CATERPILLAR®

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Owner's Manual

SR4 HV Generators

Table of Contents

Foreword

This manual contains operation instructions and maintenance information for SR4 HV generators.

The manual should be considered a reference for the new operator and a refresher for the experienced individual. It is important to read, study and keep this manual close at hand.

Illustrations guide the operator through the correct procedures of checking, starting, operating and stopping the engine driven generator.

The maintenance section of the publication is a guide to equipment care and contains illustrated step-by-step instructions.

Some photographs in this publication may show details or attachments that may be different from your equipment. In addition, some guards and covers may have been removed for illustrative purposes.

Continuing improvement and advancement of product design may have resulted in changes to your engine driven generator which may not be covered in this publication.

Whenever a question regarding your generator or this publication arises, please consult your Caterpillar dealer for the latest available information.

Generator Identification

Every Caterpillar generator has a serial number stamped on the nameplate and on the frame. The plate is located on the left side of the generator. The number identifies the generator type, capacity, and nominal voltage of the generator.

Ordering Parts

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Their parts stocks are up to date and include all parts normally required to protect your investment in Caterpillar equipment.

When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the equipment for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

Important Safety Information

Most accidents involving 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 other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

Warning Signs and Labels

There are several specific safety signs on your generator. Their exact location and description of the hazard are reviewed in this section. Please take the time to familiarize yourself with these safety signs.

Make sure that you can read all safety signs. Clean and replace these if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvent, gasoline, etc.

You must replace a label if it is damaged, missing, or cannot be read. If a label is on a part that is replaced, make certain that a new label is attached to the replacement part. See your Caterpillar dealer for new labels.

WARNING: Do not operate this equipment unless you have read and understand the instructions in the Operation Guide. Improper operation is dangerous and could result in injury or death. Contact any Caterpillar dealer for a replacement guide. Proper operation is your responsibility.

⚠ WARNING

If this generator is to be connected to a utility electrical distribution system, it must be isolated from the distribution system by means of;

A. Opening the main switch in the case of a portable generator temporarily connected to the system or,

B. A double throw (transfer) switch in the case of a permanent connection to the system.

Failure to do so could result in personal injury or death due to electrical shock.

The above warning does not apply when a generator and utility distribution system are designed and approved by the utility to run in parallel.

General

Do not allow unauthorized or untrained personnel on or near equipment.

Do not wear loose clothing or jewelry while working around equipment.

Stop the engine before making adjustments or repairs to the engine or generator unless otherwise specified.

Attach a "DO NOT OPERATE" tag on the start switch, start button, air start knob and/or remote starting system, before servicing the engine or generator. These tags, Form SEHS7332, are available from your Caterpillar dealer.

Be sure the remote starting system is inoperative on the equipment being serviced.

Disconnect and tape the battery ground lead or put the automatic start-stop switch to the STOP position before working on the equipment to prevent accidental starting.

To prevent injury, install guards over all exposed drive shafts, pulleys and any application with exposed rotating parts.

Always use tools that are in good condition and be sure you understand how to use them before performing any service work. Remove all tools, electrical cords and any other loose items from the engine before starting.

Engine speeds, temperatures and load are the best indications of performance. Rely on your instruments, record and compare readings to detect developing abnormalities.

Wear a hard hat, face shield, clothing, shoes, respirator or other protective items when necessary.

When using pressure air, always use approved safety equipment.

If you are working inside an enclosed engine room with engine running, make certain to wear ear protective devices to prevent hearing damage.

Climbing

Some engines in permanent installations may require the use of climbing equipment to provide access for normal routine maintenance. It is the responsibility of the owner and/or user to provide safe access which conforms to SAE J185 and/or local building codes.

Keep all climbing equipment, ladders, stairs, platforms clean and free of slippery surfaces and tripping hazards.

Secure the climbing equipment so it will not move or fall while in use.

Never jump from an elevated platform, ladder, or stairs.

Maintain all climbing equipment so it is in safe operating condition.

Fire or Explosion Prevention

Be sure the engine room is properly ventilated.

Keep the engine room and floor area clean.

Observe NO SMOKING signs. Do not smoke around batteries. Hydrogen gas generated by charging batteries is explosive. Keep batteries in a well ventilated area.

Never store flammable liquids near the engine.

Store oily rags in metal covered containers.

Always have a fire extinguisher on hand and know how to use it. Inspect and have it serviced as recommended on its instruction plate or label.

Do not use carbon tetrachloride fire extinguishers. Fumes are toxic and the liquid has a deteriorating effect on insulation.

Electrical Shock Prevention

All electrical equipment must be grounded according to local building codes.

Always disconnect the engine starter circuit when working on the generator.

Be sure all electrical power is disconnected from electrical equipment being serviced.

Do not work on electrically "hot" equipment.

Do not touch the heat sink on the generator regulator when the generator is running. It is electrically "hot."

Check all connections periodically for tightness and insulation.

Insulate all connections and disconnected wires.

Keep all electrical equipment clean and dry.

Burn Prevention

Do not touch any part of an operating generator. Allow the generator to cool before any repairs are performed.

Preparing to Start

Be sure all protective guards and covers are installed if an engine must be started to make adjustments or checks. To help prevent an accident caused by parts in rotation, work carefully around them.

Starting

Do not start the engine or move any of the controls if there is a warning tag attached to the controls.

Make sure no one is working on, or close to the engine or engine driven components, before starting it.

Start and operate the engine in a well ventilated area. If it is necessary to operate in a closed area, vent the exhaust to the outside.

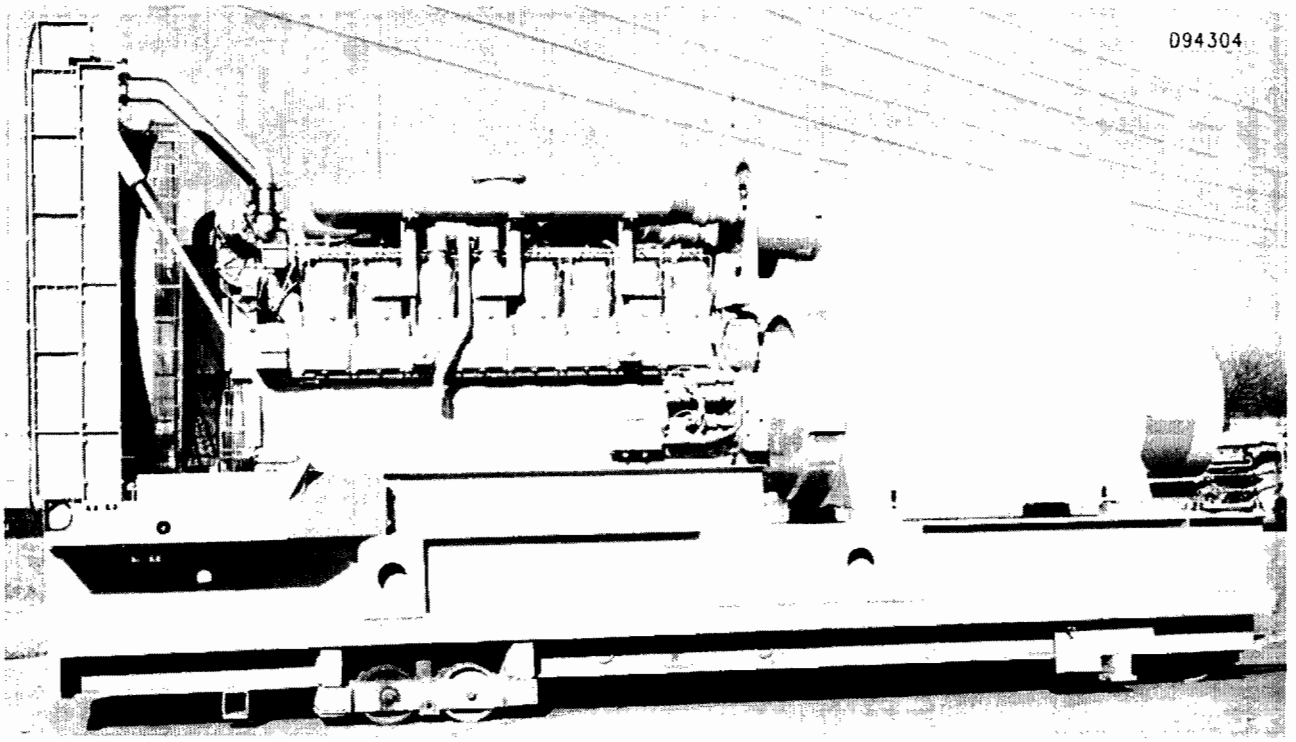
Stopping

Only use the Emergency Stop button in an emergency situation. Do NOT start the engine until the problem necessitating the emergency stop has been located and corrected.

Upon initial startup and overhaul, be prepared to stop the engine should an overspeed occur. This may be accomplished by cutting the fuel and air supply to the engine.

Model View

SR4 HV Generator



SR4 HV Package Generator Set

Glossary

Actuate – To put into motion.

Anode – The positive end of a diode or rectifier.

Blocking Rectifier – Permits direct current (DC) flow in only one direction.

Bolted – Use of a bolt to hold to or more parts together.

Bridge – A circuit used to measure small quantities of current, voltage or resistance.

Bridge Rectifier – A circuit used to change alternating current (AC) to direct current (DC).

Build-up – A gradual increase (Voltage).

Cathode – The negative end of a diode or rectifier.

Capacitance – The ability to store an electrical charge.

Capacitor – A device which will store an electrical charge.

Circuit Breaker – An automatic switch used to open a circuit.

Circulating Current – The flow of current between two or more generators working in parallel (or working in parallel with a utility line).

Conduct – To allow the flow of current.

Continuity – A circuit which provides a path for current flow.

Control – Any device or circuit which controls another device.

Direct Current – (DC) controller reactor: gives resistance to current flow to the rectifier according to the voltage droop setting.

Damping – To smooth out.

De-energize – To stop current from going to a component.

Distribution Winding – An arrangement of winding, in groups which are in several slots, that go from one end of the core to the other.

Droop – Decrease.

Excitation – Controlled direct current (DC) used to make a magnetic field.

Energize – To activate or turn on.

Electrostatic Charges – Electricity caused by induced voltage and stored charge.

Exciter – Supplies direct current (DC) to the field windings of the generator.

Field – Magnetic lines of force around a conductor caused by current flow in the conductor.

Field Windings – Many turns of wire wrapped around an iron core. When a direct current (DC) flows through the field windings, it causes a magnetic field (like that of a bar magnet).

Flashing – A process of putting direct current (DC) from an outside source into the field windings to cause the generator to have an output voltage.

Flux – Magnetic lines of force.

Full Wave Rectifier – Changes both the positive and negative voltage of an alternating current (AC) to direct current (DC).

Gain – The ratio of the input magnitude to the output magnitude.

Gate – An electronic part of a controlled rectifier (thyristor).

Generate – To make electricity.

Grounded – To make a connection to ground or to a component which is connected to ground.

Humidity – The water content in the air.

Impedance – The resistance of a circuit to alternating current.

Impulse Modulated – To vary the amplitude, frequency or phase of a wave by impressing one wave on another wave of constant properties.

Induce (to) – To transfer power from one device to another by means of a magnetic or electric field.

Induced – Power transferred via electromagnetic fields.

Interference – An unwanted mixture of signals, usually associated with electrical noise.

Instrumentation – Group of instruments for measuring a system function.

Insulated – Covered with a nonconductive material.

Lead – Wire.

Line Voltage – The output voltage of the generator measured between the generator leads (phases).

Lock In – When a contact closes to keep a device energized until reset.

Lock Out – When a contact opens to keep a device de energized.

Magnetic – Having the characteristics of a magnet.

Magnification – Enlargement.

Module – An assembly of electronic components and circuits.

Moisture – Water.

Oscillation – A flow of electricity which periodically changes direction or magnitude.

Phase Winding – Group of generator stator coils in which electric power for one phase of the load is induced.

PM – Permanent magnet.

PMPE – Permanent magnet pilot exciter.

Polarity – The positive or negative characteristics of two poles.

Pulsating – Characteristic of current similar to mechanical vibration.

Radio Suppression – Reduce the amplitude of radio frequency interference.

Reciprocating – Movement in a straight line first one direction and then the other.

Rectifier – A diode device used for converting alternating current (AC) into pulsating direct current (DC).

Rotating Rectifier – A rectifier which mounts to a plate on the generator shaft and rotates with it.

Regenerative Power – Power that works against the primary power.

Reset – To return a switch or circuit to a ready condition.

Residual Magnetism – Slight magnetism remaining in a device after the removal of excitation.

RFA – Rotating field assembly.

Rotor – The windings of a generator that rotate.

Saturable Reactor – Acts like a valve, as load changes a valve opens or closes to give more or less current to the output.

Saturated – Magnetized to the point where a large increase in current will give only a small increase in magnetic force.

SCR – Silicone Controlled Rectifier (semiconductor).

SE – Self excited. Uses a small part of generator output to provide excitation current to the generator and uses residual magnetic field for start-up.

Semiconductor – Components such as transistors, diodes, thyristors, etc having electrical characteristics between a conductor and insulation.

Series Boost – An attachment which allows the generator output to continue for a short time during a line failure This allows the circuit breakers to trip in sequence.

Short – Any electrical connection between two or more components that is not desired.

Shutdown – When the engine is stopped either manually or automatically.

Simultaneous – At the same time.

Solid-state – An electrical component with no moving parts.

Stator – The windings of a generator that do not rotate (are stationary).

Surge – A sudden increase in voltage or current.

Tap – Connection at some midpoint of a circuit to get power from the circuit.

Transfer - To move from one point to another or to convert from one state to another.

Transient Peak Voltage - A high voltage condition lasting for a short time.

Turn-on - To start or activate.

Varistor - A device whose resistance decreases as the voltage is increased.

Voltage Droop Resistor - Variable resistor for control of voltage change when generator is paralleled with another generator or utility
voltage level rheostat: Gives a range of control for adjusting voltage output level.

Voltage Spike - Brief high voltage.

Windings - Layers of wire on a core.

Wiring - The wires of a circuit.

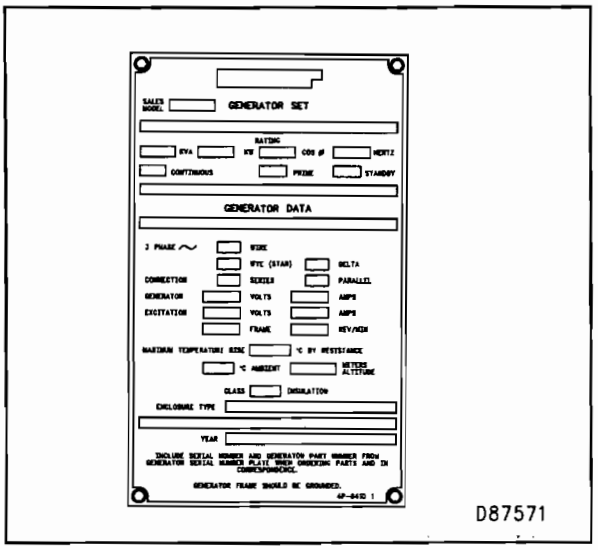
Wound - Circled.

General Information

Generator Identification

The generator identification and information plate is located on the left side of the generator.

When service is required, use the information given on these plates. The information contains the serial number, model number and the generator set (engine and generator) rating. All pertinent generator data is also included on the plate to provide the necessary information to order parts.



Generator Construction

The SR4 HV Generators described in this manual are brushless revolving field type with two bearing close coupled construction. The generators are manufactured in many sizes and ratings with various optional features such as enclosures, terminal boxes, and controls. Generator excitation current is supplied from a direct connected brushless rotating DC exciter.

The generators may be supplied with various controls designed to provide the user's exact power needs. Controls are normally shipped loose, but may be contained in separate wall mounted cubicles, in free standing control cubicles, or in a control box mounted to the generator frame if so requested by the customer.

Generators are supplied with permanent magnet (PM) generators to provide power to the regulator under short circuit conditions, or field flashing (in case generator or brushless exciter loses residual magnetism) and to reduce electromagnetic interference.

Generators are supplied with a mounted terminal box which is designed to accommodate the connections to the load. A separate compartment within this box accommodates accessory connections to RTD's, space heaters, exciter and PMG leads.

The basic generator includes frame and stator, rotor, enclosures and brushless exciter with permanent magnet generator mounted on the shaft to provide power to the voltage regulator.

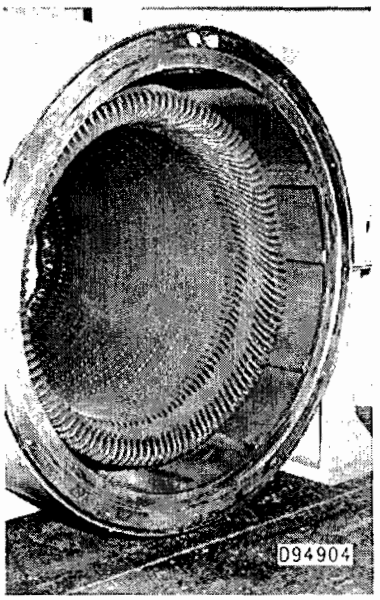
The generator frame is fabricated of heavy steel members welded to the endbell or bearing bracket pilot rings. The feet are welded to the frame to simplify installation and alignment with the prime mover. Eye bolts are fastened to the frame to enable lifting of the generator with an overhead hoist.

Stator Construction

The generator stator has fabricated bar and plate steel construction. It is machined to tolerance to provide alignment with the rotor. Non-oriented, silicon steel laminations with core plated insulation on both sides are used to reduce core loss and temperature rise in the machine and to improve efficiency. The stacked laminations are skewed to reduce harmonic distortion caused by the slots and are secured under pressure with clamping plates without welding on the laminations.

Winding overhang on the stator is insulated between phases. Surge ropes are used to support the winding overhang. The windings are braced to withstand single-phase and three-phase fault conditions.

Windings are inserted into the stator slots and the entire assembly is vacuum pressure impregnated with 100 percent epoxy resin. Stator leads terminate in standard connection lug or strap copper terminals for ease of connection to the load.



