EC FOR NON-ROAD ENGINES.				EC TYPE APPROVAL NO. eURL*97/68AA*0001*00			
THIS 3116 ENGINE CONFORMS TO 2000 U.S. EPA AND CALIFORNIA REGULATIONS LARGE NON-ROAD COMPRESSION-IGNITION ENGINES.							
THIS ENGINE IS CERTIFIED TO OPERATE ON COMMERCIALY AVAILABLE DIESEL FUEL.							
DATE OF MANUFACTURE MONTH : 08						7E-8050 01	

FMT:3500

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

CATERPILLAR INC.		INFORMATION IMPORTANTE SUR LE MOTEUR					
MODÈLE MOTEUR : 3116 - DÉBIT : 6,6 l - JEU SOUPAPES : 0,38 mm ADMISSION : 0,64 mm ÉCHAPPEMENT							
CAT	FAMILLE DE MOTEURS : XCPXL06.6MFB	Kw (HP) MAXI PUBLIES : 164 (220)	MAXI RÉGIME NOMINAL (tr/mn) : 2600	MAXI RÉGIME RALENTI (tr/mn) : 875	MAXI DÉBIT D'INJ. À PUIS. MAXI (mm³/STROKE) (PISTON) : 104	MAXI CALAGE INITIAL D'INJ. (DEGRÉS) (AVANT PMH) : 11.5	DISPOSITIF ANTI-POLLUANT : EM,DI,TC,SPL,CAC
CE MOTEUR 3116 EST CONFORME AUX DIRECTIVES 97/68/EC POUR LES MOTEURS NON ROUTIERS.				NO APPROBATION TYPE EC eURL*97/68AA*0001*00			
CE MOTEUR 3116 EST CONFORME AUX RÉGLEMENTATIONS 2000 DE L'AGENCE AMÉRICAINE DE PROTECTION DE L'ENVIRONNEMENT (EPA) ET DE LA CALIFORNIE POUR LES GROS MOTEURS NON ROUTIERS À COMPRESSION-CONTACT.							
CE MOTEUR EST HOMOLOGUÉ POUR FONCTIONNER AVEC LE CARBURANT DIESEL DU COMMERCE.							
DATE DE FABRICATION (MOIS) 08							

Étiquette d'homologation anti-pollution

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

This information is pertinent in the United States and in Canada.



IMPORTANT ENGINE INFORMATION  Manufacturer Perkins Engines Co. LTD			Engine Type	
Engine Family: 5PKXL04.4RH2 List: Displacement: 4.4 List: RH37881		 Refer to Manufacturer e11*97/68FA* 2001/63*0247*00	Factory setting	Reset if Applicable
EPA Family Max Values	Advertised kw:86. Fuel Rate: 85.0 mm3/stk Init. Timing:0 DEG ATDC idle RPM: ****		<input type="checkbox"/> 2372/2500	<input type="checkbox"/>
Settings are to be made with engine at normal operating temperature with transmission in neutral. This engine conforms to 2004 U.S. EPA non - road and California off - road Regulations for large C.I. engines and is certified to operate on commercially available diesel fuel.			<input checked="" type="checkbox"/> 2372/2500	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>
Emission Control System: **** ** ECM	Valve Lash Cold (inch): Exhaust 0.*** Inlet 0.***	Engine Label	Use Service Tool to verify current engine settings	
Hanger No. _____ position (**)		Label No. 3181A081		

Illustration 45
 Typical example

g01159950

Operation Section

Lifting and Storage

i02472970

Product Lifting

SMCS Code: 7000; 7002

Lifting of Generator Sets

NOTICE

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

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

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

Some removals require lifting the fixtures in order to obtain proper balance and safety. Consult your Caterpillar dealer for information regarding fixtures for proper lifting of your complete package.

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.

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

The lifting labels are located on the lifting eyes. These labels designate the proper lifting locations for the generator set. Some generator sets may be lifted at the base of the generator set and other generator sets may have a single lifting point on top of the generator set.

Engine Lifting with a Fuel Tank

Do not lift the unit with fuel in the fuel tank.



i02283885

Product Storage

SMCS Code: 7002

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

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

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

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

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

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

Generator Storage

Store the generator set in a dry area in order to minimize condensation on the windings. Use space heaters to keep the windings dry, when possible. Wrap the genset in plastic with bags of desiccant for extended storage. Test the insulation of the generator when the generator is removed from storage. Refer to this Operation and Maintenance Manual, "Insulation - Test". Dry the generator if the insulation is not acceptable. refer to this Operation and Maintenance Manual, "Generator - Dry".

Features and Controls

i03646563

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.

i04732919

Control Panel

SMCS Code: 7451

Electronic Control Module (Generator Set)

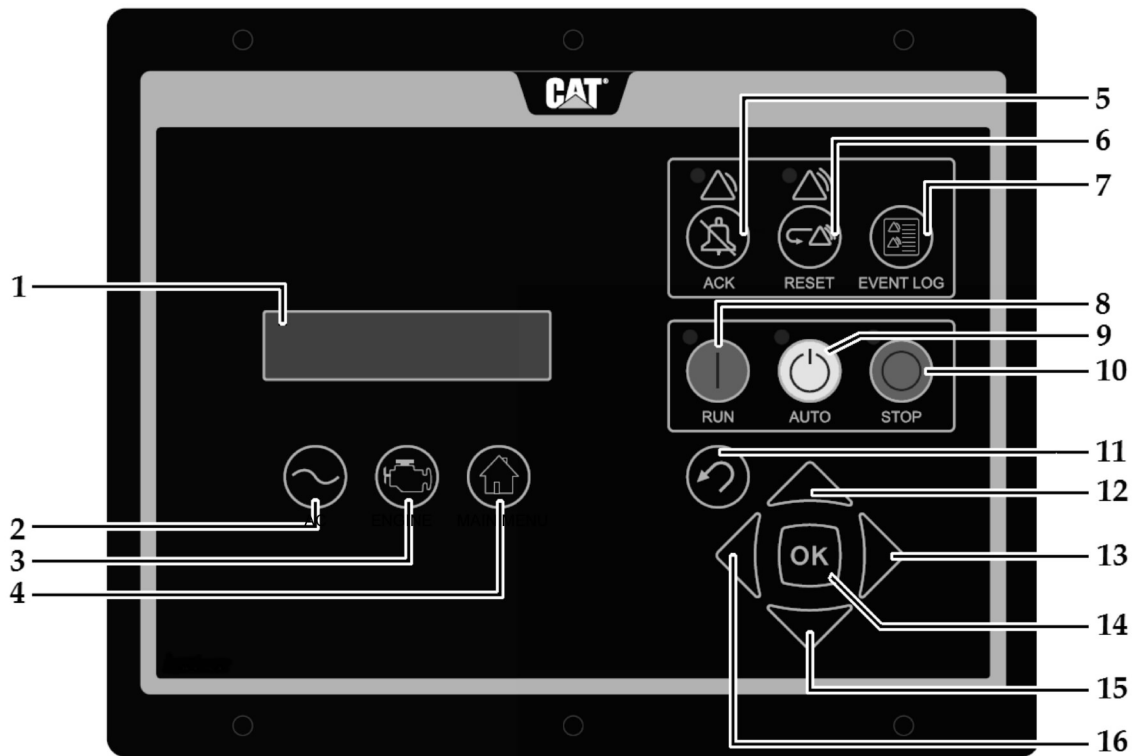


Illustration 47

g02082653

EMCP 4 Control System Panel

- | | |
|----------------------------|-----------------|
| (1) Display screen | (7) Event log |
| (2) AC overview key | (8) Run key |
| (3) Engine overview key | (9) Auto key |
| (4) Main menu key | (10) Stop key |
| (5) Alarms acknowledge key | (11) Escape key |
| (6) Reset shut down 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

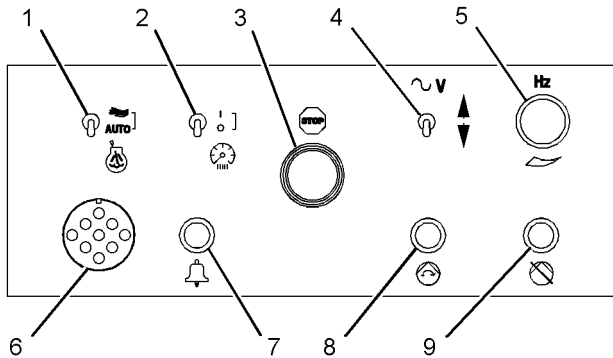


Illustration 48

g01185966

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

Starting Aid Auto/Manual Switch (1) – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold-weather conditions. When the starting aid switch is in the ON position, the solenoid valve is energized. The switch then meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

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

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

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

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

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

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

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

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

Annunciator Module



Illustration 49

g02111119

- (20) Alarm acknowledge button

General Information

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

There are 17 pairs of LED indicators on the front panel of the annunciator. The 16 pairs of LED indicators are used to announce events, diagnostics, and ready signals. The 17th pair of LED indicators is used as a combined network/module status LED. The 17th pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

Basic Operation

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

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button (20).

To test the LED indicators or the horn when the data link is either connected or disconnected, hold the “Lamp Test” button in.

Configuration

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

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, “EMCP4.1/4.2”.

Engine Starting

i03907410

Starting the Engine

SMCS Code: 1000; 1450

WARNING

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

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 checks the system prior to start of the crank cycle. The EMCP checks that no system faults are present. The EMCP checks that all previous shutdown faults have been reset. The EMCP also checks that the engine is not already running. If the engine is equipped with prelube, the EMCP checks the status of the prelube. If the prelube is not complete, the EMCP will not crank the engine.
3. The EMCP begins the crank cycle.
4. The EMCP cranks the engine until the crank cycle time reaches the setpoint for total crank time or until the engine starts.
5. The EMCP deactivates the starting motor relay (SMR) when the engine speed reaches the setpoint for crank terminate speed.

i02344933

Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

WARNING

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

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

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

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

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

NOTICE

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

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

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

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

1. Turn the start switch on the stalled engine to the OFF position. Turn off all the engine's accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.
4. Start the engine.
5. Immediately after the engine is started, disconnect the jump start cables in reverse order.

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the proper voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, "Battery - Replace" and Testing and Adjusting Manual, "Battery - Test".

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

Engine Operation

i01457002

Engine Operation

i01646252

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.

Fuel Conservation Practices

SMCS Code: 1000; 1250

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

- Avoid spilling fuel.

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

- Be aware of the properties of the different fuels. Use only the recommended fuels. Refer to the Operations and Maintenance Manual, "Fuel Recommendations" for further information.
- Avoid unnecessary idling.

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

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbocharger is operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system.

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

- Ensure that the belts are properly adjusted. The belts should be in good condition. Refer to the Specifications manual for further information.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

Generator Operation

i03502801

Generator Operation

SMCS Code: 4450

S/N: N6D1-Up

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 50. 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.

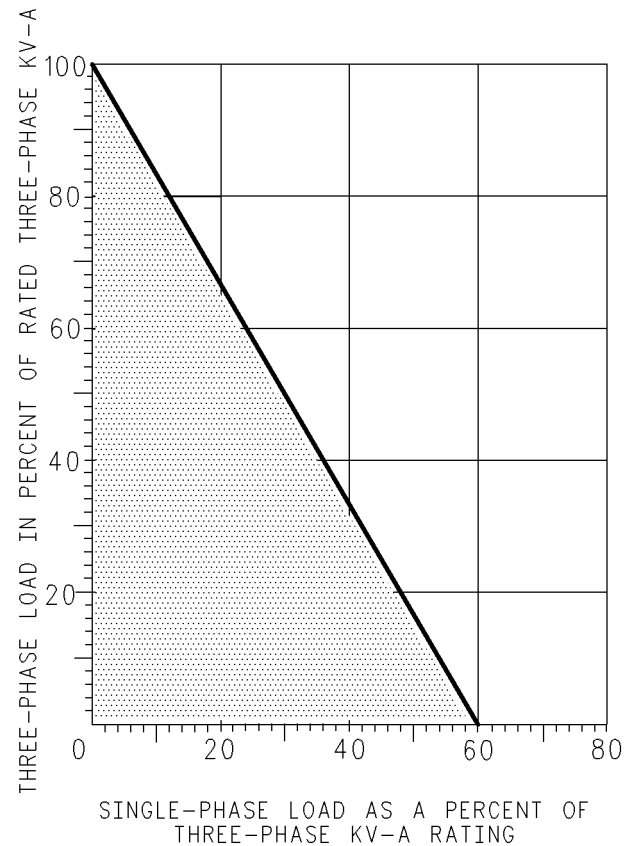


Illustration 50

g00627416

Allowable Combinations of Unbalanced Loads

Block Loading

The block loading is the instantaneous application of an electrical load to a generator set. This load may be anywhere from a moderate percentage of the rated load up to the rated load.

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

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

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

Note: ISO stands for International Standards Organization.

Power Factor

The power factor is the ratio of apparent power to total power. The power factor is expressed as a decimal. The power factor represents that portion of the current which is doing useful work. The portion of current which is not doing useful work is absorbed in maintaining the magnetic field in motors or other devices. This current is called the reactive load. This current does not require engine power to be maintained.

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

The power factor of a system may be determined by a power factor meter or by calculations. Determine the power requirement in kW by multiplying the power factor by the kVA that is supplied to the system. As the power factor goes up, the total current that is supplied to a constant power demand will go down. A 100 kW load that is at 0.8 power factor will draw more current than a 100 kW load that is at 0.9 power factor. A high power factor will result in a full engine load at less than the generator rated amperage. A lower power factor increases the possibility of overloading the generator.

Note: The Caterpillar generators are rated at a power factor of 0.8 unless the generator is specified otherwise.

Excitation System

The generator uses the PMG excitation system. This system does not use a permanent magnet. The voltage regulator is powered by two auxiliary windings. These windings are independent of the circuit for detecting voltage. The first winding is labelled as "X1" and "X2". This winding has a voltage that is proportional to the output voltage of the generator. The second winding is labelled as "Z1" and "Z2". This winding has a voltage that is proportional to the current of the stator. The voltage from the power supply is rectified and filtered before being used by the regulator monitoring transistor. This principle ensures that regulation is not affected by interference that is generated by the load.

Standby Electric Sets

Most standby units are installed with controls for automatic starting. Standby units start without an operator in attendance.

Standby units can not automatically change the governor speed. Standby units can not automatically change the setting of the voltage level. The governor speed and voltage level must be preset for the proper operation of that unit. Whenever the generator is operated manually, ensure that the settings for governor speed and voltage level are correct for automatic operation. Check all switches on the Standard Control Panel for the proper setting. Check all push buttons on the Premium Control Panel for the proper setting. On the Standard Control Panel, the Start Select Switch should be in the AUTOMATIC position. On the Premium Control Panel, the "AUTO" push button is pressed.

Generator Options

Battery Disconnect Switch

This switch is a single-pole switch. This switch cannot be used with dual electric starters.

Instrumentation

Three different remote start/stop panels are available. Extensions for the wiring harness are available in order to mount the panels. Contact your Caterpillar dealer for more information.

i04121652

Voltage Regulators (R450 Automatic Voltage Regulator (AVR) (If Equipped))

