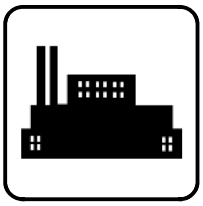
Service

Industrial Generator Sets



Models:

20–400 kW

Alternators:

Fast-Response™ II (Permanent Magnet Alternator)

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6353 3/12b

California Proposition 65

⚠ WARNING

Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Designation _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Controller Identification

Record the controller description from the generator set operation manual, spec sheet, or sales invoice.

Controller Description _____

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

Table of Contents

Notes

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING

Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Battery

WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

WARNING

Explosion.
Can cause severe injury or death.
Relays in the battery charger cause arcs or sparks.

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (–) lead first when disconnecting the battery. Reconnect the negative (–) lead last when reconnecting the battery. Never connect the negative (–) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

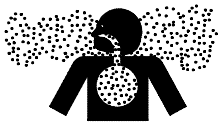
Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building.

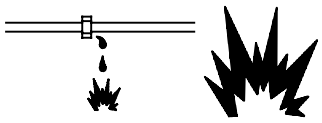
Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Fuel System

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Propane (LP)—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

Natural Gas—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.

Fuel tanks. Explosive fuel vapors can cause severe injury or death. Gasoline and other volatile fuels stored in day tanks or subbase fuel tanks can cause an explosion. Store only diesel fuel in tanks.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP vapor gas or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

LP liquid withdrawal fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LP liquid withdrawal gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to at least 90 psi (621 kPa). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/ Moving Parts

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING

Hazardous voltage.
Backfeed to the utility system can cause property damage, severe injury, or death.

If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply.

⚠ CAUTION

Welding the generator set.
Can cause severe electrical equipment damage.

Never weld components of the generator set without first disconnecting the battery, controller wiring harness, and engine electronic control module (ECM).

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Testing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. When the end cover is removed, do not expose the photo transistor circuit board mounted on the generator set end bracket to any external light source, as exposure to light causes high voltage. Keep foreign sources of light away from the photo transistor circuit board during testing. Place black electrical tape over the LED on the circuit board before starting the generator set.

Installing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. Ensure that the foil side of the photo transistor circuit board, the end of the shaft, and the threaded holes are clean and free of metal particles and chips. Metal debris may short-circuit the photo transistor circuit board and cause hazardous voltage in the generator set. Do not reconnect the generator set to the load until the AC voltmeter shows the correct output.

Welding on the generator set. Can cause severe electrical equipment damage. Before welding on the generator set perform the following steps: (1) Remove the battery cables, negative (-) lead first. (2) Disconnect all engine electronic control module (ECM) connectors. (3) Disconnect all generator set controller and voltage regulator circuit board connectors. (4) Disconnect the engine battery-charging alternator connections. (5) Attach the weld ground connection close to the weld location.

Installing the battery charger. Hazardous voltage can cause severe injury or death. An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death. Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Engine block heater. Hazardous voltage can cause severe injury or death. The engine block heater can cause electrical shock. Remove the engine block heater plug from the electrical outlet before working on the block heater electrical connections.

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Install a transfer switch in standby power installations to prevent the connection of standby and other sources of power. Electrical backfeed into a utility electrical system can cause severe injury or death to utility personnel working on power lines.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

⚠ WARNING

Airborne particles.
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Heavy Equipment

⚠ WARNING

Unbalanced weight.
Improper lifting can cause severe injury or death and equipment damage.

Do not use lifting eyes.
Lift the generator set using lifting bars inserted through the lifting holes on the skid.

Hot Parts

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Canadian installations only. For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

Notes

This manual provides troubleshooting and repair instructions for the generator set models listed on the front cover using permanent magnet alternators.

Wiring diagram manuals are available separately.

Refer to the generator set controller operation manual for operating instructions. Refer to the engine operation manual for generator set engine scheduled maintenance information. Refer to the engine service manual for generator set engine repair and overhaul information.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

List of Related Materials

Separate literature contains voltage regulator setup information not provided in this manual when the generator set has a controller with an integrated digital voltage regulator. Figure 1 lists the available literature part numbers.

Manual Description	Literature Part No.
Decision-Maker® 550 Controller Operation Manual	TP-6200
Decision-Maker® 3000 Controller Operation Manual	TP-6694
Decision-Maker® 6000 Controller Operation Manual	TP-6750

Figure 1 Related Literature

Service Assistance

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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East China Regional Office, Shanghai
Phone: (86) 21 6288 0500
Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea
North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

1.1 Introduction

The specification sheets for each generator set provide specific alternator and engine information. Refer to the respective specification sheet for data not supplied in this manual. Consult the generator set operation manual, installation manual, engine operation manual, and engine service manual for additional specifications.

A permanent magnet alternator is identified with one of the following prefix designations: 4P, 4Q, 4S, 4U, 4UA, or 4V. Example: Gen. Model 4S11. The letters W and X *do not* appear in alternator model designations relevant to the information in this manual.

The generator set is a rotating-field alternator with a smaller rotating-armature alternator turned by a common shaft. The main rotating-field alternator supplies current to load circuits while the rotating-armature (exciter) alternator supplies DC to excite the main alternator's field.

The generator set is a 4-pole, rotating-field with brushless, permanent magnet (PM) alternator excitation system. The PM system provides short-circuit excitation current up to 300% at 60 Hz (approximately 275% at 50 Hz) for a minimum of 10 seconds to allow selective circuit breaker tripping.

Solid state voltage regulator is PM powered, maintenance free, and encapsulated for moisture protection. The voltage regulator provides ±1/2%, no load to full load voltage regulation, adjustable volts/Hz, underspeed protection, 3-phase RMS sensing, and over excitation protection as standard.

1.2 20–400 kW/25–500 kVA Permanent Magnet Alternator Concept

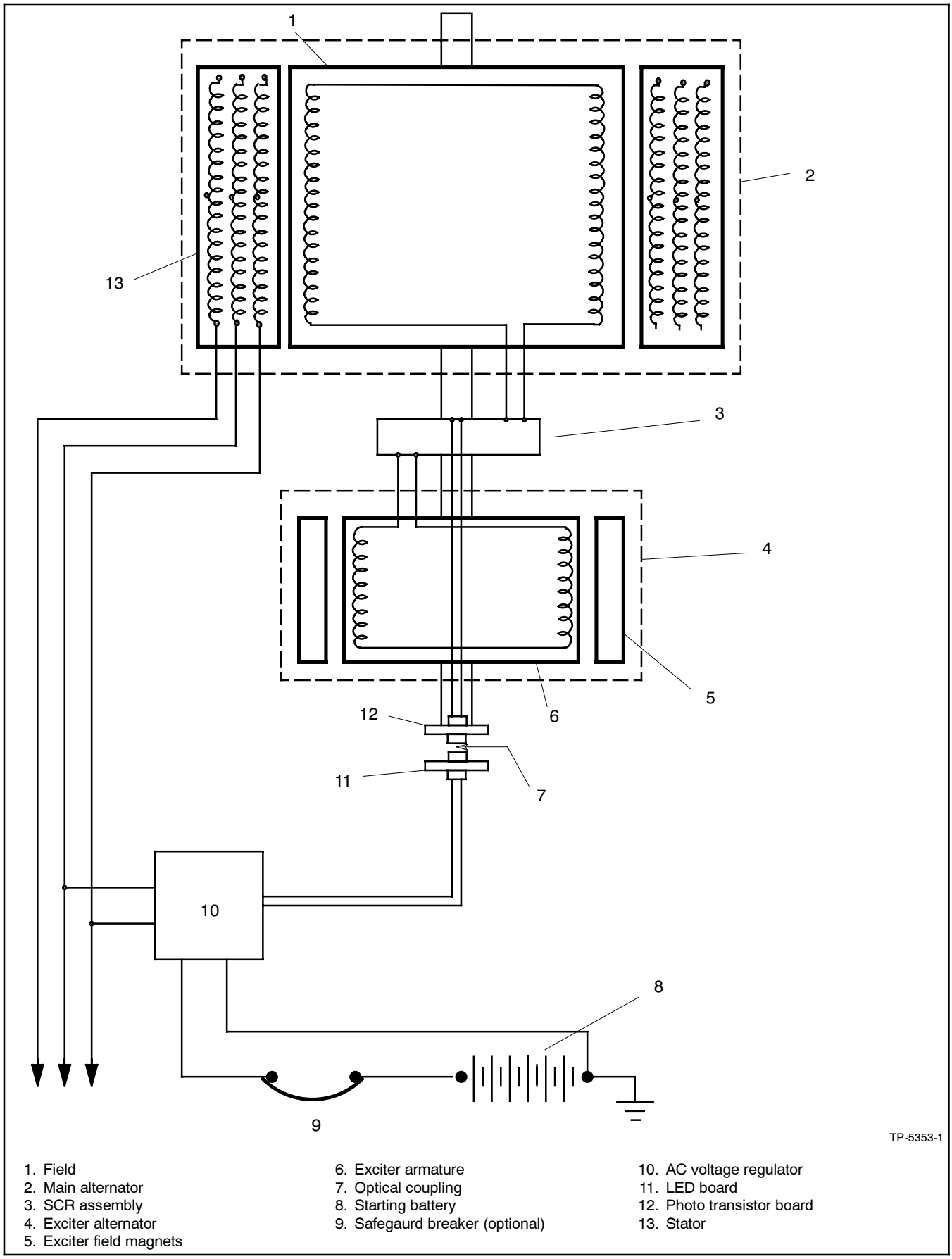
The alternator excitation system uses a permanent magnet exciter with a silicon controlled rectifier (SCR) assembly which controls the amount of DC current fed to the alternator field. This type of system uses a voltage regulator which signals the SCR assembly through an optical coupling. The voltage regulator monitors engine speed and alternator output voltage to turn a stationary light emitting diode (LED) on or off, according to engine speed and output voltage. The LED is mounted on the end bracket opposite a photo transistor board which rotates on the shaft. The photo transistor picks up the signal from the LED and tells the SCR assembly to turn on or off, depending upon the need, as dictated by the voltage regulator. See Figure 1-1.

The voltage recovery period of this type of alternator is several times faster than the conventionally wound field brushless alternator because it does not have to contend with the inductance of the exciter field. It also has better recovery characteristics than the static excited machine because it is not dependent upon the generator set output voltage for excitation power. Possibly the greatest advantage of this type machine is its inherent ability to support short-circuit current and allow system coordination for tripping downstream branch circuit breakers.

The generator set systems deliver exciter current to the main field within 0.05 seconds of a change in load demand.

1.3 Short Circuit Performance

When a short circuit occurs in the load circuit(s) being served, output voltage drops and amperage momentarily rises to 600%–1000% of the generator set's rated current until the short is removed. The SCR assembly sends full exciter power to the main field. The alternator then sustains up to 300% of its rated current. Sustained high current will cause correspondingly rated load circuit fuses/breakers to trip. The safeguard breaker kit serves to collapse the generator set's main field in the event of a sustained heavy overload or short circuit.



1. Field
2. Main alternator
3. SCR assembly
4. Exciter alternator
5. Exciter field magnets
6. Exciter armature
7. Optical coupling
8. Starting battery
9. Safegaurd breaker (optional)
10. AC voltage regulator
11. LED board
12. Photo transistor board
13. Stator

Figure 1-1 Alternator Schematic

1.4 Electrical Values

Component Specification	Model	Value
Alternator field resistance (F+/ F-)	20-60 kW	2.0-2.9 ohms
Alternator field resistance (F+/ F-)	80-150 kW	1.8-2.2 ohms
Alternator field resistance (F+/ F-)	180-400 kW	1.0-1.5 ohms
Exciter armature resistance	20-30 kW (24 pole)	0.19 ohms
Exciter armature resistance	40-60 kW (24 pole)	0.13 ohms
Exciter armature resistance	80-150 kW (16 pole)	0.27 ohms
Exciter armature resistance	180-300 kW (16 pole)	0.26 ohms
Exciter armature resistance	350/400 kW (8 pole)	0.62 ohms
End bracket to bearing outer race clearance	20-400 kW	6.35 mm (0.25 in.)
Speed sensor air gap	20-400 kW	0.36-0.71 mm (0.014-0.028 in.)
Speed sensor voltage	20-400 kW	2 (black) & 16 (white) 3-6 volts DC 2 (black) & 24 (red) 8-10 volts DC

1.5 Torque Values

Use the torque values shown below during alternator assembly. For assembly torque values not shown, use the guidelines in Appendix C, General Torque Specifications.

Component Specification	Model	Torque Value
Ground lug assembly nuts	20-400 kW	45 Nm (34 ft. lb.)
SCR assembly terminal nuts	20-150 kW	0.9 Nm (8 in. lb.)
SCR assembly mounting bolts	180-400 kW	0.9 Nm (8 in. lb.)
Fan to rotor flange bolts	20-300 kW	29 Nm (260 in. lb.)
Fan to rotor flange bolts	350/400 kW	35 Nm (28 ft. lb.)
End bracket to stator bolts	20-300 kW	47 Nm (35 ft. lb.)
End bracket to stator bolts	350/400 kW	95 Nm (70 ft. lb.)
Exciter field assembly to end bracket	350/400 kW	45 Nm (34 ft. lb.)
Terminal block to stator bolts	350/400 kW	9.5 Nm (7.0 ft. lb.)
Drive disks to rotor shaft bolts	20-300 kW	68 Nm (50 ft. lb.)
Drive disks to rotor shaft bolts	350/400 kW	115 Nm (85 ft. lb.)
End bracket grease fitting	180-400 kW	9.5 Nm (7 ft. lb.)
End bracket grease vent screw	180-400 kW	9.5 Nm (7 ft. lb.)
Photo transistor circuit board, insulator, and magnetic actuator to rotor shaft screws	20-400 kW	4.7 Nm (42 in. lb.)
Alternator adapter to stator bolts	350/400 kW	95 Nm (70 ft. lb.)
Alternator adapter to flywheel housing bolts	20-400 kW	See chart following
Drive discs to flywheel bolts	20-400 kW	See chart following