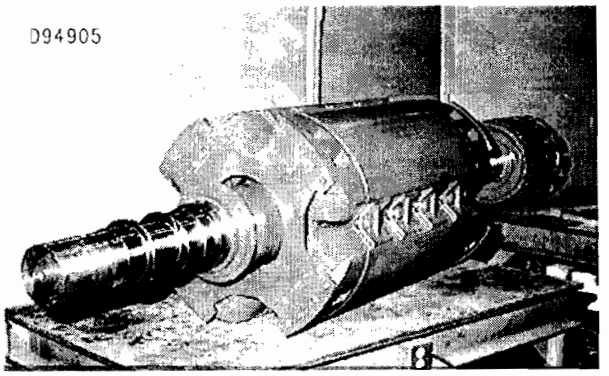
Generator Stator

Rotor Construction

The generator rotor consists of the shaft, spider, fans, field poles and windings.

The shaft is machined from high strength steel stock or forging. Mechanical center line is scribed on the drive end for units with floating bearings for proper alignment.

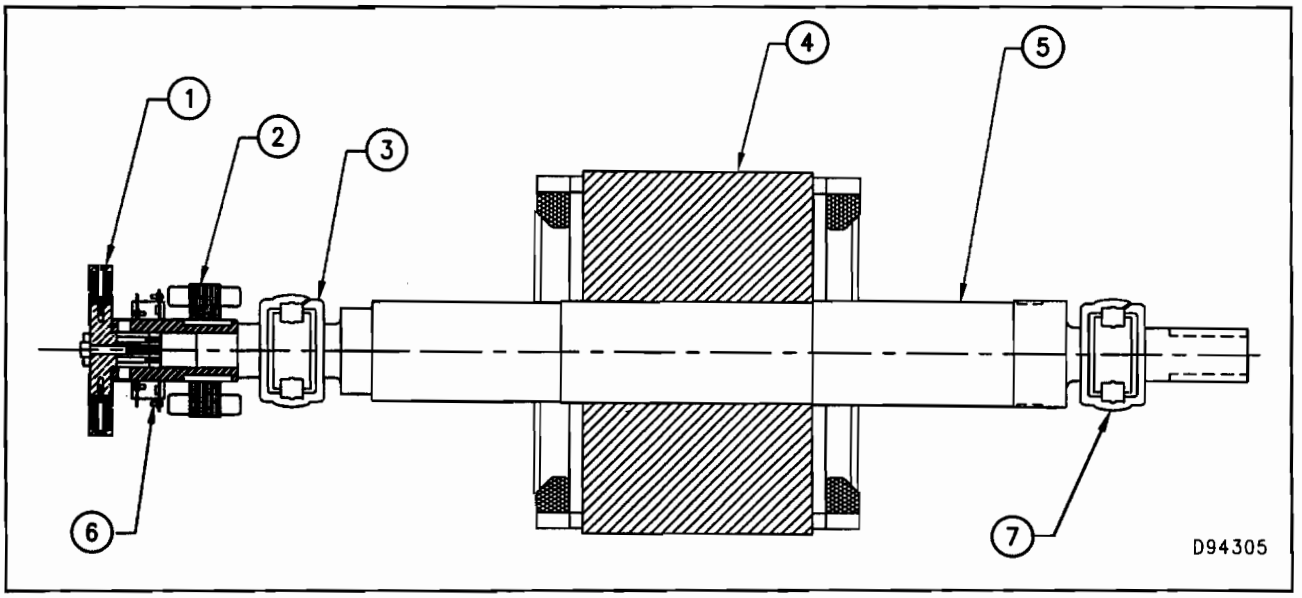
The spider is laminated and is an integral part of the rotor pole.



Generator Rotor

The poles are individually punched and are made of high strength laminations which are held together with rivets or bolts. The field windings use insulated copper wire which are layer wound on the laminated poles. Damper bars are inserted below the surface of the pole face and are welded/brazed to a continuous shorting ring or plate. The entire pole assembly is vacuum pressure impregnated with 100 percent epoxy resin. The rotor assembly is shrunk and keyed on the shaft. The rotor is dynamically balanced to specific limits to assure compliance to NEMA vibration limits and long bearing life. A fan is dynamically balanced and mounted on the shaft at the drive end.

Rotating Field Assembly (RFA)



Rotating Field Assembly (RFA) Components - PMPE Type

(1) Pilot exciter field - permanent magnet (PM).
(2) Exciter armature (rotor).
(3) Bearing (ODE).
(4) Main field (rotor).
(5) Rotor shaft.
(6) Rectifiers.
(7) Bearing (DE).

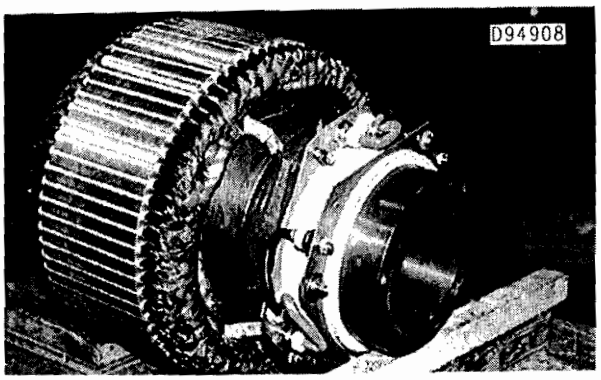
The RFA components attach to the rotor shaft (5), which is supported by the opposite drive end (ODE) bearing (3) and the drive end (DE) bearing (7).

Brushless Exciter

The brushless exciter is an inverted synchronous AC generator with the field winding stationary and three phase armature windings rotating with the generator rotor. The AC output is rectified through a full wave semiconductor bridge.

The exciter armature is built of laminations and riveted under pressure. Three phase windings are inserted in the slots and the entire assembly is vacuum pressure impregnated with 100 percent epoxy resin. The exciter armature is pressed on a tubing and keyed in position.

A three phase full wave rectifier made of three forward and three reverse diodes are mounted on two separate rings which act as negative and positive polarity heat sinks. The rectifier assembly is keyed on the same tubing as the exciter armature. Both exciter armature and rectifier assembly are dynamically balanced. The sleeve tubing is pressed and keyed on the main rotor shaft.



Brushless Excitation System

The exciter stator is built of laminations stacked under pressure and welded. Field windings are inserted and the entire assembly is vacuum pressure impregnated with 100 percent epoxy resin. The stator is mounted on the bearing bracket (end bell).

Permanent Magnet Generator

The permanent magnet (PM) generator provides power to the voltage regulator under all operating conditions regardless of the main generator output conditions. The PM is a single phase AC generator with rotating permanent magnets providing excitation which rotates on the same shaft as the brushless exciter and alternator rotor. The stator windings are Vacuum Pressure Impregnated (VPI) with epoxy resin. The PM stator electrically connects to the voltage regulator and has the ability to provide a minimum 250 percent of rated three-phase short circuit capability for ten seconds at the alternator terminals for 50 Hz applications and 300 percent of rated three-phase short circuit capability for ten seconds at the alternator terminals for 60 Hz applications.

Enclosures

Steel wrappers enclose the generator frame. A removable sheet metal covers the entire exciter assembly. Ambient air is drawn into the machine through openings at the exciter end and exhausted through screened openings enclosing the blower assembly at the drive end. Enclosures are open drip proof as standard, and can be provided with air filters when such an option is specified.

Bearings

The bearings are "regreasable" design. The bearing housings are provided with grease fittings for easy lubrication.

Heavy duty ball bearings are used on 2500 frames.

Split roller bearings are used on 2900 frames.

Space Heaters

All SR4 HV generators are provided with space heaters, installed for operation in high humidity conditions. For more information on space heaters, refer to the Generator Maintenance section of this manual.

Embedded Temperature Detectors

SR4 HV generators are provided with 100 Ohm platinum resistance temperature detectors (RTD). The detectors are installed in the slots of the main armature (stator). The detectors are used with customer provided equipment to measure and/or monitor the main armature winding temperature.

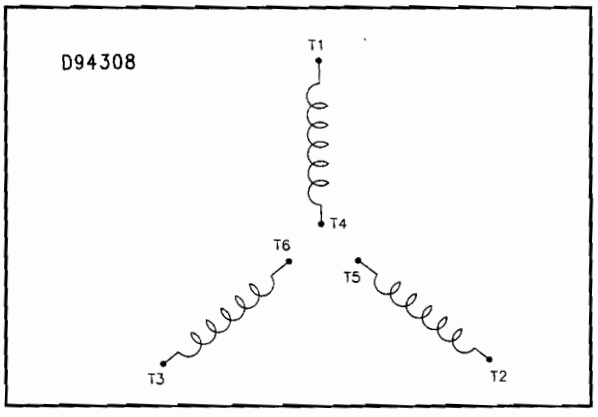
Bearing Temperature Detectors

100 Ohm platinum bearing temperature detectors are provided as standard on all SR4 HV generators. Used with customer provided equipment to measure and/or monitor the bearing temperature, bearing temperature detectors may help to prevent premature bearing failure.

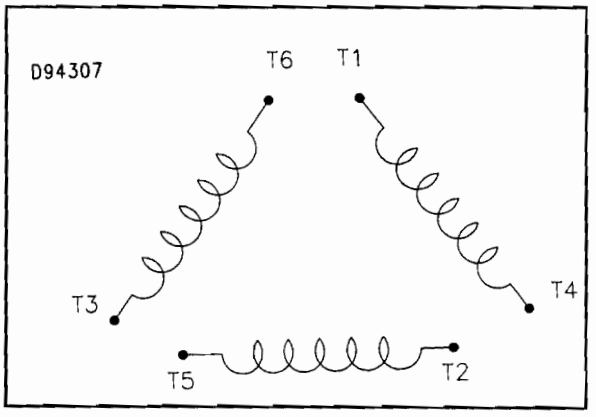
Generator Lead Connections

Lead numbering marked according to the following diagrams. The standard diagram and the terminal connections are as shown below.

Numbering is clockwise from the top and from the outside inward.



6 Lead Wye Configuration



6 Lead Delta Configuration

Grounding The Frame

In any generator set installation the frame of the generator must be positively connected to an earth ground. This connection is the last one to be removed. If the generator set is on flexible or resilient pads, the ground connection must be flexible 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, and are frequent sources of radio frequency interference. Silver soldered, bolted joints are electrically and mechanically sound.

Neutral Connection

"Y" – connected generators usually have the neutral grounded when the generator is installed unless definite measures are taken to prevent grounds on the load side. The grounding of the neutral is to prevent damage from occurring to the load side equipment.

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

There are some instances in which it is undesirable to ground the neutral wire. In these applications where definite measures (ground fault protective circuits) have been taken to detect grounds to the phases leads, an ungrounded generator neutral lead is acceptable.

Ground fault protection requires that the entire group of distribution be studied and treated as a system. The owner should engage a certified and registered consultant if a new distribution system is being developed, or if an existing system is to be modified for ground fault protection.

Single Units

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

In applications where definite measures are taken to prevent grounds to load leads, an ungrounded neutral can be used. Be certain to check with your local wiring codes.

Multiple Units

Operation of multiple generators in parallel, having neutrals grounded, may result in circulating currents though the neutral connections. A slightly higher temperature rise and nuisance tripping of any ground fault devices may occur. One possible solution is to match the zero sequence reactance and third harmonic voltage of all the generators running in parallel. Another possible solution is to install a neutral grounding reactor or resistor in the ground circuit to limit the flow of circulating currents to an acceptable level and avoid nuisance tripping. Many other solutions are possible. A consultant may be able to provide you with the best possible solution.

Parallel To Utility

When a Wye connected generator is to operate in parallel with a utility system (infinite bus), and the secondary of the utility system step-down transformer is also a Wye connection, grounding of both Wye neutrals may result in circulating currents through the neutrals. In addition, the coordination of ground fault protection requires an entire system study. The study should be done by a certified and registered consultant who is familiar with generator systems. Only such an individual can accurately determine the proper grounding method to be used.

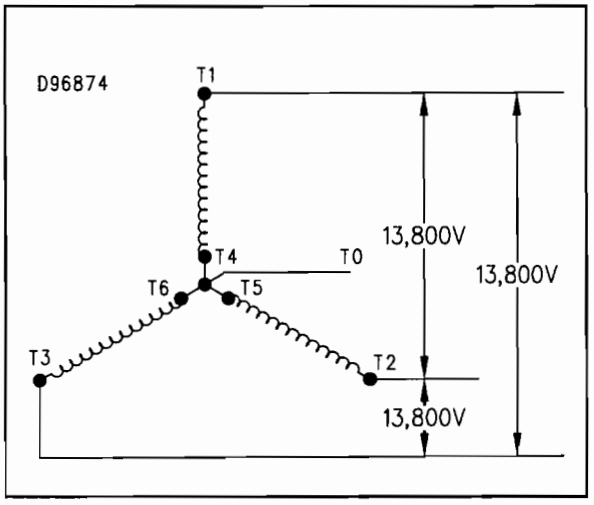
Voltage Connections

Three Phase

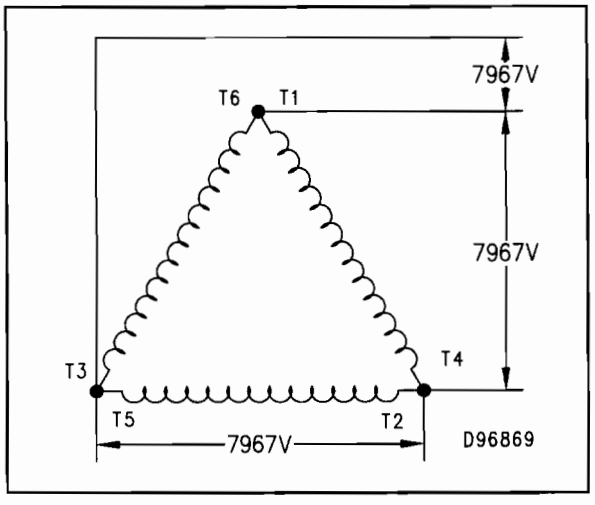
The connections for wye and delta are given in the following diagrams.

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

When using Delta configuration and the generator and the generator winding pitch is not ⅔, there will be circulating currents within the Delta and therefore, a derate will be required.



Typical Wye Connection (60 Hz 6 Lead)



Typical Delta Connection (60 Hz 6 Lead)

Single Phase Current From a Three-Phase Generator

Three phase and single phase current can be taken simultaneously from a generator connected for three phase service. Connecting the load to any two of the three phase leads in both Wye and Delta configurations will provide single phase voltage at the same voltage as three phase power. Connecting the load to any phase lead and neutral of the Wye configuration will produce voltage at 58% of three phase voltage.

NOTE: Refer to "Generator Operation" section of this manual for allowable single phase loading unbalance.

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

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

Generator Performance

Generator Loading

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, allowing the engine to work at its rated capacity. An electrical unbalance can result in an electrical overload and overheating if one phase current exceeds the nameplate amperage.

Block Loading

Block Loading is the instantaneous application of an electrical load to a generator set. This load may be anywhere from a moderate percentage of the rated load up to the rated load itself.

The block loading capability of a generator set depends upon engine transient response, voltage regulator response and type, altitude of operation, type of load, and the amount of load at the time the block load is applied.

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

Power Factor

Power factor may be thought of as the efficiency of the load - the ratio of apparent power to total power. Power factor is expressed as a decimal and denotes that portion of current supplied to a system doing useful work. The portion of current not doing useful work is absorbed in maintaining the magnetic field in motors. This current, although it is called the reactive load, does not require engine power to maintain it.

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

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

NOTE: Caterpillar SR4 HV Generators are designed at 0.8 power factor, unless otherwise specified.

Low Idle Adjustment

Electric sets normally have a higher low idle setting than do industrial engines. Low idle will be approximately 2/3 the full speed of 60 Hz units (4/5 full load speed of 50 Hz units).

On electric sets with some Woodward governors and Caterpillar electronic governors, there is no low idle stop. On electric sets with mechanical governors and natural gas electric sets, the low idle is set at the factory, and should only be adjusted by your Caterpillar dealer if adjustment ifs required.

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

Installation

Receiving Inspection

Two-bearing generators are shipped completely assembled.

If the generator is received during cold weather, allow the unit to reach room temperature before removing the protective packing material. This will reduce the condensation of moisture on cold surfaces and prevent early failures due to wet windings and insulating materials.

Unpacking And Storage

Moving Generator

Unpack the equipment with care to avoid scratching painted surfaces. Move the unit to the mounting location either by attaching an overhead hoist to the eye bolts installed on the generator frame or by lifting the generator from underneath the skid with a forklift. Hoist and hoist cables should have a rating of not less than the weight of the generator. When moving unit with forklift, make certain it is completely onto and balanced on the forklift tines.

⚠ WARNING

Apply lifting force to structural points specifically provided for that purpose. DO NOT use enclosure lifting holes to lift the whole unit. Use lifting means adequate for the weight. Failure to observe these Instructions can result In Injuries to personnel and damage to the generator.

Storage

Short Term Storage

If the generator is not to be installed in its operating location immediately, it is recommended that it be stored in a clean dry area not affected by rapid changes in temperature and humidity. Space heaters should be energized to keep condensation from the windings. All accessory equipment supplied with the unit should be stored with the generator, and the combined unit covered with durable cover for protection against dust, dirt, moisture and other airborne contaminants.

Long Term Storage

Units which are to be in storage for a period longer than six months should be prepared for storage as follows:

1. Install desiccant bags in the exciter cover and inside the fan screen.

2. Vacuum seal the unit in a covering of plastic or other material designed for that purpose.

3. Adequately tag the generator to insure that preservative greases and desiccant bags are removed before the unit is placed in operation.