SMCS Code: 4467

S/N: N6D1-Up

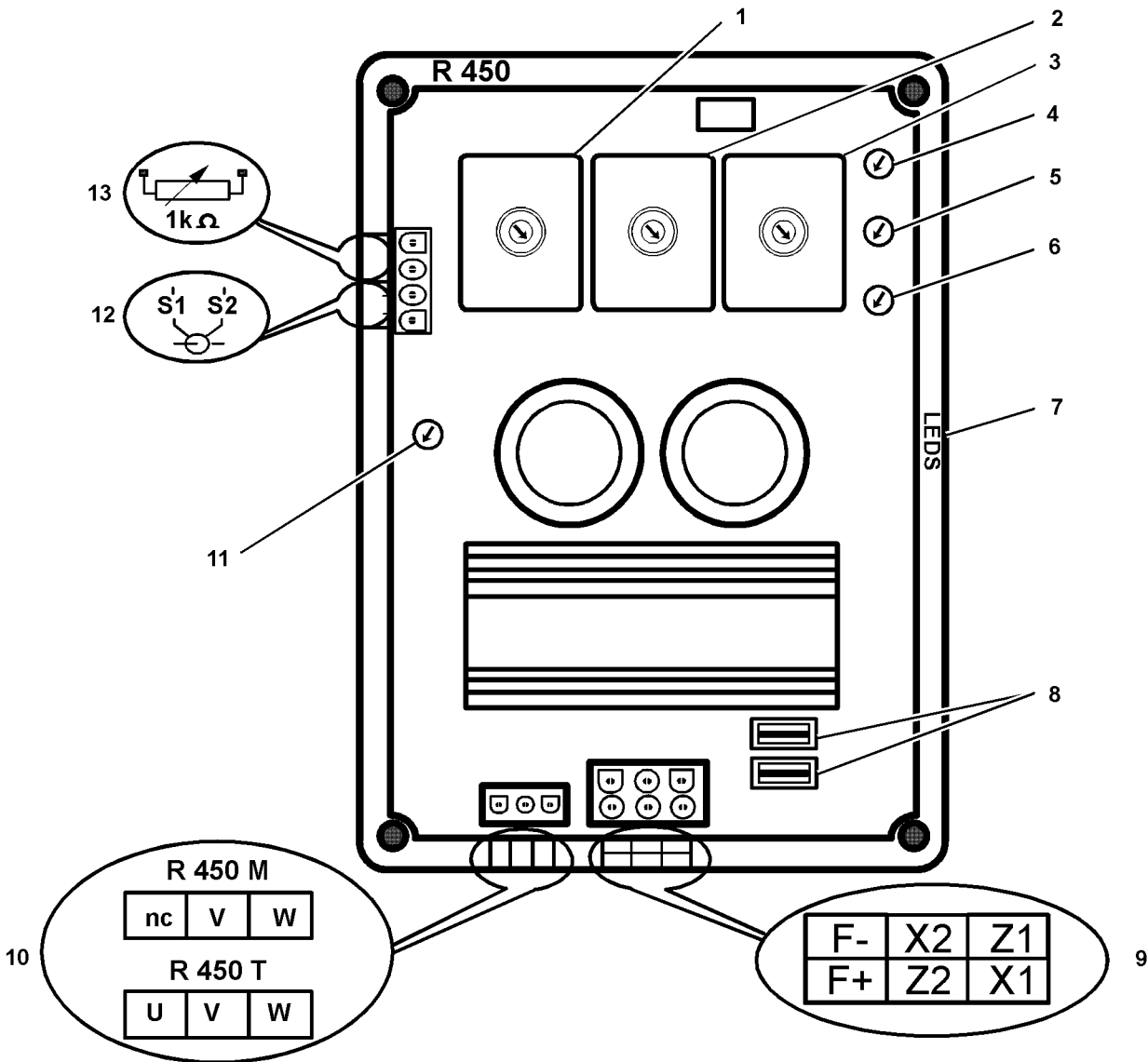


Illustration 51

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

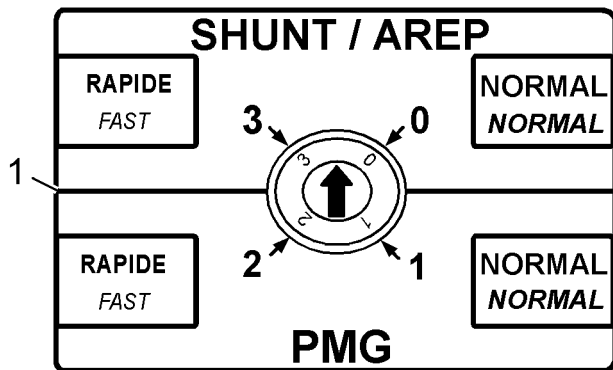


Illustration 52

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

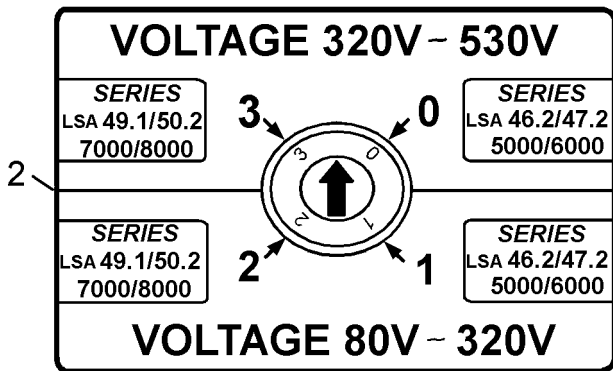


Illustration 53

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

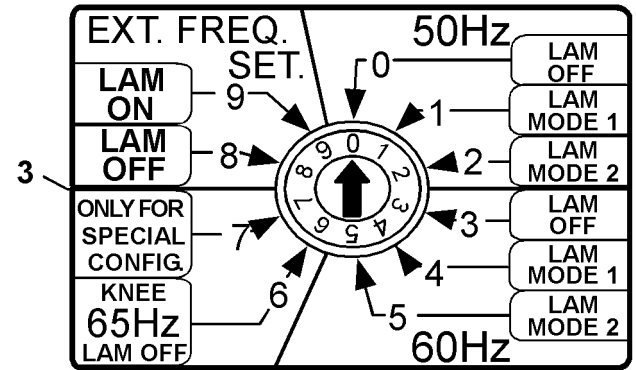


Illustration 54

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

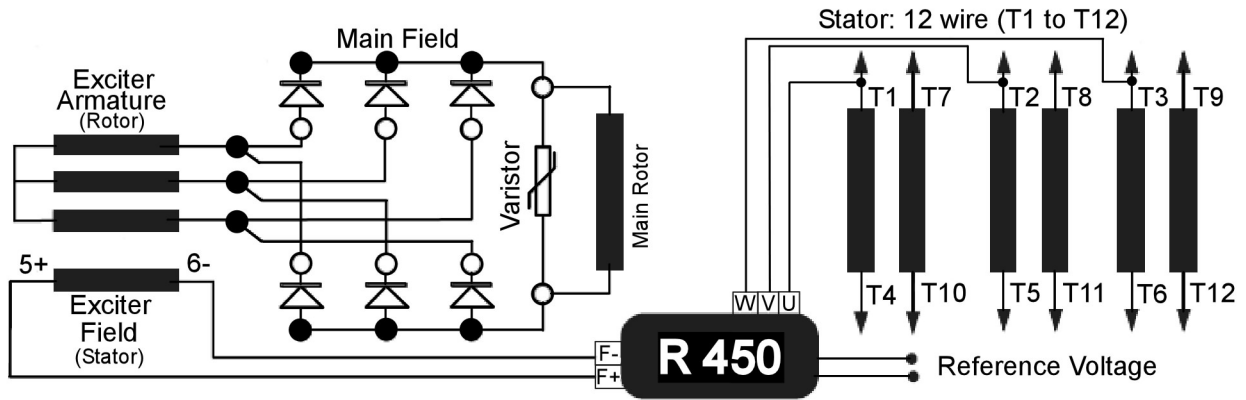


Illustration 55

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

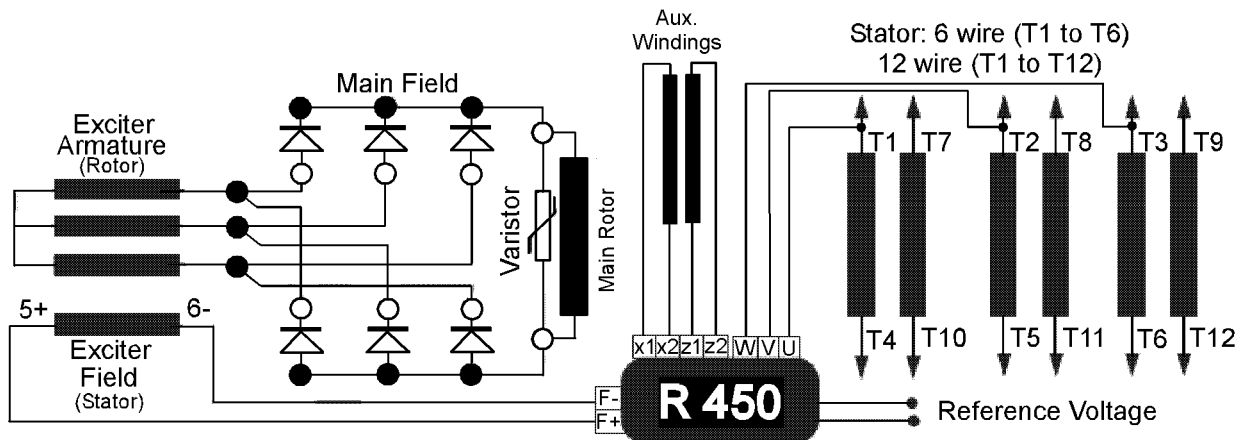


Illustration 56

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

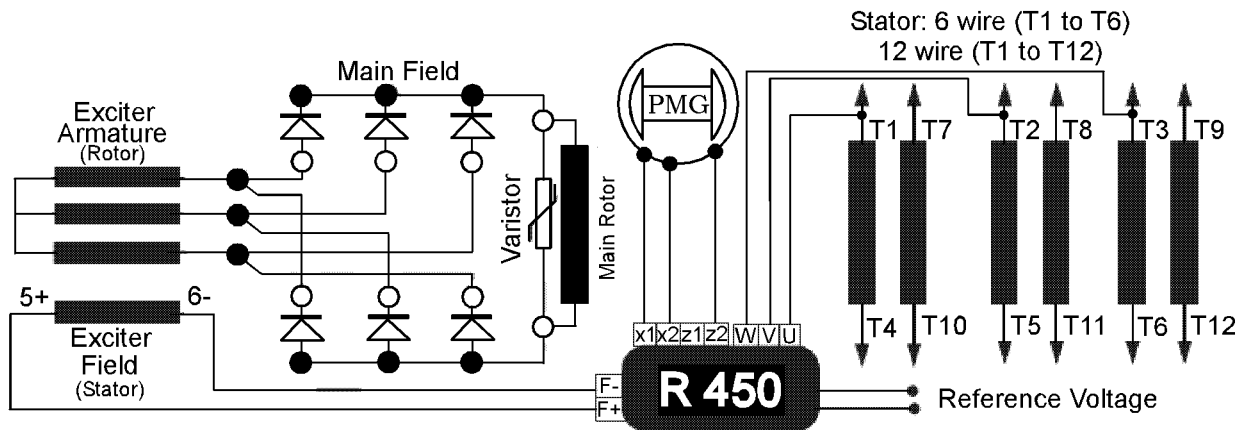


Illustration 57

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 green 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

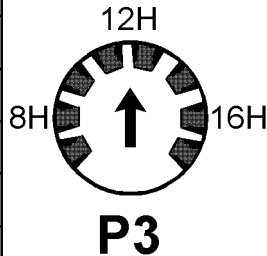


Illustration 58

g02355098

In the case of a permanent short-circuit, the excitation current must reach $2.9 \times$ 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.

i04112656

Voltage Regulators

SMCS Code: 4467

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

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

WARNING

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

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

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

The voltage regulator is located in the enclosure for the control panel or in the terminal box on the generator.

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

These voltage regulators may have an optional remote potentiometer for voltage adjustment. This potentiometer is 450 ohms 0.5 W minimum. The adjustment range is 5%. The voltage range is limited by the internal potentiometer "P2". Remove "ST4" in order to connect the potentiometer. A 1000 ohm potentiometer can also be used to extend the adjustment range.

R230 Adjustments

Table 2

R230 Regulator	
Voltage regulation	±0.5%
Voltage detection range	85 to 139 V (50/60 Hz)
Rapid response time for a transient voltage variation amplitude of ±20%	500 ms
Voltage setting	"P1"
Stability setting	"P2"
8 Amp Fuse for protection of the power supply	10 amperes for 10 seconds
50 or 60 Hz selection with jumper "ST3" ⁽¹⁾ .	
Underspeed protection and adjustment of frequency threshold via potentiometer "P3"	

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

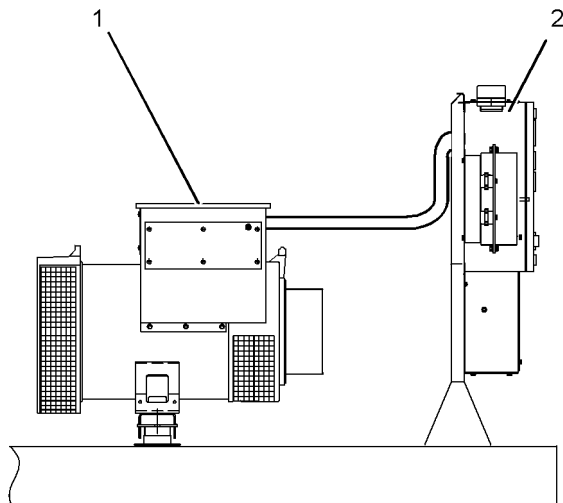


Illustration 59

g01148000

The voltage regulator is located in the terminal box on the generator or in the enclosure for the control panel.

- (1) Terminal Box on the Generator
- (2) Enclosure for the Control Panel

The generator set may include one of the following voltage regulators.

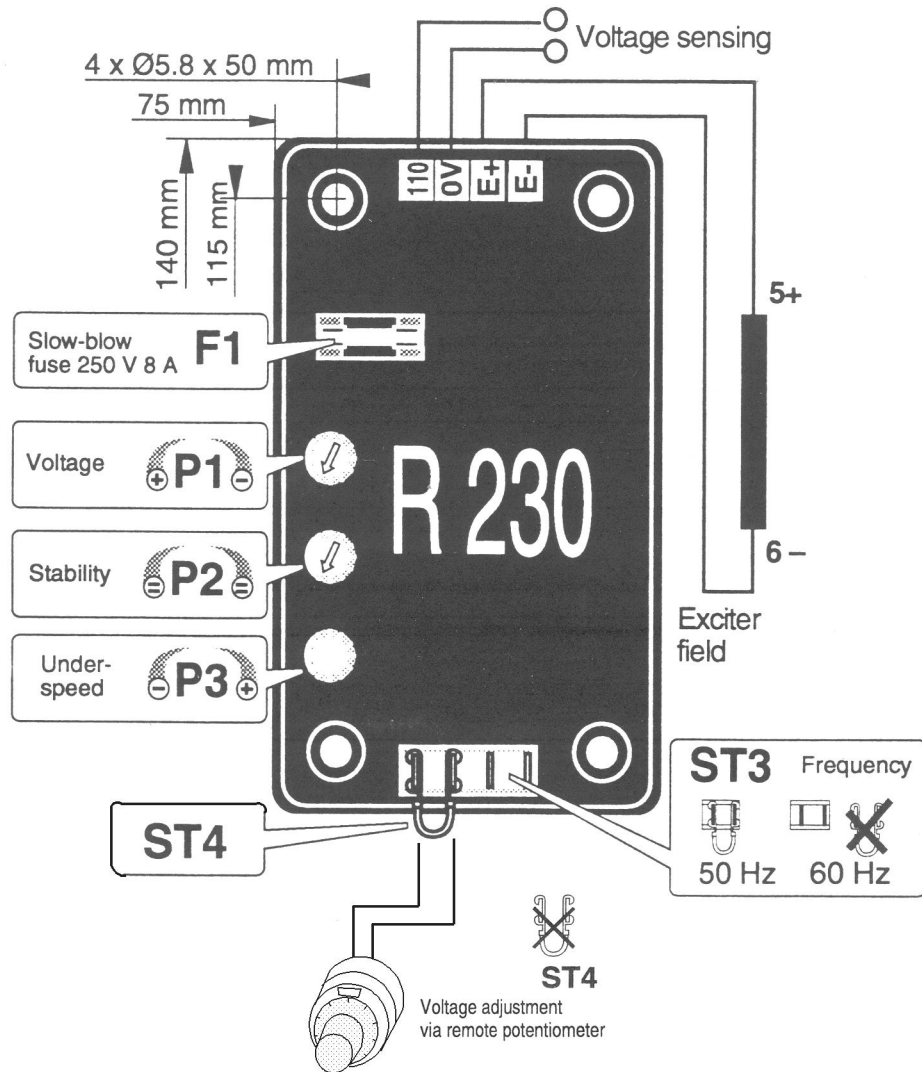


Illustration 60
 R230 Voltage Regulator with components

g00952495

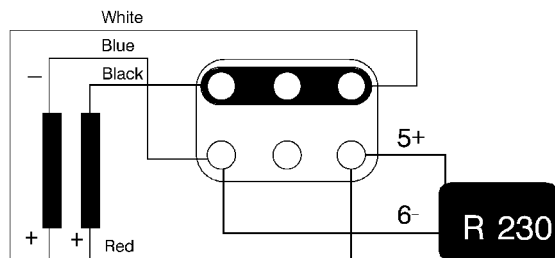


Illustration 61
 R230 connections

g00952510

Use the following procedure to adjust the R230 voltage regulator.

1. Make sure that the ST3 wire is connected for 50 Hz applications. Remove the ST3 wire for 60 Hz applications. Also, the engine speed must be changed from the factory setting in order to change the frequency of the generator.
2. Turn potentiometer P1 to the full counterclockwise position.
3. Turn the potentiometer ST4 to the middle of the total rotation for the potentiometer, if equipped. Run the generator at the rated speed. If the voltage does not increase, the field may need to be energized. Refer to the "Special Use" section.

4. Turn potentiometer P1 until the rated output voltage is obtained.
5. Adjust the stability with potentiometer P2.
6. The sealed potentiometer P3 is set at the factory for 50 Hz or 60 Hz.

R438 and R448 Adjustments

NOTICE

ST9 must be closed for AREP excitation.

Table 3

R438 and R448 Automatic Voltage Regulators	
Maximum current for short circuit	3 x I _n for 10 seconds
Standard power supply	Two auxiliary windings
Supply for shunt	max 48 VAC at 50/60 Hz
Rated overload current	8 amperes for 10 seconds
Electronic protection for overload and short circuit opening on voltage sensing	Excitation ceiling current for 10 seconds and return to approximately 1 ampere THE GENERATOR MUST BE STOPPED IN ORDER TO RESET THE PROTECTION.
Fuse "F1" on input side	"X1" and "X2"
Fuse "F2" on output side	"E+" and "E-"
Voltage sensing	5 VAC that is isolated by the transformer
Terminals for 0 to 110 VAC	95 to 140 ACV
Terminals for 0 to 220 VAC	170 to 260 ACV
Terminals for 0 to 380 VAC	340 to 520 VAC
Voltage regulation	±1%
Rapid response time or normal response time from the location of jumper "ST2"	
Voltage adjustment via potentiometer "P2" (other voltages via the step down transformer)	
Underspeed protection and adjustment of frequency threshold via potentiometer "P4"	
Maximum adjustment for excitation via potentiometer "P5" (4.5 to 10 amperes)	
50 or 60 Hz selection with jumper "ST3" ⁽¹⁾ .	

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

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

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

1. Disconnect the power supply wires X1, X2, Z1 and Z2.
2. Disconnect sensing leads 0V, 110V, 220V and 380V on the generator.
3. Connect the main power supply 200V-240V, as shown. X1,X2:120V
4. Install a 10 Amp DC ammeter in series with the exciter field.
5. Turn potentiometer P5 to a full counterclockwise position and activate the power supply. If there is no output current from the voltage regulator, turn potentiometer P2 clockwise until the ammeter indicates a stable current.
6. Switch off the power supply. Switch on the power supply. Turn potentiometer P5 until the required maximum current is obtained. The maximum current must not be greater than 10 Amperes.