1.6 Alternator Adapter to Flywheel Housing Torque Values

Model	Engine	Alternator	Hardware Type,	Torque, Nm (ft. lb.)	Hardware Sequence
20 kW	Ford LRG-425	4P, 4Q	3/8-16, grade 8 bolt	53 (39)	Bolt, washer (3)
20-40 kW	John Deere		3/8-16, grade 8 bolt	53 (39)	Bolt, hardened washer
25-60 kW	GM		3/8-16, grade 8 bolt	53 (39)	
50/60 kW	John Deere		3/8-16, grade 8 bolt	53 (39)	
			M10, grade 10.9 bolt		
60-150 kW	GM	4S, 4V	3/8-16 grade 8 bolt	53 (39)	
60-180 kW	John Deere		3/8-16 grade 8 bolt	53 (39)	
			7/16-14, grade 8 bolt	60 (44)	
			M10, grade 10.9 bolt	65 (48)	
135/150 kW	DDC Series 50/60 Gas		7/16-14, grade 8 bolt	60 (44)	
150-275 kW	DDC Series 50/60 Gas	4UA	7/16-14, grade 8 bolt	85 (63)	
180 kW	Doosan		M10, grade 10.9 bolt	65 (48)	
200 kW	DDC Series 40		3/8-16, grade 8 bolt	53 (39)	
200-250 kW	Doosan		M10, grade 10.9 bolt	65 (48)	
			7/16-14, grade 8 bolt	85 (63)	
200-300 kW	John Deere		3/8-16, grade 8 bolt	53 (39)	
			7/16-14, grade 8 bolt	85 (63)	
			M10, grade 10.9 bolt	65 (48)	
200-300 kW	Volvo		7/16-14, grade 8 bolt	85 (63)	
			M10, grade 10.9 bolt	65 (48)	
230-300 kW	DDC Series 60 Diesel		7/16-14, grade 8 bolt	85 (63)	
350/400 kW	DDC Series 60		7/16-14, grade 8 bolt	85 (63) steel/cast iron	
				60 (44) aluminum	
350/400 kW	Volvo		1/2-13, grade 8 bolt	130 (96)	

1.7 Drive Discs to Flywheel Torque Values

Model	Engine	Alt.	Hardware Type,	Torque, Nm (ft. lb.)	Hardware Sequence
20 kW	Ford LRG-425	4P, 4Q	3/8-16, grade 8 stud	53 (39)	Stud, spacer, hardened washer, nut
20-40 kW	John Deere		3/8-16, grade 8 stud	53 (39)	Stud, spacer, hardened washer, grade 8 nut
25-60 kW 50/60 kW	GM John Deere		3/8-16, grade 8 stud	53 (39)	Stud, spacer, hardened washer, nut
60-125 kW 80-180 kW	GM John Deere	4S, 4V	3/8-16, grade 8 stud	53 (39)	
135/150 kW	DDC Series 50/60 Gas		1/2-13, grade 8 bolt	60 (44)	Bolt, hardened washer
150-275 kW	DDC Series 50/60 Gas	4UA	1/2-13, grade 8 bolt	130 (96)	
180 kW	Doosan		M12, grade 10.9 bolt	122 (90)	
200 kW	DDC Series 40		3/8-16, grade 8 stud	53 (39)	Stud, spacer, hardened washer, grade 8 nut
200 kW	Doosan		1/2-13, grade 8 bolt	130 (96)	Bolt, hardened washer
			M12, grade 10.9 bolt	122 (90)	
200-300 kW	John Deere		1/2-13, grade 8 bolt	130 (96)	
200-300 kW	Volvo		1/2-13, grade 8 bolt	130 (96)	
			M12, grade 10.9 bolt	122 (90)	
230-300 kW	DDC Series 60 Diesel		1/2-13, grade 8 bolt	130 (96)	
250 kW	Doosan		3/8-16, grade 8 stud	53 (39)	Stud, spacer, hardened washer, grade 8 nut
350/400 kW	DDC Series 60		1/2-13, grade 8 bolt	130 (96)	Bolt, hardened washer
350/400 kW	Volvo		7/16-14, grade 8 bolt	85 (63)	

Section 2 Troubleshooting

This section contains generator set troubleshooting, diagnostic, and repair information.

Use the chart on the following page to diagnose and correct common problems. First check for simple causes such as a dead engine starting battery or an open circuit breaker. The chart includes a list of common problems, possible causes of the problem, recommended corrective actions, and references to detailed information or repair procedures.

Maintain a record of repairs and adjustments performed on the equipment. If the procedures in this manual do not explain how to correct the problem, contact an authorized distributor/dealer. Use the record to help describe the problem and repairs or adjustments made to the equipment.

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Controller												
x	x									Controller circuit board(s) inoperative	Troubleshoot starting circuit/replace board.	—
				x						Controller fault	Troubleshoot the controller.†	Generator set O/M
x	x			x						Controller fuse blown	Replace the blown controller fuse. If the fuse blows again, troubleshoot the controller.†	W/D
x										Controller master switch inoperative	Replace the controller master switch.	—
x										Controller master switch in the OFF/RESET position	Move the controller master switch to the RUN or AUTO position.	Generator set O/M
x										Engine start circuit open	Move the controller master switch to the RUN position to test the generator set. Troubleshoot the auto start circuit and time delays.	Generator set O/M, W/D, ATS O/M, S/M
Cooling System												
						x		x		Air openings clogged	Clean the air openings.	—
						x				Coolant level low	Restore the coolant to normal operating level.	Generator set O/M
						x				Cooling water pump inoperative	Tighten or replace the belt. Replace the water pump.	Eng. O/M or S/M
				x						High temperature shutdown	Allow the engine to cool down. Then troubleshoot the cooling system.	Generator set O/M, Eng. O/M
				x						Low coolant level shutdown, if equipped	Restore the coolant to normal operating level.	Generator set O/M
						x				Thermostat inoperative	Replace the thermostat.	Eng. S/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

‡ If the unit has a 550 controller, refer to the 550 controller operation manual for voltage regulator settings. Go to Menu 20, Factory Setup and verify that the application software (code version) is correct for the generator set model and alternator voltage.

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Electrical System (DC circuits)												
x	x									Battery connections loose, corroded, or incorrect	Verify that the battery connections are correct, clean, and tight.	Generator set O/M
x	x									Battery weak or dead	Recharge or replace the battery. The spec sheet provides recommended battery CCA rating.	Generator set O/M, S/S
x	x									Starter/starter solenoid inoperative	Replace the starter or starter solenoid.	Eng. S/M
x				x						Engine harness connector(s) not locked tight	Disconnect the engine harness connector(s) then reconnect it to the controller.	W/D
				x						High water temperature switch inoperative	Replace the inoperative switch.	Engine S/M, or W/D
				x						Fault shutdown	Reset the fault switches and troubleshoot the controller.	Generator set O/M
				x						High exhaust temperature switch inoperative	Replace the inoperative switch.	Engine S/M, or W/D
Engine												
	x	x			x			x		Air cleaner clogged	Clean or replace the filter element.	Eng. O/M
	x	x				x		x	x	Compression weak	Check the compression.†	Eng. S/M
			x		x	x		x	x	Engine overload	Reduce the electrical load. See the generator set spec sheet for wattage specifications.	S/S
									x	Exhaust system leak	Inspect the exhaust system. Replace the inoperative exhaust system components.†	I/M
									x	Exhaust system not securely installed	Inspect the exhaust system. Tighten the loose exhaust system components.†	I/M
		x	x		x			x		Governor inoperative	Adjust the governor.†	Governor literature
					x				x	Valve clearance incorrect	Adjust the valves.†	Eng. S/M
									x	Vibration excessive	Tighten all loose hardware.	—
	x	x			x					Ignition system inoperative (gas/gasoline only)	Check the ignition system (spark plugs, spark plug wires, etc.).	Eng. O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

‡ If the unit has a 550 controller, refer to the 550 controller operation manual for voltage regulator settings. Go to Menu 20, Factory Setup and verify that the application software (code version) is correct for the generator set model and alternator voltage.

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Fuel System												
	x	x			x					Air in fuel system (diesel only)	Bleed the diesel fuel system.	Eng. O/M
	x	x								Ether canister empty or system inoperative, if equipped (diesel only)	Replace or repair the ether starting system.	Eng. O/M
	x			x						Fuel tank empty or fuel valve shut off	Add fuel and move the fuel valve to the ON position.	—
	x				x			x		Fuel feed or injection pump inoperative (diesel only)	Rebuild or replace the injection pump.†	Eng. S/M
	x	x			x					Fuel or fuel injectors dirty or faulty (diesel only)	Clean, test, and/or replace the inoperative fuel injector.†	Eng. S/M
	x	x		x	x					Fuel filter restriction	Clean or replace the fuel filter.	Eng. O/M
	x									Fuel solenoid inoperative	Troubleshoot the fuel solenoid.†	Eng. S/M
	x				x					Fuel pressure insufficient (gas only)	Check the fuel supply and valves.†	S/S, Gen. O/M
	x	x			x			x		Fuel injection timing out of adjustment (diesel only)	Adjust the fuel injection timing.†	Eng. S/M
Alternator												
			x							AC output circuit breaker open	Reset the breaker and check for AC voltage at the generator side of the circuit breaker.	—
x										Transfer switch test switch in the OFF position	Move the transfer switch test switch to the AUTO position.	ATS O/M
			x							Transfer switch fails to transfer load	Move the ATS test switch to the AUTO position. Troubleshoot the transfer circuit and time delays.	ATS O/M, S/M
			x							Wiring, terminals, or pin in the exciter field open	Check for continuity.	Section 3, W/D
			x							Main field (rotor) inoperative (open or grounded)	Test and/or replace the rotor.†	Section 3
			x							Stator inoperative (open or grounded)	Test and/or replace the stator.†	Section 3
									x	Vibration excessive	Tighten loose components.†	—
			x	x						Voltage regulator digital settings incorrect (digital controller only)	Adjust the voltage regulator.	Section 3 ‡
			x	x						Voltage regulator inoperative	Replace the voltage regulator fuse, If the fuse blows again, troubleshoot the voltage regulator.	Section 3 ‡
			x	x						Voltage regulator out of adjustment	Adjust the voltage regulator.	Section 3 ‡

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

‡ If the unit has a 550 controller, refer to the 550 controller operation manual for voltage regulator settings. Go to Menu 20, Factory Setup and verify that the application software (code version) is correct for the generator set model and alternator voltage.

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Lube System												
	x	x					x		x	Crankcase oil type incorrect for ambient temperature	Change the oil. Use oil with a viscosity suitable for the operating climate.	Eng. O/M
						x	x		x	Oil level low	Restore the oil level. Inspect the generator set for oil leaks.	Eng. O/M
				x						Low oil pressure shutdown	Check the oil level.	Eng. O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

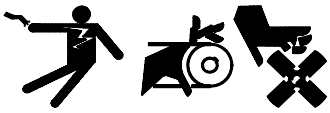
‡ If the unit has a 550 controller, refer to the 550 controller operation manual for voltage regulator settings. Go to Menu 20, Factory Setup and verify that the application software (code version) is correct for the generator set model and alternator voltage.

Notes

3.1 Alternator Troubleshooting

This section provides information on testing components of the generator set. Contact an authorized service distributor/dealer for the appropriate technical manuals for the alternator and voltage regulator.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Use the following flowcharts to troubleshoot the generator set when no voltage or high voltage is detected. The remaining parts of this section give additional and more detailed information about the individual checks/tests mentioned in the flowchart. Use the flowchart to initially isolate the possible problem.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

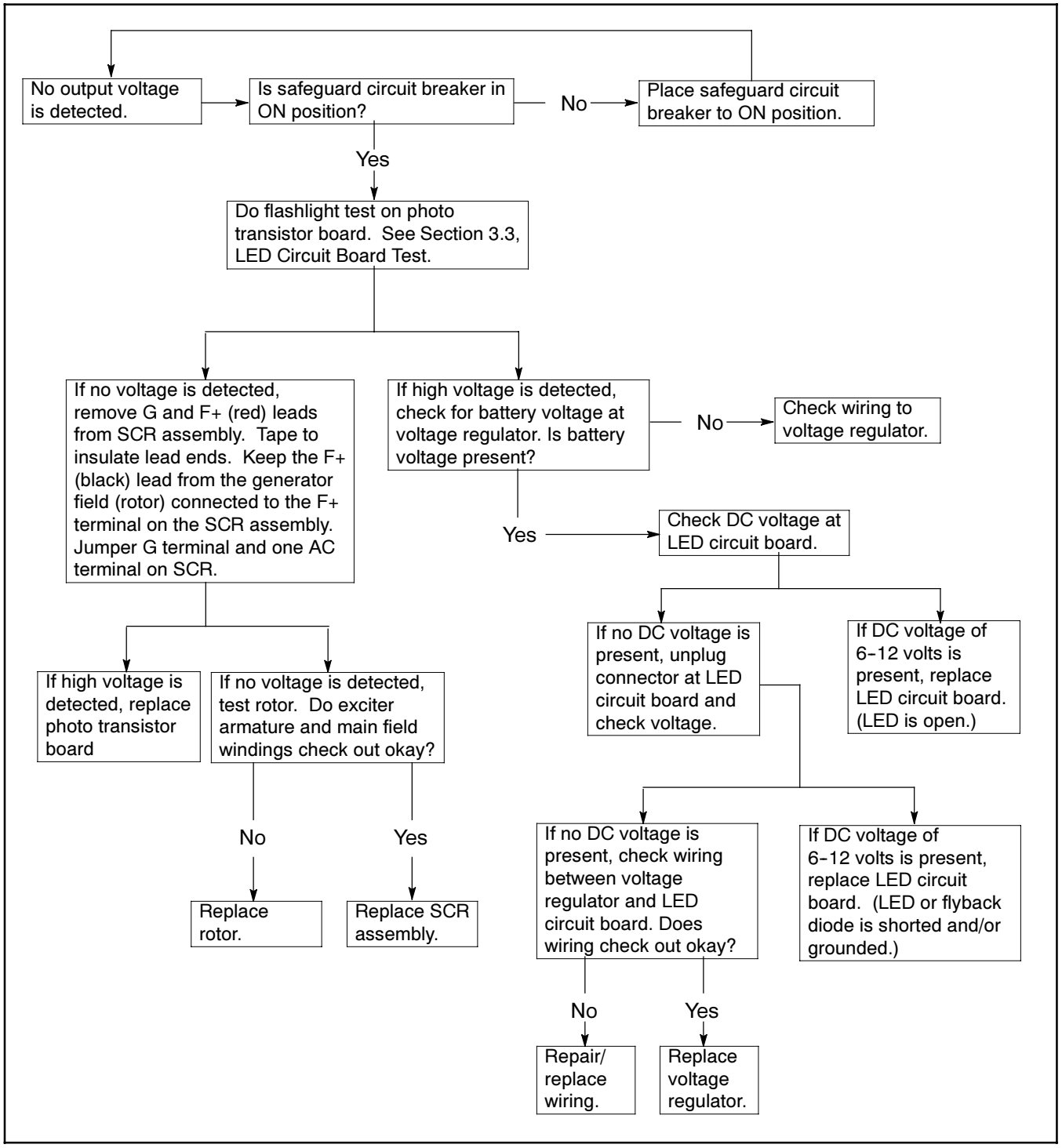
⚠ WARNING

Hazardous voltage. Moving parts.
Can cause severe injury or death.