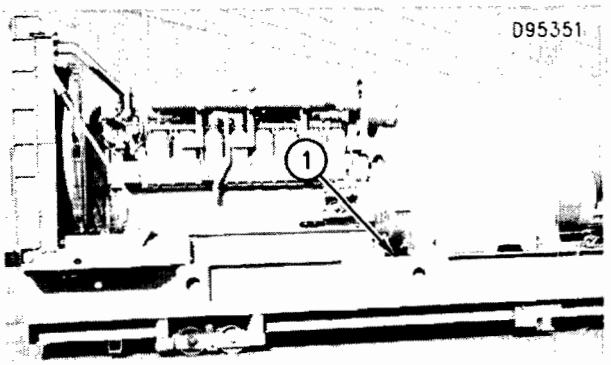
Bearing Inspection

Grease used in ball bearing generators is subject to time deterioration. If the generator is stored for one year or longer, it is recommended that new ball bearings be installed and greased to the proper level before putting into operation. If inspection indicates that bearings are free of rust or corrosion, and no noise or excessive vibration appear on start-up, replacement is not necessary.

Location

The location of the generator must comply with all local and special industrial regulations. Attempt to locate the generator in clean, dry, well ventilated area, easily accessible for inspection and maintenance. Air inlet and discharge openings must not be obstructed tc the flow of coolant air. If the location is subject to harsh environmental conditions, the generator can be field modified to incorporate dust filters and space heaters. In addition it is recommended that a more rigid periodic maintenance be established.

Two Bearing Close Coupled Alignment

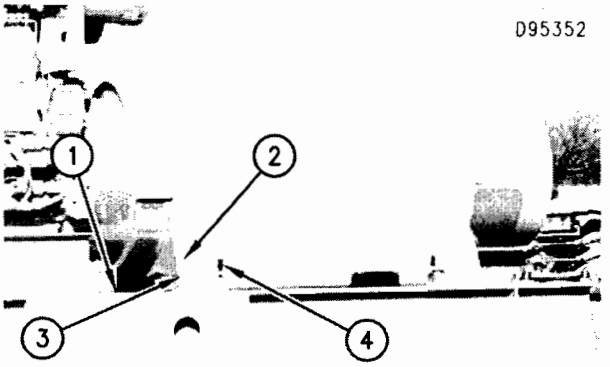


1. If base (1) of the generator set is fastened to a foundation, loosen all bolts which fasten the engine and generator supports to the base.

2. Check to be sure that there is clearance between the bolts and the bolt holes in the base and between the engine and generator supports at all locations.

3. Check the clearance between the base and the foundation at all mounting locations. Use shims as necessary to prevent deflection of the base as the base-to-foundation bolts are tightened. When there is no deflection in the base, tighten all base-to-foundation bolts to the final torque.

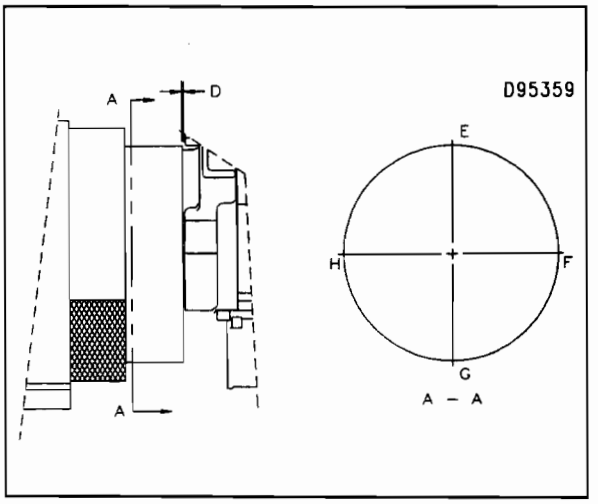
4. Loosen all bolts which fasten the generator to the flywheel housing. Tighten every other bolt to the final torque.



5. At the engine and generator support locations, check the clearance between the mating surfaces. Be sure to check the clearance over the entire length of the supports. This is especially important on generators with long supports (2). Install shims (3) as necessary until all of the mounting surfaces are flat and parallel.

6. Tighten all bolts (4) which fasten the engine and generator supports onto the base to one-half of their final torque.

7. Loosen all bolts.

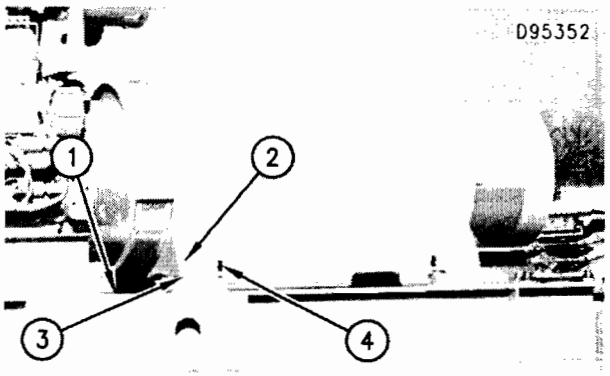


8. Check the gap (D) between the generator and the flywheel housing at locations (E), (F), (G) and (H). Location (E) must always be at the top. Make a record of each measurement.

If the gaps at locations (G) and (E) are less than .026 mm (.001 in) or more than 0.13 mm (.005 in), install an equal amount of shims under each generator support as necessary.

After a correction has been made to shim thickness, tighten the generator support bolts to one-half of their final torque. Check the gaps at locations (E) and (G). Use this procedure again and again until the gap measurements are 0.13 mm (.005 in) or less, but no less than 0.026 mm (.001 in).

If the gaps at locations (F) and (H) are more than 0.13 mm (.005 in) or less than .026 mm (.001 in), loosen the bolts in the generator supports and move the rear of the generator to the appropriate side. Do this procedure again and again until the gap measurements are 0.13 mm (.005 in) or less, but no less than 0.026 mm (.001 in). Tighten bolts to their final torque.



9. Install a dial indicator on the base (1) next to the indicator tip touching support (2) next to support mounting bolt (4). Tighten this bolt to the final torque and at the same time check the indicator. If there is more than .13 mm (.005 in) of indicator movement, the shim thickness is incorrect under the bolt. Install shims as necessary. Do this procedure again and again until all engine and generator support mounting bolts have been tightened to their final torque and support deflection is within its specification.

Post-Installation Alignment

- Check the alignment after the generator set has been in operation about 40 hours. Correct alignment if not satisfactory (refer to preceding paragraphs).

Electrical Measurements

In the event the generator was subjected to rapid changes in temperature or freezing or wet climate during shipment or storage, it is recommended that the insulation resistance of each winding be measured.

NOTICE

These tests should be conducted before any power and control connections are made.

Refer to the "Generator Maintenance" section of this manual for insulation measurements of the following:

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

Protective Devices

The output to the load of the generator should always be protected with an overload protection device such as a circuit breaker or fuses. Fuses should be sized using the lowest possible current rating above the full load current rating. 115 percent of rated current is commonly recommended. Size fuses or circuit breaker in accordance with NEMA, IEC, and Local Electrical Codes.

Starting The Engine

Electric Starting

NOTE: For more information on engine operation see SEBU6916, Operation & Maintenance Manual for 3500B Generator Set Engines & 3500 Generator Set Engines With EUI Option.

NOTE: Startability will be improved at temperatures below 0°C (32°F) by the use of a starting aid. A jacket water (coolant) heater or other means can be used to heat the engine.

NOTICE

Do not crank the engine for more than 30 seconds. allow the starting motor to cool for two minutes before cranking again.

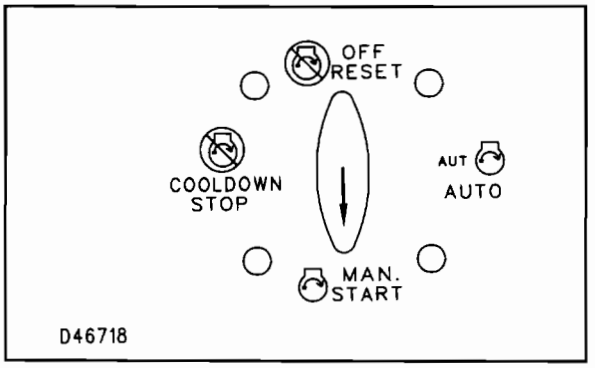
The crank cycle time and the total number of crank cycles are programmable. The crank cycle time is the amount of time that the starting motor will be energized and allowed to cool down between cycles. The total number of crank cycles is the number of cycles that are performed. If the engine does not start within this number of cycles, electrical power to the ECM will be disconnected. This disables the fuel injection system. The OVERCRANK indicator on the instrument panel or on the control panel will illuminate in order to warn of an overcrank.

Automatic Starting

If the Engine Control Switch (ECS) is in the AUTOMATIC position, the engine will automatically start when a remote start/stop contact is closed. The engine will accelerate to rated speed within a programmed warm-up cycle when the oil pressure sensors indicate there is sufficient oil pressure for rated speed.

Manual Starting

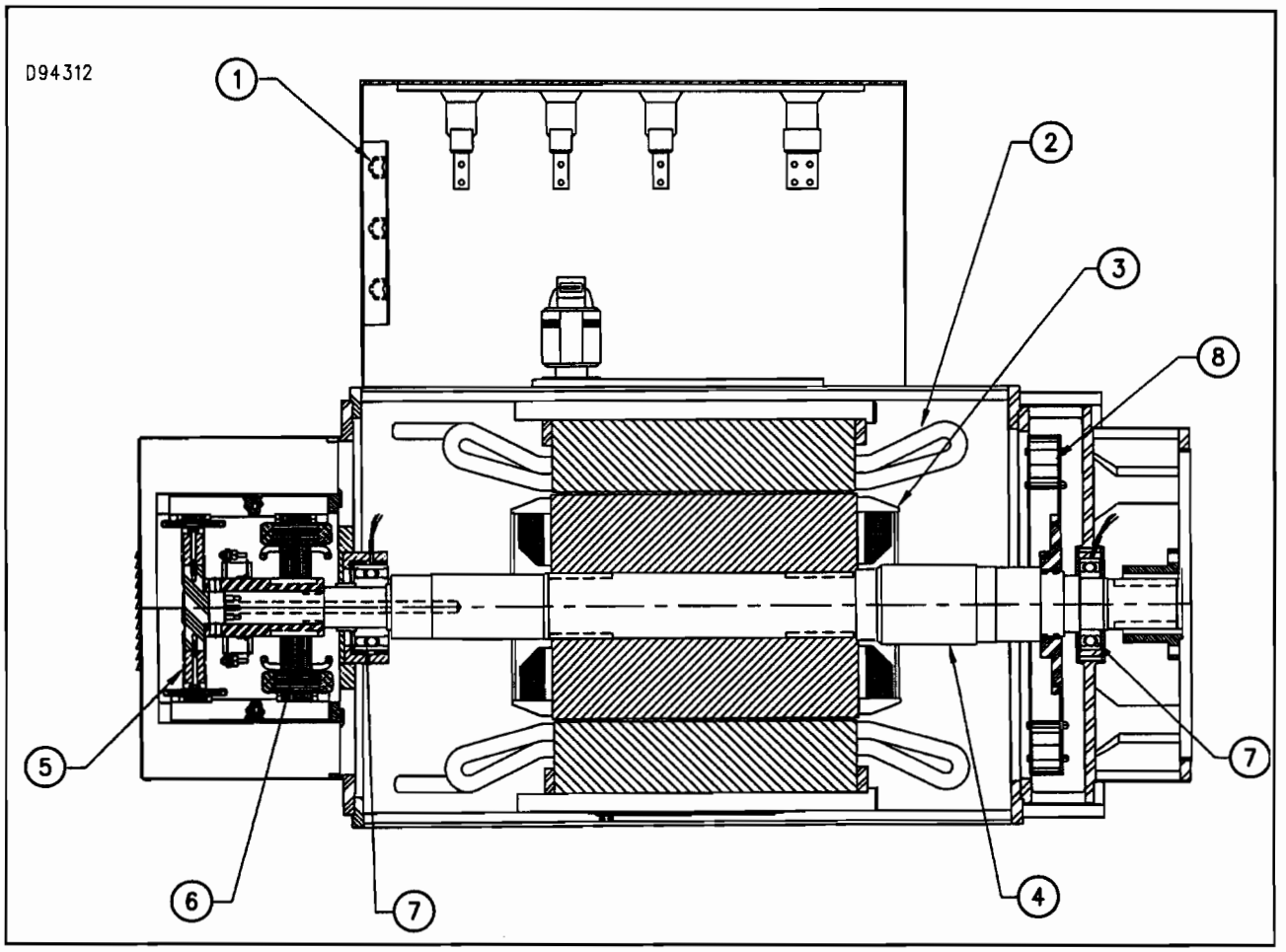
1. Perform all prestart checks.
2. Open the main electrical circuit breaker.



Engine Control Switch (ECS), shown at the Manual Start position.

3. Turn the ECS to Manual Start position in order to start the engine. The ECM will allow the engine to be run at rated speed when the oil pressure sensors indicate sufficient pressure for rated speed.

Generator Operation

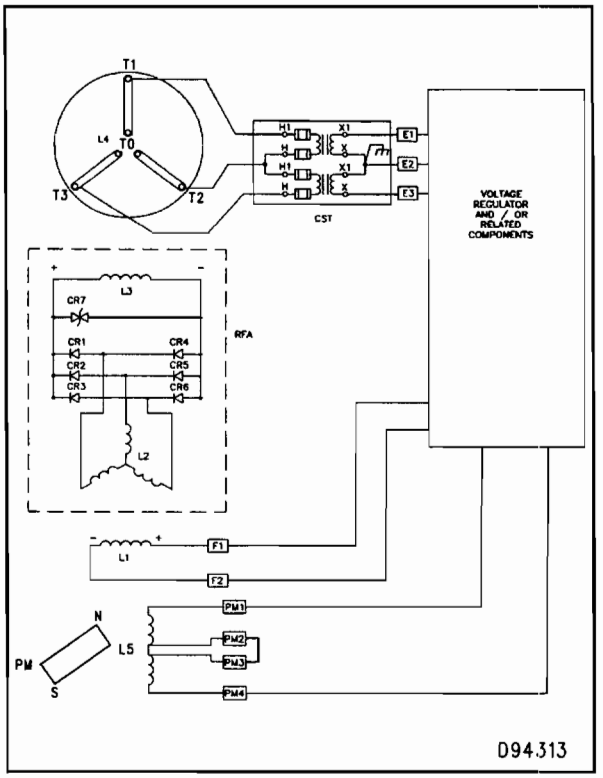


SR4 HV Generator

(1) Generator terminal strip.
(2) Main armature (stator).
(3) Main field (rotor).
(4) Rotor shaft.
(5) Permanent magnet pilot exciter (PMPE).
(6) Exciter.
(7) Bearing.
(8) Fan.

An engine supplies the power to turn the rotor shaft (4). The armature of exciter (6) and main field (3) attach to the rotor shaft (4). As the rotor shaft (4) turns, exciter (6) and the rectifier components generate DC current. This DC current is supplied to the main field (3) and creates a magnetic field around the poles of the main field (3). As the main field (3) turns with the rotor shaft (4), the magnetic field also rotates and induces an AC voltage into the stationary main armature (2). Main armature (2) is a coil with many turns of wire and the current that flows through it also flows to the load.

Exciter (6) supplies DC current to the main field (3). The load (terminal) voltage is controlled by varying the small current to the armature of the exciter (6).



PMPE Generator Wiring Diagram

(CR1-CR6) Diodes.
(CR7) Varistor.
(L1) Exciter field (stator).
(L2) Exciter armature (rotor).
(L3) Main field (rotor).
(L4) Main armature (stator).
(L5) Pilot exciter armature.
(PM) Permanent magnet.
(RFA) Rotating field assembly.
(CST) Customer supplied transformer.

Permanent magnet pilot excited generators receive power for the voltage regulator from a pilot exciter. The pilot exciter consists of permanent magnet (PM) and pilot exciter armature (L5). The pilot exciter operates independently from the generator output voltage. Constant excitation during large load application is possible, because the irregularities that occur in the generator output voltage (caused by load conditions) are not fed back to the exciter. The independent operation also allows the generator to supply and sustain excessive currents for short periods of time.

When the engine starts turning the Rotating Field Assembly (RFA), permanent magnet (PM) induces an AC voltage in Pilot exciter armature (L5). Pilot exciter armature (L5) has one coil of wire and generates single-phase AC. The resulting AC flows through wires PM1 and PM4 to the voltage regulator. Within the voltage regulator the single-phase AC is rectified to DC and a controlled amount is fed to the exciter field (L1) through F1 and F2.

DC now flows to exciter field (L1) and a magnetic field is created, in which exciter armature (L2) is rotating. Exciter field (L1) and exciter armature (L2) generate three-phase AC. The AC is then rectified to DC by three-phase full wave bridge rectifier circuit (diodes CR1-CR6). The DC output from the bridge rectifiers carried to main field (L3) by conductors which are routed through a passage in the generator shaft. Current through the main field (L3) creates the magnetic field of the generator. As main field (L3) rotates, it induces a three-phase AC voltage in main armature (L4) which is sent to terminals T0, T1 T2 and T3, which are connections for the load.

To keep the output voltage constant with changing loads, it is necessary to control the exciter current. This control is the function of the voltage regulator. The voltage regulator senses and uses the generator output voltage at wires E1, E2, and E3. The voltage regulator uses the current generated from the permanent magnet (PM) and pilot exciter armature (L5) at wires PM1 and PM4. This current is controlled by the voltage regulator and sent through wires F1 and F2.

NOTE: For more information on the voltage regulation, see RENR1246 Service Manual.

PMPE generators provide the magnetism for start-up of the generator. Permanent magnet (PM) supplies the initial magnetism required at start-up. Flashing the field is not required for start-up of the generator.

Generator Circuit Protection

The voltage regulator and related components also protect the generator. All voltage regulators have fuses, which will stop the current flow to the exciter. With no voltage applied to the exciter, the generator output voltage reduces to a very low level. These fuses are of the type that open very rapidly. This protects against secondary damage caused by another component failure. If a fuse is replaced, use only the same type and amperage rating. A larger amperage rating or a fuse that does not open rapidly will not prevent damage to other components.

All voltage regulators have excessive current protection circuits which also opens the excitation circuit.

NOTE: For more information on voltage regulation, see RENR1246 Service Manual.