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

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

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

Special Use

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

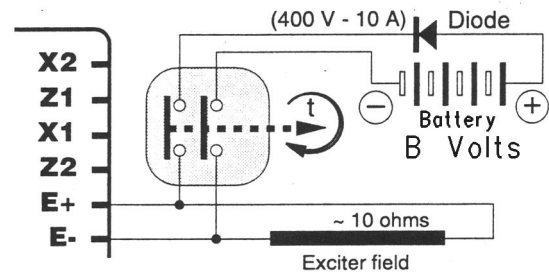


Illustration 66

g00952830

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

Table 4

Applications	B Volts	Time
Voltage build-up	12 (1A)	1 - 2 seconds
De-energized parallel operation	12 (1A)	1 - 2 seconds
Standby parallel operation	24 (2A)	5 - 10 seconds
Battery starting	48 (4A)	5 - 10 seconds
Voltage that is sustained at overload	48 (4A)	5 - 10 seconds

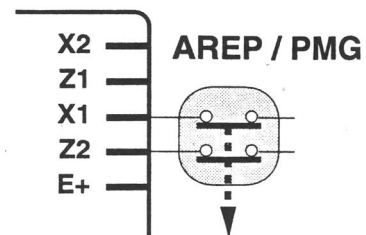


Illustration 67

g00952821

R450 Automatic Voltage Regulator (AVR) (If Equipped)

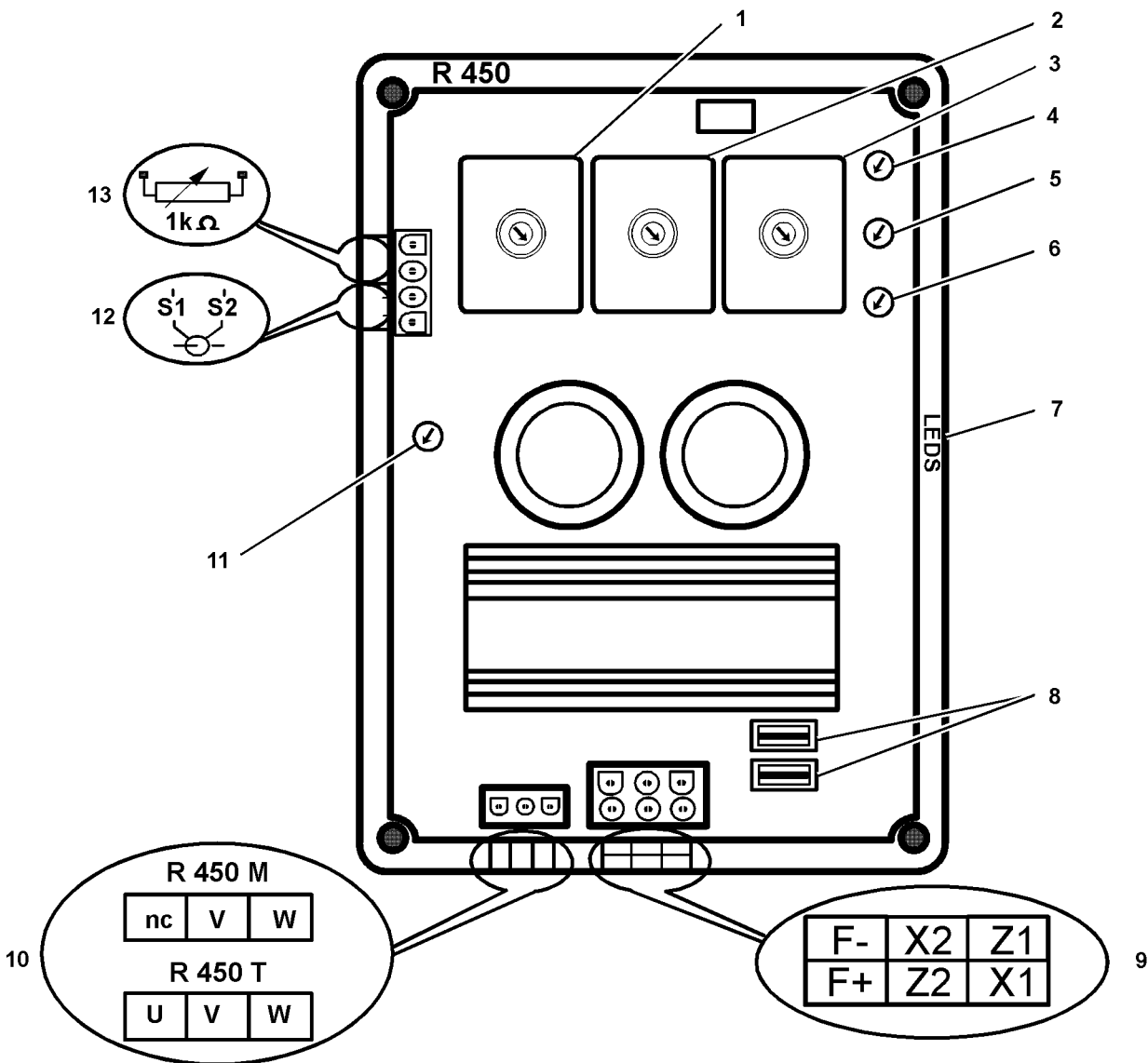


Illustration 68

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

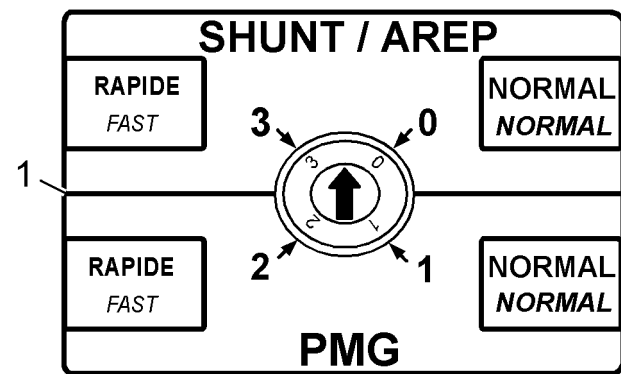


Illustration 69

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

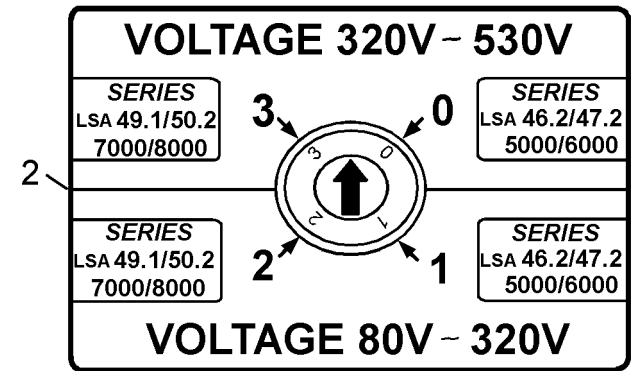


Illustration 70

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

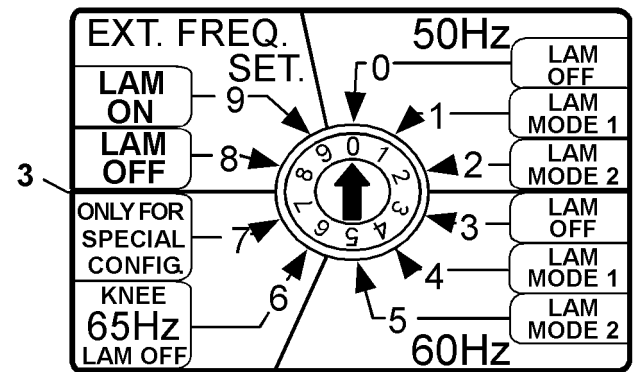


Illustration 71

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

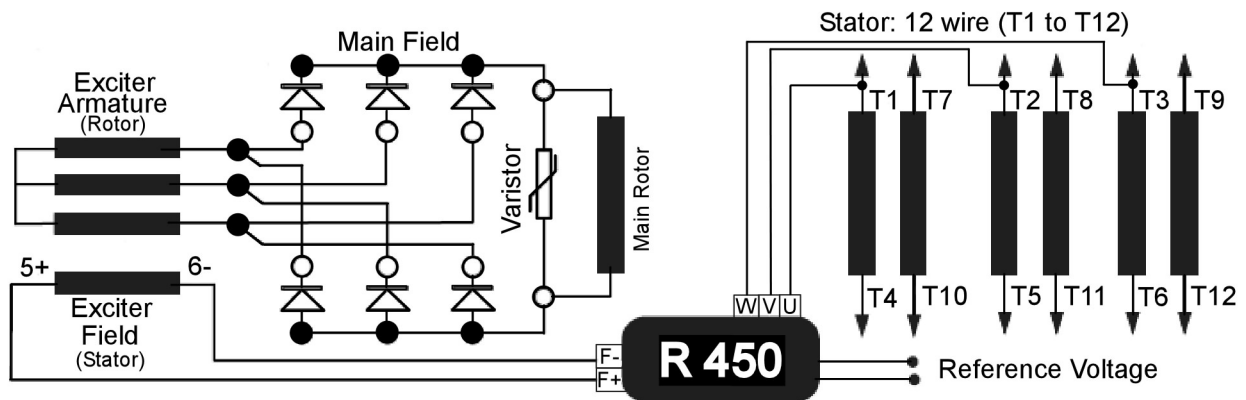


Illustration 72

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

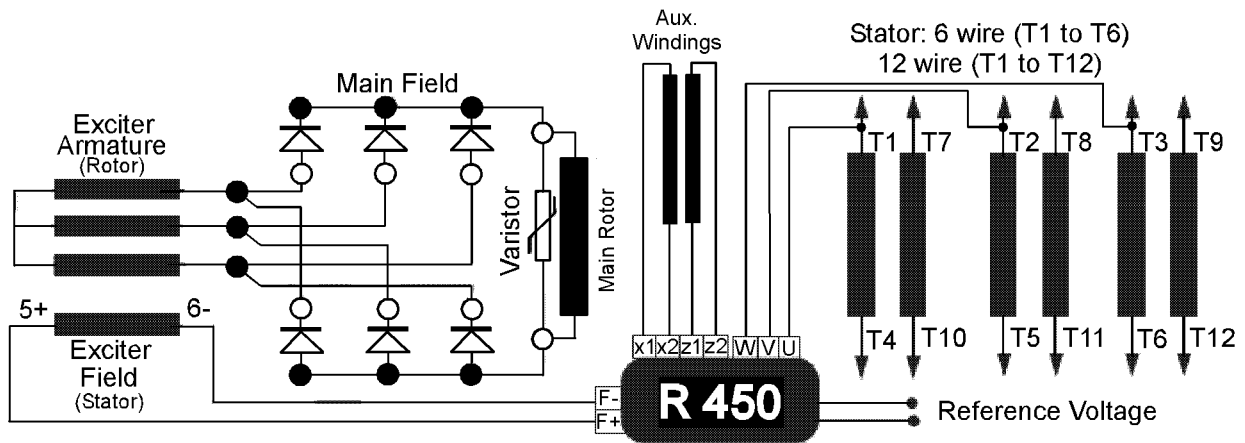


Illustration 73

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

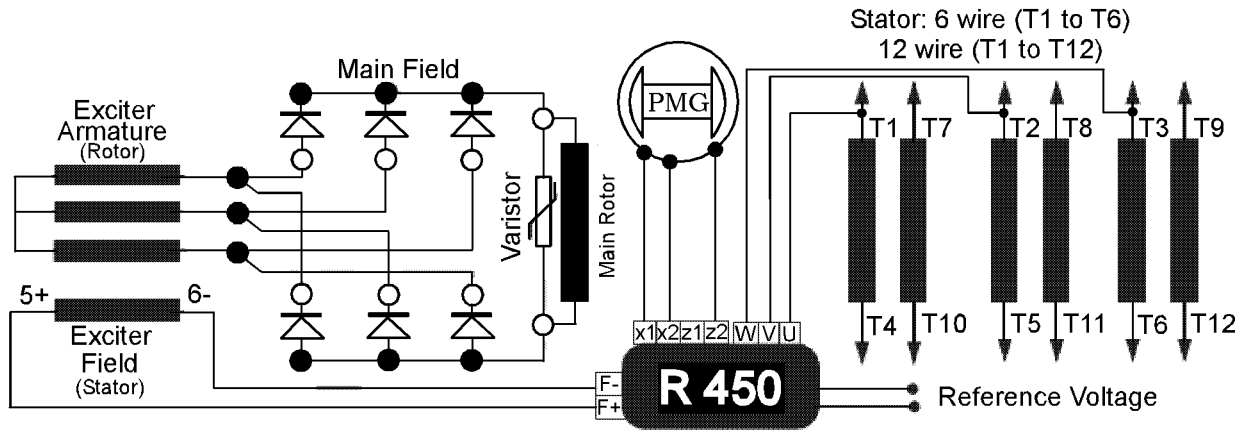


Illustration 74

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 green 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

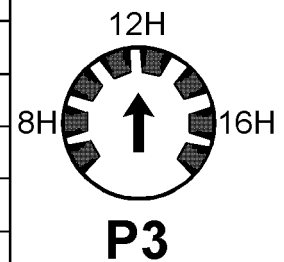


Illustration 75

g02355098

In the case of a permanent short-circuit, the excitation current must reach $2.9 \times$ 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.

i04745135

Generator Lead Connections

SMCS Code: 4450

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

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

WARNING

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

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

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

Grounding the Frame

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

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

Neutral Connections

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

If the neutral wire is grounded and one of the phase leads becomes grounded, the excessive current will open a load circuit breaker. Also, the excessive current will cause the generator voltage to collapse. The result depends on the following items: electrical characteristics of the generator, type of fault, and trip rating of the circuit breaker. An undervoltage device may be required in order to provide an adequate short circuit protection.

There are some cases when the neutral wire is not grounded. An ungrounded generator neutral lead is acceptable when the possibility of grounds to the phase leads has been eliminated. An example of such measures 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

Each unit should be connected to a common ground.

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.

Connection Diagrams

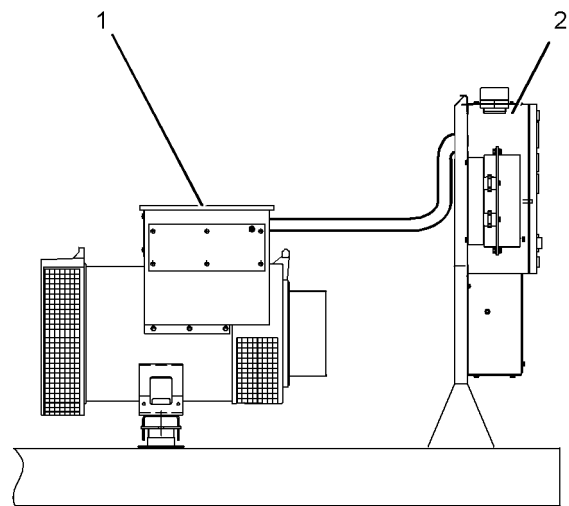


Illustration 76

g01148000

The generator lead connections are located in the terminal box on the generator or in the enclosure for the control panel.

- (1) Terminal Box on the Generator
- (2) Enclosure for the Control Panel

The generator lead connections are located in the terminal box on the generator or in the enclosure for the control panel.

Change the position of the wire terminals in order to modify the connection. The code for the winding is specified on the nameplate.

Wiring Code A for Three-Phase Configuration

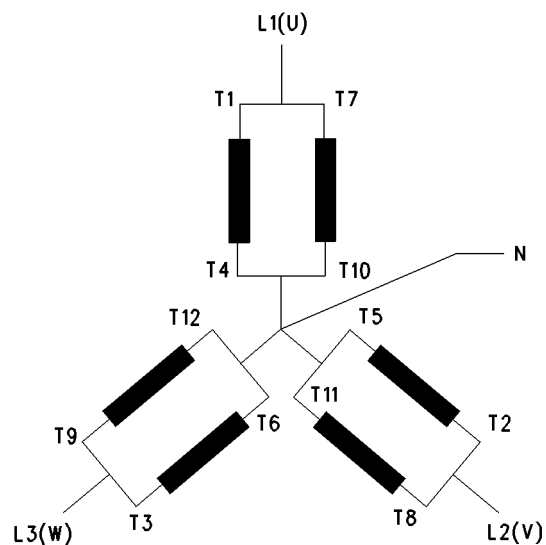


Illustration 77

g00952030

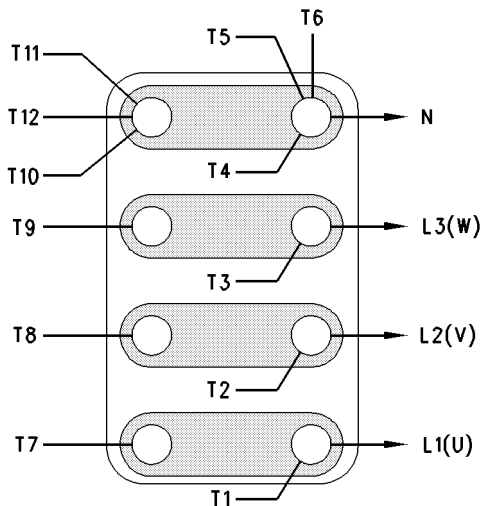


Illustration 78 g00952058
Factory connection for "A" wiring code

Table 5

L-L Voltage for Wiring Code A		
Winding	50 Hz	60 Hz
6	190-208	190-240
7	220-230	-
8	-	190-208

R 230 voltage sensing – 0 => (T8) / 110 V => (T11)

R 438 LS voltage sensing – 0 => (T3) / 220 V => (T2)

Wiring Code B for Single-Phase Configuration or Three-Phase Configuration

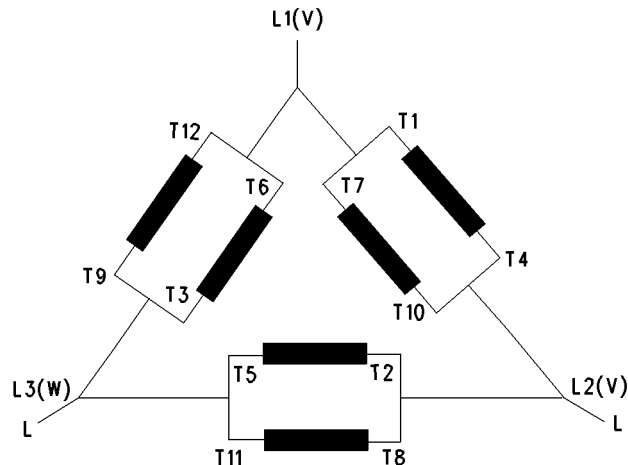


Illustration 79 g00952097

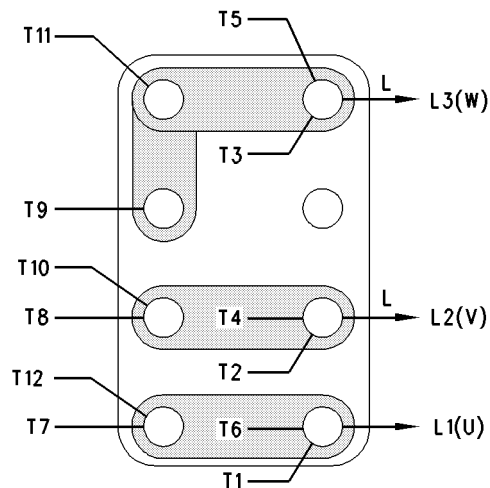


Illustration 80 g00952196
Factory connection for "B" wiring code

Table 6

L-L Voltage for Wiring Code B		
Winding	50 Hz	60 Hz
6	110-120	120
7	120-130	-
8	-	110-120