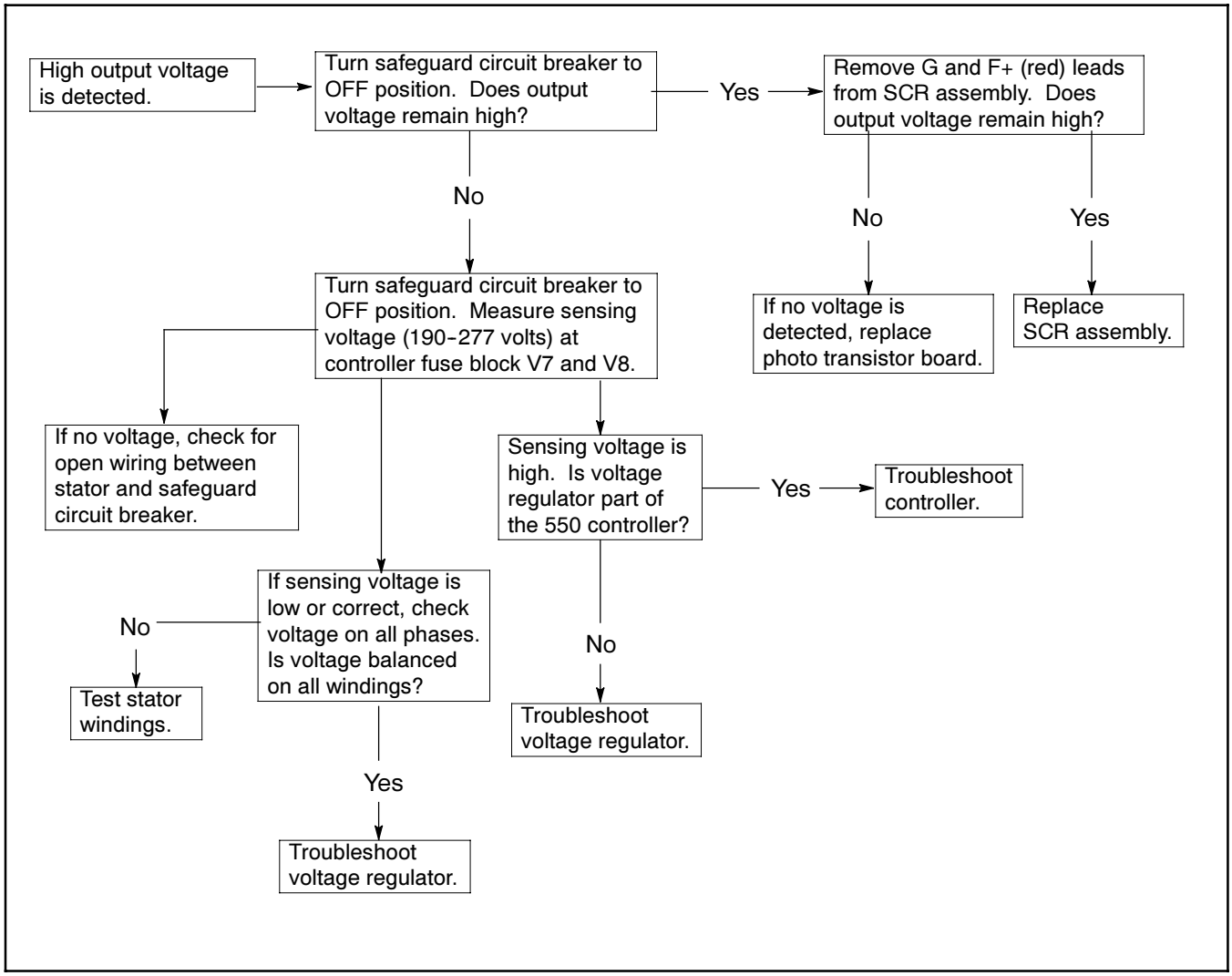
Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

3.1.1 Troubleshooting Alternator, No Output Voltage



3.1.2 Troubleshooting Alternator, High Output Voltage

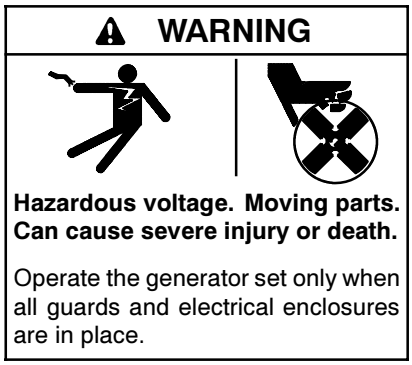


3.2 Alternator Testing

This section covers alternator testing for the following conditions:

- No output on any phase
- Overvoltage
- Fluctuating voltage

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Follow all safety precautions listed in the front of this manual and the additional precautions within the text. Figure 3-1 lists various alternator output conditions and component tests. Refer to Figure 3-2, AC Voltage Control, for assistance in troubleshooting.

3.2.1 No Output On Any Phase

1. Check the safeguard breaker (if equipped). If the safeguard breaker is open, close breaker and, with set running, check AC voltmeter for proper output voltage.

2. If proper output does not show, then:

   a. Check wire 1B from safeguard breaker and wire 7N (ground) to voltage regulator.

   b. Check for voltage to safeguard breaker (if equipped).

3. If all items in step 2 are okay, proceed to the LED circuit board flashlight test as described in Section 3.3, LED Circuit Board Test, and automatic voltage regulator (AVR) test described in Section 3.5, Automatic Voltage Regulator Operation and Adjustment.

4. If the tests indicate the LED circuit board and AVR are functioning correctly, visually inspect the photo transistor board for damage (open foil pattern or heat discoloration).

5. If the photo transistor board test appears good, proceed to the exciter armature test as described later in this section.

6. If the exciter armature test indicates the armature is functioning correctly, proceed to the alternator field test as described later in this section.

7. If the alternator field test indicates the field is functioning correctly, replace SCR assembly or the photo transistor board as described lin Section 3.4, SCR Assembly and Photo Transistor Board.

Components and Circuits to Test Under Certain Alternator Output Conditions

Alternator Output Condition	LED Board	Photo Transistor Board	Automatic Voltage Regulator ‡	SCR Assembly	Safeguard Breaker	Exciter Armature	Alternator Field	Alternator Stator	Voltage Adjustment Potentiometer
No Output	●	●	●	●	●	●	●	●	●*
Overvoltage		●†	●	●					
Fluctuating Voltage	●	●	●	●		●	●	●	

* No output voltage if voltage adjustment potentiometer circuit is open or shorted to ground.
† Overvoltage will occur if an outside light source is present when the LED board is removed.
‡ If the unit has a 550 controller, the voltage regulator is part of the controller, see the controller operation or service manual for operation, setup, and/or troubleshooting.

Figure 3-1 Troubleshooting Guide

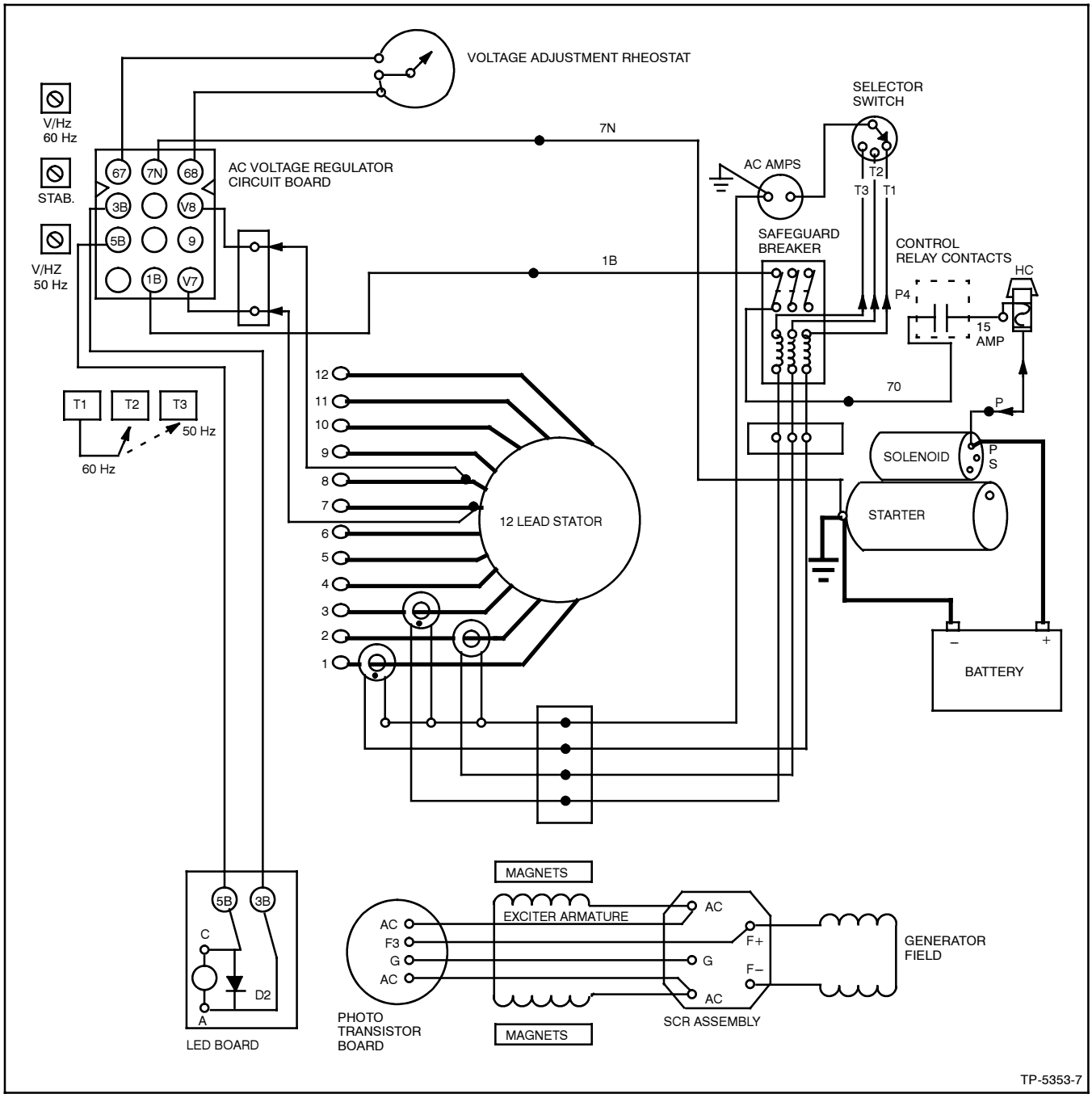


Figure 3-2 AC Voltage Control, Typical

3.2.2 Overvoltage

Note: If overvoltage occurs, disconnect harness plug at AVR. If overvoltage continues, the problem lies in the photo transistor circuit and/or SCR assembly; proceed through the following checks. If output voltage disappears, the problem is in the AVR, including connections and/or wiring.

1. Examine photo transistor board for visible signs of damage (open foil pattern or heat discoloration). Replace photo transistor board if visibly damaged. If overvoltage continues after replacement of photo transistor board, proceed to Step 2.
2. Remove green (center) lead from G terminal and red lead from F+ terminal of SCR assembly. Tape each terminal end of leads to prevent contact with adjacent metal components.
3. With safeguard breaker open, start generator set. The lack of AC output indicates the SCR assembly is functioning properly. If overvoltage continues, replace the SCR assembly.

   Note: When replacing SCR assembly, do not exceed torque value of 0.9 Nm (8 in. lb.) when tightening SCR mounting bolts.

4. If overvoltage is measured with the safeguard breaker closed, check for an open circuit in leads V7 and V8 to the AVR or controller fuse block. If these circuits are open or shorted, repair or replace. Check the voltage rheostat circuit at leads 67 and 68. Repair or replace as necessary.

5. If all the circuits described in step 4 are okay, check the AVR as described in Section 3.5.

3.2.3 Fluctuating Voltage

1. Check the alternator output leads for proper connections. Refer to the respective wiring diagrams manual.

2. Check for loose connections to the AVR, LED board, photo transistor board, or SCR assembly.

3. Check the stator for shorted or open windings; refer to stator testing later in this section.

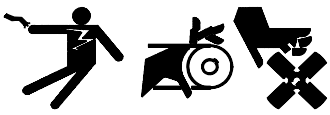
4. Verify the AVR adjustment. See Section 3.5, Automatic Voltage Regulator Operation and Adjustment.

5. Check the SCR and photo transistor circuit board by performing the flashlight test. See Section 3.3, LED Circuit Board Test.

3.3 LED Circuit Board Test

The following procedure provides information on testing the LED circuit board. Certain steps require that the generator set be running. When the generator set is not running, disable the generator set. See the safety precautions listed below. Disconnect all load from the generator set during this test.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

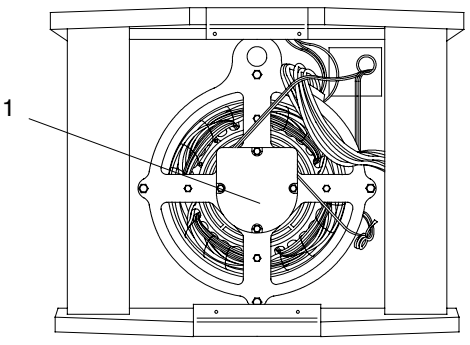
Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Testing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. When the end cover is removed, do not expose the photo transistor circuit board mounted on the generator set end bracket to any external light source, as exposure to light causes high voltage. Keep foreign sources of light away from the photo transistor circuit board during testing. Place black electrical tape over the LED on the circuit board before starting the generator set.

1. Remove the junction box panels from the generator end of unit and remove the photo transistor board/LED board cover. See Figure 3-3.



1. Photo transistor/LED board cover

Figure 3-3 Photo Transistor Board Cover

2. With the generator set running at no load, shine a flashlight on the exposed photo transistor board. See Figure 3-4.

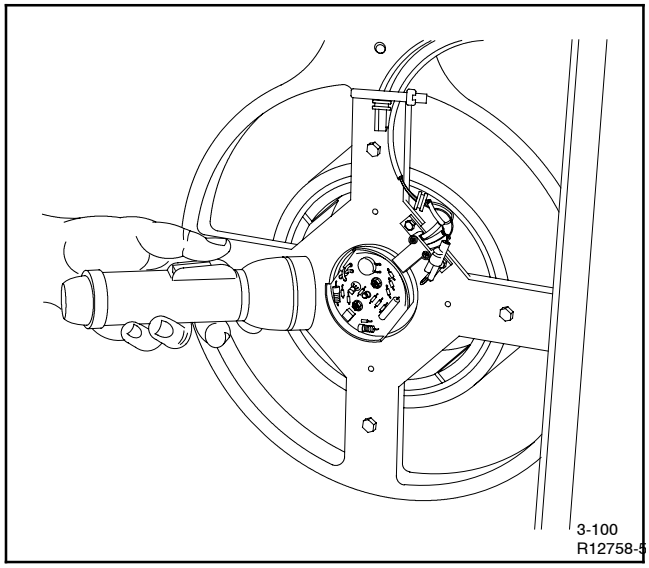


Figure 3-4 LED Flashlight Test

3. Observe the AC output voltmeter. High AC output voltage indicates the SCR assembly and photo transistor board are functioning properly. The fault is likely in the wiring, AVR, or LED circuit board as the output voltage should drop to low level when the flashlight is removed. If no output is observed, check the SCR assembly and photo transistor board.