Idling

Permanent equipment damage can be caused by having the generator set in operating mode while idling the engine. If engine adjustments require that the engine be run at idle speed, the generator set regulating system should be made inoperative by one of the methods that follow.

Where the generator set is equipped with optional field circuit breakers, be sure the circuit breaker is set to OFF while engine is running at idle speed.

Where the generator set includes an optional automatic/manual control with switch that has OFF position, be sure to set the switch to OFF while engine is running at idle speed.

Where the generator set does not include switches described above, remove wires from voltage regulator input terminals during under speed operation of the generator set.

Check for vibration. If excessive, loosen one foot mounting bolt slightly and if vibration decreases, add shims until tightening of the bolt reduces the vibration level. Repeat in turn for all mounting bolts. If vibration levels remain above the allowable limits, recheck the alignment steps outlined in "Two Bearing Close Coupled Alignment" procedure.

Initial Start Up Procedures

Generator output must be disconnected from load. Main circuit breaker must be open.

Turn auto-voltage adjust rheostat to full counterclockwise position.

Start the prime mover and bring the set to rated speed. Turn voltage adjust rheostat to obtain desired voltage.

Close output circuit breaker and apply load in gradual steps until the rated load is reached. Note voltage regulation with changes in load steps.

Check for vibration levels at no load and rated load. A slight increase in vibration level from no load to full load is normal. As the load is maintained for 2-3 hours the vibration levels will gradually increase and reach a final level.

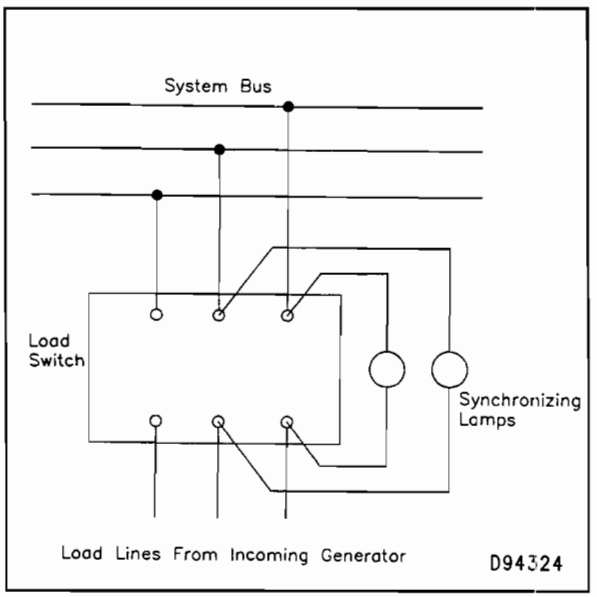
Parallel Operation

For the generator to operate in parallel with another system, the phase sequence of the generator must be the same as the system. Phase sequence check can be determined by a phase rotation meter or incandescent lamp methods described in electrical machinery handbooks.

The output voltage at the paralleling point must be the same at each instant which requires that two voltages be of the same frequency, same magnitude and same rotation, and must coincide with each other.

Voltmeters indicate whether the voltage magnitude is the same and frequency meters indicate whether the frequencies are the same. Whether the voltages are in phase and exactly at the same frequency is indicated by a synchroscope or by synchronizing lamps.

A synchroscope can be utilized to indicate the difference in phase angle between incoming machine and the system. The generator can also be paralleled by using incandescent lamps connected as shown. The voltage rating of series lamps must equal the voltage rating of the generator.



Each prime mover in the system must have the same speed regulating characteristics, and the governors must be adjusted to give the same speed regulation by applying load that is proportional to full load rating of the generator.

Voltage regulator must include paralleling circuitry. Paralleling current transformers must give the same secondary current.

Current transformer secondary winding provides reactive KVA droop signal to the voltage regulator. Accidental reversal of this electrical wiring will cause the voltage to rise rather than droop. If this occurs during paralleling, stop the unit and reverse the wires at the voltage regulator terminals.

If set is provided with unit parallel switch, set switch to PARALLEL position on the unit being synchronized.

Synchronize the generator by adjusting speed (frequency) slightly higher than the system. Observe the synchroscope or the lamps. The lamps should fluctuate from bright to dark at the rate of one cycle every 2 to 3 seconds. When the generator is in phase the lights will be dark, close the circuit breaker. Immediately after closing the breaker measure the line current, kW and kVAR of the generator. The readings should be within the rating of the unit.

A high ammeter reading accompanied by a large kW reading indicates faulty governor control.

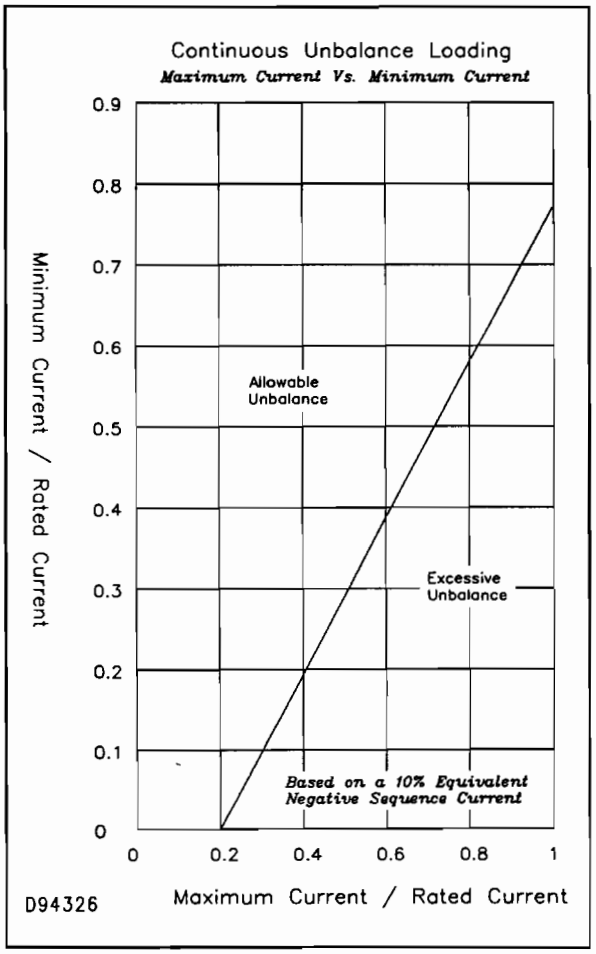
A high ammeter reading accompanied by a large kVAR unbalance indicates problems with voltage regulator. Adjustments of the cross current or voltage droop rheostat should improve the sharing of kVAR.

To shut down the generator operating in parallel, gradually reduce the kW load by turning the governor switch to reduced speed. When kW load and line current approach zero, open the generator circuit breaker. Close the unit parallel switch (if generator is so equipped). Operate the generator unloaded for several minutes to dissipate the heat in the winding.

Continuous Operation

The generator should be operated within the nameplate values of kW, power factor and voltage. If generator is to operate below the rated power factor and voltage, the kVA rating should be decreased to prevent overheating of the field and stator windings.

When generator is carrying unbalanced loads (phase currents varying more than 10 percent of rated value) rotor overheating may result. The rotor heating is caused by negative sequence currents flowing in the field pole face. For a general guide to the allowable phase unbalance see the Continuous Unbalance Loading chart (which is based on a 10 percent equivalent negative sequence current).



The guide is used in the following manner. Find the point where the vertical line (determined by the maximum current in any of the phases, expressed in percent of rated current) crosses the horizontal line (determined by the minimum current in any of the phases, expressed in percent of rated current). The point where these two lines intersect should be within the permissible "allowable unbalance" region for safe operation of the generator.

Loss of field excitation can result in the unit operating out of synchronism with the system when operating is parallel. This will cause damage to rotating rectifiers and severe mechanical stresses on the shaft and other parts. Protective devices should open the generator circuit breaker.

Circulating Currents

When two units are paralleled, there will be circulating currents. These currents are not doing useful work, but are flowing between the generators. By determining the total generator amperage going to the load, the amount of circulating current can be determined.

Circulating currents are caused by voltage differences between two units.

With cold generator sets, circulating current may be as high as 25% of rated amperes, without being considered harmful. Circulating current is part of the total generator current and this total must not exceed the amperage rating.

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

Parallel Operation Of Governors

This section is a general description of the function of the engine governor in relation to the load division between parallel electric sets. For detailed information on governor controls and adjustments, see the Operation and Maintenance and Service Manuals for the engine.

It is very important that two basic facts be understood concerning load division between generator sets operating in parallel. First, the power supplied to the generator and thus to the load is a function of the engine. The engine governor settings and the positions of the governor controls determine the amount of power delivered by the engine and the kW load carried by the generator.

If the governor control setting is advanced, the engine and generator will assume more kW load. Likewise, decreasing the governor control setting will result in a reduction of load on the unit. Any other units on the line will, conversely, either reduce or gain load at the same time, assuming no change in total load or no change in the governor settings of the other units has taken place.

Second, the division of power is not determined by generator excitation or terminal voltage. The Power Factor at which a generator will operate when paralleled with other generators is determined by its excitation.

Governors furnished with Caterpillar Generator Sets can be either of two types, governors with fixed speed droop or governors with adjustable speed droop. The values of speed droop used are commonly 3% and 0%. Governors with adjustable speed droop can be adjusted so their characteristics match quite closely the characteristics of governors with fixed speed droop. If adjusted for 0% speed droop (isochronous) operation, then the same speed from no load to full load can be obtained.

Summary:

The preceding discussion of governor operation can be summarized as follows:

1. The simplest governor combination for parallel electric sets is to have approximately 3% speed droop characteristic for each governor. If a constant frequency from no-load to full-load is required, one governor can be adjusted for isochronous operation. This is called a "lead unit".

2. In order for all paralleled units to accept their full share of the load, the following governor adjustments are required:

- The same full load speed.
- The same high idle (no load) speed in the case of governors adjusted for speed droop operation.
- Governor controls set to the high idle position so that the full governor range is available.
- Operation of an isochronous governor in parallel with speed droop governors requires special techniques.
- Any number of electric sets can be operated in parallel. However, only one governor of the group can be adjusted for isochronous operation, except in the special cases of electric governors with automatic load sharing.

Stopping

To remove a generator from the line perform the following:

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

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

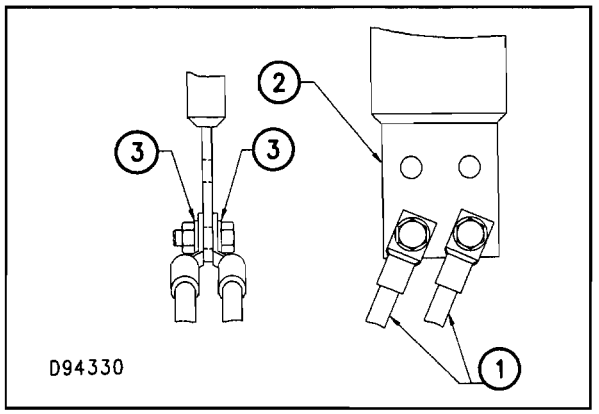
3. Remove the load from the outgoing unit. The amperage may never go to zero due to circulating currents.

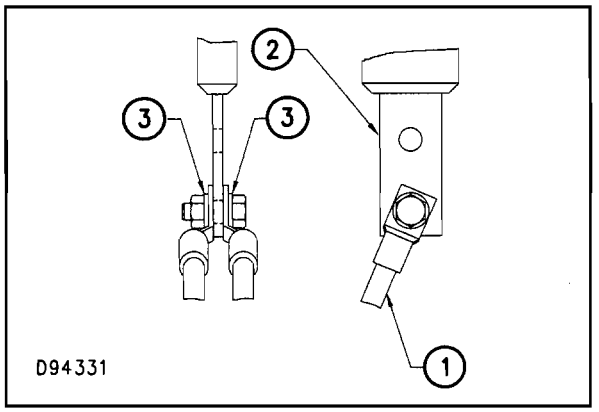
4. Open the circuit breaker.

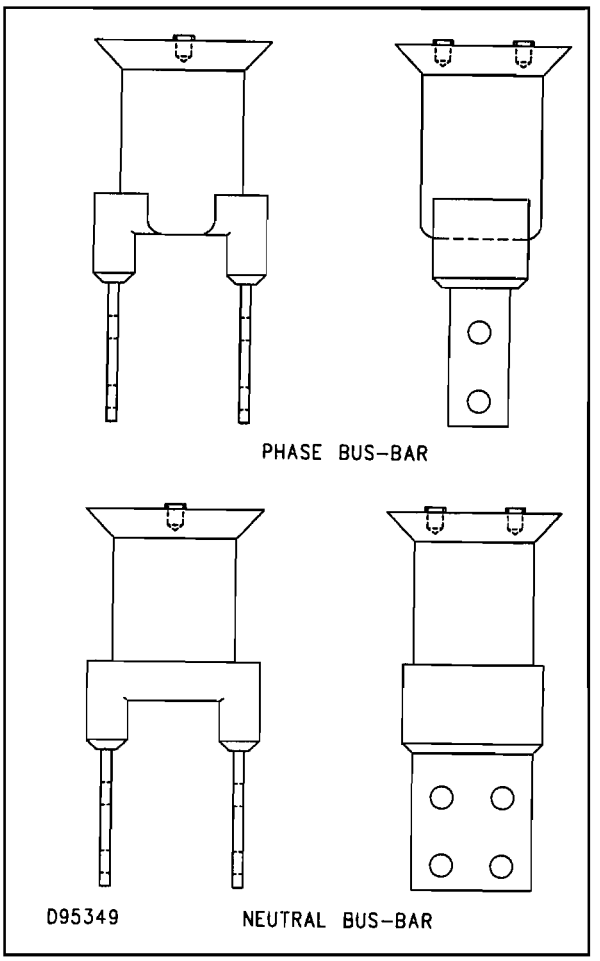
5. Allow the engine to cool for five minutes

6. Stop the engine.

Connecting Generator Leads to Terminal Strip







Fasten generator leads (1) to bus bar strip (2) in the following manner:

1. When more than one lead fastens to the bus bar, place leads on each side of the bus bar. Use flat plated washer (3) under the bolt head and under the nut.

2. Group and tie all generator phase leads together after connecting to the bus bar.

Ensure that a minimum clearance of 190 mm (7.5 in) exists between insulated phase to phase connections and 127 mm (5.0 in) exists between uninsulated phase to ground connections.

Ensure that a minimum clearance exists between cables. Minimum clearance between cables will depend on the type of cable used. Refer to the cable manufacture's specifications for minimum clearance.

Generator Maintenance

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Rotating electric machines are complex structures that are subjected to mechanical, electrical, thermal and environmental stresses of varying magnitude. Of the various components, the insulation systems are the most susceptible to aging or damage due to these stresses. The service life of an electric machine will, therefore, largely depend on the serviceability of the insulation systems. Adequate inspection and testing programs are advocated to assure that the equipment is maintained in satisfactory condition to minimize the possibility of in-service failure.

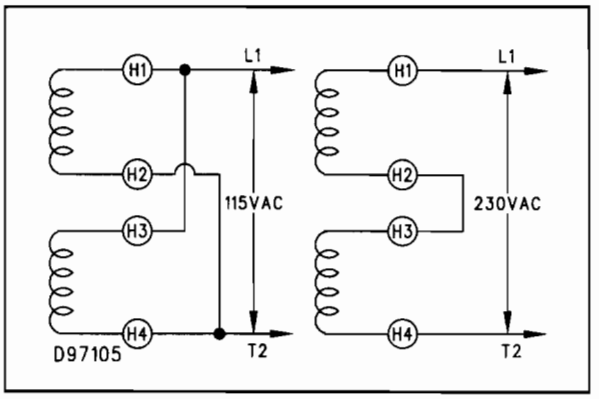
A regular maintenance and inspection program can provide an evaluation of the present condition of the equipment and indicate potential long term problems. The extent to which a maintenance program is pursued will depend on application, environmental conditions, and the operator's own experience and philosophy. A regular maintenance program involving periodic disassembly and knowledgeable visual examination of the equipment, together with the application of electrical tests is strongly recommended. It should be recognized that over potential tests can damage insulation that is contaminated or in marginal condition. Where there is uncertainty, refer to I.E.E.E. Standard 432-1992 or consult Caterpillar dealer.

Space Heaters

The SR4 HV Generator is capable of operating in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings and result in poor performance and even damage to the windings. Whenever the generator is not in use, insure that the space heaters are in operation.

Whenever the generator is operating, insure that the space heaters are disconnected.

An external source of either 115 or 230 volts AC is required to operate the space heaters.



Space Heater Connection to External Source H1, H2, H3, H4 Terminal Strip Terminals.

If 115 VAC source is available, connect both heaters in parallel across the source (L1-T2). If 230 VAC source is available, connect both heaters in a series across source (L1-T2).

Service Conditions Reducing Insulation Life

Electric machines and their insulation systems are subjected to mechanical, electrical, thermal and environmental stresses that give rise to many deteriorating influences. The most significant of these are the following:

Thermal Aging – This is the normal service temperature deteriorating influence on insulation.

Over-Temperature – This is the unusually high temperature of operation caused by conditions such as overload, high ambient temperature, restricted ventilation, foreign materials deposited on windings or winding faults.

Overvoltage – This is an abnormal voltage higher than the normal service voltage such as caused by switching or lightning surges. Operating above rated nameplate voltage will reduce insulation life.

Contamination – This deteriorates electrical insulation by conducting current over insulated surfaces or by attacking the material reducing electrical insulation quality or physical strength or by thermally insulating the material that causes the material to operate at higher than normal temperatures. Such contaminants include the following:

(A) Water or extreme humidity.

(B) Oil or grease including unstable anti-wear and extreme pressure lubricants.

(C) Conducting and nonconducting dusts and particles.

(D) Industrial Chemicals such as acids; solvents and cleaning solutions.

Physical Damage – This contributes to electrical insulation failure by opening leakage paths through the insulation. Physical damages includes the following:

(A) Physical shock.

(B) Vibration.

(C) Over-speed.

(D) Short-circuit forces or line starting.