R 230 voltage sensing – 0 => (T8) / 110 V => (T11)

R 438 LS voltage sensing – 0 => (T3) / 110 V => (T2)

Wiring Code D for Three-Phase Configuration

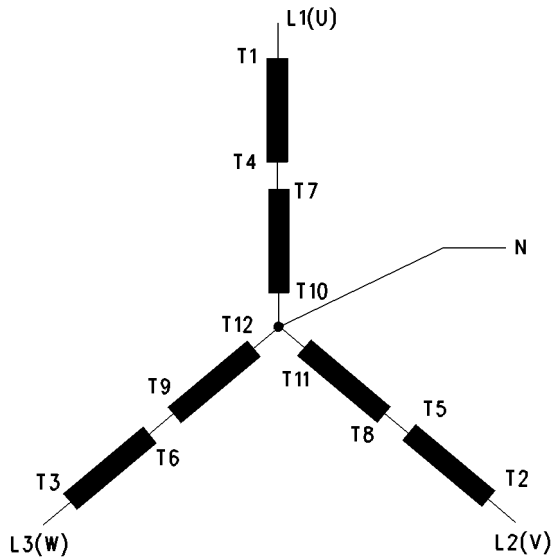


Illustration 81 g00952201

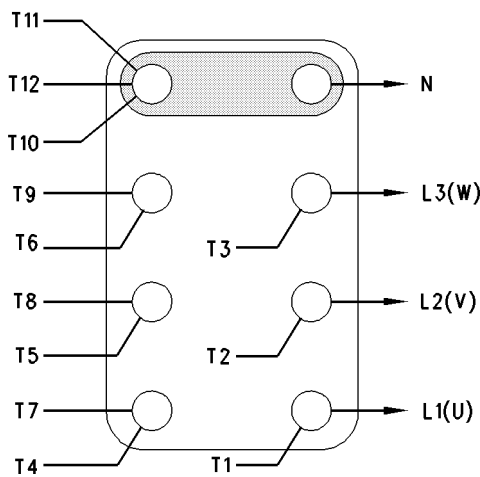


Illustration 82 g00952365
 Factory connection for "D" wiring code

Table 7

L-L Voltage for Wiring Code D		
Winding	50 Hz	60 Hz
6	380-415	380-480
7	440-460	-
8	-	380-416

R 230 voltage sensing – 0 => (T8) / 110 V => (T11)

R 438 LS voltage sensing – 0 => (T3) / 380 V => (T2)

Wiring Code F for Single-Phase Configuration or Three-Phase Configuration

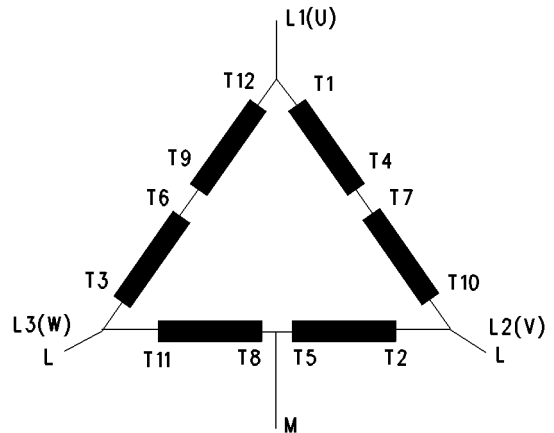


Illustration 83 g00952381
 Voltage LM equals one half of voltage LL.

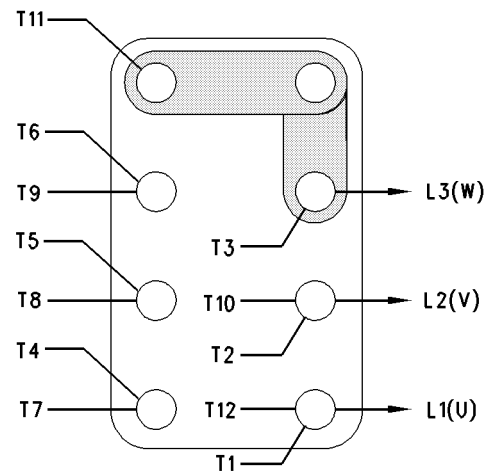


Illustration 84 g00952390
 Factory connection for "F" wiring code

Table 8

L-L Voltage for Wiring Code F		
Winding	50 Hz	60 Hz
6	220-240	220-240
7	250-260	-
8	200	220-240

R 230 voltage sensing – 0 => (T8) / 110 V => (T11)

R 438 LS voltage sensing – 0 => (T3) / 220 V => (T2)

Wiring Code FF for Single-Phase Configuration

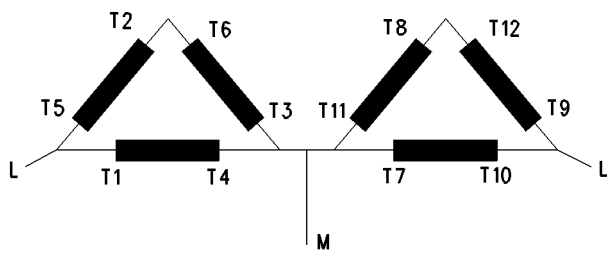


Illustration 85 g00952416
Voltage LM equals one half of voltage LL.

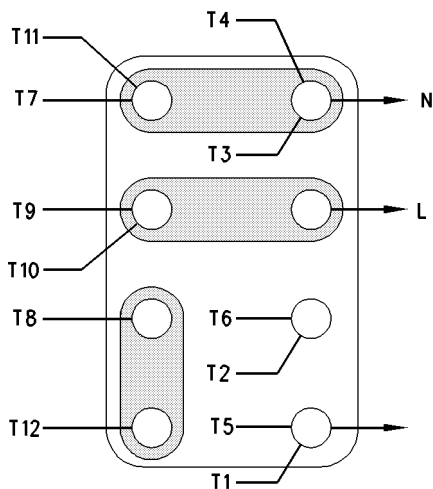


Illustration 86 g00952430
Factory connection for "FF" wiring code

Table 9

L-L Voltage for Wiring Code FF		
Winding	50 Hz	60 Hz
6	220-240	220-240
7	250-260	-
8	200	220-240

R 230 voltage sensing – 0 => (T1) / 110 V => (T4)

R 438 LS voltage sensing – 0 => (T10) / 220 V => (T1)

1000 Series Generators, Single Phase with 4 Leads, Winding Dedicated Type M or Type M1

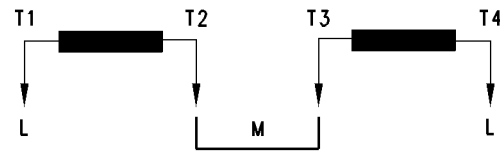


Illustration 87 g00952989
Wiring diagram for a connection in series

Table 10

Voltage at 50/60 Hz		Connect.	Output		
L-L	L-M		L	L	M
220	110	T2 - T3	T1	T4	T2 - T3
230	115				
240	120				

R 230 voltage sensing – 0 => (T1) / 110 V => (T2)

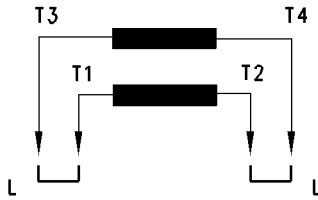


Illustration 88

g00953002

Wiring diagram for a parallel connection

Table 11

Voltage at 50/60 Hz		Connect.	Output		
L-L	L-M		L	L	M
110	-	T1 - T3 T2 - T4	T1 - T3	T2 - T4	-
115	-				
120	-				

R 230 voltage sensing – 0 => (T1) / 110 V => (T2)

2000/3000 Series Connections for Exciter Field

Connection for Series Arrangement (SHUNT)

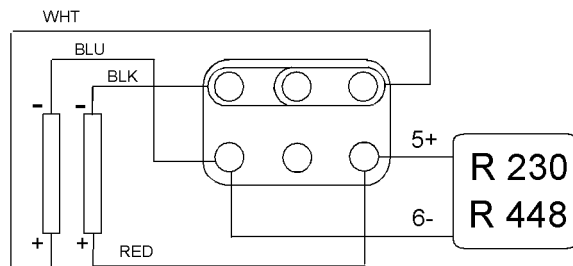


Illustration 89

g01147977

(WHT) White
 (BLU) Blue
 (BLK) Black
 (RED) Red

Connection for Parallel Arrangement (AREP excitation and PMG excitation)

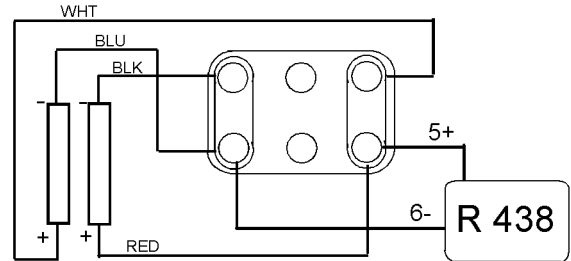


Illustration 90

g01147978

(WHT) White
 (BLU) Blue
 (BLK) Black
 (RED) Red

R 791 T Interference Suppression

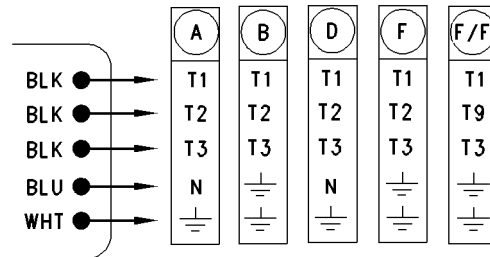


Illustration 91

g00953025

Connect the interference suppression, as shown. The letters in the circles represent the wiring codes for the generators.

(BLK) Black
 (BLU) Blue
 (WHT) White
 (A) Wiring code "A"
 (B) Wiring code "B"
 (D) Wiring code "D"
 (F) Wiring code "F"
 (FF) Wiring code "FF"

Cold Weather Operation

i03898009

Cold Weather Operation

SMCS Code: 1000; 1250

Caterpillar Diesel Engines can operate effectively in cold weather. During cold weather, the starting and the operation of the diesel engine is dependent on the following items:

- The type of fuel that is used
- The viscosity of the engine oil
- The operation of the glow plugs
- Optional Cold starting aid
- Battery condition

Refer to Special Publication, SEBU5898, "Cold Weather Recommendations for Caterpillar Machines".

This section will cover the following information:

- Potential problems that are caused by cold weather operation
- Suggest steps which can be taken in order to minimize starting problems and operating problems when the ambient air temperature is between "0° to -40 °C (32° to -40 °F)".

The operation and maintenance of an engine in freezing temperatures is complex . This is because of the following conditions:

- Weather conditions
- Engine applications

Recommendations from your Caterpillar dealer are based on past proven practices. The information that is contained in this section provides guidelines for cold weather operation.

Hints for Cold Weather Operation

- If the engine will start, operate the engine until a minimum operating temperature of 80° C (176° F) is achieved. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.

- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a period of time and the engine can still have the ability to start readily.
- Install the correct specification of engine lubricant before the beginning of cold weather.
- Check all rubber parts (hoses, fan drive belts, etc) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm.
- Fill the fuel tank at the end of each shift.
- Drain the water from the fuel system. Refer to this Operation and Maintenance Manual, "Fuel System Primary Filter/Water Separator - Drain".
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.
- Ensure that the glow plugs are in working order. Refer to Testing and Adjusting Manual, "Glow Plug - Test".

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.

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

- For jump starting with cables in cold weather, refer to the Operation and Maintenance Manual, "Starting with Jump Start Cables." for instructions.

Viscosity of the Engine Lubrication Oil

Correct engine oil viscosity is essential. Oil viscosity affects the amount of torque that is needed to crank the engine. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.

Recommendations for the Coolant

Provide cooling system protection for the lowest expected outside temperature. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended coolant mixture.

In cold weather, check the coolant often for the correct glycol concentration in order to ensure adequate freeze protection.

Engine Block Heaters

Engine block heaters (if equipped) heat the engine jacket water that surrounds the combustion chambers. This provides the following functions:

- Startability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. A block heater can be 110 Volts or 240 Volts. The output can be 750/1000 Watts. Consult your Caterpillar dealer for more information.

Idling the Engine

When idling after the engine is started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be "raced" in order to speed up the warm up process.

While the engine is idling, the application of a light load (parasitic load) will assist in achieving the minimum operating temperature. The minimum operating temperature is 80° C (176° F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. This should be performed before the engine is returned to full operation. During operation in very cold temperature conditions, damage to engine valve mechanisms can result from engine operation for short intervals. This can happen if the engine is started and the engine is stopped many times without being operated in order to warm up completely.

When the engine is operated below normal operating temperatures, fuel and oil are not completely burned in the combustion chamber. This fuel and oil causes soft carbon deposits to form on the valve stems. Generally, the deposits do not cause problems and the deposits are burned off during operation at normal engine operating temperatures.

When the engine is started and the engine is stopped many times without being operated in order to warm up completely, the carbon deposits become thicker. This can cause the following problems:

- Free operation of the valves is prevented.
- Valves become stuck.
- Pushrods may become bent.
- Other damage to valve train components can result.

For this reason, when the engine is started, the engine must be operated until the coolant temperature is 80° C (176° F) minimum. Carbon deposits on the valve stems will be kept at a minimum and the free operation of the valves and the valve components will be maintained.

In addition, the engine must be thoroughly warmed in order to keep other engine parts in better condition and the service life of the engine will be generally extended. Lubrication will be improved. There will be less acid and less sludge in the oil. This will provide longer service life for the engine bearings, the piston rings, and other parts. However, limit unnecessary idle time to ten minutes in order to reduce wear and unnecessary fuel consumption.

The Water Temperature Regulator and Insulated Heater Lines

The engine is equipped with a water temperature regulator. When the engine coolant is below the correct operating temperature jacket water circulates through the engine cylinder block and into the engine cylinder head. The coolant then returns to the cylinder block via an internal passage that bypasses the valve of the coolant temperature regulator. This ensures that coolant flows around the engine under cold operating conditions. The water temperature regulator begins to open when the engine jacket water has reached the correct minimum operating temperature. As the jacket water coolant temperature rises above the minimum operating temperature the water temperature regulator opens further allowing more coolant through the radiator to dissipate excess heat.

The progressive opening of the water temperature regulator operates the progressive closing of the bypass passage between the cylinder block and head. This ensures maximum coolant flow to the radiator in order to achieve maximum heat dissipation.

Note: Do not restrict the air flow. Restriction to the air flow can damage the fuel system. Caterpillar strongly discourages the use of all air flow restriction devices such as radiator shutters. Restriction of the air flow can result in the following: high exhaust temperatures, power loss, excessive fan usage, and reduction in fuel economy.

A cab heater is beneficial in very cold weather. The feed from the engine and the return lines from the cab should be insulated in order to reduce heat loss to the outside air.

Insulating the Air Inlet and Engine Compartment

When temperatures below $-18\text{ }^{\circ}\text{C}$ ($-0\text{ }^{\circ}\text{F}$) will be frequently encountered, an air cleaner inlet that is located in the engine compartment may be specified. An air cleaner that is located in the engine compartment may also minimize the entry of snow into the air cleaner. Also, heat that is rejected by the engine helps to warm the intake air.

Additional heat can be retained around the engine by insulating the engine compartment.

i02237624

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

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

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

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

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

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

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

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

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

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

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

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

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

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

Engine Stopping

i02334873

Stopping the Engine

SMCS Code: 1000

NOTICE

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

Avoid accelerating the engine prior to shutting it down.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Note: Individual applications will have different control systems. Ensure that the shutoff procedures are understood. Use the following general guidelines in order to stop the engine.

1. Remove the load from the engine. Reduce the engine speed (rpm) to low idle. Allow the engine to idle for five minutes in order to cool the engine.
2. Stop the engine after the cool down period according to the shutoff system on the engine and turn the ignition key switch to the OFF position. If necessary, refer to the instructions that are provided by the OEM.

Maintenance Section

Refill Capacities

i04120394

Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

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 in order to find the capacity of the auxiliary oil filter.

Table 12

Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	13.5 L (14.3 qt)	16.5 L (17.5 qt)

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

Coolant

Table 13

Engine Refill Capacities	
Compartment or System	Liters
Engine Only	9 L (9.5 qt)
External System Per OEM ⁽¹⁾	

⁽¹⁾ The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.

i04327214

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 14

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
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 15

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Performance Requirement	Cat ECF Specifications Requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements
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 16 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 16 (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 16

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
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 17

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

(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 18

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"

(continued)

(Table 18, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
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
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"

(continued)

(Table 18, contd)

Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
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/m³ (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/m³, and for the maximum API gravity of 45 is 801.3 kg/m³.
- (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 19 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 19

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 20

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 concentration 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 NO ₂) 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 NO ₂) 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 21

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 22

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

System Pressure Release

i02909163

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

WARNING

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

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

Fuel System

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

High Pressure Fuel Lines (If Equipped)

WARNING

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

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

This is because of the following differences:

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

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

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

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

Engine Oil

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

i03642798

Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE

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

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

NOTICE

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

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

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

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

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

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.