4. If high output voltage exists with the flashlight off, stop the generator set and place a small piece of black electrical tape over the phototransistor. Restart the unit.

   If the output voltage is reduced, there is a source of external light contamination. STOP the generator set. Find the external light source and eliminate it or block it from reaching the phototransistor circuit board.

   If the output voltage remains high, there is a failure in the phototransistor circuit board or SCR assembly.

5. With the generator set running, approximately 1–2 volts DC should be observed at 3B (+) and 5B (–) at the LED board. See Figure 3-5. Shine the flashlight on the photo transistor. The DC voltage reading should drop, showing the AVR is functioning. If voltages are not observed, refer to the AVR test. Stop the generator set.

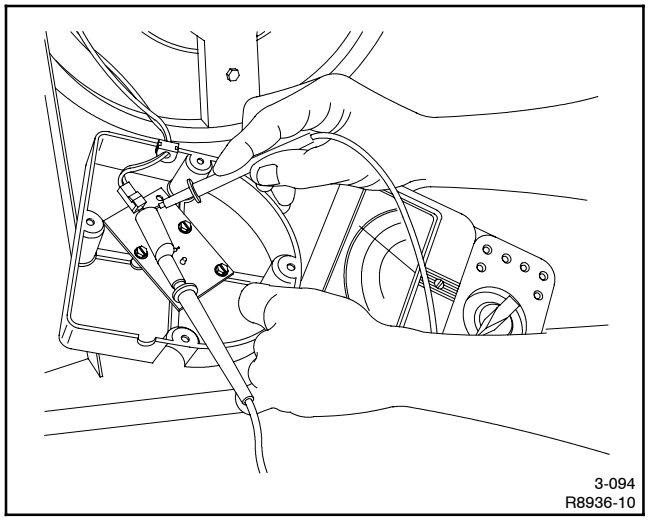


Figure 3-5 Checking LED Board

3.4 SCR Assembly and Photo Transistor Board

The SCR assembly is located behind the exciter armature and controls current flow to the alternator field. The command and sensing circuitry is located on the shaft-mounted photo transistor board. See Figure 3-6. The generator set will only function if both components are functional.

The following test determines which component is defective. Since it is necessary to remove the end bracket from the set to correctly test these components, do not begin this procedure unless there is reasonable certainty that these components are defective.

See Section 3.1, Alternator Troubleshooting. Examine the photo transistor board for visible signs of damage (open foil patterns and heat discoloration) before removing the entire SCR assembly for testing.

Refer to Section 3.10, End Bracket Removal and Replacement, if the end bracket only needs removal. Refer to Section 4, Alternator Disassembly/Reassembly, for complete alternator disassembly.

To test the SCR assembly and photo transistor board, the following components are needed:

- One 120-volt/110-watt light bulb with socket
- Switch, DPST (double-pole/single-throw) 120 volt 10 amp minimum)
- Fuse, 1 amp (in holder)
- 120 volt AC plug with cord
- One *known-functional* SCR assembly and photo transistor board

This test simulates the normal operation of the components when the alternator is running. In the test, a *known-functional* component (example: photo transistor board) is matched with a component of unknown quality (example: SCR assembly). If the components do not function normally during the test, it is reasonable to assume that the component of unknown quality is defective. Test either component in this manner.

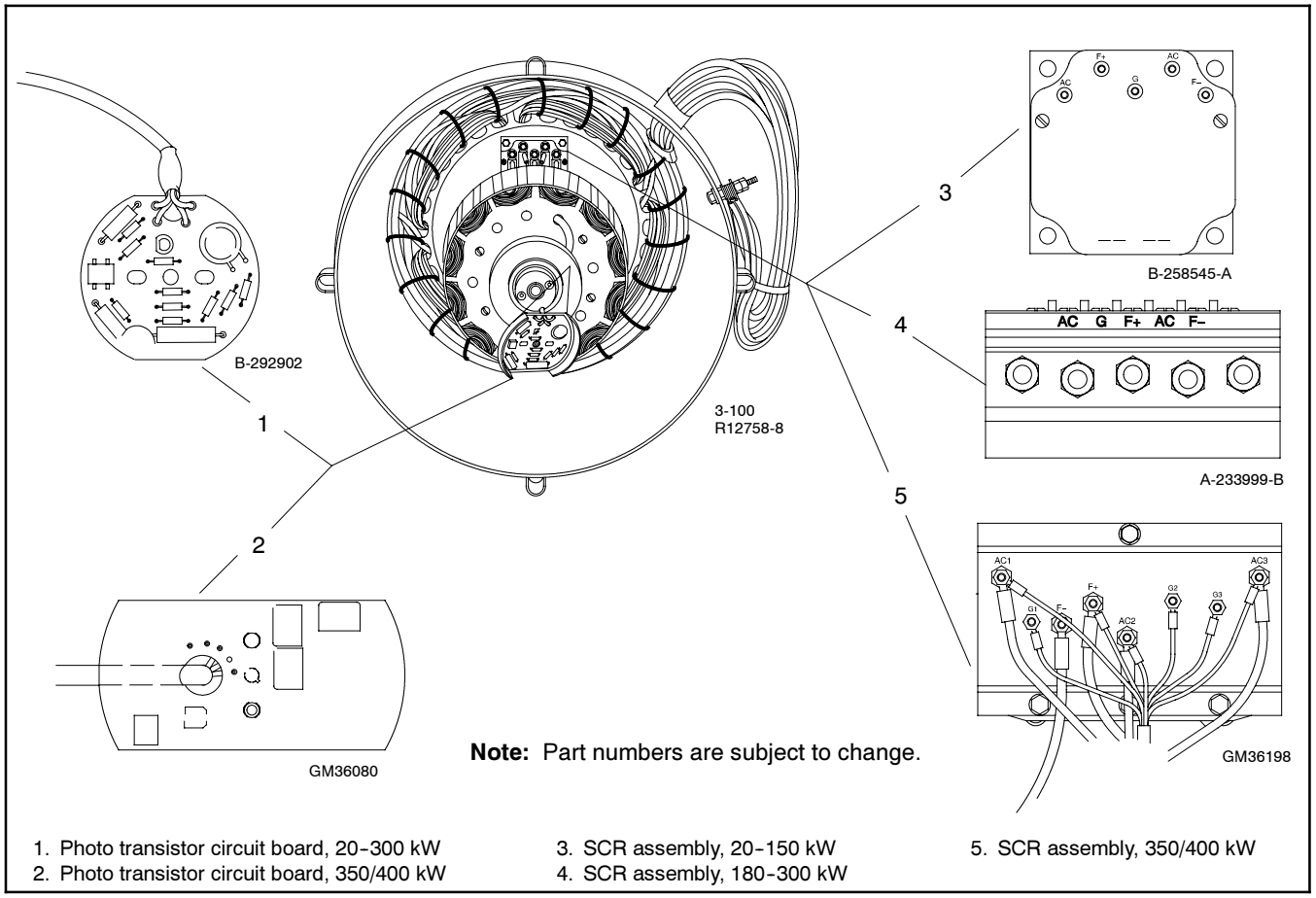


Figure 3-6 Phototransistor Circuit Board and SCR Assembly Types and Locations

Hazardous voltage can cause severe injury or death. Carefully follow instructions in the equipment manual when testing or servicing generator set in the presence of voltage.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

1. Connect components as illustrated in Figure 3-7. If testing the photo transistor board, SCR assembly must be *known-functional.* If testing the SCR assembly, the photo transistor board must be *known-functional.*

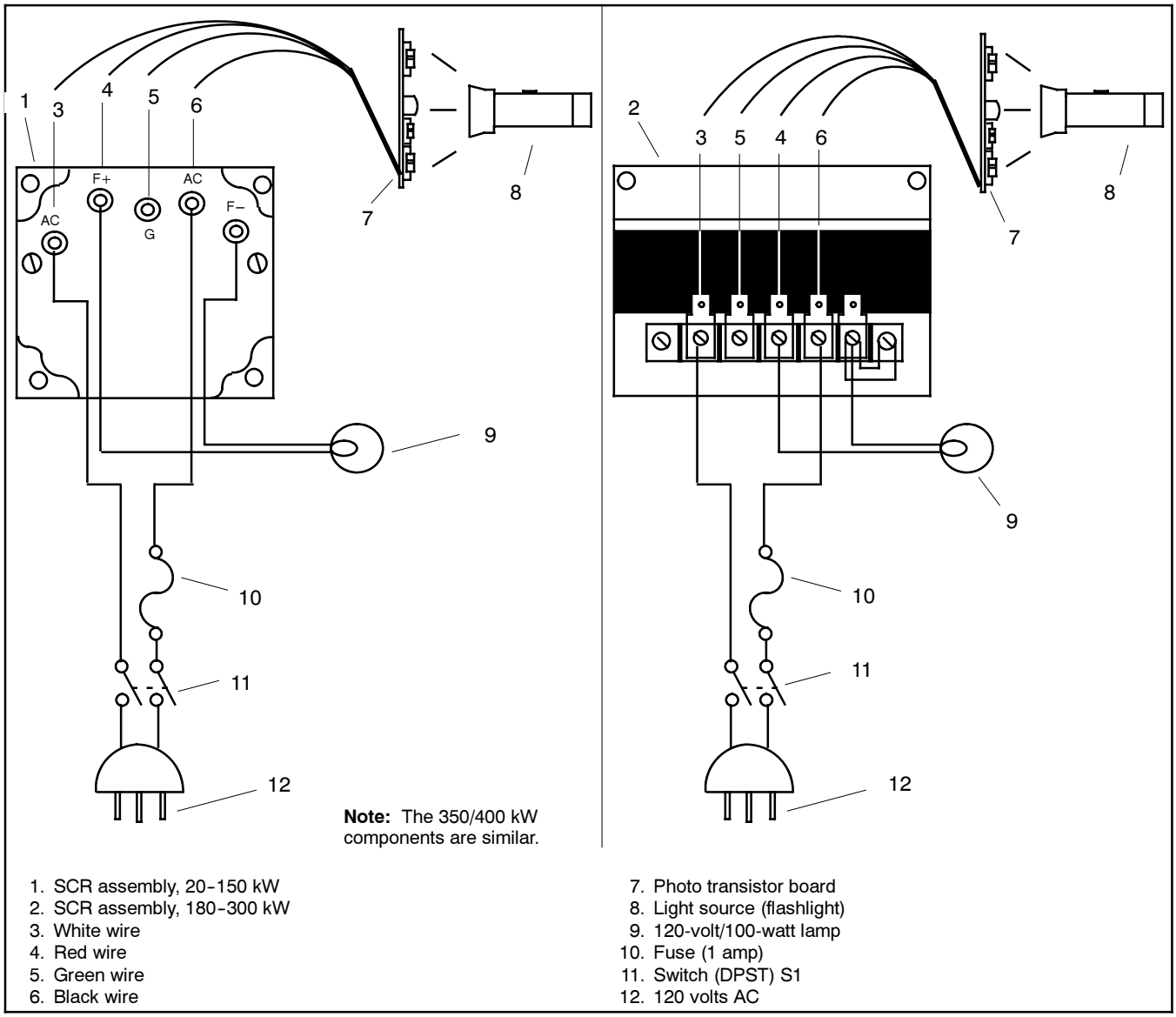
   Note: When testing the SCR assembly used on 20-150 kW models, connections must make good electrical contact with the SCR foil pattern. Secure all SCR connections with terminal nuts to ensure good electrical contact with foil pattern during testing. The SCR-threaded terminals are insulated from the SCR foil pattern and are not in contact except when *bridged* by the terminal nut, electrical lead, terminal, etc. Do not exceed 0.9 Nm (8 in. lb.) when tightening the SCR terminal nuts.

2. With the cord switch in the OFF position, plug in the electrical cord.

3. Turn the cord switch to the ON position.

4. Apply light source directly to the photo transistor board. Shield the photo transistor board from all sources of light during this test. If both components are *functional,* the test fixture light bulb will light when the external light source is applied to the photo transistor board. Remove the light source; the fixture light bulb should go out. If the test fixture light bulb does not light or is lit prior to receiving external light source, the component being tested is defective (in this example the SCR). Replace the SCR assembly.

Note: When replacing SCR assembly, do not exceed a torque value of 0.9 Nm (8 in. lb.) when tightening SCR mounting bolts.



1. SCR assembly, 20–150 kW
2. SCR assembly, 180–300 kW
3. White wire
4. Red wire
5. Green wire
6. Black wire
7. Photo transistor board
8. Light source (flashlight)
9. 120-volt/100-watt lamp
10. Fuse (1 amp)
11. Switch (DPST) S1
12. 120 volts AC

Figure 3-7 SCR Assembly and Photo Transistor Board

3.5 Automatic Voltage Regulator Operation and Adjustment

The following procedure applies to the analog voltage regulator. If the unit has a controller with an integrated digital voltage regulator, see the controller operation and/or service manuals for operation and adjustment.

The AVR monitors output voltage magnitude and frequency to supply current to the stationary LED board. See Figure 3-8 for the voltage regulator adjustments. The volts/Hz adjustment is factory-set and normally requires no further adjustment. If replacement of the controller circuit board or operation of the generator under extreme loads results in voltage instability, adjust the potentiometers according to the following procedure. See Figure 3-9 and Figure 3-10.