(E) Erosion by foreign matter.

(F) Damage by foreign objects.

(G) Thermal cycling.

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

Visual Inspection Methods

To achieve maximum effectiveness, a visual inspection program should be directed initially to those areas that have been shown by previous experience to be most prone to the forms of damage or degradation caused by the influences listed. The most suspect areas for deterioration or damage to which inspection should be directed are:

Ground Insulation – Ground insulation is generally defined as that insulation intended to isolate the current carrying components from the noncurrent bearing components.

Support Insulation – Support insulation, such as block, slot wedges, etc. are usually made from compressed laminates of fibrous materials, polyester or similar felt pads impregnated with various types of bonding agents.

Deterioration Or Degradation Of Insulation From Thermal Aging – Examination of coils reveal general puffiness, swelling into ventilation ducts or a lack of firmness of the insulation, suggesting a loss of bond with consequent separation of the insulation layers from themselves or from the winding conductors or turns.

Abrasion – Coil and connection surfaces may be damaged by abrasion or contamination from other sources, such as chemicals or abrasive or conducting substances.

Cracking – Cracking or abrasion of insulation may result from prolonged or abnormal mechanical stress. In stator windings, looseness of the bracing structure is a certain guide to such phenomena and can itself cause further mechanical or electrical damage if allowed to go unchecked.

Erosion – Erosion may be caused by foreign substances impinging against coil insulation surfaces.

Insulation Maintenance Tests

Insulation tests are conducted for two reasons:

1. To discern existing weakness or faults.

2. To give some indication of expected service reliability.

Insulation Resistance Tests At Low Voltage

These tests are usually made on all or parts of an armature or field circuit to ground. They primarily indicate the degree of contamination of the insulating surfaces or solid insulation by moisture and other conducting influences and will not usually reveal complete or uncontaminated ruptures.

Insulation resistance tests are based on determining the current through the insulation and across the surface when a direct voltage is applied. The current is dependent on the voltage and time of application, the area and thickness of the insulation and on temperature and humidity conditions during the test.

The insulation resistance test is used to determine the insulation condition prior to application of more extensive testing measures. Refer to the following electrical measurement procedures for testing detail. Contact dealer or refer to I.E.E.E Std. 432-1992 when more extensive insulation tests are required.

Exciter Field (Stator)

1. Disconnect the exciter leads from the terminals in the terminal box.

2. Connect exciter leads to one clamp of 500 volt megger and connect the other clamp to the generator frame.

3. Apply 500 volts from the megger and measure the resistance reading after one minute. The minimum reading should be 1.0 megohm. If not, refer to dry out procedures.

4. Short the exciter field leads to the generator frame for several minutes after the megger has been disconnected. This will allow the voltage build up to be properly discharged.

Exciter Armature (Rotor)

1. Disconnect the exciter armature leads from the rotating rectifiers. Disconnect the generator field leads from the positive and negative rectifier heat sinks.

2. Never apply megger to rotating rectifiers. Connect the leads of exciter armature to one clamp of a 500 volt megger and connect the other clamp to suitable connection on the shaft.

3. Record the megohm reading after one minute of applying 500 volts.

4. One minute reading must be a minimum of 1 megohm. If not, refer to dry out procedures.

5. Ground the exciter leads to the shaft after disconnecting the megger.

Generator Field (Rotor)

1. Connect the positive and negative leads to one clamp of the 500 volt megger and connect the other clamp to the shaft.

2. Record the megohm reading after one minute of applying 500 volts.

3. One minute reading must be a minimum of 1 megohm. If not, refer to dry out procedures.

4. Ground the field leads to the shaft after disconnecting the megger.

Generator Armature (Stator)

1. Disconnect power connections and all control apparatus from the generator terminals.

2. Measure insulation resistance of each phase separately with the two other phases shorted to the frame.

3. Use a 500 volt megger connected between the lead of the phase to be measured and generator frame. The minimum one minute insulation resistance (corrected to 40°C (104°F) should not be less than that given by the following formula:

$$\text{resistance in megohms} = \frac{\text{rated generator voltage} + 1000}{1000}$$

If less than above, refer to dry out procedure.

4. Ground the leads to the frame after the one minute megger test.

Recommended Periodic Resistance Checks

Use a megohmmeter (megger) to check generator main stator winding insulation resistance periodically. The frequency of the insulation resistance test is determined by the generator's environment and by previous megohmmeter test indicators.

NOTE: Test the main stator windings with a meghmmeter in the following situations:

1. Before initial startup of generator set.

2. After generator storage.

3. Every three months if generator is operating in a humid environment or is not protected from the elements by an enclosed area.

4. Every six months if the generator is installed in an enclosed area with relatively low humidity and minimal variation in temperature.

5. If the generator has not been run under load for three months or more.

6. Test every week and use space heaters if the generator is exposed to a sea water environment or if the surrounding conditions are very humid (relative humidity above 75%) or if a recent test reading was less than three megohms. In applications where salt and high humidity are present, space heaters must be operated whenever the generator is not operating under load. This is the only way to maintain megohmmeter test readings above one megohm.

Drying Methods

If the insulation resistance readings are below the recommended minimum values specified, use one of the drying methods described below. The method selected should be based on the size and location of the unit, available equipment and the experience of personnel.

Remove voltage regulator and cover all inlet and discharge openings. Provide an opening at the top of the machine, preferably at the fan end, through which moisture can evaporate. Monitor winding temperatures. DO NOT APPLY HEAT TOO RAPIDLY. Winding temperature should be raised gradually at a rate of 10 degrees centigrade per hour up to 85 degrees Celsius (185 degrees Fahrenheit). Measure insulation resistance at one hour intervals. Typically the insulation resistance will slowly drop while the temperature is coming up, and then gradually increase and level off.

The following methods can be used for drying a generator:

- Self Circulating Air Method.
- Oven method.
- Controlled Current Method.

Self Circulating Air Method

To circulate air, run the engine with the generator load disconnected. Operate the generator space heaters.

Oven Method

Place the entire generator inside a forced air drying oven for four hours at 65°C (150°F).

NOTICE
Use a forced air type oven rather than a radiant type oven. Radiant ovens can cause localized overheating.

Controlled Current Method

Tools Needed		
8T-0900	Clamp-On Ammeter (up to 1200 amps)	1
	External Power Source Circuit	1

Heat to dry the generator windings can be created by allowing a controlled current to flow through the generator. No high voltages are generated during the following procedure, therefore insolation breakdown will not occur as it might with normal operation of a wet winding.

1. Make an external power source.

2. Disconnect wires F1 and F2 from the voltage regulator. Disconnect the generator load. Connect the generator output leads (T0), (T1), (T2), and (T3) together. Install the clamp-on ammeter to generator output lead T1.

NOTE: When measuring line current on multiple lead units, measure the current in each conductor per phase and add the currents together

3. Adjust rheostat to give maximum resistance. Connect the external power source to wires F1 + and F2 -.

4. Run the generator set at idle speed.

NOTICE
Do not exceed the rated phase current listed on the generator nameplate. The windings can be easily damaged if the rated phase current is exceeded.

5. While monitoring the phase current, slowly increase the RPM until the rated phase current is obtained or until full generator set speed is obtained.

6. If more phase current is still necessary, slowly turn the rheostat until the rated phase current is obtained.

7. Stop the dying procedure every hour and check the insulation resistance. Continue the drying procedure by repeating the above steps until the insulation resistance is acceptable.

Cleaning Instructions

⚠ WARNING

Before working inside the generator, make certain that the starter motor can not be activated by any automatic or manual signal.

When the generator set is in operating, voltages of up to 600V are present in these areas near or on the regulator:

1. The regulator terminal strip.

2. The excitation transformer terminal strip.

Do not short these terminals to ground with any part of the body or any conductive material. Loss of life or severe injury could result from electrical shock or contact with molten metal.

Proper maintenance of electrical equipment requires periodic visual examination of the machine and windings and appropriate electrical and thermal checks. Insulation surfaces should be examined for cracks and accumulations of dirt and dust to determine required action. Lower than normal insulation resistance can be an indication that conductive contaminant is present. The contaminant may be carbon, salts, metal dusts or virtually any dirt saturated with moisture. These contaminants develop a conductive path to produce shorts or grounds with subsequent failure. Cleaning is also advisable if heavy accumulation of dirt and dust can be seen or are suspected to be restricting ventilation as manifested by excessive heating.

NOTICE
Without visual, electrical or thermal evidence that dirt is present, cleaning should not be initiated since unnecessary winding deterioration may occur.

If harmful dirt accumulations are present, a variety of cleaning techniques are available. The one selected will depend on;

1. The extent of the cleaning operation to be undertaken.

2. The type of enclosure and the voltage rating of the machine involved.

3. The type of dirt to be removed.

Field Service Cleaning - Assembled Machines

Where cleaning is required at the installation and complete disassembly of the machine is unnecessary or not feasible, dry dirt, dust or carbon should first be picked up by a vacuum cleaner to prevent the redistribution of the contaminant. A small nonconducting nozzle or tube connected to the vacuum cleaner may be required to reach dusty surfaces or to enter into narrow openings. After most of the dust has been removed, a small brush can be affixed to the vacuum nozzle to loosen and allow removal of dirt more firmly attached.

After the initial cleaning with vacuum, compressed air may be used to remove the remaining dust and dirt. Compressed air used for cleaning should be clean and free of moisture or oil. Air pressure or velocity should be a maximum of 210 kPa (30 psi) to prevent mechanical damage to the insulation. Disassembly of the machine and more effective cleaning by a Caterpillar Dealer may be required if the above described field service cleaning procedure don't yield effective results.

Disassembled Machines

An initial insulation-resistance reading should be taken on the machine to check electrical integrity. A minimum reading of one megohm would be expected with severely contaminated machines. A zero reading may indicate an insulation breakdown requiring repair, not just cleaning.

The high pressure hot water wash method of cleaning, which sprays a high velocity jet of hot water and water containing a mild detergent is normally effective in cleaning windings including those subjected to flooding or salt contamination. The detergent spray is followed by multiple sprays with clean water to remove or dilute the detergent. The machine should then be dried until normal insulation resistance values are obtained at room temperature. Solvents are effective for removing oil or grease and may be required if water or detergent is not adequate.

MAINTENANCE SCHEDULES FOR SR4 HV GENERATORS POWERED BY CATERPILLAR 3500 SERIES ENGINES

DAILY CHECKS

1. Check and record operating temperatures on generator bearings.

2. Check and record operating temperatures on generator stator windings.

3. Check control panel voltmeter for proper stability and voltage output.

4. Monitor power factor and generator loading during normal operation.

WEEKLY CHECKS

Visually inspect bearing seals for seepage. Inspect generator air filters for build up of contaminants. Clean or replace as required.

EVERY 2000 HOURS OR 6 MONTHS OF OPERATION (1301–1800 RPM)

1. Check generator set vibration levels using a Broad Spectrum Analyzer.

2. Check condition of the bearings using a shock pulse instrument that measures spike energy on ball or roller bearings. On generators equipped with sleeve bearings, visually inspect the liner surface for abnormal wear patterns

3. Remove generator outlet box cover. Visually inspect stator output leads, protective sleeving and insulation for cracking or physical damage.

4. Check all exposed electrical connections for tightness.

5. Check transformers, fuses, capacitors and lightning arrestors for loose mounting or physical damage.

6. Check all lead wires and electrical connections for proper clearance and spacing.

7. Clean inside of outlet box, air screens, bearing housings and air baffles with compressed air and electrical solvent.

EVERY 7500 HOURS OR YEARLY (1600–1800 RPM)

EVERY 9000 HOURS OR YEARLY (1301–1600 RPM)

1. Remove generator outlet box cover.

2. Visually inspect stator output leads, protective sleeving and insulation for cracking or physical damage. (Same as 2000 hour check)

3. Check all exposed electrical connections for tightness.

4. Check transformers, fuses, capacitors and lightning arrestors for loose mounting or physical damage.

5. Check all lead wires and electrical connections for proper clearance and spacing.

6. Check insulation resistance to ground on all generator windings:

A. Main rotating assembly
B. Main stator assembly
C. Exciter and PMG stationary fields
D. Exciter armature assembly

7. Check space heaters for proper operation.

8. Check exciter armature for proper rotating rectifier connection tightness.

EVERY 15,000 HOURS OR 3 YEARS OF OPERATION (1601-1800 RPM)

EVERY 18,000 HOURS OR 3 YEARS OF OPERATION (1301-1600 RPM)

Remove generator outlet box cover. Visually inspect stator output leads.

2. Visually inspect stator output leads, protective sleeving and insulation for cracking or physical damage. (Same as 7500/9000 hour check)

3. Check all exposed electrical connections for tightness.

4. Check transformers, fuses, capacitors and lightning arrestors for loose mounting or physical damage.

5. Check all lead wires and electrical connections for proper clearance and spacing.

6. Check insulation resistance to ground on all generator windings.

A. Main rotating assembly
B. Main stator assembly
C. Exciter and PMG stationary fields
D. Exciter armature assembly

7. Visually inspect generator windings for oil, grease, or dirt contamination. Excessive contamination may necessitate surface cleaning with compressed air and electrical solvent.

EVERY 30,000 HOURS OR 6 YEARS (1601-1800 RPM)

EVERY 36,000 HOURS OR 6 YEARS (1301-1600 RPM)

1. Disassemble generator including rotor removal.

2. Check insulation resistance to ground on all generator windings.

A. Main rotating assembly
B. Main stator assembly
C. Exciter and PMG Stationary fields
D. Exciter armature assembly

3. Clean generator windings using compressed air and electrical solvent or de-greaser and high pressure hot water wash dependent upon severity of contamination.

4. Dry windings to acceptable resistance levels.

5. Remove bearings.

6. Measure shaft bearing surfaces, endbell bearing wells and housings for roundness and proper size.

7. Install new factory replacement bearings.

8. Pack bearing with the type and amount of grease specified on the lubrication plate mounted on the generator, or see the lubrication chart in the Maintenance Section under "Bearing Lubrication".

NOTE: Refer to the disassembly and assembly of generators section for additional detail on maintenance procedures.

Bearing Lubrication

Lubricate bearings in accordance with the lubricating instructions on the nameplate of the generator.

Use Caterpillar Special Grease (SPG) 2S-3230 for ball bearings on 2500 frames. This is a NLGI No. 2 Grade (without molybdenum disulfide) with thicker Polyyrea, and a temperature range of -29 to 177°C (-20 to 350°F). Use NLGI 1 or 0 Grade for extremely low temperatures.

Use Caterpillar 100-2764 Grease for spherical roller bearings on 2900 frames.

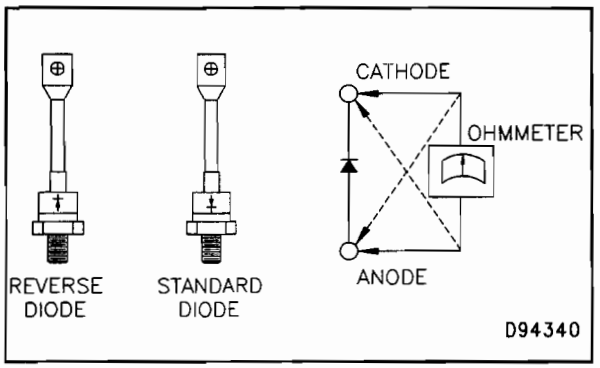
Bearing OD mm (")	Bearing ID mm (")	Part No.	Generator Frame Size	Bearing Bore In Bracket mm (")	Bearing Shield Type	Grease Required In Cavity (oz.)	Rotor Shaft Diameter mm (")
230 (9.055)	130 (5.118)	9U-8241	2500[1]	229.97–229.92 (9.0544–9.052)	Open	6.0-8.4	129.87–129.62 (5.1130–5.1030)
215 (8.4646)	100 (3.9370)	141-4612	2500[2]	214.98–215.03 (8.4639–8.4657)	Single	7.2-10.1	100.02–100.00 (3.9377–3.9371)
N/A[3]	N/A[3]	139-0349	2900[3]	N/A[3]	Double	5.2-7.2	127.00–126.97 (5.000–4.999)
N/A[3]	N/A[3]	139-0350	2900[3]	N/A[3]	Double	5.2-7.2	127.00–126.97 (5.000–4.999)

[1] Bearing on drive end.
[2] Bearing on exciter end.
[3] Split spherical roller bearing, shield and bearing bore part of housing. All parts that wear are part of the replacement bearing.

Testing Brushless Exciter Rotating Rectifier With An Ohmmeter

If a failure of a rectifier is suspected, remove the exciter cover and test rectifiers with an ohmmeter as follows.

Remove nut and washer holding rectifier in heat sink and remove diode lead wire, then lift rectifier from heat sink.

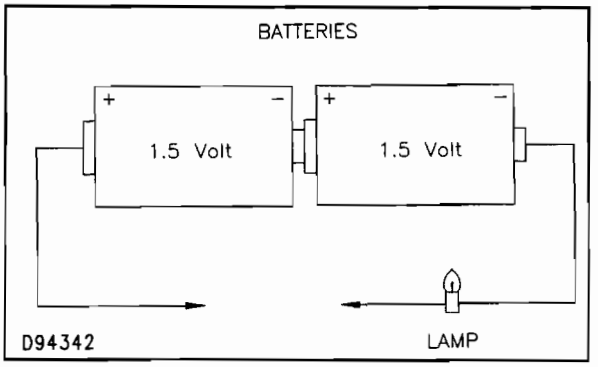


Refer to the above diagram and connect ohmmeter leads across rectifier in one direction. Note meter reading. Reverse leads and note meter reading. The meter should indicate a low resistance when leads are across rectifier in one direction and a high resistance when leads are across rectifier in the other direction.

If the meter indicates a low resistance in both directions, the rectifier is shorted. A high resistance in both directions indicates an open rectifier.

Replace defective rectifiers with rectifiers of the same operating characteristics as rectifiers installed in the generator at the factory. Order rectifiers by part number including the model and type of the exciter as well as the generator serial number.