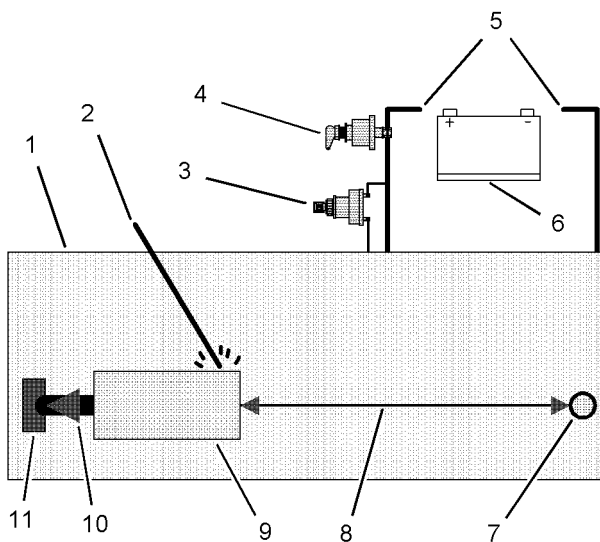


Illustration 92

g01075639

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

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

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

i04744839

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.

When Required

Battery - Recycle	94
Battery or Battery Cable - Disconnect	95
Fuel System - Prime	108
Generator - Dry	117
Generator Load - Check	119
Generator Set - Test	119
Rotating Rectifier - Inspect/Test	126

Every Week

Battery Electrolyte Level - Check	95
Coolant Level - Check	98
Electrical Connections - Check	100
Engine Air Cleaner Service Indicator - Inspect ...	101
Engine Oil Level - Check	104
Fuel System Primary Filter/Water Separator - Drain	113
Fuel Tank Water and Sediment - Drain	116
Generator - Inspect	117

Every 500 Service Hours

Engine Crankcase Breather Element - Replace ..	103
Rotating Rectifier - Check	125

Every Year

Alternator - Inspect	94
Belts - Inspect/Adjust/Replace	95

Coolant Sample (Level 2) - Obtain	99
Engine - Clean	101
Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace	101
Engine Mounts - Inspect	104
Engine Oil Sample - Obtain	104
Engine Oil and Filter - Change	105
Fuel System Primary Filter (Water Separator) Element - Replace	109
Fuel System Secondary Filter - Replace	114
Hoses and Clamps - Inspect/Replace	122
Rotating Rectifier - Check	125
Starting Motor - Inspect	126
Water Pump - Inspect	129

Every 3 Years

Battery - Replace	94
Coolant Extender (ELC) - Add	97
Coolant Temperature Regulator - Replace	100

Every 6 Years

Coolant (ELC) - Change	96
------------------------------	----

i04744807

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.

When Required

Battery - Recycle	94
Battery - Replace	94
Battery or Battery Cable - Disconnect	95
Engine - Clean	101
Fuel System - Prime	108
Generator - Dry	117
Generator Set - Test	119
Rotating Rectifier - Inspect/Test	126

Daily

Coolant Level - Check	98
Electrical Connections - Check	100
Engine Air Cleaner Service Indicator - Inspect ...	101
Engine Oil Level - Check	104
Fuel System Primary Filter/Water Separator - Drain	113
Generator Load - Check	119
Walk-Around Inspection	127

Every Week

Generator - Inspect	117
---------------------------	-----

Every 50 Service Hours or Weekly

Fuel Tank Water and Sediment - Drain	116
--	-----

Every 100 Service Hours or 3 Months

Generator Winding Insulation - Test	120
---	-----

Every 250 Service Hours

Coolant Sample (Level 1) - Obtain	99
Engine Oil Sample - Obtain	104

Initial 500 Hours (for New Systems, Refilled Systems, and Converted Systems)

Coolant Sample (Level 2) - Obtain	99
Engine Valve Lash - Check	108

Every 500 Service Hours or 1 Year

Battery Electrolyte Level - Check	95
Belts - Inspect/Adjust/Replace	95
Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace	101
Engine Crankcase Breather Element - Replace ..	103
Engine Oil and Filter - Change	105
Fuel System Primary Filter (Water Separator) Element - Replace	109
Fuel System Secondary Filter - Replace	114
Hoses and Clamps - Inspect/Replace	122

Every 1000 Service Hours or 1 Year

Engine Valve Lash - Check	108
Rotating Rectifier - Check	125

Every 2000 Service Hours or 1 Year

Alternator - Inspect	94
Engine Mounts - Inspect	104
Starting Motor - Inspect	126
Turbocharger - Inspect	126

Every 3000 Service Hours or 2 Years

Water Pump - Inspect	129
----------------------------	-----

Every 3000 Service Hours or 3 Years

Coolant Temperature Regulator - Replace	100
---	-----

Every 6000 Service Hours or 3 Years

Coolant Extender (ELC) - Add	97
------------------------------------	----

Every 12 000 Service Hours or 6 Years

Coolant (ELC) - Change	96
------------------------------	----

Overhaul

Overhaul Considerations	123
-------------------------------	-----

i02676048

i02322315

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.

i00993589

Battery - Recycle

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

Always recycle a battery. Never discard a battery.

Always return used batteries to one of the following locations:

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

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. Switch the engine to the OFF position. Remove all electrical loads.
2. Turn off any battery chargers. Disconnect any battery chargers.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the NEGATIVE “-” terminal on the starting motor. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the POSITIVE “+” terminal on the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Dispose of 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 engine start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.

8. Connect the NEGATIVE “-” cable to the NEGATIVE “-” battery terminal.

i02724529

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

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

WARNING

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

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

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

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

3. Keep the batteries clean.

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

- Use a solution of 0.1 kg (0.2 lb) baking soda and 1 L (1 qt) of clean water.
- Use a solution of ammonium hydroxide.

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.

i02323088

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. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connections must be disconnected.
3. Remove the positive connection.
4. Clean all disconnected connections and battery terminals.
5. 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 correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.
6. Tape the cable connections in order to help prevent accidental starting.
7. Proceed with necessary system repairs.
8. In order to connect the battery, connect the positive connection before the negative connector.

i04120321

Belts - Inspect/Adjust/Replace

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

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

To maximize the engine performance, inspect the belt (1) for wear and for cracking. Replace the belt if the belt is worn or damaged.

- If the belt (1) has more than four cracks per 25.4000 mm (1 inch), the belt must be replaced.
- Check the belt for the following items: cracks, splits, glazing, grease, splitting, and broken ribs
- Remove any deposits that are on the belt.

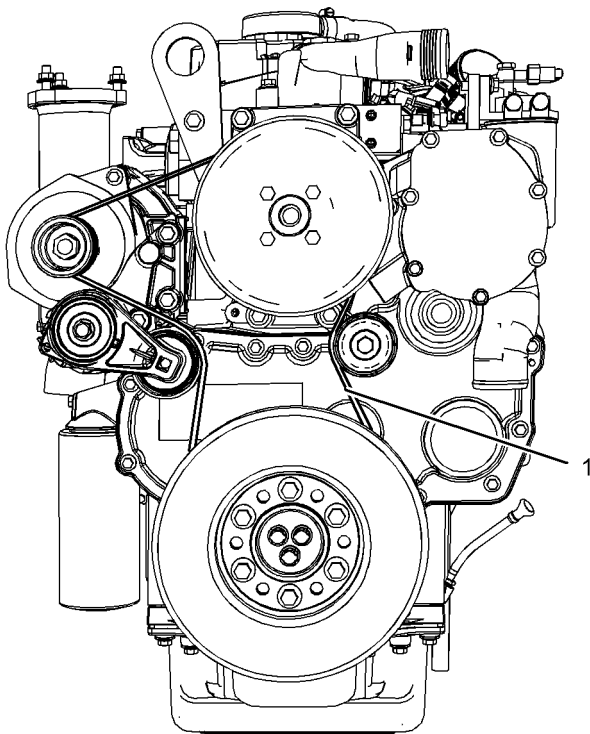


Illustration 93
Typical example

g01347573

i04745510

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
International, 1-309-578-7372

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

Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

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

Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

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.

i04745732

Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

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

NOTICE

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

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

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

 **WARNING**

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

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

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

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

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

NOTICE

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

Refer to Special Publication, NENG2500, "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" or to this Operation and Maintenance Manual, "Fluid Recommendations" for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i03842450

Coolant Level - Check

SMCS Code: 1395-082

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

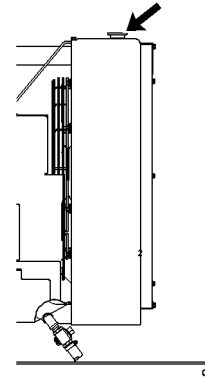


Illustration 94
Cooling system filler cap

g00285520

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.

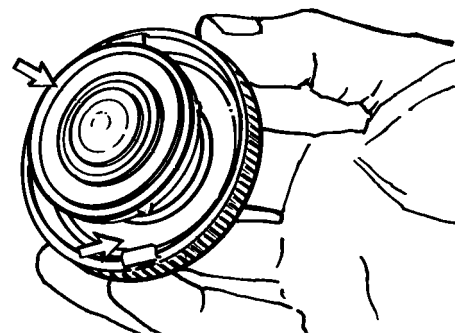


Illustration 95
Typical filler cap gaskets

g00103639

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.

i04746321

Coolant Sample (Level 1) - Obtain

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

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

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

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

Table 23

Recommended Interval		
Type of Coolant	Level 1	Level 2
Cat DEAC	Every 250 service hours	Every year ⁽¹⁾
Conventional heavy duty-coolant		
Commercial coolant that meets the requirements of the Caterpillar EC-1 standard		
Cat ELC or conventional EC-1 coolant	Optional	Every year ⁽¹⁾

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

NOTICE

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

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

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

Use the following guidelines for proper sampling of the coolant:

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

Submit the sample for Level 1 analysis.

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

i04638756

Coolant Sample (Level 2) - Obtain

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

An S·O·S 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 contaminants
- Identification of buildup of the impurities that cause corrosion and scaling

- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported and appropriate recommendations are made.

Obtaining the Sample

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

Submit the sample for Level 2 analysis.

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

i04535903

Coolant Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This procedure 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. For additional information refer to this Operation and Maintenance Manual, "Fluid Recommendations" or consult your Cat dealer.

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

i02398768

Electrical Connections - Check

SMCS Code: 4459-535

 **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.

Checking the electrical connections is an important part of the maintenance for the generator set. Improper connections may cause the generator set to malfunction.

Check all exposed electrical connections for tightness.

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

- Transformers

- Fuses
- Capacitors
- Lightning arresters

Check the connections for the following components:

- Load cables
- Cables for the generator
- Potential transformers
- Current transformers

Check all lead wires and electrical connections for proper clearance. Inspect all cables for chafing, abrasion and corrosion.

i02345750

Engine - Clean

SMCS Code: 1000-070

WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE".

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.

Periodic cleaning of the engine is recommended. 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: Caution must be used in order to prevent electrical components from being damaged by excessive water when the engine is cleaned. Pressure washers and steam cleaners should not be directed at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator, the starter, and the ECM. Protect the fuel injection pump from fluids in order to wash the engine.

i04748266

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

SMCS Code: 1051; 1054-040; 1054-070; 1054-510

NOTICE

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

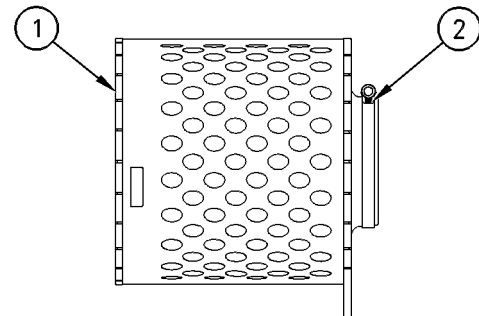


Illustration 96

g00109823

(1) Air cleaner element. (2) Clamp.

1. Loosen clamp (2) which fastens air cleaner element (1) to the air inlet. Remove the dirty air cleaner element and clamp.
2. Install clamp (2) on new air cleaner element (1).
3. Install new air cleaner element (1) to the air inlet and tighten clamp (2). Refer to Torque Specifications, SENR3130 for the correct torque.

i02335405

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 element or in a remote location.

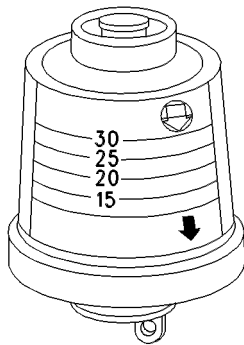


Illustration 97

g00103777

Typical service indicator

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

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

Test the Service Indicator

Service indicators are important instruments.

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

The service indicator may need to be replaced frequently in environments that are severely dusty.

i02326553

Engine Crankcase Breather Element - Replace

SMCS Code: 1317-510-FQ

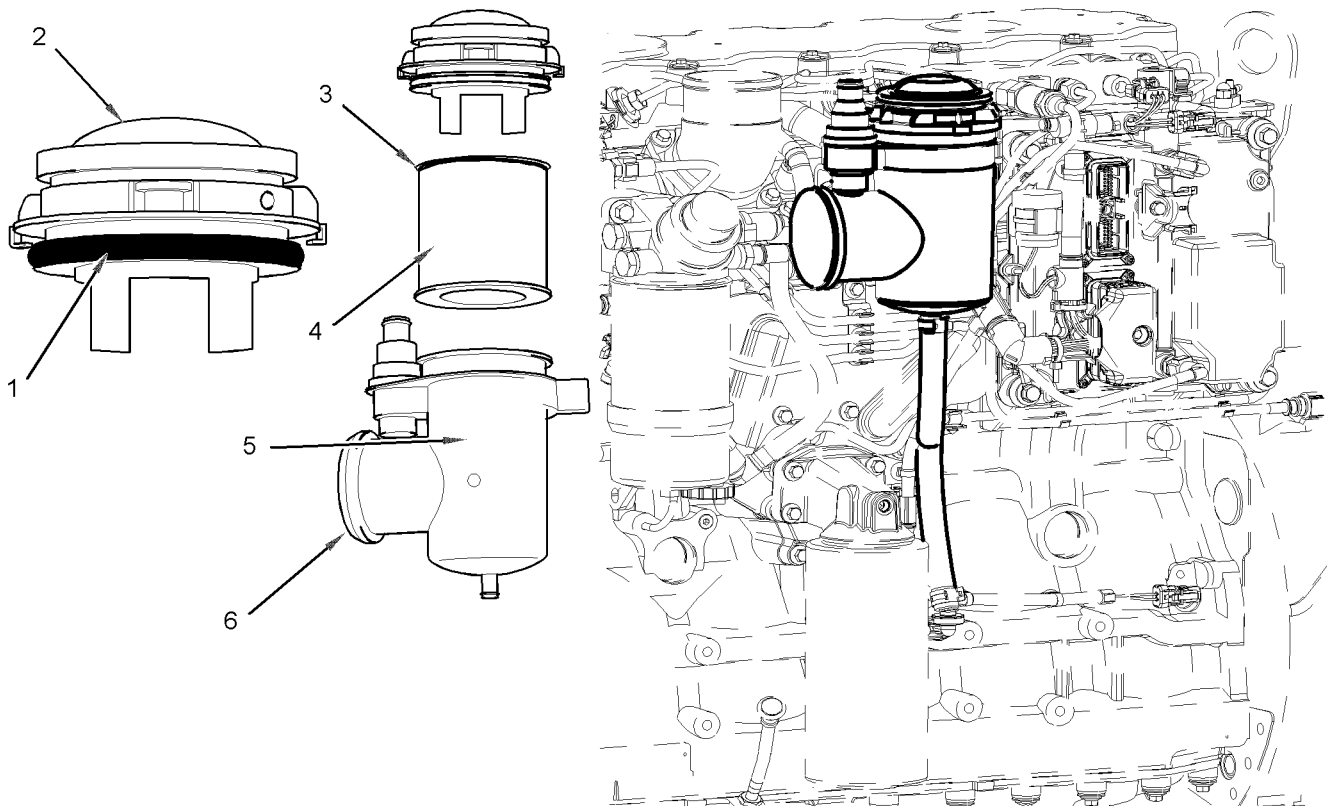


Illustration 98

g01156334

The breather assembly

(1) The O-ring for the top cover
(2) The top cover

(3) The O-ring for the filter element
(4) The filter element

(5) The breather body
(6) The side cover

NOTICE

Ensure that the components of the breather assembly are installed in the correct position. If installed incorrectly, engine damage can result.

Note: There are several vent holes under the top cover (2) and under the side cover (6). Keep the area around the vent holes clean. Do not restrict the vent holes.

1. Remove all dirt and oil from the outside of the breather assembly. Remove the top cover (2) by turning the top cover counterclockwise until the lugs disengage. The breather element includes an O ring (3). Remove the breather element (4) by turning and lifting the element. Discard the element. Clean the inner surfaces of the breather body (5). Clean the top cover and inspect the O ring (1) in the top cover. If the O ring in the top cover is worn or damaged, replace the O ring.

- Lubricate the O ring (3) in the new filter element (4) with clean engine lubricating oil. Carefully insert the element into the breather body (5). Lubricate the O ring (1) in the top cover with clean engine lubricating oil. Carefully insert the top cover (2) into the breather body (5). Rotate the top cover clockwise until the lugs are fully engaged.

i02456872

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 Special Publication, SENR3130, "Torque Specifications" for the recommended torques. Refer to the OEM recommendations for more information.

i02335785

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.

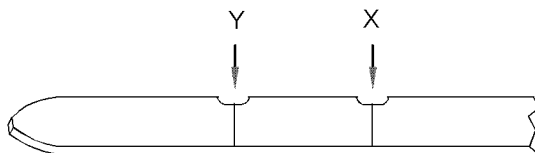


Illustration 99

g01165836

(Y) "Min" mark. (X) "Max" mark.

NOTICE

Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, wait for ten minutes in order to allow the engine oil to drain to the oil pan before checking the oil level.

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

- Remove the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

i04237495

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. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

WARNING

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

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

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

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE

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

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGJ0047, "How To Take A Good S·O·S Oil Sample". Consult your Cat dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02655561

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.

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.