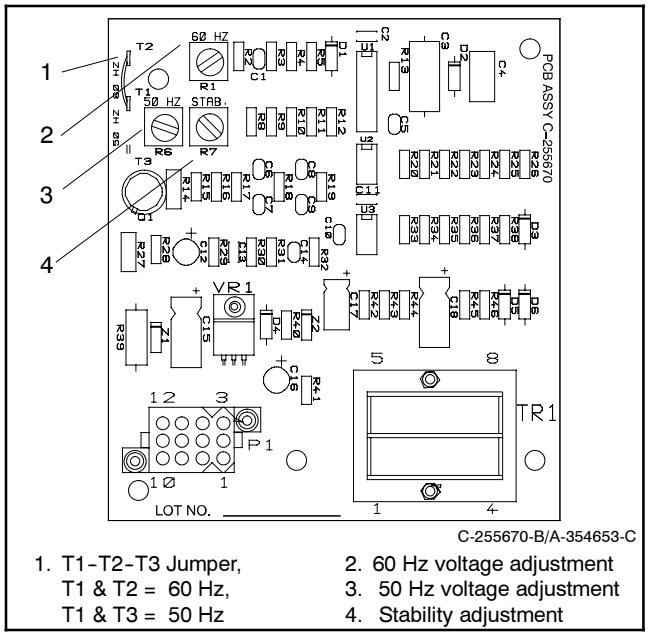
	C-255670/ A-354653	GM47955/ GM63560
60 Hz Voltage Adjustment	X	X
50 Hz Voltage Adjustment	X	X
Stability Adjustment	X	X
Voltage Adjustment (Coarse)		X
T1-T2-T3 Jumper	X	
DIP Switches		X

Figure 3-8 Voltage Regulator Adjustments

Volt/Hz Potentiometer (50/60 Hz). This adjustment determines engine speed (Hz) at which generator output voltage will begin to drop.

Stability Potentiometer. Fine tunes voltage regulator to reduce light flicker.

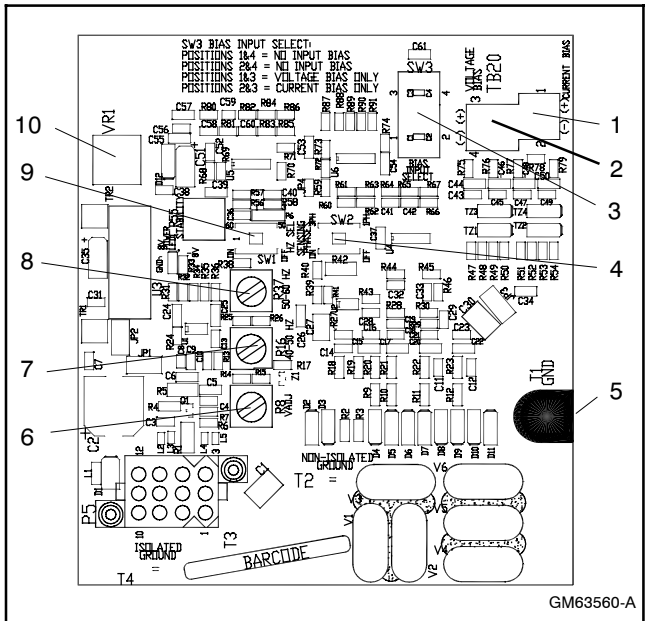
Voltage Adjustment Potentiometer. This adjustment provides a ±30% coarse voltage adjustment. (Bias adjust voltage regulator only).



C-255670-B/A-354653-C

1. T1-T2-T3 Jumper, T1 & T2 = 60 Hz, T1 & T3 = 50 Hz
2. 60 Hz voltage adjustment
3. 50 Hz voltage adjustment
4. Stability adjustment

Figure 3-9 Voltage Regulator C-255670/A-354653



GM63560-A

1. 4-20mA current bias lead input
2. Voltage bias lead input
3. Dip switch for bias input select, 1 & 4 = No input bias, 2 & 4 = No input bias, 1 & 3 = 0-5 VDC voltage bias only, 2 & 3 = 4-20mA current bias only
4. Switch #2—Phase sensing, On = 3 Phase, Off = 1 Phase
5. Grounding pad
6. Voltage adjustment potentiometer
7. 50 Hz V/Hz adjustment potentiometer
8. 60 Hz V/Hz adjustment potentiometer
9. Switch #1—Frequency select, On = 60 Hz, Off = 50 Hz
10. Stability potentiometer

Figure 3-10 Voltage Regulator GM47955/GM63560 (with Bias Adjust)

3.5.1 Volt/Hz Potentiometer Adjustment

This adjustment determines engine speed (Hz) at which alternator output voltage will begin to drop. The bias adjust voltage regulator has DIP switch for specific applications, see Figure 3-11.

	DIP Switch Position	
	On	**Off**
SW1 Hz Selection	60	50
SW2 Sensing Phase Selection	3 Phase	1 Phase
SW3 Bias Input Selection		
No Input Bias	1, 2, & 4	3
Voltage Bias (±10% from a -3 to +3 volt source)	1 & 3	2 & 4
Current Bias (±10% from a 4-10 mA source)	2 & 3	1 & 4

Figure 3-11 Bias Adjust Voltage Regulator with DIP Switches

1. Place the generator set master switch to OFF/RESET position (Decision-Maker® 1 and 3+).
2. Make the selection for single- or three-phase sensing at SW2. (Bias adjust voltage regulator only).
3. Make the frequency selection, either 50 or 60 Hz at SW1 (Bias adjust voltage regulator).

   OR

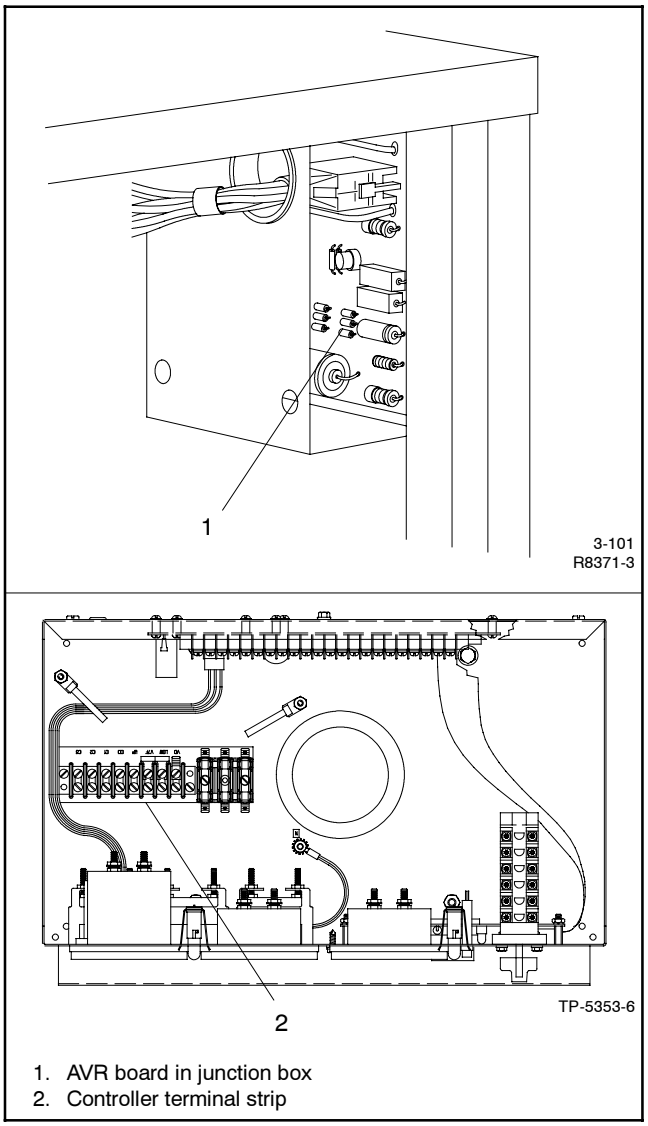
   Place the T1-T2-T3 Jumper is the respective position. T1 & T2 = 60 Hz or T1 & T3 = 50 Hz. (Non-bias adjust voltage regulator).
4. Turn stability potentiometer fully counterclockwise.
5. Connect a 100-watt light bulb across terminals V0 and V7 on controller terminal strip or across terminals on the frequency meter of the Decision-Maker 3+ controller.
6. Start the generator set. With the generator running at no load, observe light bulb flicker. Excessive light bulb flicker indicates poor stability.
7. Adjust stability potentiometer until minimum flicker is obtained.
8. Use the coarse voltage adjustment (bias adjust voltage regulator only) and then use controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make adjustments to the generator set while running under normal load (if required).
9. Set SW3 for No Input Bias. Refer to Figure 3-11. (Bias adjust voltage regulator only).
10. Adjust the engine speed to the desired cut-in frequency (factory setting is 57.5-58.0 Hz for 60 Hz models or 47.5-48.0 Hz for 50 Hz models) as measured on frequency meter. See the governor manual for information on engine adjustment.
11. Rotate the volts/Hz adjustment potentiometer clockwise until voltage level begins to drop (as measured on voltmeter). When set to these specifications, the generator set will attempt to maintain normal output until engine speed drops below the frequency set in the previous step (as load is applied).
12. Adjust the engine speed to obtain a full load engine speed of 1800 rpm (60 Hz) or 1500 rpm (50 Hz). Confirm and adjust the output voltage as needed.
13. Use the coarse voltage adjustment (bias adjust voltage regulator only) and then use the controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make final adjustments to the generator set while running under normal load.
14. Readjust stability potentiometer (if necessary).

To determine whether the AVR is functioning properly, reduce the engine speed (Hz) and watch for a corresponding drop in AC voltage. At 60 Hz operation, the voltage will remain constant until the engine speed drops below 58 Hz (approximately). If AC frequency drops below 58 Hz, the AC voltage will decline. At 50 Hz operation, the AC voltage remains constant until the engine speed is reduced to 48 Hz (approximately). If the AVR is not functioning properly, refer to the following test to determine the cause of malfunction.

3.5.2 Automatic Voltage Regulator Test

With the safeguard breaker closed (if equipped):

1. Disconnect the wiring harness connector from the voltage regulator and check for continuity between the voltage sensing leads V7 and V8 (pins 4 and 10). See Figure 3-12. If this circuit is open , repair or replace. An open circuit will normally result in a high voltage or overvoltage condition. Check the 15-amp fuse.



1. AVR board in junction box
2. Controller terminal strip

Figure 3-12 AVR and Connections

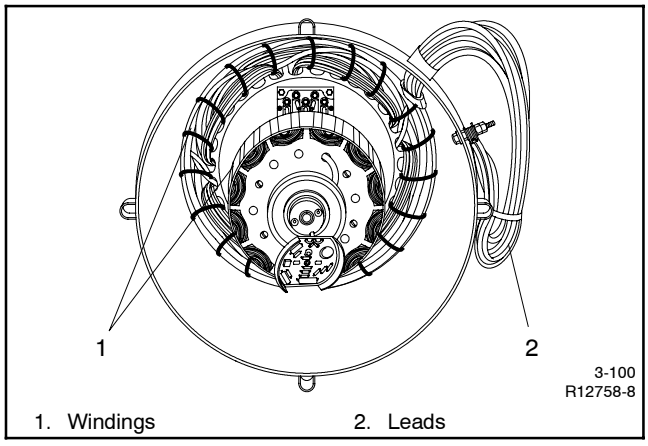
2. If there is continuity between V7 and V8, check for continuity in the voltage adjustment circuit (leads 67 and 68). With the harness disconnected, check resistance between pins 1 and 3. This resistance should change as the voltage adjust rheostat is turned. Repair or replace defective components as necessary. A defective voltage adjust rheostat usually results in a nonadjustable voltage.
3. Check for battery voltage at the voltage regulator harness plug (pins 2 and 11) with the generator set running. If there is not a voltage reading, check the safeguard circuit breaker. If battery voltage is not present, there should be a very low voltage at the main output leads.
4. While the generator set is running, check for approximately 1–2 volts DC output at terminals 3B (+) and 5B (–) on the LED board. Disconnect the separate 3B/5B connector and check for 8 volts (approximately) at the connector. If voltage is not measured at connector, check for open or short circuit in wiring back to voltage regulator. If a fault exists in the voltage regulator wiring, repair or replace as necessary. If the voltage regulator wiring tests good, replace the voltage regulator. Low voltage at the LED circuit board may cause a low output voltage fault.

3.6 Stator

Note: Generator sets use a skewed (slanted) rotor with a straight stator. When replacing either rotor or stator, be sure replacement is same as original.

1. Check the alternator output leads for proper connections. Refer to the wiring diagrams manual.
2. Check the stator windings for:
   - Shorted windings: Inspect for burnt or hot windings. Replace the stator if these conditions exist. See Figure 3-13.

     Note: Disconnect V7, V8, V9, V0 at AC from controller terminal blocks before doing test.



1. Windings
2. Leads

Figure 3-13 Stator

- Open windings: With ohmmeter, check **each pair** of leads for low resistance readings (continuity). High resistance across A or low resistance (continuity) across B and ground indicates a faulty stator; replace stator. See Figure 3-14.

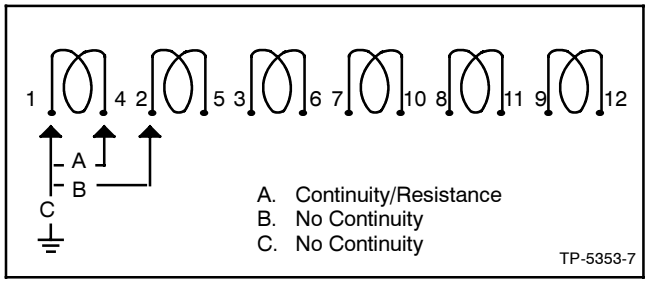


Figure 3-14 Stator Winding Test

3.7 Alternator Field

Hazardous voltage can cause severe injury or death. Carefully follow instructions in the equipment manual when testing or servicing generator set in the presence of voltage.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

1. Disconnect the battery (negative lead first).

   Remove the end bracket. Refer to Section 3.10, End Bracket Removal and Replacement, if only the end bracket needs removal. Refer to Section 4, Alternator Disassembly/Reassembly, for complete alternator disassembly.

   Disconnect the F+ and F− leads from the SCR assembly.

2. With an ohmmeter, check for continuity across the F+ and F− leads. See Figure 3-15. Resistance readings are shown in Section 1.4, Specifications, Electrical Values.