Testing Brushless Exciter Rotating Rectifiers With A Test Lamp



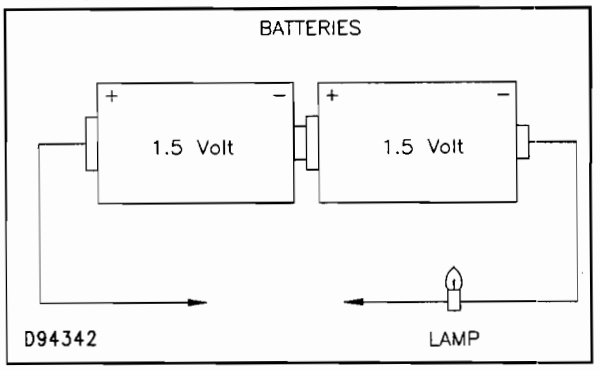
If an ohmmeter is not available, field rectifiers may be tested with a test lamp consisting of standard flashlight batteries and a flashlight bulb as shown in the above drawing. Test as follows.

Remove rectifier.

Connect leads of tester across rectifier in one direction; then reverse leads. The light should light when the leads are across the rectifier in one direction and should not light when placed across rectifier in the other direction.

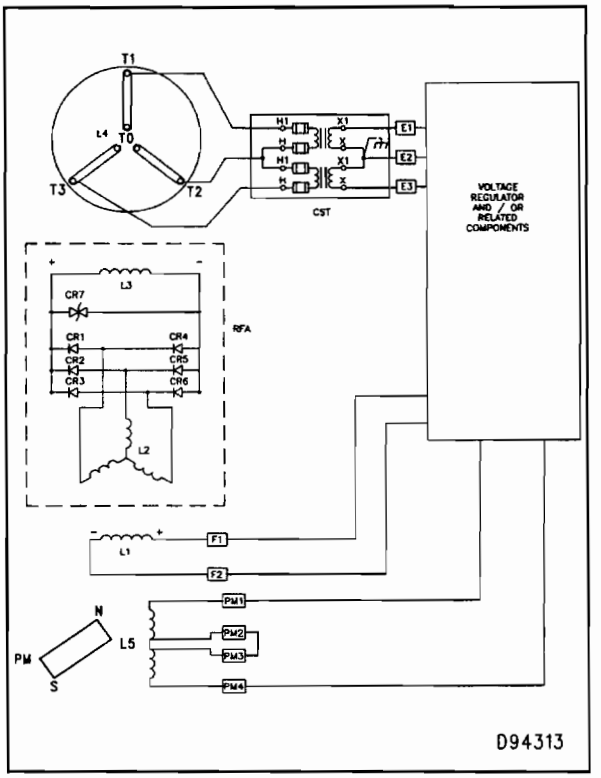
If the light lights in both directions the rectifier is shorted. If the light does not light in either direction, the rectifier is open.

Testing Varistor With Test Lamp



Disconnect one lead and check with lamp tester. The lamp should not light when the test leads are placed across the surge protector in either direction. If the lamp lights, it indicates a shorted surge protector. Replace defective surge protector with one of the same operating characteristics as the surge protector installed in the generator at the factory. Order by part number and include the serial number of the generator. Following replacement of the surge protector, make certain field lead tie-down lacing is securely wound on shaft and tied.

Winding Resistance Check



PMPE Generator Wiring Diagram

(CR1-CR6) Diodes.
(CR7) Varistor.
(L1) Exciter field (stator).
(L2) Exciter armature (rotor).
(L3) Main field (rotor).
(L4) Main armature (stator).
(L5) Pilot exciter armature.
(PM) Permanent magnet.
(RFA) Rotating field assembly.
(CST) Customer supplied transformer.

Tools Needed		
6V-7070	Digital Multimeter	1

The resistance of windings (L1), (L2), (L3), (L4) and (L5) can be checked. The winding being tested must be isolated (disconnected) from the other components before measuring the resistance. The following resistance measurements are approximations. If the measured value is not near the listed approximation, the winding is probably defective. From a more precise resistance value, see the Technical Marketing Information (TMI) for the generator arrangement in question.

If the measured value is not near the listed approximation, the winding is probably defective. From a more precise resistance value, see the Technical Marketing Information (TMI) for the generator arrangement in question.

NOTE: The temperature of the winding effects the resistance. As the winding temperature increases, so does the winding resistance. As the winding temperature decreases so does the winding resistance. Therefore, correct measurement can only be performed when the winding is at room temperature.

Armature windings (L2), (L4) and (L5) have very little resistance and will measure near 0 ohms. Use a milliohmmeter to measure the resistance of the armature windings.

- Exciter Armature (Rotor - L2) – less than 0.1 ohms
- Main Armature (Stator - L4) – less than 0.1 ohms
- Pilot Exciter Armature (L5) – less than 0.1 ohms

Use a multimeter to measure the resistance of field windings (L1) and (L3).

- Exciter field (Stator - L1)
approximately – 3.0 to 6.0 ohms
- Main field (Rotor - L3)
approximately – 0.75 to 2.0 ohms

NOTE: There should be no continuity between any winding and ground, or any winding and another winding.

Generator Set Functional Test

Tools Needed		
6V-7070	Digital Multimeter	1
	12 V DC Battery	1

The generator set functional test is a simplified test that can be performed when necessary to determine if the generator is functional. Final generator testing should be on the generator set under load.

This test determines if:

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

1. Disconnect wires F1 and F2 from the voltage regulator. Disconnect the generator from load.

2. Connect a 12 V DC automotive type battery to wires F1 + and F2 -.

NOTICE
Do not operate the generator set at more than half of rated speed. Higher speeds, under the conditions of this test can cause damage to the system.

3. Operate the generator set at half the rated speed.

4. Measure and record the AC voltage across the following terminals: T1 and T2, T1 and T3, T2 and T3.

5. Monitor the same voltages as Step 4, while decreasing and then increasing the generator set speed 10%. Do not exceed half of rated speed.

6. The measured voltages of Step 4 should be near the same and at least 85 V AC. The voltages of Step 5 should decrease and increase 10%, with the corresponding change in generator set speed.

Varistor Check

Varistor (CR7) can be checked by measuring the resistance between the positive (+) rectifier terminal and the negative (-) rectifier terminal. The resistance should be 15,000 ohms or greater.

Generator Start-up Checklist

RATING INFORMATION

Engine Serial Number: _____	Arrangement No.: _____
Generator Serial Number: _____	Arrangement No.: _____

GENERATOR NAME PLATE INFORMATION

	Voltage	Package (prime, continuous, standby): _____
	Amperage	Kilowatts

Storage Location: _____

Main stator megger reading: Before Storage: _____ After Storage: _____

Generator dried for 24 hours prior to startup? (Y/N) ____ Drying method _____

SPACE HEATERS		**Yes**	**No**	**Comments**
	Space heaters operating property			
	Space heaters operated 48 hours prior to start-up			

MEGGER TEST (SEHS9124)		**30 sec. reading**	**60 sec. reading**	**30 sec. Corrected**	**60 sec. Corrected**	**Ambient Temperature**	**Comments**
Beginning of Storage	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	PMG Stator						
Start-up	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	PMG Stator						

REGULATOR		**Voltage**	**Amps**	**Comments**
No Load	F1 to F2	DC		
	E1 to E2	AC		
	E1 to E2	AC		
	E2 to E3	AC		
	PM 1 to PM 4	AC		
Full Load	Generator Excitation name plate information	DC		Compare to F1 to F2
	F1 to F2	DC		
	E1 to E2	AC		
	E1 to E2	AC		
	E2 to E3	AC		
	PM 1 to PM 4	AC		

ELECTRICAL		Yes	No	Comments
	Unit property grounded			
	Check diodes			
	Over current protection			
	Over voltage protection			
	Check for loose wiring			
	Adjust voltage			
	Adjust frequency			

MECHANICAL		Data	Comments
	Bearing temperature readings at full load	Front _____ Rear _____	
	Stator termperature readings at full load	A0 _____ B0 _____ C0 _____	
	Air gap on main stator	Top _____ Bottom _____	
	Air gap on exciter stator	Top _____ Bottom _____	
	Air gap of PMG	Top _____ Bottom _____	
	Ambient air to generator @ Full Load	Temperature _____	
	Supplier air opening to generator	Size of Opening _____	

SWITCH GEAR /PARALLEL OPERATION

Manufacture:

	Setting 1	Setting 2	Setting 3	Comments
Circuit breaker Type				
Overload setting				
Reverse power relay				
VAR/PF Controller				
Load share				

INSTALLATION & LOAD INFORMATION

Neutral grounding system	UPS
Enclosure type:	Size
Motor	Other Loads
Total SKVA	Lighting
Total HP	Computers
	Welding
	Non-linear
	Other

FULL LOAD DATA

Voltage	Amps		KW	KVARS	P.F.			

Troubleshooting Table

Between regular preventive maintenance inspections, be alert for any signs of generator set trouble. Common symptoms as well as the probable cause and possible remedy are listed in the table. Correct any minor trouble immediately. **Minor defects left uncorrected can cause serious damage which can result in costly repairs and down time.**

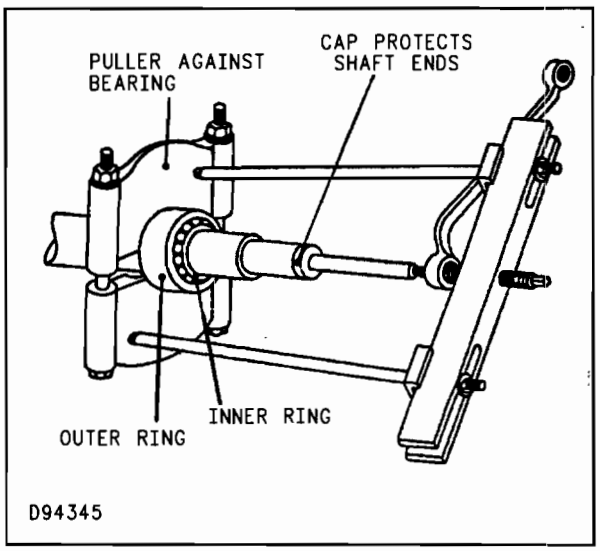
Troubleshooting Procedures		
Symptoms	**Probable Cause**	**Remedy**
No voltage.	Open circuit breaker or fuses (if voltage is sampled on load side of fuses or circuit breaker).	Check reset circuit breaker or replace fuses of open.
	Overvoltage, undervoltage, or overload devices tripped (when protective devices incorporated in circuit).	Check for cause of abnormal condition. Correct any deficiencies. Reset device. Check generator nameplate for nominal operating values.
	Open circuit in exciter field.	Check out continuity of exciter field and leads to voltage control. (Use ohmmeter or wheatstone bridge). If open in field coils, remove exciter field assembly for repair or replacement.
	Loss of residual magnetism in exciter field poles if a manual voltage regulator is used which requires field flashing to bring generator voltage to level where regulator will operate.	Adjust manual adjust potentiometer to full resistance. Flash field by making a flash connection of DC across terminals F1 to F2. When voltage regulator is such that flashing is required install automatic field flashing system.
	Open circuit in stator windings.	Check for continuity in windings. Return to factory for repair if open.
	Malfunction of automatic voltage regulator.	See troubleshooting of voltage regulator. Correct deficiencies.
	Short circuited generator output leads.	Clear leads to restore voltage build up.
	Open in rotating rectifiers.	Check rotating rectifiers and replace if open.
	Open in alternator field.	Check for continuity and return rotor to factory for repair if field coils are open.
	Shorted surge protector.	Check for shorts and replace.
	Shorted rotating rectifiers.	Check for shorts. Replace if shorted.
	Shorted exciter armature.	Check for shorts. Replace if shorted.
	Shorted leads between exciter armature and generator field.	Test and repair.
	Defective voltage regulator (when used).	Check regulator, adjust or repair or replace if defective.
Low voltage.	Defective rectifiers in rotating rectifier assembly.	Check rectifier assembly. Replace defective rectifier.
	Improper adjustment of voltage adjust rheostat.	Adjust rheostat.
	Excessive load.	Reduce load. With three phase generators, the load on each leg should be as evenly balanced as possible and should not exceed the rated current on any leg.
	Line loss.	Increase size of line wire.

Troubleshooting Procedures (cont'd.)		
Symptoms	**Probable Cause**	**Remedy**
Low Voltage (cont'd).	High resistance connections. Connections will be warm or hot.	Make better connections.
	Shorted field.	Test field coils for possible short by checking resistance with an ohmmeter or resistance bridge. Return rotor assembly to factory for repair if alternator field coils are shorted.
	Low power factor.	Reduce inductive (motor) load. Some AC motors draw approximately the same current regardless of load. Do not use motors of larger horsepower rating than is necessary to carry the mechanical load.
	Weak field due to operating in warm temperature.	Improve the ventilation of generator. Field current can be increased providing the generator temperature rating stamped on the nameplate is not exceeded.
	Defective rectifiers in rectifier assembly. (stationary)	Check rectifier assembly. Replace defective fuses or rectifiers.
	Excessive load.	Reduce to rated value.
	Defective bearing.	Replace bearing.
	Improper speed of engine driven generator set due to defective governor, ignition system, or carburetor.	Check and correct deficiencies.
	Voltage regulator not operating properly (if used).	Check regulator. Repair or replace if defective.
Fluctuating voltage.	Prime mover speed fluctuating.	Check frequency and voltage of incoming power when generator set is motor driven. Engine governor on engine driven generator sets.
	Loose internal or load connections.	Make better connections.
	Generator overloaded.	Reduce load to rated value.
	DC excitation voltage fluctuating.	Trace DC excitation circuit. Correct any defects.
	Overspeed.	Correct speed of prime mover.
High voltage.	Improper adjustment of voltage adjust rheostat or voltage regulator.	Adjust rheostat and/or voltage regulator.
Overheating.	Clogged ventilating screens and air passages.	Clean all screens and air passages.
	Dry or defective bearings.	Replace defective bearings.
	Coupling misaligned.	Align generator set.
	Generator field coils shorted or grounded.	Test field coils for short. Replace or repair shorted rotor.
Vibration.	Misalignment of generator and prime mover.	Align generator set.
	Generator not properly mounted.	Check mounting. Correct defective mounting.
	Transfer of vibration to generator from another source.	Isolate generator set from source of vibration by installing vibration dampeners between the generator set base and foundation.

Disassembly And Assembly

NOTE: For a complete list of tools needed for disassembly and assembly see "Required Test Equipment, Tools And Materials" located at the end of the Disassembly And Assembly Section.

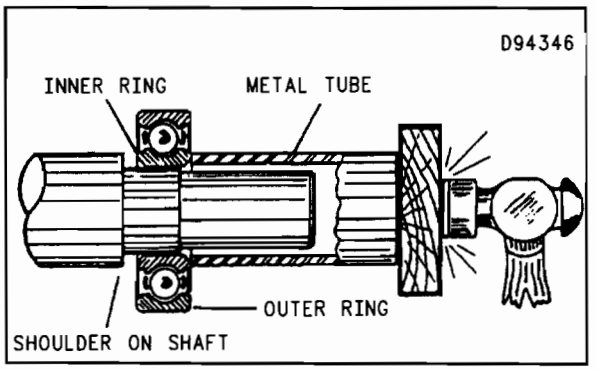
Bearing Removal



Remove bearing from generator shaft.

Remove the end bell to expose bearings. Use a puller to remove the bearing from the shaft end with a cap. If the bearing is going to be used again, make certain puller applies pressure only against the bearing inner ring.

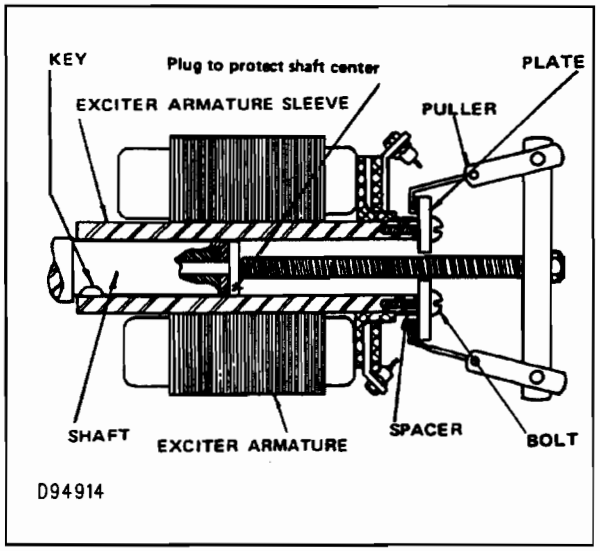
Bearing Installation



Install bearing to generator shaft.

Heat the bearing to a temperature of 104 to 121°C (219 to 250°F) in a clean thermostatically controlled oven. Start the heated bearing into the shaft. Then use a fiber or soft metal tube to tap bearing into place. Make certain that pressure is applied only to the bearing inner ring. Press bearing onto shaft until inner ring is against bearing shoulder on the shaft. Assemble the generator after the bearing has cooled.

Exciter Armature And Rotating Rectifier Assembly Removal



Removing Exciter Armature and Rotating Rectifier Assembly

Remove exciter armature and rotating rectifier bridge assembly as a unit as described in the following general instructions.

Remove exciter cover. Disconnect alternator field leads from positive (+) and negative (-) terminals located on the heat sinks of the rotating rectifier assembly. Remove exciter armature retaining bolt and washer.

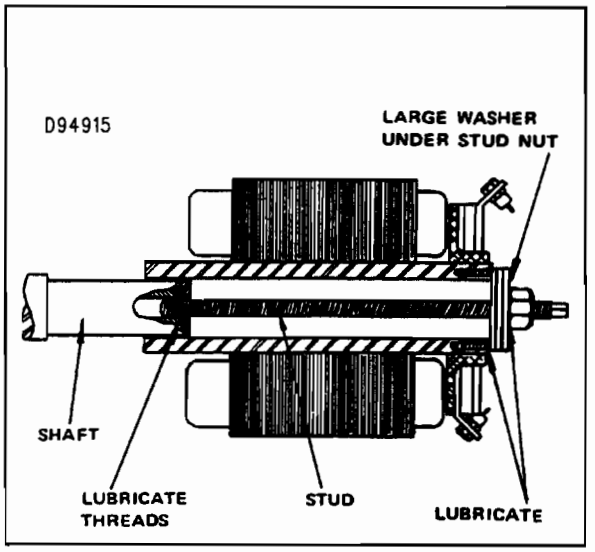
The exciter armature is a "slip fit" on the generator shaft. If the armature cannot be removed by hand, remove with a puller.