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Do not drain the engine lubricating oil when the engine is cold. As the engine lubricating oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with draining cold oil. Drain the oil pan with the engine stopped. Drain the oil pan with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Lubricating Oil

Note: Ensure that the vessel that will be used is large enough to collect the waste 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 oil pan:

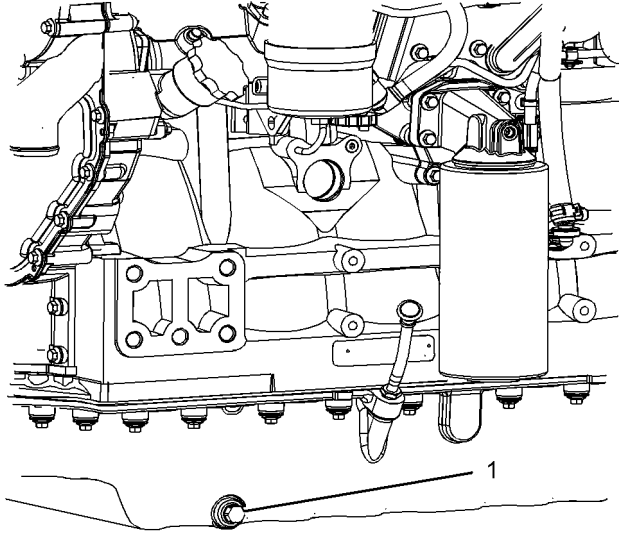


Illustration 100

g01333817

Typical example

- 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 oil drain plug (1) in order to allow the oil to drain. If the engine is equipped with a shallow oil pan, 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. If necessary, replace the O ring seal. Tighten the drain plug to 34 N·m (25 lb ft).

Replace the Oil Filter

NOTICE

Caterpillar oil filters are manufactured to Caterpillar specifications. Use of an oil filter that is not recommended by Caterpillar could result in severe 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.

Note: Some oil filters may be installed horizontally.

Note: The following actions can be carried out as part of the preventive maintenance program.

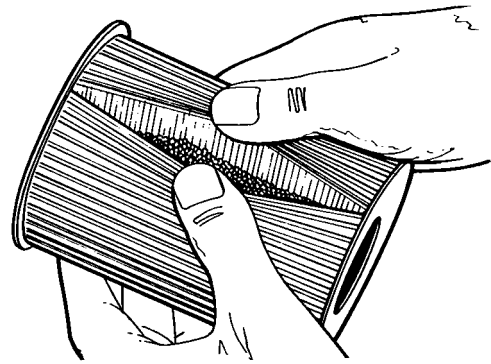


Illustration 101

g00588944

Element with debris

2. Cut the oil filter open with a 175-7546 Oil Filter Cutter. 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.

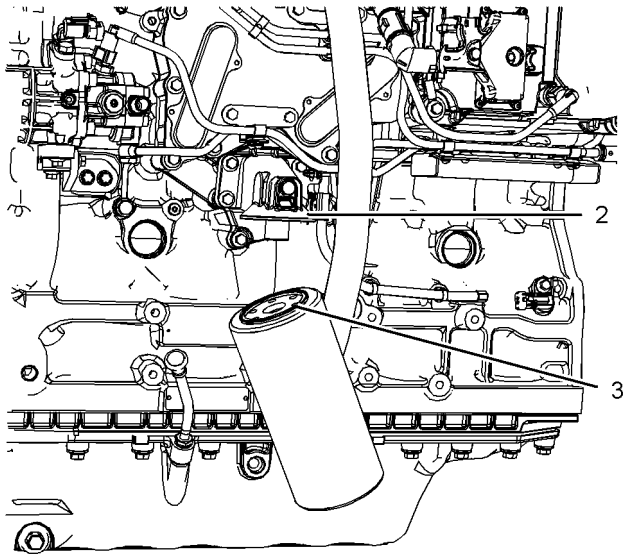


Illustration 102

g01333549

Typical example

3. Clean the sealing surface of the oil filter base (2).
4. Apply clean engine oil to the O ring seal (3) for the new oil filter.

Note: Some oil filters may be installed horizontally. Refer to illustration 103. This type of oil filter assembly can be drained before the filter is removed. The torque for this drain plug (4) is 12 N·m (8 lb ft). If necessary, install a new O ring seal (5). Start at step 1 in order to remove the oil filter and install the oil filter.

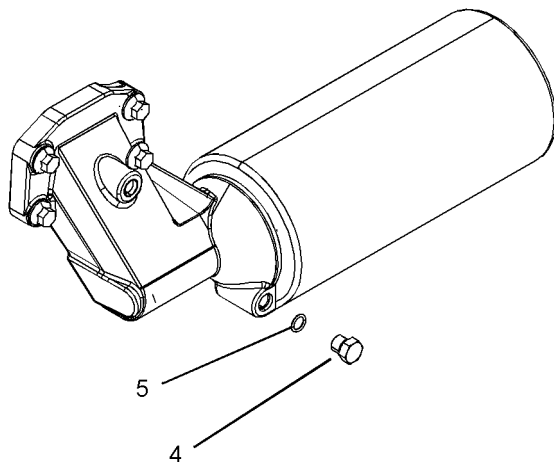


Illustration 103

g01333818

Typical example

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 engine oil filter. Spin on the oil filter until the O ring seal contacts the oil filter base. Rotate the oil filter $\frac{3}{4}$ of a full turn.

Fill the Oil Pan

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on suitable oils. Fill the oil pan with the correct amount of new engine lubricating oil. Refer to this Operation and Maintenance Manual, "Refill Capacities" for more information on refill capacities.

NOTICE

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

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 oil pan for a minimum of ten minutes.

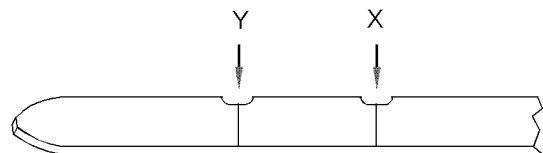


Illustration 104

g01165836

Typical example

4. Remove the engine oil level gauge in order to check the oil level. Maintain the oil level between the "MIN" and "MAX" marks on the engine oil level gauge.

i03964791

Engine Valve Lash - Check

SMCS Code: 1105-535

Note: Procedures for adjusting the valve lash can be found in Systems Operation/Testing and Adjusting, "Valve Lash Adjustment". Consult your Cat dealer for assistance.

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.

i02656266

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

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.

Refer to the Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" before adjustments and repairs are performed.

Note: Refer to Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

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.

If air enters the fuel system, the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low pressure fuel lines are disconnected.
- A leak exists in the low pressure fuel system.
- The fuel filter has been replaced.

Hand Fuel Priming Pump

Use the following procedures in order to remove air from the fuel system:

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the "ON" position.

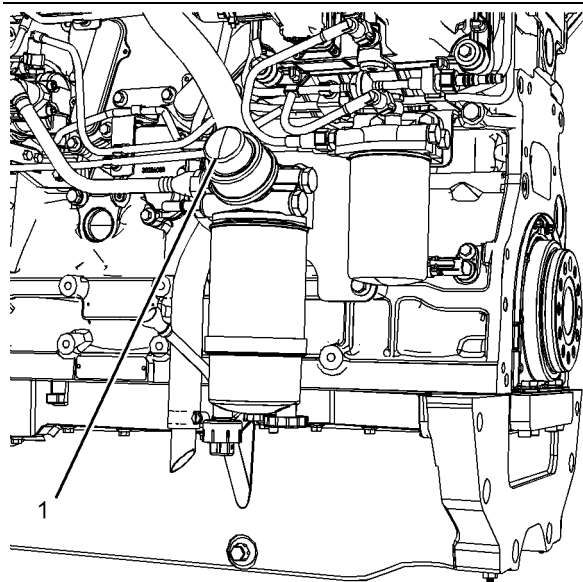


Illustration 105

g01333855

Typical example

2. Operate the fuel priming pump (1). Count the number of operations of the fuel priming pump. After 100 depressions of the fuel priming pump stop.
3. The engine fuel system should now be primed and the engine should now be able to start.
4. Operate the engine starter and crank the engine. After the engine has started, operate the engine at low idle for a minimum of five minutes, immediately after air has been removed from the fuel system.

Note: Operating the engine for this period of time will help ensure that the fuel system is free of air.

Note: Do not loosen the high pressure fuel line in order to purge air from the fuel system. This procedure is not required.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

Electric Fuel Priming Pump

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the "ON" position.

NOTICE

The electric fuel priming pump will operate for 90 seconds. If necessary the electric fuel priming pump can be stopped during the 90 seconds of operation, by operation of the switch.

2. Turn the keyswitch to the "RUN" position. Operate the switch for the electric priming pump. After 90 seconds of the electric fuel priming pump operation the fuel system will be primed and the electric fuel priming pump will turn off.
3. The engine should now be able to start.
4. Operate the engine starter and crank the engine. After the engine has started, operate the engine at low idle for a minimum of five minutes, immediately after air has been removed from the fuel system.

Note: Operating the engine for this period of time will help ensure that the fuel system is free of air.

Note: Do not loosen the high pressure fuel line in order to purge air from the fuel system. This procedure is not required.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

i03242661

Fuel System Primary Filter (Water Separator) Element - Replace

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

Type One Filter

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.

Note: Refer to Testing and Adjusting Manual , "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.

2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside of the water separator.

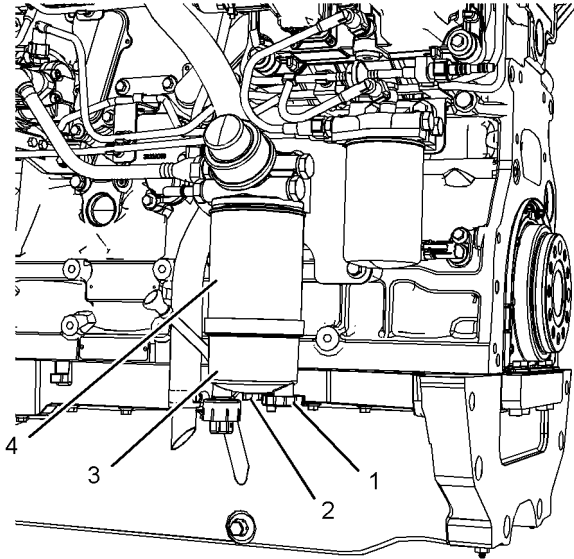


Illustration 106

g01333866

Typical example

3. Install a suitable tube onto the drain (1). Open drain (1). Allow the fluid to drain into the container. Remove the tube.
4. Tighten the drain (1) by hand pressure only.
5. If equipped, remove the wiring harness from the sensor on the bottom of the bowl.
6. Hold bowl (3) and remove screw (2). Remove bowl (3) from canister (4).
7. Use a 1U-8760 Chain Wrench in order to remove canister (4). Discard old seals (5 and 6) and the canister in a safe place.
8. Clean bowl (3).

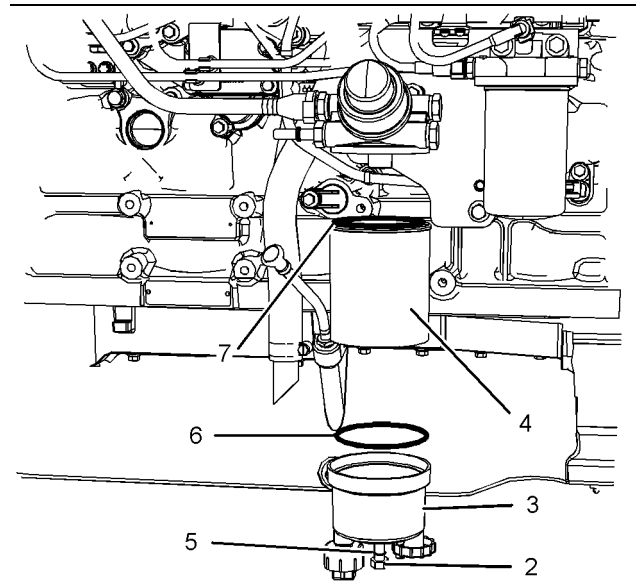


Illustration 107

g01333552

Typical example

9. Lubricate the O ring seal (7) with clean engine oil on the new canister.
10. Install the new canister. Spin on the canister until the O ring seal contacts the filter base. The canister will require a $\frac{3}{4}$ of a full turn or one full turn in order to tighten the canister correctly. Refer to the information on the canister.
11. Install new O ring seal (5) onto setscrew (2). Install new O ring seal (6) into the bowl (3).
12. Align the bowl to the canister. Ensure that the sensor (if equipped) is in the correct position. Install setscrew (2). Tighten the setscrew to a torque of 5 N·m (44 lb in).
13. If equipped, install the wiring harness to the sensor.
14. Remove the container and dispose of the fuel in a safe place.
15. The secondary filter must be replaced at the same time as the primary filter. Refer to the Operation and Maintenance Manual , "Fuel System Filter - Replace".

Type Two Filter

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.

Note: Refer to Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.
2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside of the water separator.

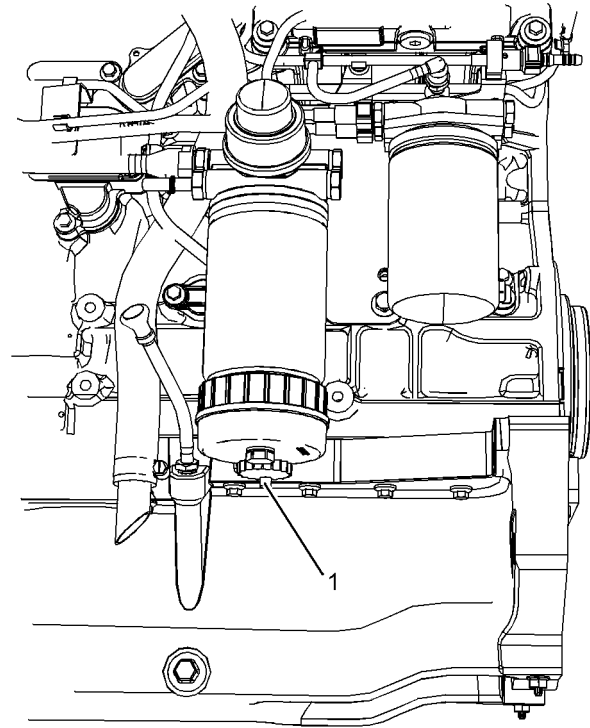


Illustration 108

g01372133

typical example

3. Install a suitable tube onto the drain (1). Open the drain (1). Allow the fluid to drain into the container. Remove the tube.
4. Tighten the drain (1) by hand pressure only.
5. If equipped, remove the wiring harness from the sensor on the bottom of the bowl (3).

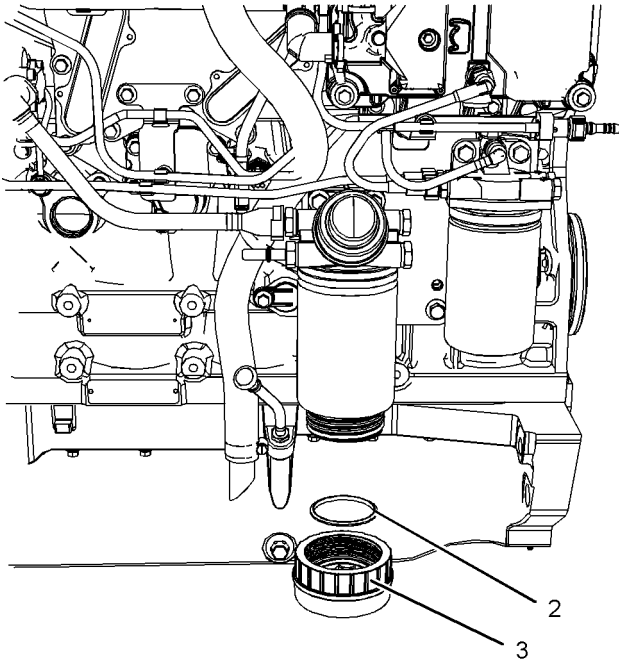


Illustration 109
typical example

g01372134

6. Rotate the bowl (3) counterclockwise in order to remove the bowl. Remove the O ring seal (2). Clean the bowl.

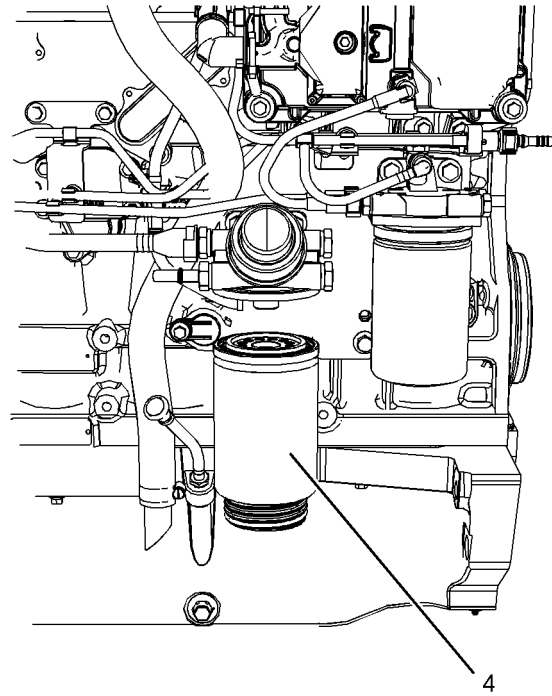


Illustration 110
typical example

g01372135

7. Use a 1U-8760 Chain Wrench in order to remove the old canister (4).

i02656272

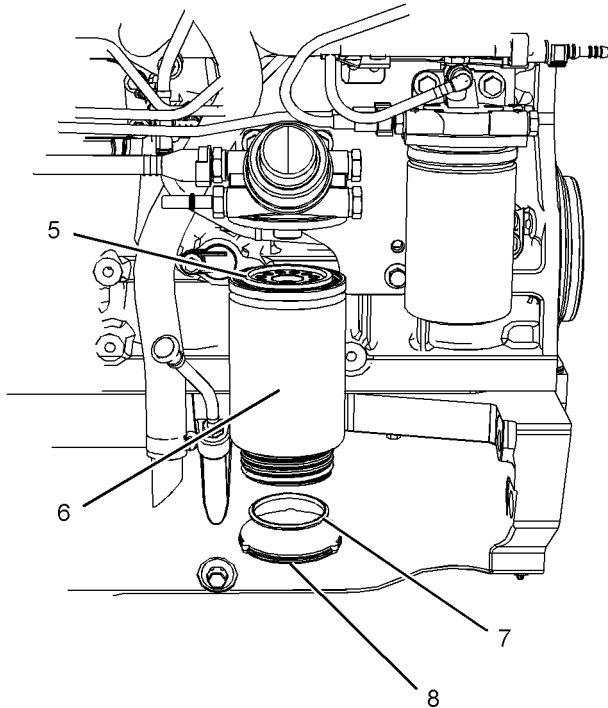


Illustration 111
typical example

g01372137

8. Lubricate the O ring seal (5) with clean engine oil on the new canister. Install the new canister (6). Spin on the canister until the O ring seal contacts the sealing surface. Then rotate the canister 360 degree in order to tighten the canister correctly.
9. Remove the cap (8) from the threaded end of the new canister and remove the new O ring seal (7). Install the new O ring seal into the bowl (3).
10. Lubricate the O ring seal (7) with clean engine oil. Install the bowl onto the new canister. Tighten the bowl to 15 N·m (11 lb ft).
11. If equipped, install the wiring harness to the sensor. Open the fuel supply valve.
12. Remove the container and dispose of the fluid in a safe place.
13. The secondary filter must be replaced at the same time as the primary filter. Refer to the Operation and Maintenance Manual , "Fuel System Filter - Replace".