3. Check for a grounded alternator field. No continuity should exist between the field leads and the rotor assembly.

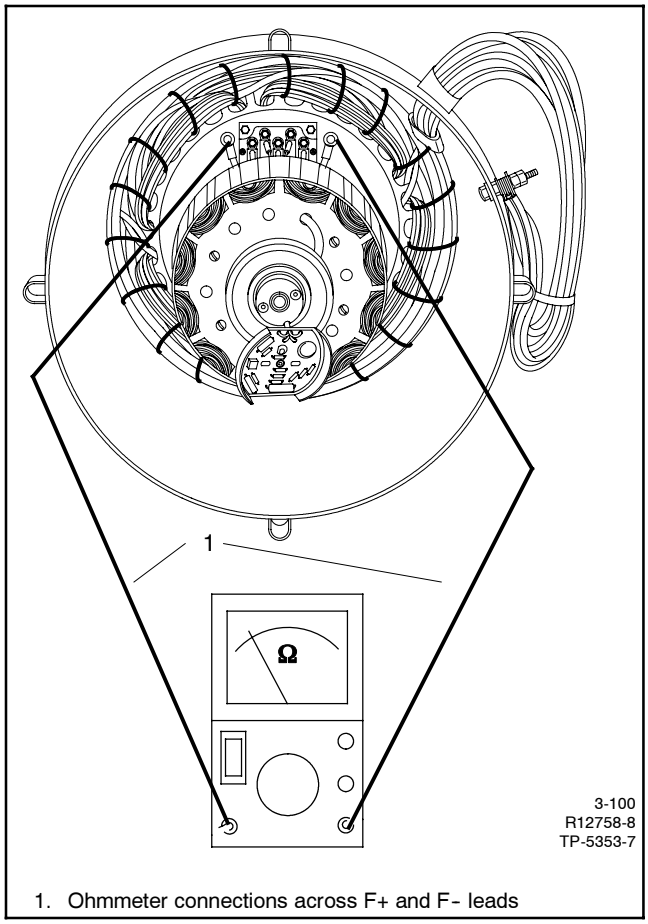
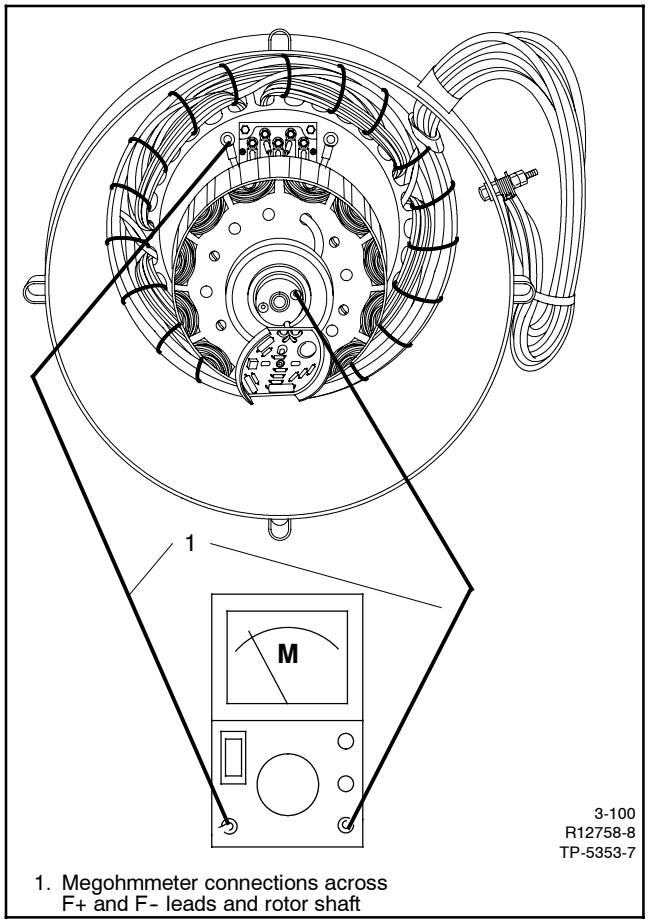


Figure 3-15 Field Continuity Check

4. Using a megohmmeter, apply 500 volts DC to the F+ or F− lead and the rotor shaft. See Figure 3-16. Follow the instructions of the megohmmeter manufacturer when performing this test. A reading of approximately 500 kOhms (1/2 megohm) and higher indicates the field winding is good. A reading of less than 500 kOhms (approximately) indicates deterioration of winding insulation and possible current flow to ground. Repair or replacement of the rotor assembly is necessary.

   Repair the F+ and F− leads if test should show leads shorted to ground. Solder and insulate the splices. Use new sleeving when tying leads to shaft or heat sink. Replace the alternator rotor assembly if test shows a shorted or grounded winding.



1. Megohmmeter connections across F+ and F– leads and rotor shaft

Figure 3-16 High Voltage Test

3.8 Exciter Armature

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

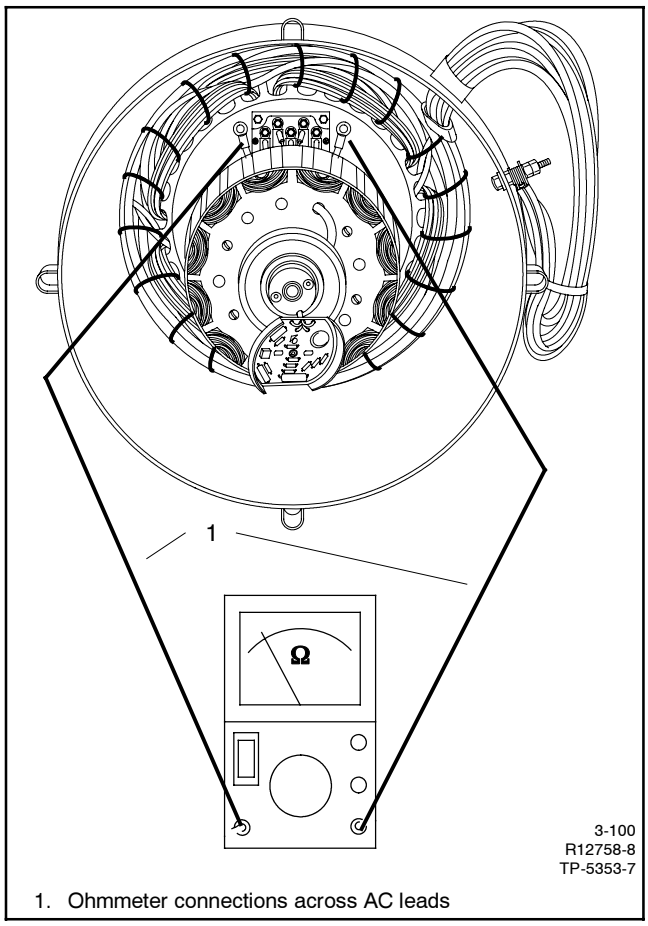
High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

1. Disconnect the battery (negative lead first).

2. Remove the end bracket. Refer to Section 3.10, End Bracket Removal and Replacement, if only the end bracket needs removal. Refer to Section 4, Alternator Disassembly/Reassembly, for complete alternator disassembly.

3. Disconnect AC leads from SCR assembly.

4. With an ohmmeter, check for continuity across the AC leads. See Figure 3-17.



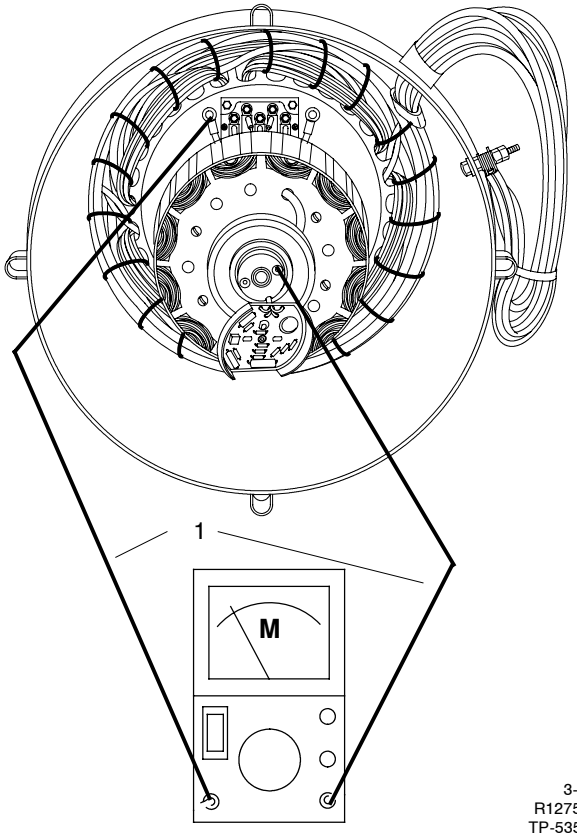
1. Ohmmeter connections across AC leads

Figure 3-17 Exciter Armature Continuity Check

5. Repair the AC leads if damaged or open. Solder and insulate the splices. Use new sleeving when tying leads to the shaft or heat sink.

6. Visually check the exciter armature for shorted winding(s) and with an ohmmeter, check for low resistance readings. See Section 1.4, Specifications, Electrical Values. See Figure 3-17. Low resistance readings indicate a faulty exciter armature requiring replacement of the rotor assembly.

7. Using a megohmmeter, apply 500 volts DC to the rotor shaft and either AC lead. See Figure 3-18. Follow the instructions of the megohmmeter manufacturer when performing this test. A reading of approximately 500 kOhms (1/2 megohm) and higher indicates the field winding is good. A reading of less than 500 kOhms (approximately) indicates deterioration of winding insulation and possible current flow to ground. Repair or replace the rotor.



1. Megohmmeter connections across either AC lead and rotor shaft

Figure 3-18 High Voltage Test

8. Repair the AC leads if the test indicates the lead is shorted to ground. Solder and insulate the splices. Use new sleeving when tying the leads to the shaft or heat sink.

9. Repair or replace the rotor assembly if the test shows the armature is shorted to ground.

3.9 Speed Sensor Test

Follow the procedure outlined below to determine if the speed sensor (overspeed fault) is emitting a signal.

1. With generator set master switch in OFF/RESET position, connect a DC voltmeter between the positive (+) lead (wire 24) at speed sensor and the ground (wire 2). The voltmeter should read approximately 8–10 volts DC.

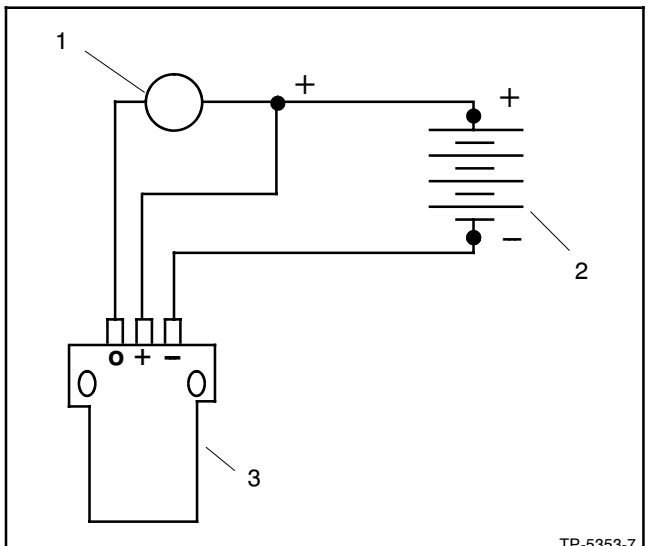
2. With the generator set running, connect a DC voltmeter negative probe to 0 terminal (wire 16—white) on speed sensor. Place voltmeter positive probe on the positive (+) terminal (wire 24—red). Voltmeter should indicate approximately 12 volts DC.

   Note: During the test, the controller leads must remain connected to the speed sensor terminals. Slide leads from speed sensor terminals only enough to expose connection for test leads. Do not disconnect leads.

If the speed sensor is emitting a signal, check continuity of the speed sensor leads (wires 2, 16, and 24) between controller P1 connector and lead terminals at speed sensor.

If the speed sensor is not emitting a signal, test the speed sensor through the following procedure:

1. Connect speed sensor, voltmeter, and DC voltage source as shown in Figure 3-19.



1. DC voltmeter
2. 12-volt battery or DC power supply
3. Sensing surface

Figure 3-19 Speed Sensor Test

2. Touch sensing surface with a flat piece of iron or steel, at least 4.1 cm (1/4 cu. in.) in size.

3. The voltmeter test reading should equal the source voltage.

4. Remove the iron or steel piece from the sensing surface and observe the voltmeter reading.

3.10 End Bracket Removal and Replacement

Use this procedure to access the SCR and photo transistor board for testing and replacement purposes when it is deemed unnecessary to remove and disassemble the entire alternator assembly.

Note: On some models, it is necessary to loosen the generator set junction box to remove the end bracket. Remove the six junction box mounting screws and pull the junction box away from the engine to remove end bracket.

1. Remove the LED board and cover. Disconnect the leads from the speed sensor.

2. Remove the screws holding the magnetic actuator and photo transistor board.

3. Reach in and remove the leads; photo transistor board leads from the SCR assembly. This will allow slack when removing the end bracket.

4. Remove the four bolts holding the end bracket to the stator.

5. Use a puller tool to remove the end bracket. See Figure 3-20.

   Note: To avoid loosening the exciter field magnets, do not attempt to remove the end bracket by pounding with a hammer.

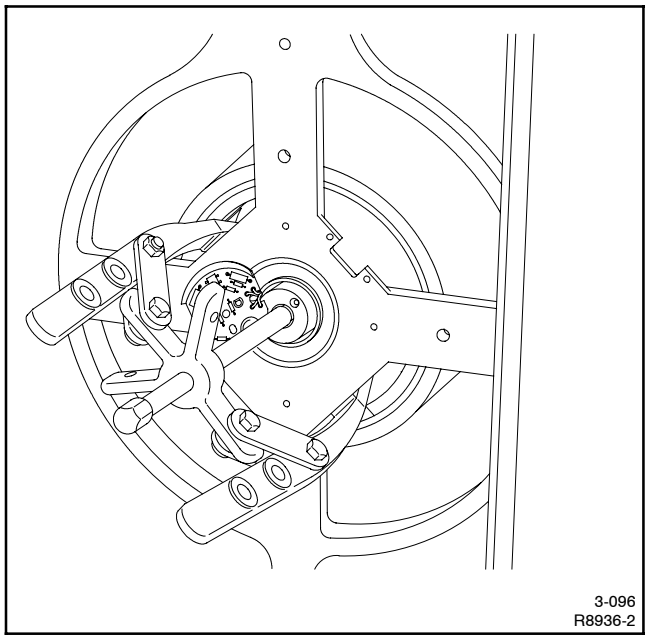


Figure 3-20 Removing End Bracket

6. Pull the end bracket and exciter field assembly over the exciter armature. Be extremely careful to avoid damaging the exciter field magnets or photo transistor board.