NOTICE

Do not pull on rotating rectifier assembly of the exciter armature windings.

Install a cap or plug to protect the shaft center. Utilizing the tapped holes in the end of sleeve, bolt to the end of the sleeve spacers and a metal plate. Install a bearing puller to the metal plate and pull exciter armature and rotating rectifier assembly from the shaft.

Exciter Armature And Rotating Rectifier Assembly Installation



Installing Exciter Armature and Rotating Rectifier Assembly

Install exciter armature and rotating rectifier assembly as a unit as described in the following general instructions.

If the "slip fit" exciter armature and rotating assembly will not easily slide onto the shaft by hand, install with a fixture as shown.

NOTE: Usually the exciter armature will slide onto the shaft most of the way by hand. The exciter armature can usually be "seated" by tapping lightly on the sleeve with a soft rubber or fiber mallet. MAKE CERTAIN MALLET HITS ONLY THE SLEEVE, NOT RECTIFIER ASSEMBLY OR ARMATURE WINDINGS.

NOTICE

If exciter armature is aligned and locked in place by a removable key, make certain the key is in place in the generator shaft and the key way In the exciter armature sleeve is aligned with key before starting the exciter armature onto generator shaft.

If unit uses an aligning lug on the exciter armature sleeve and a slot in the generator shaft rather than a removable key to align and lock the exciter armature on the shaft, make certain lug and slot are aligned and engaged.

Start exciter armature and rectifier bridge on shaft. Thread stud in rotor shaft. Install large diameter washers on stud and start stud nut. Pull exciter armature and rotating rectifier onto shaft by turning stud nut.

Install exciter armature retaining bolt and washer. Connect alternator field leads to positive (+) and negative (-) terminals located on the heat sinks of the rotating rectifier assembly. Install exciter cover.

Removing And Replacing Exciter Stator Assembly

Should it be necessary to remove the exciter stator assembly, refer to "Generator Disassembly" procedures and then remove stator as described in the following general instructions.

Remove exciter cover and exciter armature.

Disconnect exciter field leads F1 and F2. Remove any clips securing exciter field leads to the exciter frame, generator frame or the endbell.

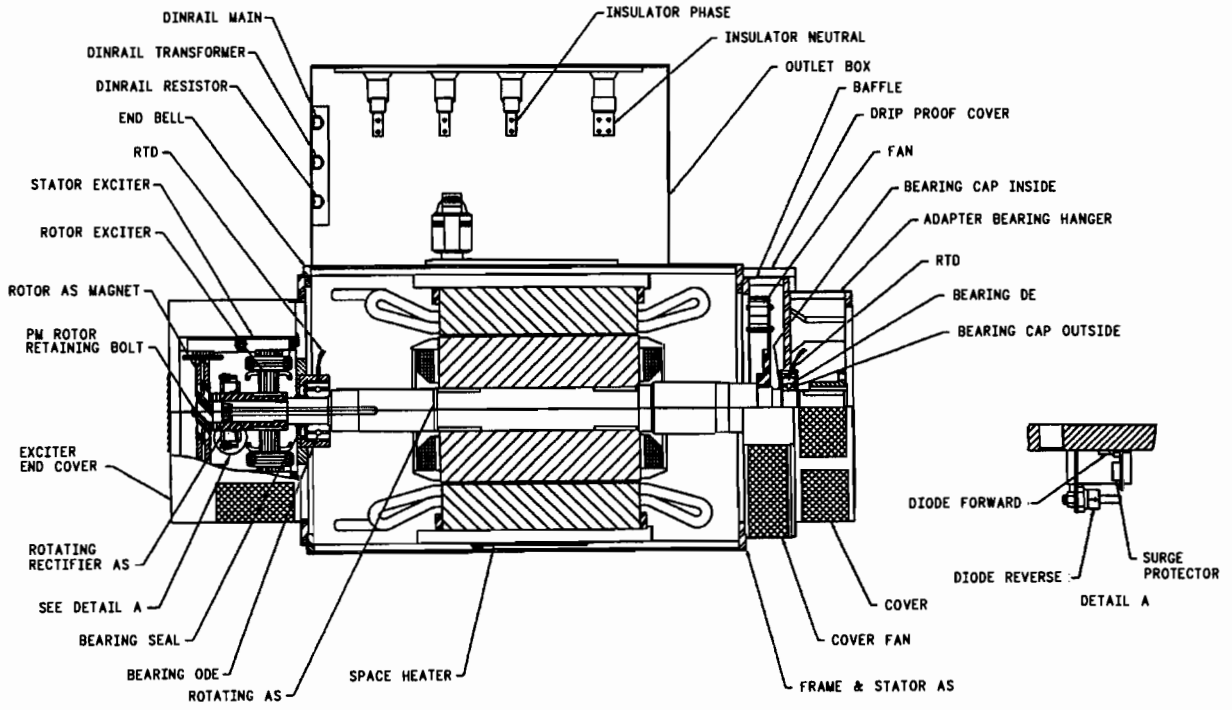
Remove generator exciter and generator end bell. Refer to "Generator Disassembly" procedures. Check for shims in end bell bearing well. Make certain the shims, if incorporated, are reinstalled when generator is reassembled.

Remove bolts securing exciter frame and stator to the end bell.

Assembly exciter stator by reversing disassembly procedures.

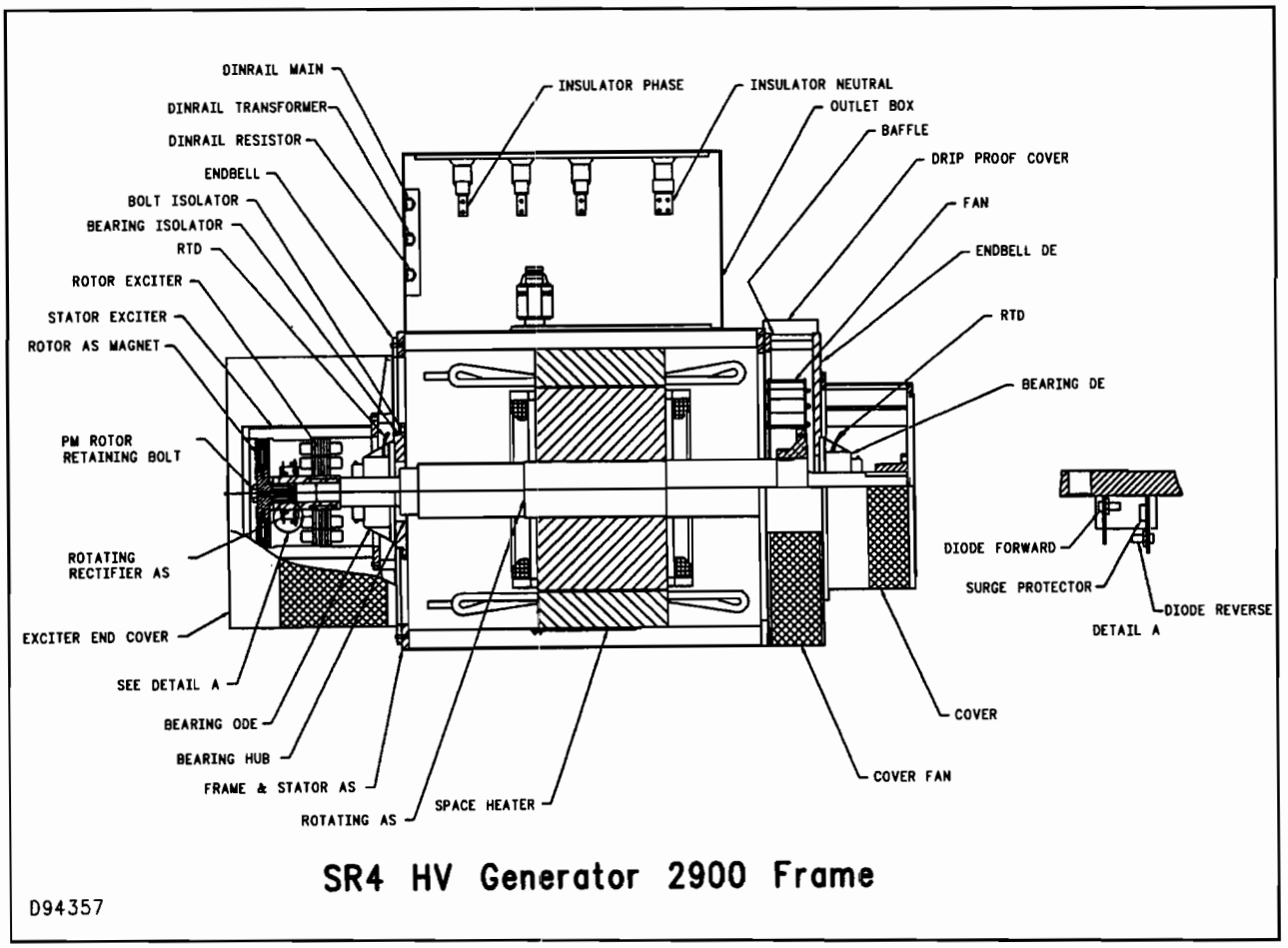
NOTE: Install exciter stator with its field leads toward generator end bell.

Assembly And Disassembly Of Generator



SR4 HV GENERATOR 2500 FRAME

D94356



SR4 HV Generator 2900 Frame

D94357

NOTE: Refer to the above drawings part identification and then disassemble generator as described in the following general instructions.

1. Remove terminal box cover and disconnect generator load leads and exciter field leads. Tag leads and terminals to make certain leads are correctly connected when unit is reassembled.

2. Remove coupling or sheaves in accordance with manufacturer's instructions.

3. Remove bolts securing generator base pads to base or foundation.

4. Move generator to location affording sufficient room for disassembly. Attach slings to the lifting eye bolts to move generator. See "Installation" instructions for handling precautions.

5. Remove exciter cover. Disconnect alternator field leads, remove exciter armature retaining bolt and washer. Remove exciter armature and rotating rectifier assembly as a unit.

6. Remove clips securing exciter field leads to exciter frame, generator frame and generator end bell.

7. Remove end bell bolts and end bell. Tap lightly with rubber or fiber mallet to loosen end bell. Check for shims in the end bell bearing housing (well). Make certain shims, when incorporated, are reinstalled when unit is assembled.

8. If the exciter stator (field) requires repair or replacement, remove bolts and remove exciter frame and stator assembly from the end bell.

9. Remove end bell bolts and end bell. Check for shims in bearing well. Remove fan from hub.

NOTE: Before loosening fan, measure distance from fan to fan baffle and maintain this distance when fan is reinstalled.

10. Install pipes over generator shaft on the drive and exciter end of rotor. Attach slings and hoist to pipes and remove rotor assembly from stator and frame. Make certain air gap is maintained between the rotor and stator during removal of the rotor.

NOTICE

Make certain pipes are of sufficient strength to support weight of rotor and that pipes do not have rough edges which would damage shaft surface.

11. Assemble generator by reversing order of disassembly procedures listed above.

SR4 HV Generators – 2900 Frame With Split Roller Bearings

General

This instruction covers the installation and removal of split bearings in SR4 HV Generators – 2900 Frame.

Lubrication

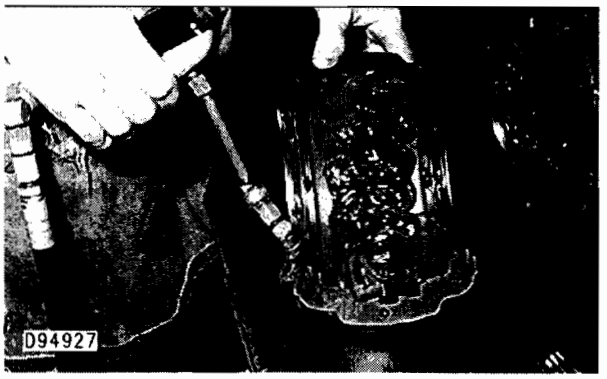


Figure 2
Filling housing with grease.

a. Replenishment – For periodic replenishment of lubrication, one or two shots form a grease gun (approximately one-half ounce) every 1000 hours for expansion bearings and every 100 hours for fixed bearings. Very stiff greases which tend to channel or very soft greases which may churn at high speed should not be used. Shell Alvania EP2 or equivalent is satisfactory.

b. Packing – Remove the protective paper from a new bearing. Remove the protective grease coat in a parts washer in rinse with clean solvent. When installing a bearing, use sufficient amount to coat the roller bearing. A similar amount fills the remaining space in a cartridge half (see figure 2). At the time of overhauling the prime mover, open up and check the generator bearings and repack. Replace the bearing, if necessary.

Bearing Replacement, Disassembly

To remove drive end bearing, proceed as follows:

1. Remove exciter and drive end covers.

2. Place wood or fiber protective strips between the generator field poles and the bottom of the stator. These strips must be of such thickness and strength as to minimize downward movement of the rotor if it rests on the stator.

3. Disconnect alternator field leads. Remove the exciter armature and PM retaining bolts. Thread two 5/8 threaded stock through the PM rotor into the shaft as shown in figure 3. Remove the PM rotor. The rotor should be removed by grasping the inside magnets and then pulling quickly and sharply straight back, overcoming the magnetic pull off the PM in a clean area, or seal it in plastic to avoid contamination with metal particles. See figures 3 and 4.

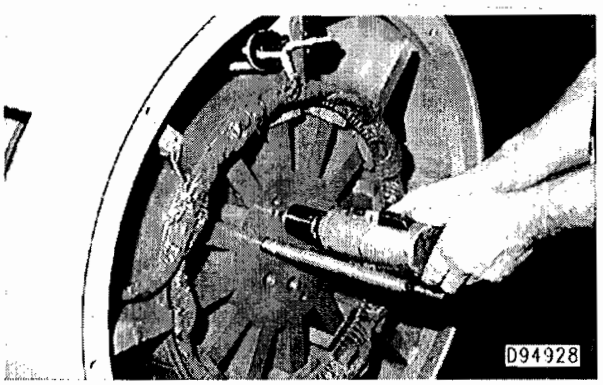


Figure 3
Loosen bolts.

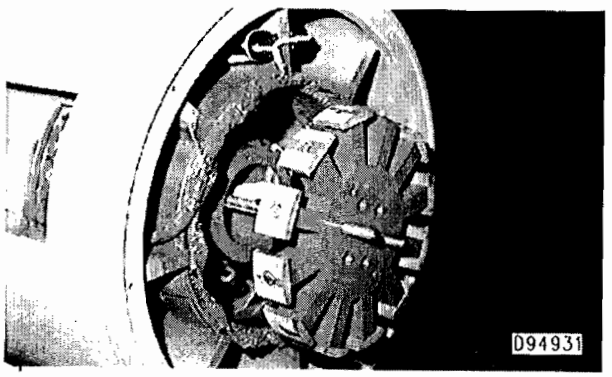


Figure 4
Remove PMG rotor.

⚠ WARNING

Take suitable precautions to prevent injury to fingers caused by the stator frame being forcibly attracted to permanent magnets on pilot rotor.

4. Remove clips securing exciter field leads to the exciter frame, generator frame and generatory endbell.

5. Connect a hoist to the lifting eyes on the exciter stator and remove the exciter stator mounting bolts. Remove the exciter stator from the endbell, being careful not to damage stator or rotor windings. The weight of the exciter stator is 75 Kg (165 lb). See figures 5 and 6.

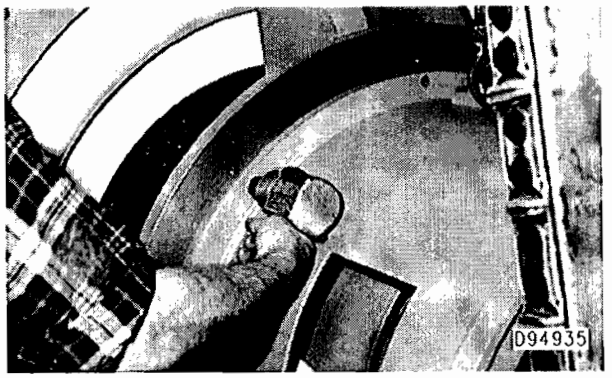


Figure 5
Remove bolts.

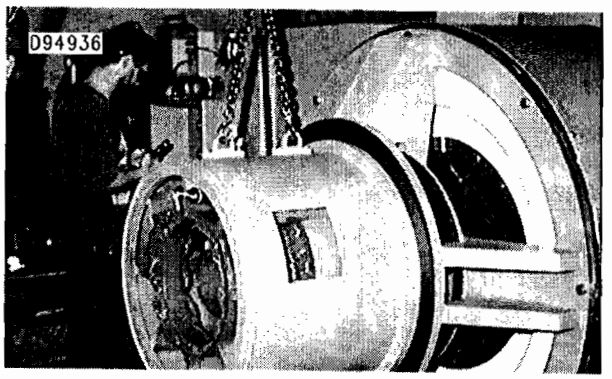


Figure 6
Remove exciter stator.

6. Remove the exciter armature and rotating rectifier as a unit.

A. Disconnect alternator field leads from the positive (+) and negative (-) terminals located on the heat sinks of the rotating rectifier assembly.

B. Using a hoist and strap, remove exciter armature and rotating rectifier. The weight of the exciter armature and rotating rectifier as a unit is 16.8 Kg (37 lb). See figure 7.