Fuel System Primary Filter/Water Separator - Drain

SMCS Code: 1260-543; 1263-543

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.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

NOTICE

The water separator can be under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

1. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel.

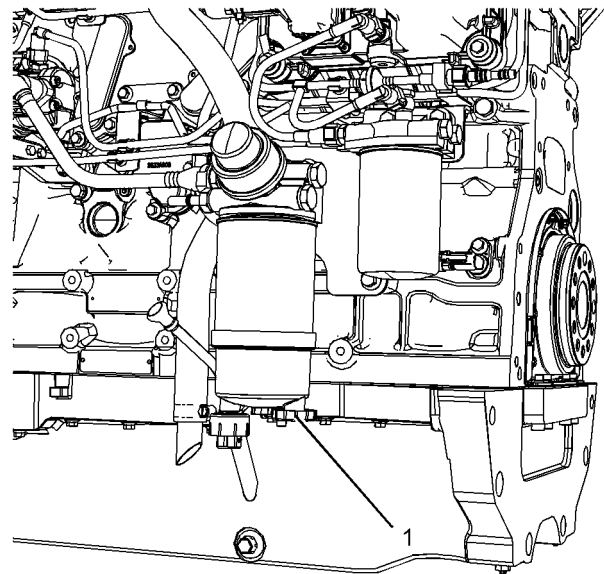


Illustration 112
Typical example

g01334411

2. Install a suitable tube onto drain (1). Open drain (1). Allow the fluid to drain into the container.
3. Tighten drain (1) by hand pressure only. Remove the tube and dispose of the drained fluid in a safe place.

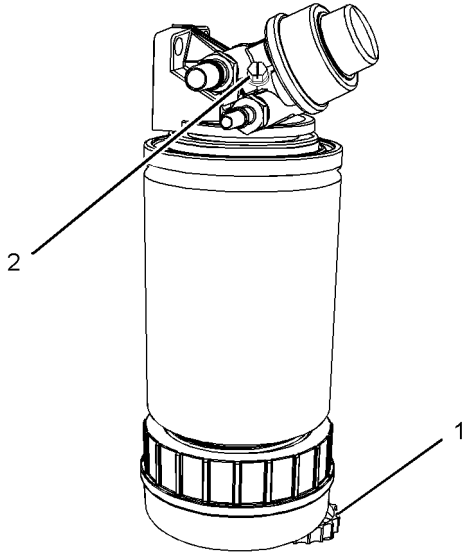


Illustration 113

g01371846

Typical example

Note: Not all primary filters require vent screw (2). This primary fuel filter that has a vent screw may be installed on a fuel system that has a low fuel tank.

1. Install a suitable tube onto drain (1). Loosen vent screw (2).
2. Open drain (1). Allow the fluid to drain into the container.
3. Tighten drain (1) by hand pressure only. Remove the tube and dispose of the drained fluid in a safe place.
4. Tighten vent screw to 6 N·m (53 lb in).

i02656273

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

Type One Filter

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.

Note: Refer to Testing and Adjusting Manual, “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

This fuel filter can be identified by the six drain holes in the filter. Refer to illustration 114.

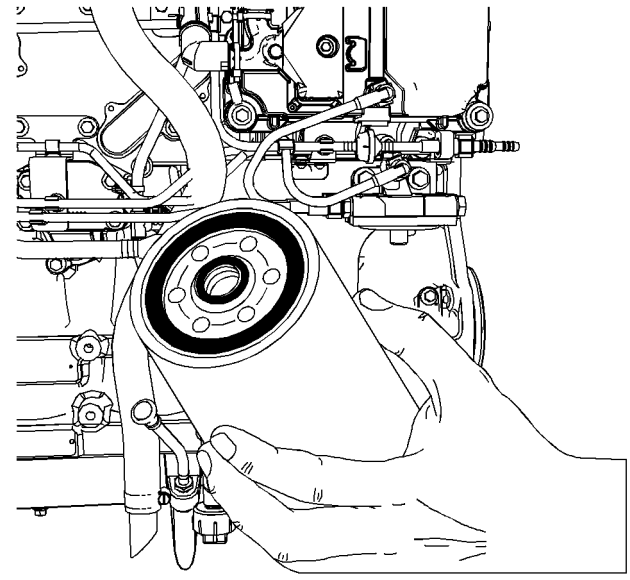


Illustration 114

g01375918

Typical example

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

NOTICE

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

1. Ensure that the fuel supply valve (if equipped) is in the OFF position. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel.

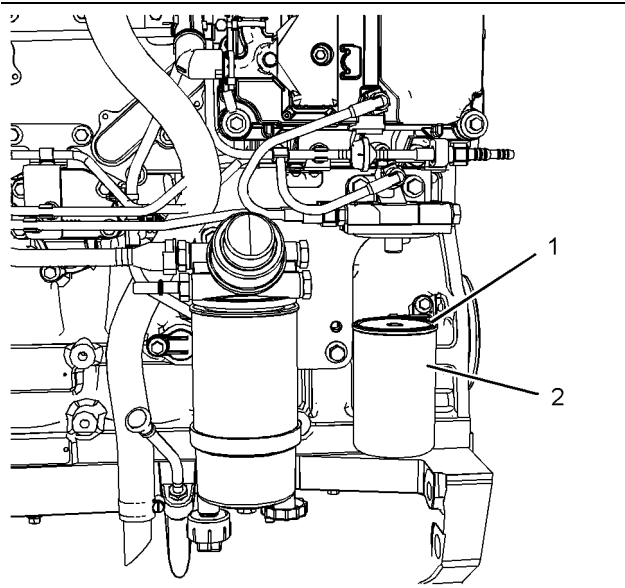


Illustration 115

g01333960

Typical example

2. Clean the outside of the fuel filter. Use 1U-8760 Chain Wrench in order to remove canister (2) from the engine and dispose of the canister in a safe place.
3. Lubricate O ring seal (1) with clean engine oil. Do not fill the new canister with fuel before the canister is installed.
4. Do not use a tool in order to install the canister. Tighten the canister by hand.
5. Install the new canister. Spin on the canister until the O ring seal contacts the filter base. The canister will require $\frac{3}{4}$ of a full turn or one full turn in order to tighten the canister correctly. Refer to information on the canister.
6. Remove the container and dispose of the fluid in a safe place. If equipped, open the fuel supply valve.
7. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information.

Type Two Filter

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.

Note: Refer to Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

This fuel filter can be identified by the 12 drain holes in the filter. Refer to illustration 116.

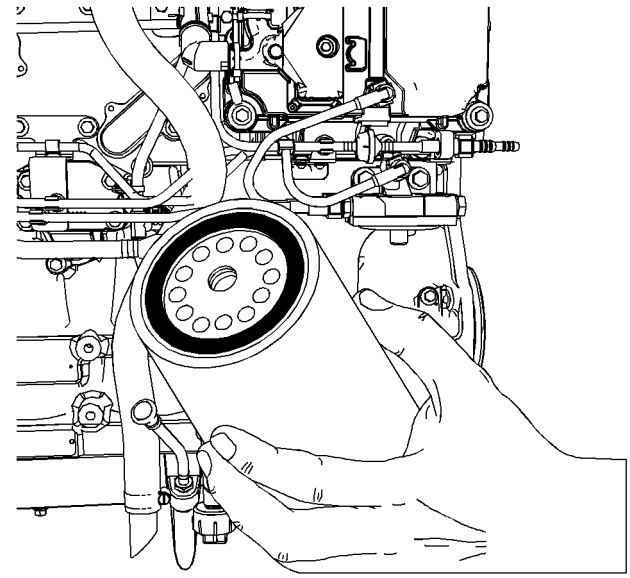


Illustration 116

g01375926

Typical example

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

NOTICE

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

1. Ensure that the fuel supply valve (if equipped) is in the OFF position. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel.

i02348492

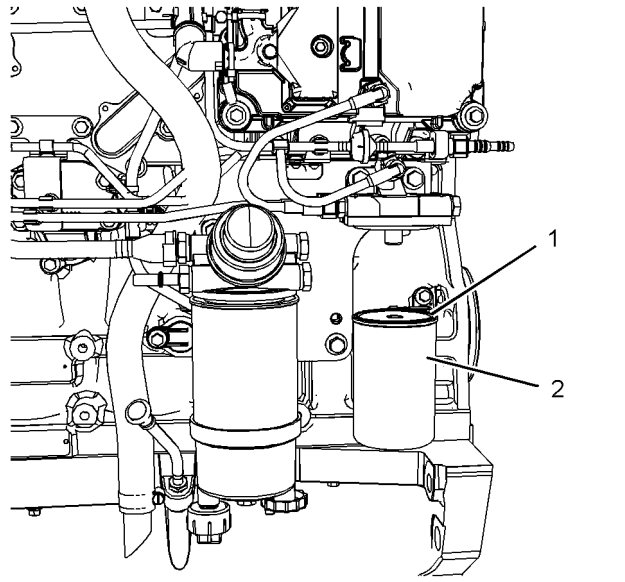


Illustration 117

g01333960

Typical example

2. Clean the outside of the fuel filter. Use 1U-8760 Chain Wrench in order to remove canister (2) from the engine and dispose of the canister in a safe place.
3. Lubricate O ring seal (1) with clean engine oil. Do not fill the new canister with fuel before the canister is installed.
4. Do not use a tool in order to install the canister. Tighten the canister by hand.
5. Install the new canister. Spin on the canister until the O ring seal contacts the sealing surface. Then rotate the canister 360 degree in order to tighten the canister correctly.
6. Remove the container and dispose of the fluid in a safe place. If equipped, open the fuel supply valve.
7. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information.

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.

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.

Water can be introduced into the fuel tank when the fuel tank is being filled.

Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Allow five minutes after the fuel tank has been filled before draining water and sediment from the fuel tank.

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

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

Fuel Storage Tanks

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

- Weekly
- Service intervals
- Refill of the tank

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

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

i03642821

Generator - Dry

SMCS Code: 4450-569

NOTICE

Do not operate the generator if the windings are wet. If the generator is operated when the windings are wet, damage can occur due to insulation breakdown.

When moisture is present or when moisture is suspected in a generator, the generator must be dried before being energized.

If the drying procedure does not restore the insulation resistance to an acceptable value, the winding should be reconditioned.

Note: For additional information, refer to Special Instruction, SEHS9124 .

Drying Methods

The following methods can be used for drying a generator:

- Self-circulating air method

- Oven method

NOTICE

Do not allow the winding temperature to exceed 85 °C (185.0 °F). Temperatures that are greater than 85 °C (185.0 °F) will damage the winding insulation.

Self-Circulating Air Method

Note: Disable the excitation before using this method.

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

Oven Method

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

NOTICE

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

Radiant type ovens can cause localized overheating.

i02283395

Generator - Inspect

SMCS Code: 4450-040

WARNING

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

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

WARNING

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

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

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

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

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

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

NOTICE

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

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

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

Cleaning (Assembled Generators)

NOTICE

Do not use water to clean the generator.

NOTICE

Do not use trichloroethane, perchlorethylene, trichloroethane or any alkaline products to clean the generator.

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

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

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

Cleaning (Disassembled Generators)

NOTICE

Do not use water to clean the generator.

NOTICE

Do not use trichloroethane, perchlorethylene, trichloroethane or any alkaline products to clean the generator.

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

Use the following for cleaning the stator, the rotor, the exciter and the diode bridge:

- Unleaded Gasoline
- Toluene
- Benzene

- Ciclohexare

Avoid permitting the solvent to run into the slots. Apply the solvent with a brush. Use a sponge on the windings frequently in order to remove the debris. Dry the winding with a dry cloth. Allow the solvent to evaporate before reassembling the generator.

Allow the generator to dry at room temperature. Check the insulation resistance. The insulation resistance should now be normal. If the insulation resistance is not normal, repeat the procedure.

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

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.

i01593517

Generator Set - Test

SMCS Code: 4450-081

WARNING

Personal injury or death can result from high voltage.

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

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

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

When servicing or repairing electric power generation equipment:

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

Table 24

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

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

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

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

The generator set functional test consists of the following steps:

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

i04748528

Generator Winding Insulation - Test

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

WARNING

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

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

Table 25

TOOLS NEEDED		
Part Number	Tool	Quantity
142-5055	Insulation Tester Megohmmeter	1

WARNING

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

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

The following materials will cause the winding insulation to deteriorate:

- moisture (water)
- dust
- grease
- other foreign matter within the generator

This deterioration reduces the resistance of the insulation. This test will measure the resistance of the winding insulation.

The insulation tester (megohmmeter) produces a high potential voltage between the test leads. During the test, a small current flows. The tester converts this current to a resistance reading.

The insulation test is performed as part of periodic maintenance in order to detect the deterioration of the winding insulation. When there is a rapid decrease in the insulation resistance in a short amount of time, the generator needs to be cleaned.

Note: For information on generator cleaning, refer to Special Instruction, SEHS9124.

When generators have not been used for a time, moisture can accumulate. Therefore, the insulation test should be performed on generators that have been idle. If moisture is known to exist, the windings must be dried prior to testing. Refer to Testing And Adjusting, "Generator - Dry".

The insulation test should be performed on generators that are being used for the first time. The insulation test should be performed more frequently in the following cases:

- The generator set is operating in a humid environment.
- The generator set is not protected from the elements in an enclosed area.
- The generator set has not been run under load for 3 months.

Note: Use of space heaters may be necessary around the generator set in the following cases:

- The generator set has not been run under load for 3 months.
- The generator set is exposed to a sea water environment.
- The humidity is above 75 percent.
- A test result was below 3 megohms.

Recondition or replace the winding in the following cases:

- The measured insulation resistance falls below the specified amount. The cleanup procedure does not correct the discrepancy.
- The measured insulation resistance falls below the specified amount. The drying procedure does not correct the discrepancy.

The specified insulation resistance is an approximate value. It can be possible to operate the generator with less than the specified value. However, a generator that has a low winding insulation resistance will be more likely to have a failure.

⚠ WARNING

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

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

The insulation test gives accurate results only when the generator windings are free of moisture and the generator windings are at room temperature.

Each winding must have a minimum insulation resistance of 1 megohm.

Main Armature (Stator L4)

1. Remove the load from the generator by either of the following:
 - Open the line circuit breaker.
 - Open the following load connections: T1, T2, T3, and T0.

Prevent these wires from coming into contact with each other and prevent these wires from contacting ground.

2. Isolate the main armature (L4) from the voltage regulator by disconnecting the wires for voltage sensing. If generator lead (T0) is connected to the generator frame or ground, open the connection.
3. Connect one test lead of the insulation tester (megohmmeter) to the generator enclosure (ground).
4. Connect the other test lead of the insulation tester (megohmmeter) to generator lead (T0).
5. The insulation resistance must be 1 megohm or more.

Exciter Field (Stator L1)

1. Isolate exciter field (L1) from the voltage regulator by disconnecting wires 5+ and 6-. Prevent these wires from coming into contact with each other and prevent these wires from contacting ground.

2. Connect one test lead of the insulation tester (megohmmeter) to the generator enclosure (ground).
3. Connect one test lead of the insulation tester (megohmmeter) to exciter field lead (5+ or 6-).
4. Measure the resistance of the exciter field winding insulation to ground. The insulation resistance must be a minimum of 0.25 megohm (250000 ohms).

Exciter Armature (Rotor L2)

1. Isolate exciter armature (L2) from the rectifier circuit. Disconnect the three wires of the exciter armature from the rectifier blocks.
2. Connect one test lead of the insulation tester (megohmmeter) to the rotor shaft.
3. Connect one test lead of the insulation tester (megohmmeter) to any one exciter field lead.
4. The insulation resistance must be a minimum of 0.25 megohm (250000 ohms).

i02349879

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

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.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will harden. Hardening of the hoses will cause hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

Refer to the OEM information for further information on removing and replacing fuel hoses (if equipped).

The coolant system and the hoses for the coolant system are not usually supplied by Perkins. The following text describes a typical method of replacing coolant hoses. Refer to the OEM information for further information on the coolant system and the hoses for the coolant 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.

1. Stop the engine. Allow the engine to cool.

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

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: For the correct coolant, see this Operation and Maintenance Manual, "Fluid Recommendations".

8. Refill the cooling system. Refer to the OEM information for further information on refilling the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's seals. Replace the cooling system filler cap if the seals are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

i02299454

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

Many options are available if a major engine failure occurs. An overhaul should be performed if the engine block or the crankshaft can be repaired.

If the engine block is repairable and/or the crankshaft is repairable, the overhaul cost should be less than the cost of a new engine with a similar exchange core.

This lower cost can be attributed to these aspects:

- 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

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

The following components may not last until the second overhaul.