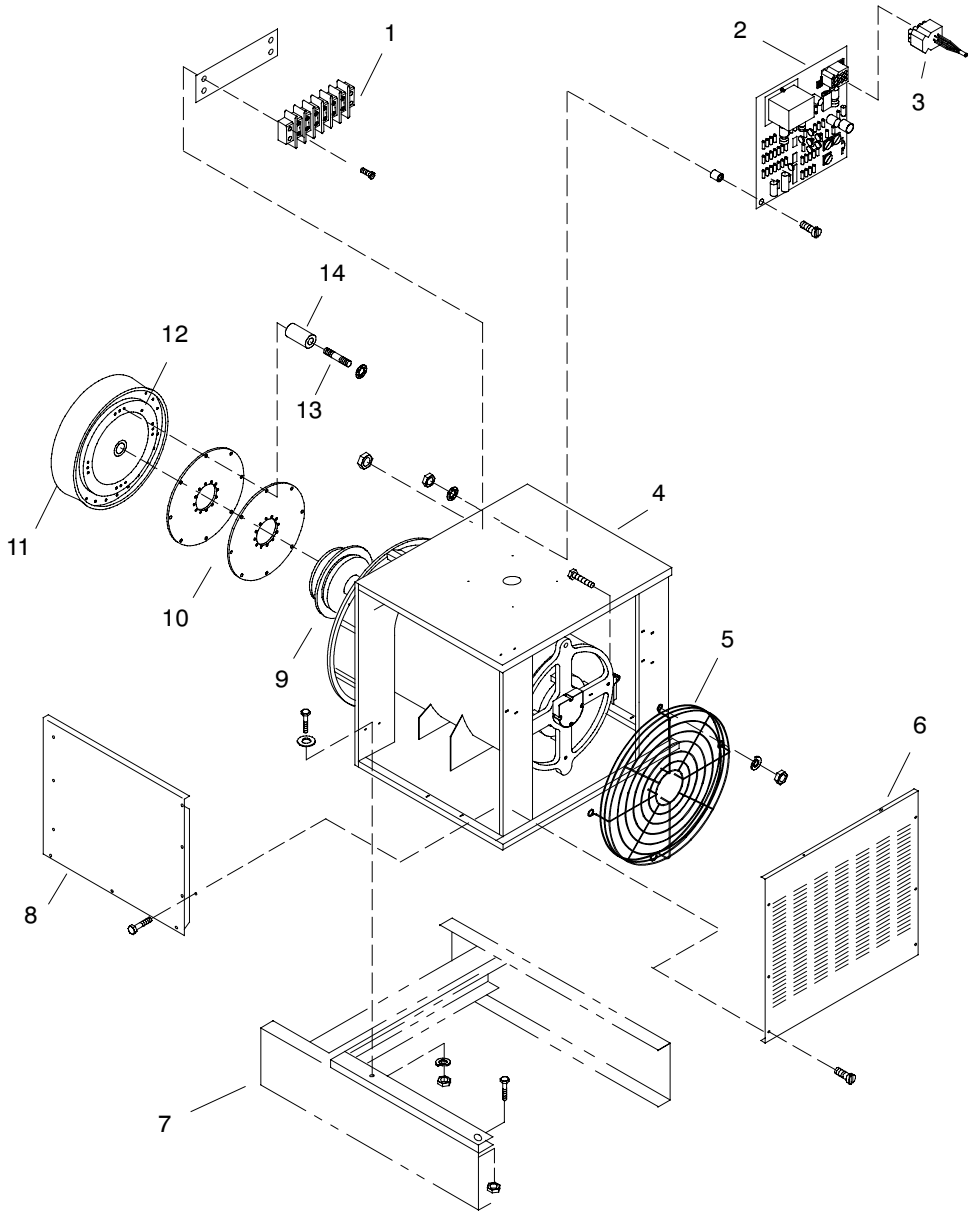
7. Reverse order of disassembly to reinstall end bracket/exciter field assembly.

Section 4 Alternator Disassembly/Reassembly

Before beginning the alternator disassembly procedure, carefully read all safety precautions at the beginning of this manual. Please observe these precautions and those included in the text during the disassembly/ reassembly procedure.

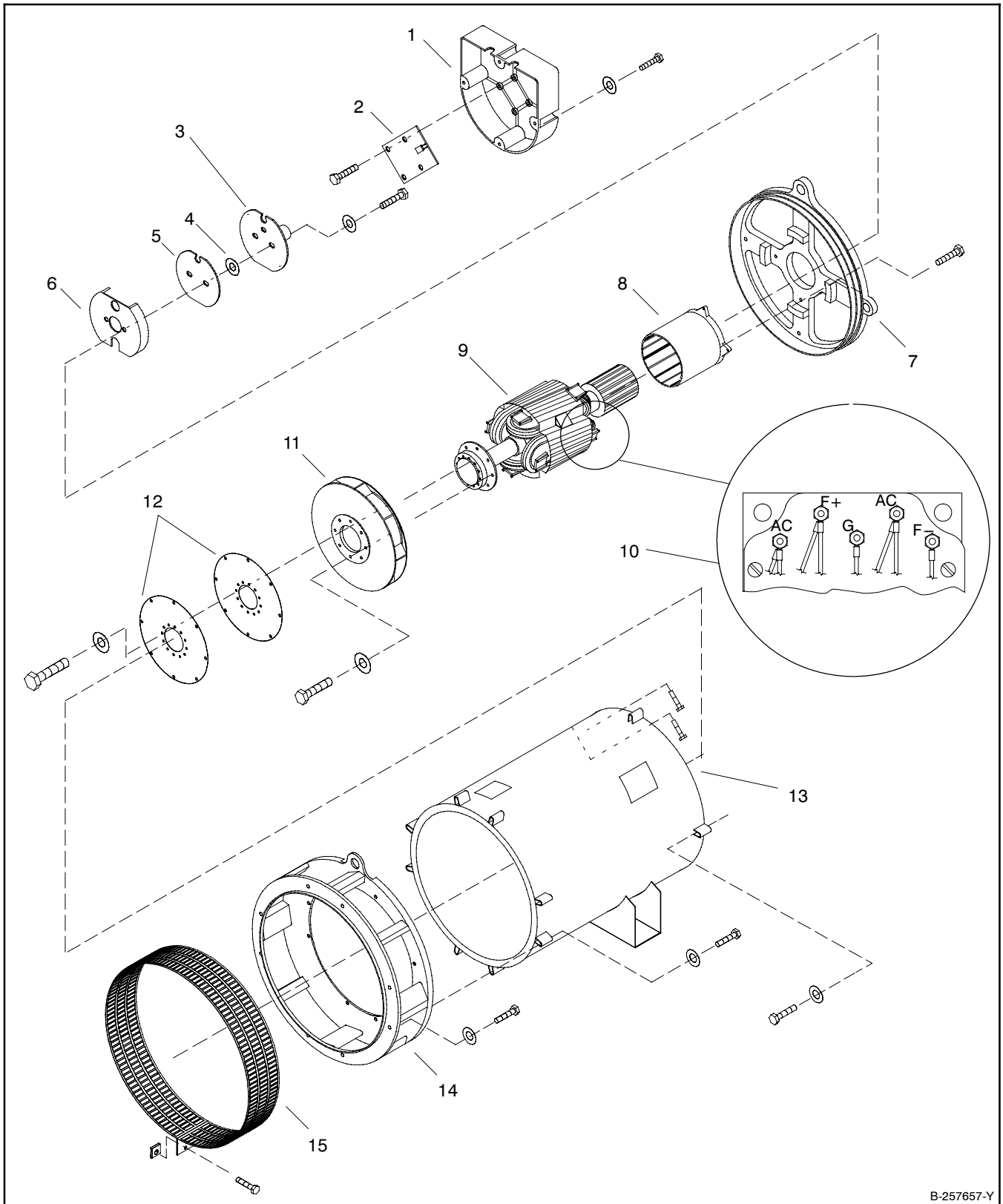
The following procedures cover many models and some steps may not apply to a particular engine. Use Figure 4-1 and Figure 4-2 to help understand component descriptions and general configuration of the alternator.

Use disassembly procedure as a step-by-step means to help disassemble the alternator. The disassembly procedure provides important information to minimize disassembly time and indicates where special configurations exist that may require taking notes. The reassembly procedure includes important alignment steps and provides critical torque specs.



1. Voltage regulator terminal strip
2. Voltage regulator
3. Voltage regulator wiring harness
4. Junction box
5. Alternator (rodent) guard
6. Junction box rear cover
7. Skid
8. Junction box side cover
9. Alternator assembly
10. Drive discs
11. Engine side of flywheel
12. Flywheel
13. Stud
14. Spacer

Figure 4-1 Alternator Components, Typical



1. LED circuit board cover
2. LED circuit board
3. Photo transistor circuit board
4. Insulating washer
5. Insulator
6. Magnetic actuator
7. End bracket
8. Exciter field assembly
9. Rotor assembly
10. SCR assembly
11. Alternator fan
12. Drive discs
13. Stator assembly
14. Alternator adapter
15. Alternator fan guard

Figure 4-2 Alternator Components, Typical

⚠ WARNING

Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

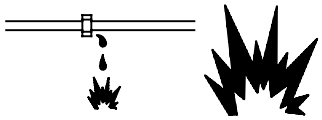
⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Propane (LP)—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

Perform the following steps prior to disassembling the generator set.

1. Disconnect (negative lead first) and remove starting batteries from work area to prevent fire hazard. Disconnect AC-powered accessories, such as battery charger, block heater, and fuel transfer pump.

2. Shut off fuel supply. Drain fuel system as necessary by emptying fuel into proper containers. Remove fuel containers from work area to prevent fire hazard. Ventilate the work area to clear fumes.

3. Disconnect fuel, cooling, and exhaust systems as necessary to tilt generator set. Disconnect output leads or load circuit cables at generator set.

4. Any cranes, hoists, or other lifting devices used in the disassembly or reassembly procedure must be rated for the weight of the generator set. Check generator set nameplate or spec sheet for weight.

4.1 Disassembly

1. Disconnect all controller-to-engine and engine-to-alternator harnesses and wiring. Disconnect alarm horn circuit board connector (if equipped), LED board and housing, and speed sensor. Remove the junction box and controller as a unit.

2. Remove the fan guard.

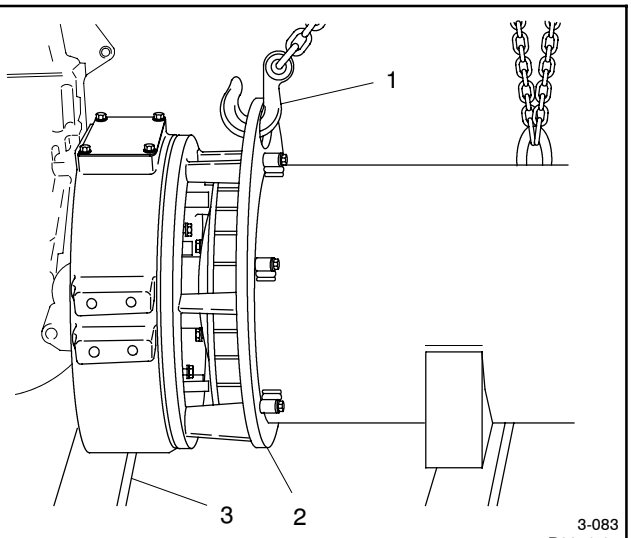
3. Remove the LED circuit board cover.

4. Remove the alternator (rodent) guard on the end bracket (if equipped).

5. Remove the speed sensor from the end bracket.

6. Remove bolts from the alternator vibromounts.

7. Suspend the alternator at both ends with hooks in lifting eyes. Use a hoist to raise the alternator end off the vibromounts. See Figure 4-3.



1. Hook
2. Alternator adapter
3. Wood block(s)

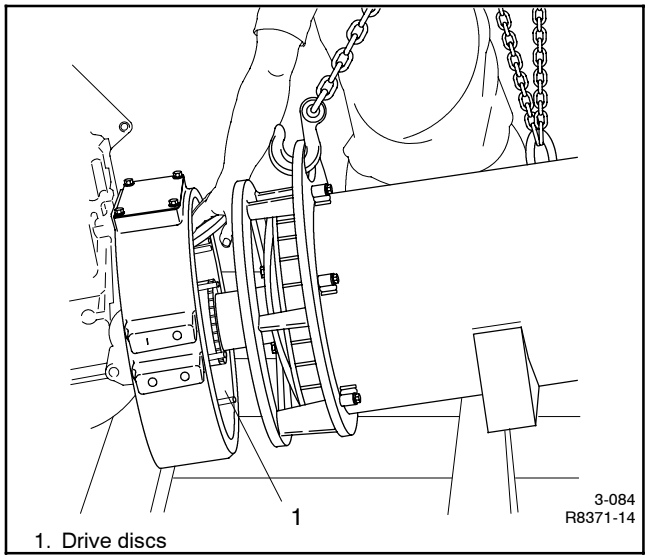
Figure 4-3 Hoisting Alternator

8. Support the engine by placing wood blocks under the flywheel housing. Lower the alternator end until the alternator flywheel housing rests on the blocks. See Figure 4-3.

9. Remove bolts holding the adapter to the flywheel housing.

10. Remove hardware holding the drive discs to the flywheel.

11. Work the drive discs over the studs (if equipped) to separate the alternator from the engine. See Figure 4-4.



1. Drive discs

Figure 4-4 Separating Alternator and Engine

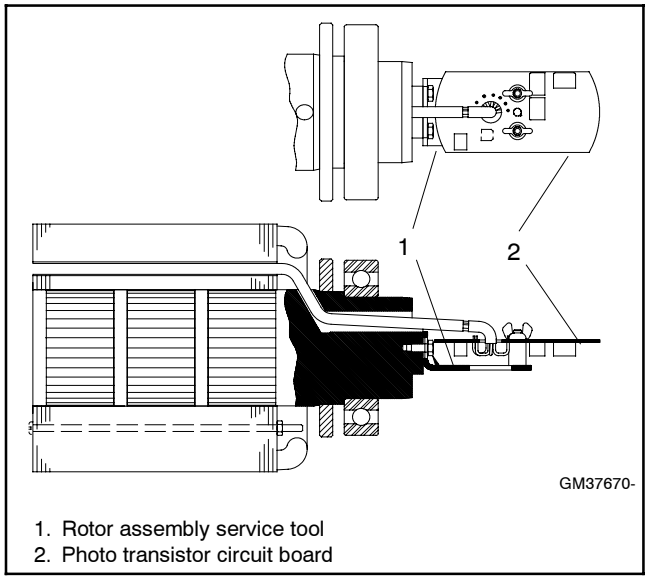
12. Use a stud remover and remove the studs from the flywheel, if damaged.

13. Set alternator assembly on the floor in a horizontal position. Remove the support slings or chains.

14. **350/400 kW only.** Remove the photo transistor circuit board *screws*. Remove the magnetic actuator and insulator. Attach service tool Y-5718, or equivalent, to rotor shaft and attach the photo transistor circuit board to the service tool. See Figure 4-5.

    The service tool positions the photo transistor circuit board so that it will pass through the end bracket hole when removing the rotor assembly.