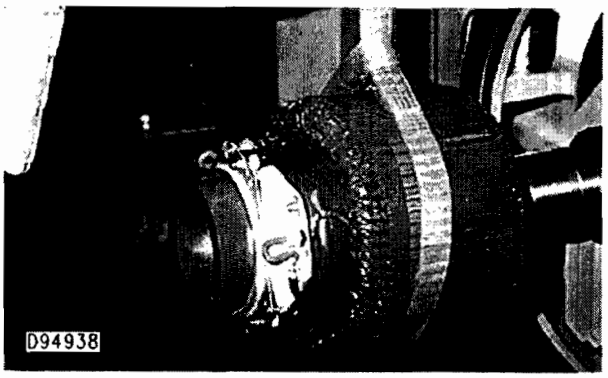


Figure 7
Remove exciter armature.

7. Place a sling about the drive end of the shaft and attach the sling to an overhead crane or hoist. Put enough pressure on the sling to hold shaft level. See figure 8.

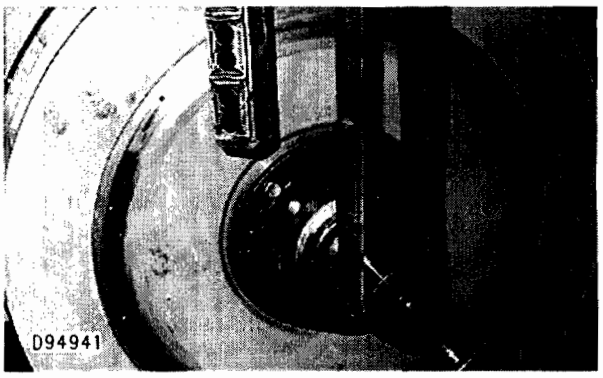


Figure 8
Sling placement.

8. Remove the bolts holding the two halves of the flanged bearing cap together. Take out the bolts holding the flanged bearing cap to the endbell and remove the two halves. Since the cartridge cannot move axially on the drive end bearing, the flanged cap halves must tilted out of the recess in the endbell. See figures 9 and 10.

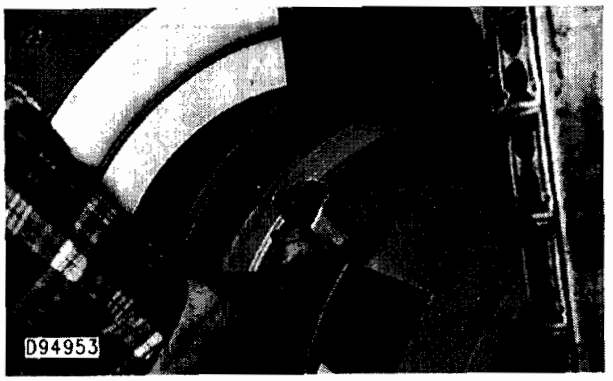


Figure 9

Figure 10

9. Remove the joint screws from the housing; remove the two halves of the housing. Leave the outer race in the housing. See figure 11.

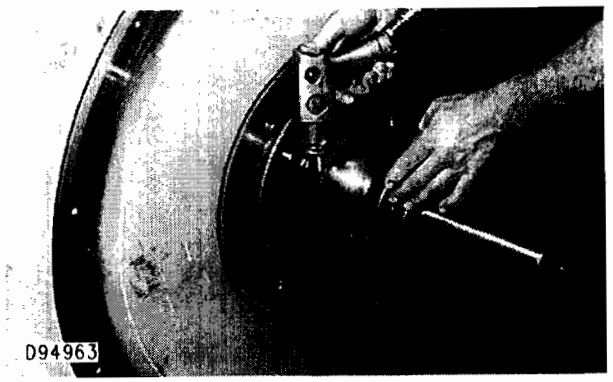


Figure 11
Remove housing.

10. Pull the outer seal off the shaft. Clean it and set it aside.

11. Remove the jointing clips from the roller cage; remove the roller cage.

12. Carefully measure the position of the inner race on the shaft so that the new inner race can be placed in exactly the same position. Measure from a specific surface on the coupling.

13. Remove the screws from the clamping rings. Remove the clamping rings and the inner race. See figure 12.

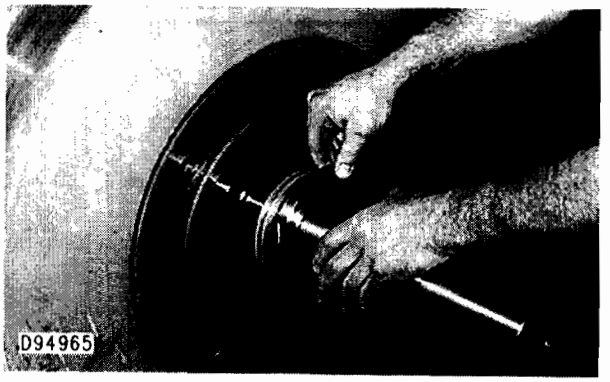


Figure 12
Remove clamping rings.

14. If the sling is to be removed, make sure that the wood or fiber strips are in position between the generator field and stator.

B. To remove the exciter end bearing, proceed as follows:

NOTE: Remove exciter per previous steps.

1. Place a strap around the exciter end of the shaft and lift enough to take the pressure off the bearing.

2. Remove the bolts holding the flanged bearing cap to the endbell; slide the bearing assemble out so that the cap is clear of the recess in the endbell.

3. Remove the joint screws from the cap; remove the two halves of the cap.

4. Remove the joint screws from the housing; remove the halves of the housing. Leave the outer race in the housing.

5. Slide the seals out of the way. Do not remove them unless they are to be replaced.

6. Remove the jointing clips from the roller cage; remove the roller cage.

7. Measure and record the position of the inner race on the inner shaft.

8. Remove the screws from the clamping rings;remove the clamping rings and inner race.

9. If the sling is to be removed, make sure that the strips are in position between the generator field and stator.

Bearing Replacement Assembly

To assemble a bearing, proceed as follows:

1. Place inner seal on shaft, if it is not already there. A coat of STP or similar substance may be applied to the shaft before moving the seal into place. See figure 13.

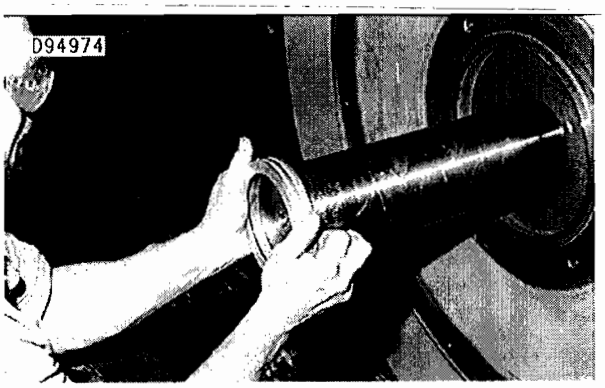


Figure 13
Install inner seal.

2. Place the two halves of the inner race at the correct position on the shaft. A light tap with a rawhide or rubber hammer may be required to spring the races over the shaft. Consult the measurements taken during disassembly. The drive end race and comm end race must be placed exactly where the original race had been. See figures 14 and 15.

NOTE: The inner race and the clamping rings are matched sets and are not interchangeable. They are stamped with identifying numbers. Make sure the numbers match and are facing the same direction.

Figure 14
Match numbers and direction.

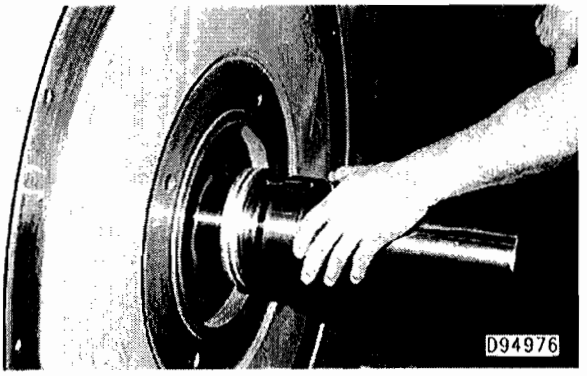


Figure 15
Placing inner race.

3. Fit the clamping rings with their joints rotated between 10 and 90 degrees from the joints in the inner race. Tighten all four clamping screws equally using a torque wrench. See figure 16.

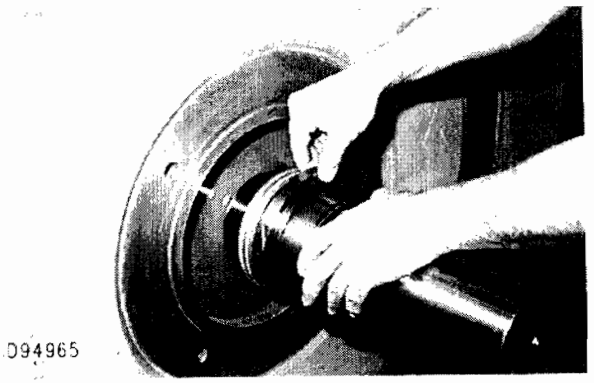


Figure 16
Install clamping rings.

4. Tap down each half of the inner race and clamping rings all around the shaft, placing a fiber or hardwood block between hammer and bearing parts. Retighten screws. Repeat until the screws are fully tight. Make sure that the rings are hard against the race shoulders all around. There should be a gap at the joints of the seating. It may be helpful to place shim stock in the tightening. The total gap is not critical provided the shaft is within the required tolerance (126.97 to 127 mm), 4.999 to 5.000 inches. Make sure the placement of the inner race is the same measurement as recorded earlier. See figure 17.

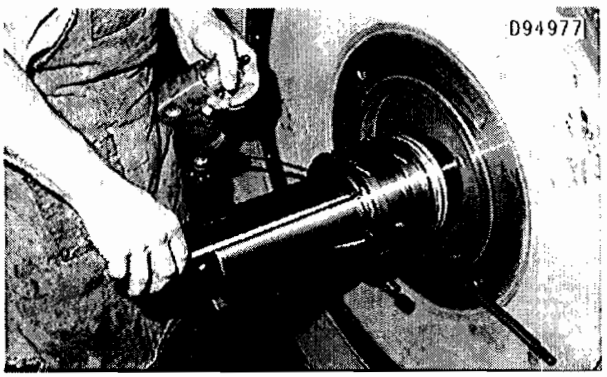


Figure 17
On drive end, positioning must be exact.

5. Place the cage around the inner race, matching the race halves. Insert the jointing clips. See figure 18.

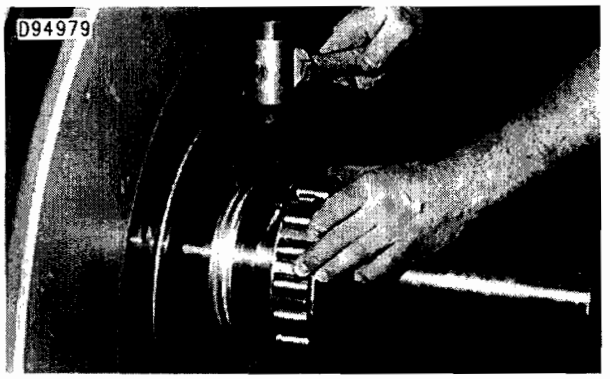


Figure 18
Installing roller cage.

6. Inject sufficient grease to fill the grease passages. Fill each half of the cartridge with grease. See paragraph on Lubrication of the approximate amounts of grease required. Also, lubricate the bores of the revolving triple labyrinth seals.

7. Place outer seal on shaft if it is not already there. Note the position of the seals in figure 19.

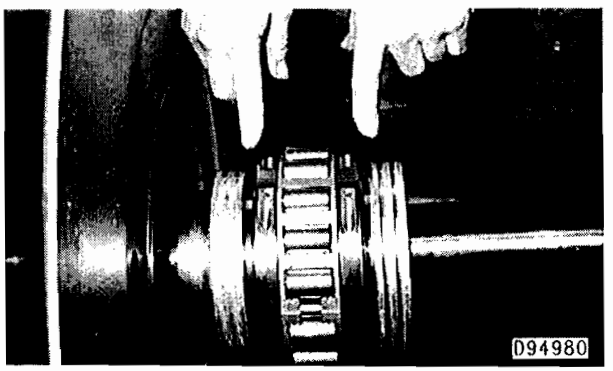


Figure 19
Note position of seals.

8. Assemble the two halves of the housing. (The outer race halves should be in the housing halves). Tighten the joint screws, making sure the end faces are flush. Lubricate the spherical seating. MolyKote or similar is advantageous. Rotate the cartridge so that the projecting boss is on top. See figure 20.

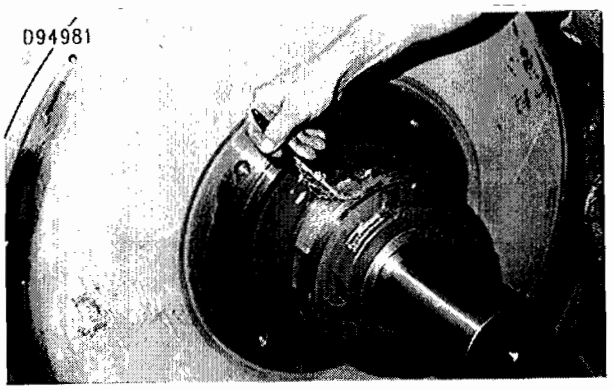


Figure 20
Lubricate spherical seating.

9. Using a crane or hoist on the generator shaft, assemble the flanged cap and seat in the recess in the endbell. The half with the threaded holes for the joining bolts goes on the bottom. The boss on the cartridge must enter the recess in the flanged cap. On the drive end, the halves must be tilted into place over the cartridge while at the same time inserting their mating surface in to the endbell recess. On the exciter end, where there is an expansion race, the two halves can be placed together and then the entire bearing assembly moved inboard to seat in the endbell. Allow the spherical seating to self-align before doing the final tightening of the joining bolts in the flanged cap. See figure 21.

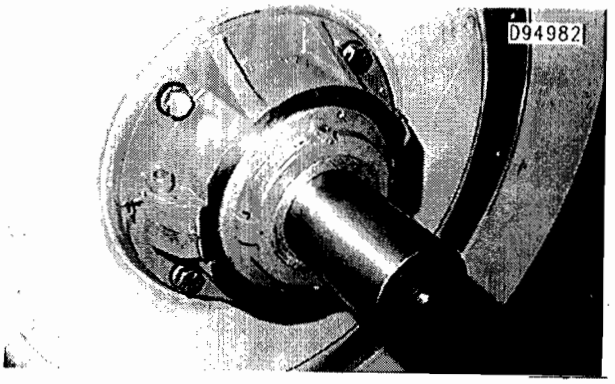


Figure 21
Assembled bearing.

10. Note that the cap screws or bolts holding the bearing assembly to the endbell on the exciter end each have a lock washer and a hardened flat metal washer. These screws must not be allowed to bottom out in their holes.

11. Remove the strips form between the generator field poles and stator. Install the exciter and PMG, reversing the removal procedure.

12. Make sure all bolts are torqued to the proper levels when assembling generator.

Test Equipment, Tools And Materials

Test Equipment

D96951

8T-0900	Clamp-On Ammeter	Clamp-on, 0 to 500 amp range for measuring of electrical current
6V-7070	Multi-meter	Digital, for measuring voltage, current, and resistance
4C-6500	Digital Thermometer	For measuring temperature in degrees Celsius
9U-6003	Megger	To measure insulation resistance
1H-3110 & 1H-3107	Exciter / Bearing Puller	For changing the bearings and exciter armature

Special Tools

	Resistive Bridge	To measure resistance of windings
	Protective Gloves	Electrical, Rubber, 13,800 V

Standard Tools

6V-3001	Crimping tool	For crimping cable
1U-7322	Flashlight	As required
8F-9866	Grease Gun	For lubricating bearings
1S-0258	Hammer	Soft-faced
4C-6477	Lamp - Fluorescent	Safety light
1U-7240	Screwdrivers	Both Phillips and Standard; sized as required
1U-7248	Wrench	Adjustable, 12 inch
8T-9293	Wrench	Torque, 40 to 250 ft-lb
1U-7460	Wrench Set	Allen, 1/8 to 1/2 inch
1U-7180	Wrench Set	Socket 1/4 to 1 inch with 3/8 inch Drive
1U-7130	Wrench Set	Socket 1/4 to 1 Inch with 1/2 inch Drive
1U-7050	Wrench Set	Standard, open-end combination sized 1/4 to 1 inch
N/A	Vacuum	Electric with nonmetallic nozzle

Materials

1U-8809	Corrosion Inhibitor	Rust Preventative
1U-8807	Detergent	As required for cleaning
4C-5522	Gloves	For chemical protection
N/A	Plastic	Protection for long-term storage
N/A	Rags	As required
N/A	Water	For cleaning
N/A	Air	Compressed, Dry
N/A	Covering Material	Waterproof Desiccant Bags, for protection from moisture during long-term equipment storage
SEHS7332	"Do Not Operate" Tags	For providing visual warnings and cautions

Reference Literature

The following literature can be obtained through any Caterpillar dealer.

Operation and Maintenance Manuals

SEBU6916, 3500B EPG Engine

SEBU6701, 3508, 3512 & 3516 Industrial & EPG Generator Engines

SEBU5853, 3508, 3512 & 3516 Industrial Engines

SEBU6156, 3508 Standby Generator Set Engine

SEBU6618, XQ125 Rental Generator Set

SEBU6499, XQ225 Rental Generator Set

SEBU6455, XQ350 Rental Generator Set

Owner's Manuals

SEBU6874, Customer Communication Module

Service Manual Modules

The Modules that follow are included in the Service Manual SENR8395

SENR5809, Electronic Modular Control Panel II

SENR5827, Electronic Modular Control Panel II For Electronically Controlled Engines

Service Manuals

SENR6430, 524/1724, 8290 Governor System

SENR4676, 2301A Speed Governor

SENR3880, 3508, 3512, 3516 Generator Set Engines

SENR3585, 2301A Load Sharing Governor

SENR6565, EPG Load Sensor and Load Sharing

NOTE: Specific Generator Service Manuals will include the necessary service information for the generator and control panel.

Special Instructions

SEHS9124, Cleaning and Drying of Electric Set Generators, included in the Service Manual SENR8395.

Additional literature may become available and may not be included above. Contact your Caterpillar dealer to check the availability, form number, and price of all literature before placing orders.

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