- Piston rings
- Thrust bearings
- Main bearings
- Connecting rod bearings
- Crankshaft seals
- Engine mounts
- Hoses

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
- Valve lifters

Testing

Test the following components during the overhaul.

- Fuel injection nozzles
- Fuel injection pump

Testing the fuel system during the overhaul will ensure that your engine operates at peak efficiency. Your Caterpillar dealer can provide these services and components in order to ensure that your fuel system is operating within the appropriate specifications.

Cleaning

Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 26 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 26

HydrosolvLiquid Cleaners		
Part Number	Description	Size
1U-8812	Hydrosolv4165	4 L (1 US gallon)
1U-5490		19 L (5 US gallon)
8T-7570		208 L (55 US gallon)
1U-8804	Hydrosolv100	4 L (1 US gallon)
1U-5492		19 L (5 US gallon)
8T-5571		208 L (55 US gallon)

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 I). 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 II).

S·O·S Coolant Analysis (Level II)

An S·O·S Coolant Analysis (Level II) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level II) provides the following information:

- Complete S·O·S Coolant Analysis (Level I)
- 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.

i01880286

Rotating Rectifier - Check

SMCS Code: 4465-535

WARNING

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

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

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

i04327496

Rotating Rectifier - Inspect/Test

SMCS Code: 4465-040; 4465-081

WARNING

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

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

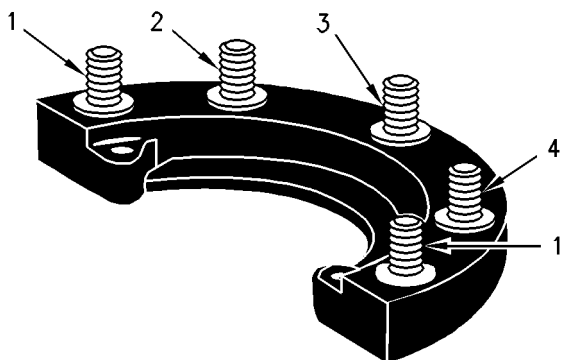


Illustration 118

g00992269

- (1) Positive DC terminal or Negative DC terminal
- (2) AC terminal
- (3) AC terminal
- (4) AC terminal

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 (1). Place the black test lead on the following rectifier terminals: AC terminal (2), AC terminal (3), and AC terminal (4). All readings on the meter should be between 0.4 and 1.0.

- b. Place the black test lead on the negative "-" terminal (1). Place the red test lead on the following rectifier terminals: AC terminal (2), AC terminal (3), and AC terminal (4). 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 (1). Place the black test lead on the following rectifier terminals: AC terminal (2), AC terminal (3), and AC terminal (4). In all cases, the meter should read "OL" (overload).
 - b. Place the black test lead on the positive "+" rectifier terminal (1). Place the red test lead on the following rectifier terminals: AC terminal (2), AC terminal (3), and AC terminal (4). 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.

i02348493

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar 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 correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, "Electric Starting System - Test" for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

i04219023

Turbocharger - Inspect

SMCS Code: 1052-040

A regular visual inspection of the turbocharger is recommended. 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 intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of oil into a turbocharger 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 renewed.

A visual inspection of the turbocharger can minimize unscheduled downtime. A visual inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Removal and Installation

For options regarding the removal, installation, and replacement, consult your Cat dealer. Refer to the Disassembly and Assembly, "Turbocharger - Remove and Turbocharger - Install" and Systems Operation, Testing and Adjusting, "Turbocharger - Inspect" for further information.

Inspecting**NOTICE**

The compressor housing for the turbocharger must not be removed from the turbocharger for inspection or removed for the cleaning of the compressor.

1. Remove the pipe from the turbocharger exhaust outlet and remove the air intake pipe to 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. Check for obvious heat discoloration of the turbocharger. Check for any loose bolts or any missing bolts. Check for damage to the oil supply line and the oil drain line. Check for cracks in the housing of the turbocharger. Ensure that the compressor wheel can rotate freely.
3. Check for the presence of oil. If oil is leaking from the back side of the compressor 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 intake air (clogged air filters), which causes the turbocharger to slobber.

4. Inspect the bore of the housing of the turbine outlet for corrosion.
5. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing. Ensure that all clamps are installed correctly and that all clamps are tightened securely.

i03577563

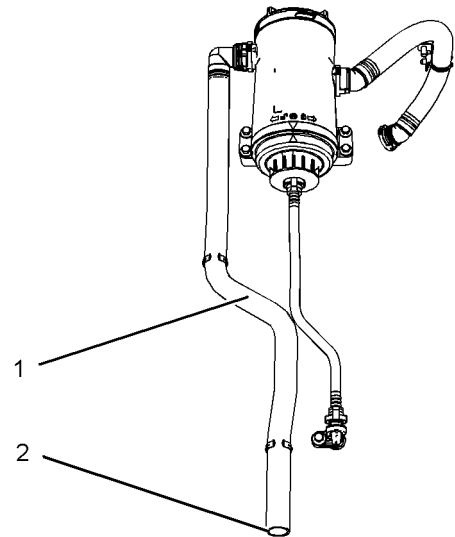
Walk-Around Inspection**SMCS Code:** 1000-040**Inspect the Tube of the Crankcase Breather**

Illustration 119

g01905095

Inspect the breather tube (1) for damage. Ensure that the outlet (2) is clean and free from any obstructions. Ice can cause obstructions in adverse weather conditions.

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 correct 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 is a fire hazard. Remove the accumulated grease and oil. Refer to this Operation and Maintenance Manual, "Engine - Clean" for more information.

- Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by the 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. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove and Install". For more information, consult your Perkins dealer or your Perkins distributor.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the rocker cover.
- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.
- Ensure that the areas around the rotating parts are clear.
- Inspect the alternator belts and any accessory drive belts for cracks, breaks or other damage.

- Inspect the wiring harness for 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.

High Pressure Fuel Lines

 **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.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

Visually inspect the high pressure fuel lines for damage or signs of fuel leakage. Replace any damaged high pressure fuel lines or high pressure fuel lines that have leaked.

Ensure that all clips on the high pressure fuel lines are in place and that the clips are not loose.

- Inspect the rest of the fuel system for leaks. Look for loose fuel line clamps.
- Drain the water and the sediment from the fuel tank on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires. Check for any loose tie-wraps or missing tie-wraps.
- Inspect the ground strap for a good connection and for good condition.

- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that can not be calibrated.

i02794230

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

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and parts contract.

Visually inspect the water pump for leaks.

Note: If engine coolant enters the engine lubricating system the lubricating oil and the engine oil filter must be replaced. This will remove any contamination that is caused by the coolant and this will prevent any irregular oil samples.

The water pump is not a serviceable item. In order to install a new water pump, refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install" or contact your Caterpillar dealer.

Warranty Section

Warranty Information

i04141951

Emissions Warranty Information

SMCS Code: 1000

S/N: N6D1-Up

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/m³ (7.085 lb/US gal)

The engine ratings are gross output ratings.

Gross Output Ratings – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel pumps
- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This will produce the net power that is available for the external load (flywheel).

Engine Rating Definitions

SMCS Code: 1000

It is important to know the use of the engine so that the rating will match the operating profile. The proper rating selection is also important so that the customer's perception of price and value is realized.

In selecting a rating for a specific application, the most important consideration is the time that is spent at full throttle. These rating definitions identify the percent of time at full throttle. The definitions also identify the corresponding times below rated rpm.

Note: The examples of the applications are only for reference. For an exact determination of the appropriate rating, follow the OEM specifications or consult your Caterpillar dealer.

A Rating – This rating is used for heavy-duty applications that are operated at rated load and at rated rpm up to 100 percent. This rating is used for engines that operate without interruption of load cycling. Typical applications include the following examples: pipeline pumping and ventilation.

B Rating – This rating is used when power and/or rpm are cyclic. The engine should be run at full load. The engine should not exceed 80 percent of the duty cycle. Typical applications include the following examples: irrigation, operation where normal pump demand is 85 percent of the engine rating, oil pumping/drilling, field mechanical pumping/drilling, and stationary/plant air compressors.

C Rating – This rating is used when power and/or rpm are cyclic. The horsepower and the rpm of the engine can be utilized continuously for one hour. This is followed by one hour of operation at the A rating or below the A rating. The engine should be run at full load. The engine should not exceed 50 percent of the duty cycle. Typical applications include the following examples: agricultural tractors, harvesters and combines, off-highway trucks, fire pumps, blast hole drills, rock crushers, wood chippers with high torque rise, and oil field hoisting.

D Rating – This rating is used when rated power is required for periodic overloads. The maximum horsepower and the rpm of the engine can be utilized continuously for a maximum of 30 minutes. This is followed by one hour of operation at the C rating. The engine should be run at full load. The engine should not exceed 10 percent of the duty cycle. Typical applications include the following examples: offshore cranes, runway snow blowers, water well drills, portable air compressors, and fire pump certification power.

E Rating – This rating is used when rated power is required for a short time for initial starting or for sudden overload. The rating is also used for emergency service when standard power is not available. The horsepower and the rpm of the engine can be utilized continuously for a maximum of 15 minutes. This is followed by one hour of operation at the C rating or by the duration of the emergency. The engine should be run at full load. The engine should not exceed 5 percent of the duty cycle. Typical applications include the following examples: standby centrifugal water pumps, oil field well servicing, crash trucks, portable air compressors, and gas turbine starting motors.

NOTICE

Operating engines above the rating definitions can result in shorter service life before overhaul.

Customer Service

i03905969

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 Caterpillar dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer 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

Please 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, Caribbean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
Fax: 22-849-4544

Far East
Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

China
Caterpillar China Ltd.
37/F., The Lee Gardens
33 Hysan Avenue
Causeway Bay
G.P.O. Box 3069
Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Shin Caterpillar Mitsubishi Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Japan
Caterpillar Power Systems, Inc.
SBS Tower (14th floor)
4-10-1, Yoga
Setagaya-Ku, Tokyo 158-0097
Phone: 81-3-5797-4300
Fax: 81-3-5797-4359

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i01028392

Ordering Replacement Parts

SMCS Code: 4450; 7567

WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

Reference Materials

- Maintenance log

i00912149

Maintenance Records

SMCS Code: 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts

i04329408

Reference Material

SMCS Code: 1000; 4450

The following literature can be obtained through any Cat dealer.

Lubricants

- Special Publication, PEHP9536, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, NEDG6022, "Cat Lubricating Grease"
- Special Publication, PEHP0002, "Data Sheet - Molybdenum (MPGM) Grease"
- Special Publication, NEHP6015, "Data Sheet - Caterpillar Special Purpose Grease (SPG)"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"

Fuels

- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

Coolants

- Special Publication, PEHP4036, "Data Sheet - Extended Life Coolant"
- Special Publication, PEHJ0191, "Cat S-O-S Coolant Analysis"
- Special Publication, SEBD0518, "Know Your Cooling System"
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"

Miscellaneous

- Service Manual, KENR6207, "C6.6 Generator Set"
- Special Publication, PECP6026, "One Safe Source" English language for use in NACD
- Special Publication, PECP6027, "One Safe Source" English language for use in COSA
- Special Publication, PECP6028, "One Safe Source"
- Special Publication, LEDM5615, "Caterpillar Marine Parts and Service Locations Directory"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, SEBF8062, "Procedure to Inspect and Clean Air Filters"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Publication, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Label, SEHS7332, "Danger Do Not Operate"

Emissions Warranty

This engine may be Certified and this engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to Certified engines is found in Supplement, SEBU6981, "Emissions Control Warranty Information". The engine is Certified if the engine has a special label that verifies the certification. A Caterpillar dealer can also inform you if the engine is certified.

Index

A

Additional Messages	18
Alternator - Inspect	94

B

Battery - Recycle	94
Battery - Replace	94
Battery Disconnect Switch (If Equipped)	43
Battery Electrolyte Level - Check	95
Battery or Battery Cable - Disconnect	95
Before Starting Engine	31
Belts - Inspect/Adjust/Replace	95
Burn Prevention	28
Batteries	28
Coolant	28
Oils	28

C

Cold Weather Operation	77
Hints for Cold Weather Operation	77
Idling the Engine	78
Recommendations for Coolant Warm Up	78
Recommendations for the Coolant	78
Viscosity of the Engine Lubrication Oil	77
Control Panel	44
Annunciator Module	46
Control Panel	46
Electronic Control Module (Generator Set)	44
Coolant (ELC) - Change	96
Drain	96
Fill	97
Flush	96
Coolant Extender (ELC) - Add	97
Coolant Level - Check	98
Coolant Sample (Level 1) - Obtain	99
Coolant Sample (Level 2) - Obtain	99
Obtaining the Sample	100
Coolant Temperature Regulator - Replace	100
Crushing Prevention and Cutting Prevention	31
Customer Assistance	133
Outside of USA and of Canada	133
USA and Canada	133
Customer Service	133

E

Electrical Connections - Check	100
Electrical System	32
Grounding Practices	32
Emissions Warranty Information	130
Engine - Clean	101

Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace	101
Engine Air Cleaner Service Indicator - Inspect	101
Test the Service Indicator	102
Engine Crankcase Breather Element - Replace	103
Engine Mounts - Inspect	104
Engine Oil and Filter - Change	105
Drain the Engine Lubricating Oil	105
Fill the Oil Pan	107
Replace the Oil Filter	106
Engine Oil Level - Check	104
Engine Oil Sample - Obtain	104
Obtain the Sample and the Analysis	104
Engine Operation	50
Engine Rating Conditions	131
Engine Rating Definitions	131
Engine Ratings	131
Engine Starting	31, 48
Engine Stopping	32, 80
Engine Valve Lash - Check	108

F

Features and Controls	43
Fire Prevention and Explosion Prevention	28
Ether	30
Fire Extinguisher	30
Lines, Tubes and Hoses	30
Fluid Recommendations	81
Cooling System	86
Diesel Engine Oil	81
Fuel	83
Greases	89
Foreword	5
California Proposition 65 Warning	5
Literature Information	4
Maintenance	4
Maintenance Intervals	4
Operation	4
Overhaul	4
Safety	4
Fuel and the Effect from Cold Weather	79
Fuel Conservation Practices	50
Fuel System - Prime	108
Electric Fuel Priming Pump	109
Hand Fuel Priming Pump	108
Fuel System Primary Filter (Water Separator) Element - Replace	109
Type One Filter	109
Type Two Filter	111
Fuel System Primary Filter/Water Separator - Drain	113
Fuel System Secondary Filter - Replace	114
Type One Filter	114
Type Two Filter	115

Fuel Tank Water and Sediment - Drain	116	Maintenance Interval Schedule (Standby Generator Sets)	92
Drain the Water and the Sediment.....	116	Maintenance Log.....	136
Fuel Storage Tanks	117	Maintenance Recommendations	90
Fuel Tank	116	Maintenance Records.....	135
G		Maintenance Section	81
General Hazard Information	25	Model View Illustrations	35
Asbestos Information	27	O	
Containing Fluid Spillage	27	Operation Section.....	41
Dispose of Waste Properly	28	Ordering Replacement Parts	134
Fluid Penetration.....	26	Overhaul Considerations.....	123
Pressurized Air and Water	26	Oil Consumption as an Overhaul Indicator	123
General Information.....	35	Overhaul Recommendation	124
Generator - Dry.....	117	P	
Drying Methods.....	117	Plate Locations and Film Locations.....	38
Generator - Inspect.....	117	Emissions Certification Film.....	38
Cleaning (Assembled Generators).....	118	Serial Number Plate (1)	38
Cleaning (Disassembled Generators).....	118	Product Description	36
Generator Isolating for Maintenance	33	C6.6 Generator Set Engine.....	36
Generator Lead Connections	71	Generator.....	37
Connection Diagrams	72	Product Identification Information.....	38
Grounding the Frame.....	72	Product Information Section	35
Neutral Connections	72	Product Lifting.....	41
Single Units.....	72	Engine Lifting with a Fuel Tank	41
Generator Load - Check.....	119	Lifting of Generator Sets.....	41
Generator Operation.....	51	Product Storage.....	42
Block Loading	51	Generator Storage	42
Excitation System	52	R	
Generator Options	52	Reference Information Section.....	131
Loading of the Generator	51	Reference Material	137
Power Factor.....	52	Coolants.....	137
Standby Electric Sets.....	52	Emissions Warranty	137
Generator Set - Test	119	Fuels	137
Generator Winding Insulation - Test	120	Lubricants	137
Exciter Armature (Rotor L2).....	122	Miscellaneous	137
Exciter Field (Stator L1)	121	Reference Materials	135
Main Armature (Stator L4)	121	Refill Capacities.....	81
H		Coolant.....	81
Hoses and Clamps - Inspect/Replace	122	Engine Oil	81
Replace the Hoses and the Clamps	122	Rotating Rectifier - Check.....	125
I		Rotating Rectifier - Inspect/Test.....	126
Important Safety Information	2	S	
L		Safety Messages.....	6
Lifting and Storage	41	Safety Section	6
M		Starting Motor - Inspect	126
Maintenance Interval Schedule (Prime Power Generator Sets).....	93	Starting the Engine	48
		Starting with Jump Start Cables	48
		Stopping the Engine	80

System Pressure Release	90
Coolant System.....	90
Engine Oil	90
Fuel System.....	90

T

Table of Contents.....	3
Turbocharger - Inspect	126
Inspecting.....	127
Removal and Installation.....	127

V

Voltage Regulators	58
Excitation Systems.....	67
R230 Adjustments.....	59
R438 and R448 Adjustment for Maximum Excitation.....	63
R438 and R448 Adjustments	61
R450 Automatic Voltage Regulator (AVR) (If Equipped).....	65
Set-up	69
Voltage Regulators (R450 Automatic Voltage Regulator (AVR) (If Equipped)).....	52, 54
Excitation Systems.....	55
Set-up	56

W

Walk-Around Inspection	127
High Pressure Fuel Lines.....	128
Inspect the Engine for Leaks and for Loose Connections	127
Inspect the Tube of the Crankcase Breather ...	127
Warranty Information	130
Warranty Section	130
Water Pump - Inspect.....	129
Welding on Engines with Electronic Controls	90

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: _____