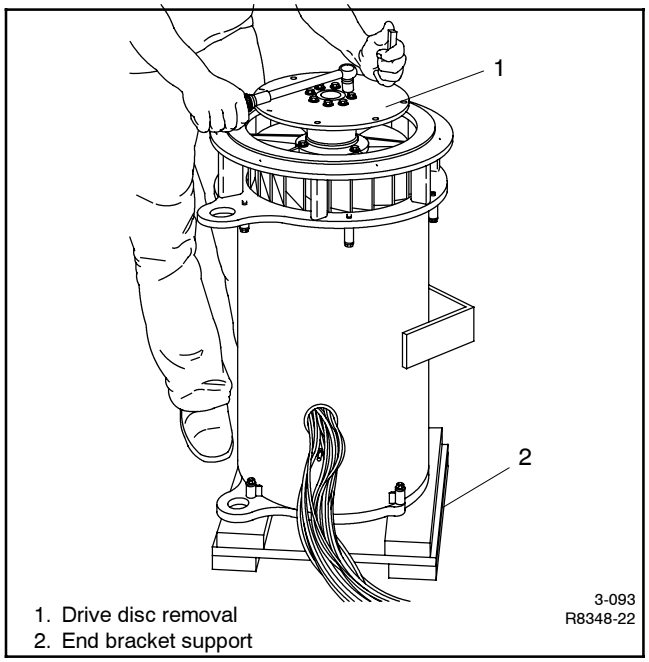
    Note: Fabricate service tool Y-5718 using Appendix F information.



1. Rotor assembly service tool
2. Photo transistor circuit board

Figure 4-5 Rotor Assembly Service Tool Y-5718

15. To remove the rotor assembly, hook hoist to adapter and place the alternator assembly on the floor in a vertical position. See Figure 4-6. Before lowering assembly, place boards along edge of end bracket to prevent damage to the photo transistor circuit board.



1. Drive disc removal
2. End bracket support

Figure 4-6 Alternator Support, Drive Disc, and Fan Removal

16. Remove the drive discs and fan from the alternator assembly. See Figure 4-6.

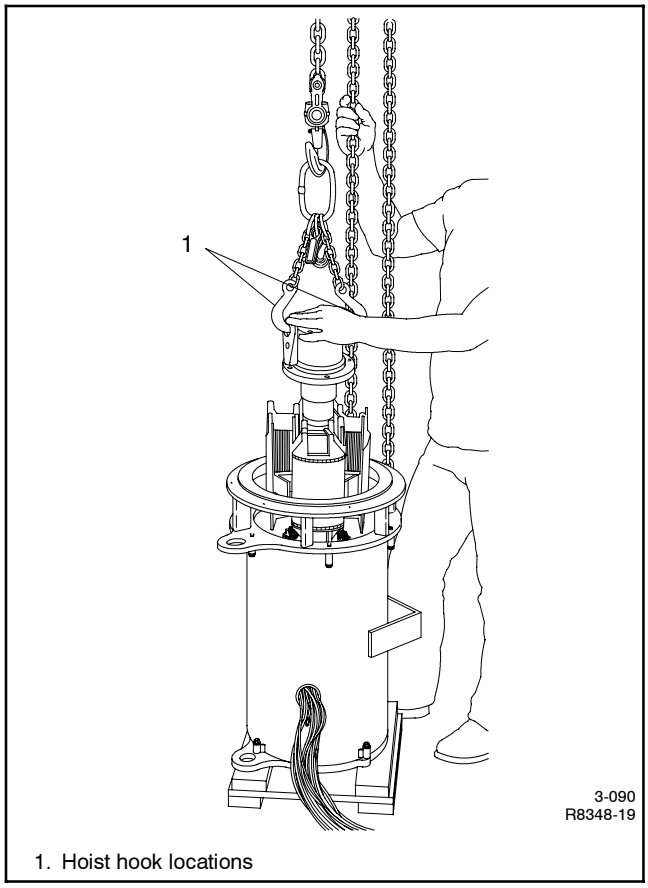
17. Fasten the lifting eye and hoist hook to the rotor flange. Hoist the rotor assembly carefully to avoid damaging the photo transistor circuit board, exciter armature, or exciter field magnets. See Figure 4-7.

18. **350/400 kW only.** Remove the photo transistor circuit board service tool.

19. While the rotor assembly is suspended, remove the photo transistor circuit board, insulator, and magnetic actuator. Remove F3, G, and AC leads from SCR assembly. Cut off photo transistor circuit board terminals to remove the circuit board. If the photo transistor circuit board is reused, leave the leads as long as possible.

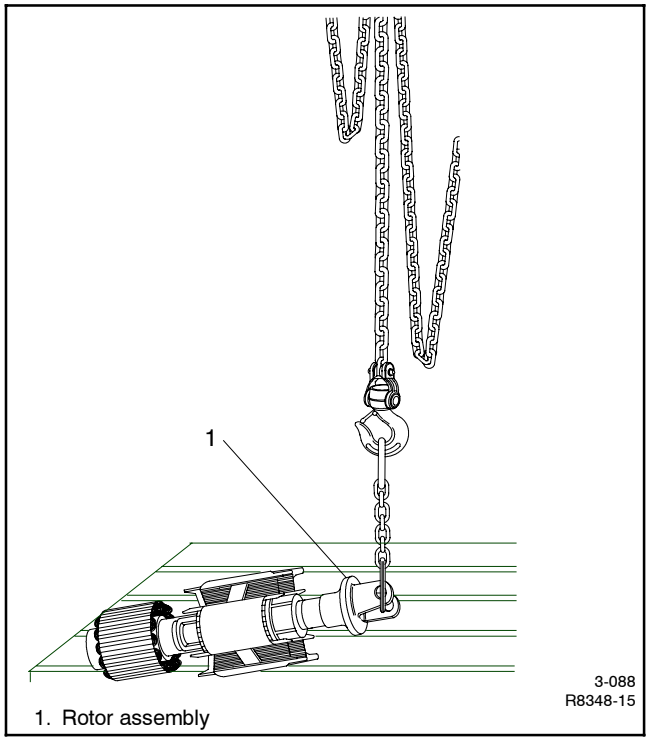
20. Slowly lower the rotor to the horizontal position. Set the rotor on a wooden surface. Take care not to damage the windings, laminations, or bearing. See Figure 4-8.

21. Use a hydraulic press to remove the bearing, if needed. Make note of the bearing location dimensions from the rotor shaft end for reference during installation.



1. Hoist hook locations

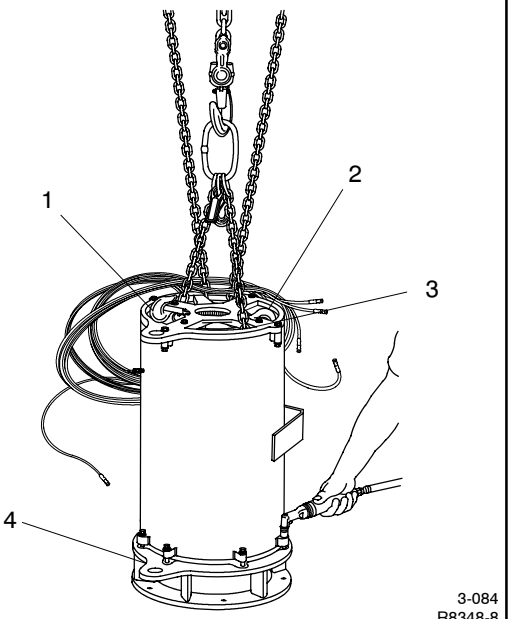
Figure 4-7 Rotor Removal



1. Rotor assembly

Figure 4-8 Lowering Rotor (20–300 kW rotor assembly shown)

22. Place the alternator assembly on the alternator adapter end in order to remove the alternator adapter and end bracket from the stator. Fasten chains to the alternator adapter and lower to a horizontal position. Fasten hook to the end bracket eye and hoist to a vertical position. See Figure 4-9.



1. Hoist hook
2. Hoist hook
3. End bracket
4. Adapter

Figure 4-9 Removing Alternator Adapter

23. Remove the alternator adapter mounting bolts. Fasten the hoist hooks to the end bracket and raise the assembly slightly. Tap the alternator adapter loose by using a rubber mallet.

24. Lower the stator assembly. Remove end bracket mounting bolts. Separate the end bracket from the stator by tapping loose with a rubber mallet.

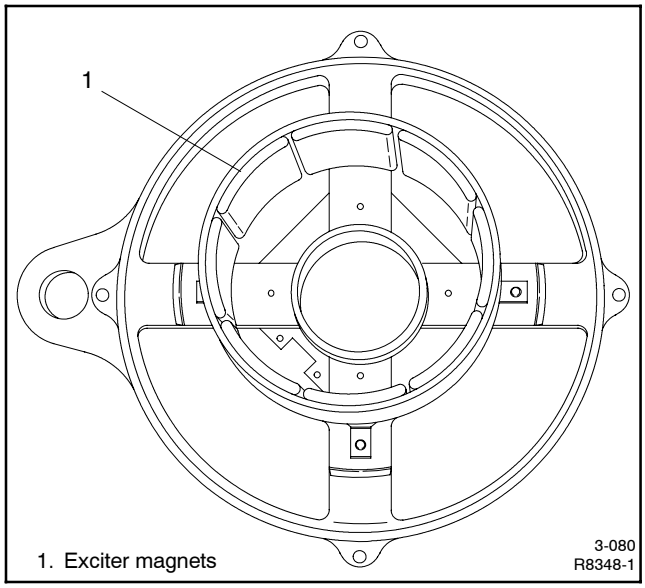
25. Remove the exciter magnets from the end bracket. See Figure 4-10.

4.2 Reassembly

1. Attach the exciter field to the end bracket with four mounting screws. See Figure 4-10. Torque to specifications.

2. Place the stator assembly in a vertical position with the end bracket side up.

   Note: The end bracket side of the stator assembly has four mounting bosses.

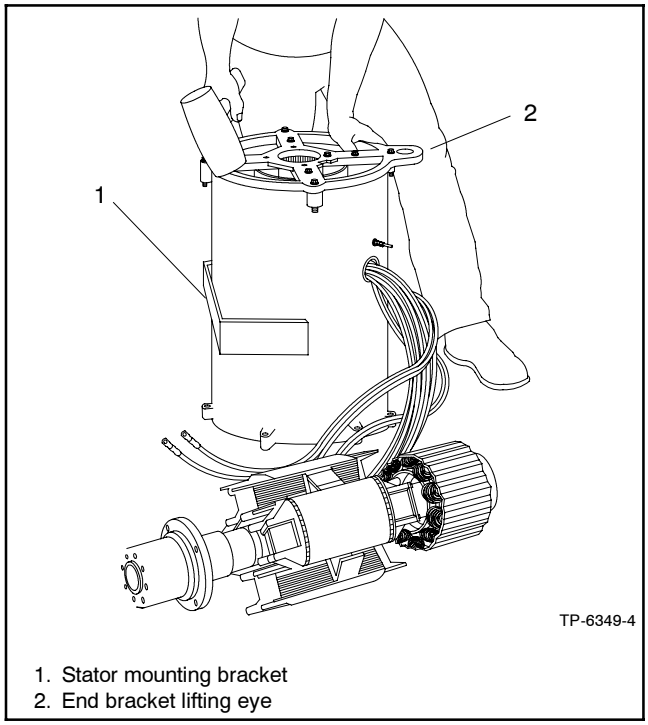


1. Exciter magnets

Figure 4-10 End Bracket View

3. Position the end bracket on the stator assembly and use bolts to align the holes. Use a rubber mallet to mount the end bracket flush with the stator assembly. See Figure 4-11.

   Place the end bracket housing eye opposite the stator mounting bracket during reassembly.

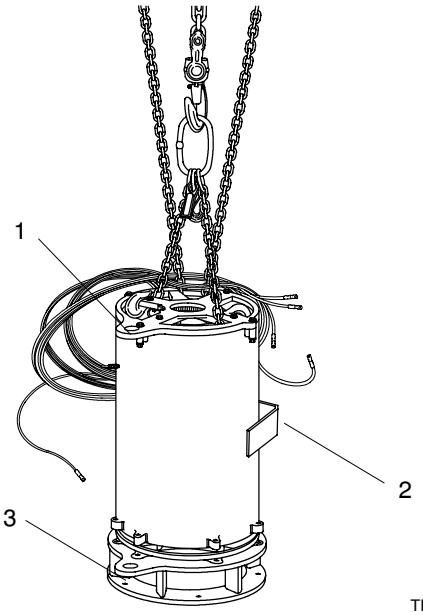


1. Stator mounting bracket
2. End bracket lifting eye

Figure 4-11 Mounting End Bracket on Stator

4. Attach the end bracket to the stator using the original hardware. Torque to specifications.

5. Attach hoist hooks to the end bracket and suspend the stator. Place the alternator adapter on the floor and lower the stator to within 6–12 mm (1/4–1/2 in.) of the adapter lip. See Figure 4-12.



1. End bracket lifting eye
2. Stator mounting bracket
3. Adapter lifting eye

Figure 4-12 Aligning Adapter and Stator

6. Position the adapter hoisting eye opposite of the stator mounting bracket and directly below the end bracket hoisting eye.

   Align the adapter with the stator and start the bolts with washers. Lower the stator onto the adapter and tighten the bolts. Torque to specifications.

7. Attach hoisting hooks to the adapter as shown in Figure 4-13. Suspend the alternator assembly. Before lowering the alternator, place boards along the edge of end bracket. Maintain sufficient clearance underneath the center of the end bracket to prevent damage to the photo transistor board and magnetic actuator when installing the rotor.

8. Rotor shaft bearing installation. Use a hydraulic press, bearing heater, or heavy rubber mallet and a piece of round steel stock with an outside diameter less than the bearing inner race to install the new bearing using measurements taken during the disassembly procedure.

9. Place the alternator assembly on the end bracket end when installing the rotor. Fasten the hoisting hook to the end bracket eye and lower the alternator assembly to a horizontal position.

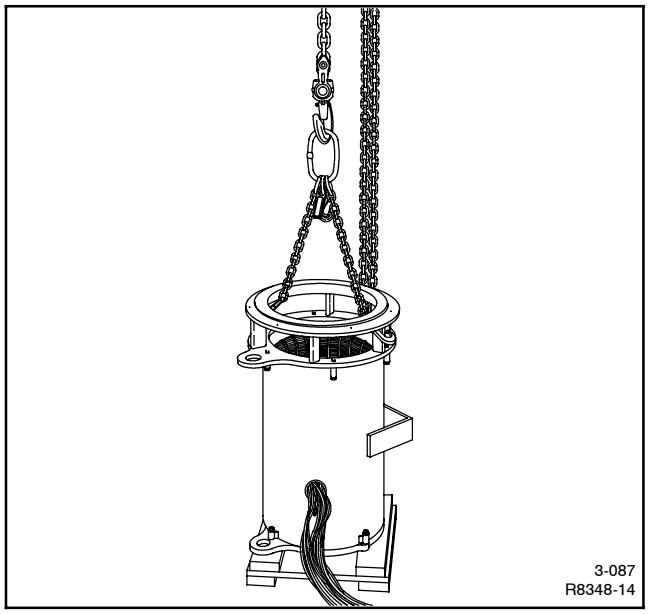
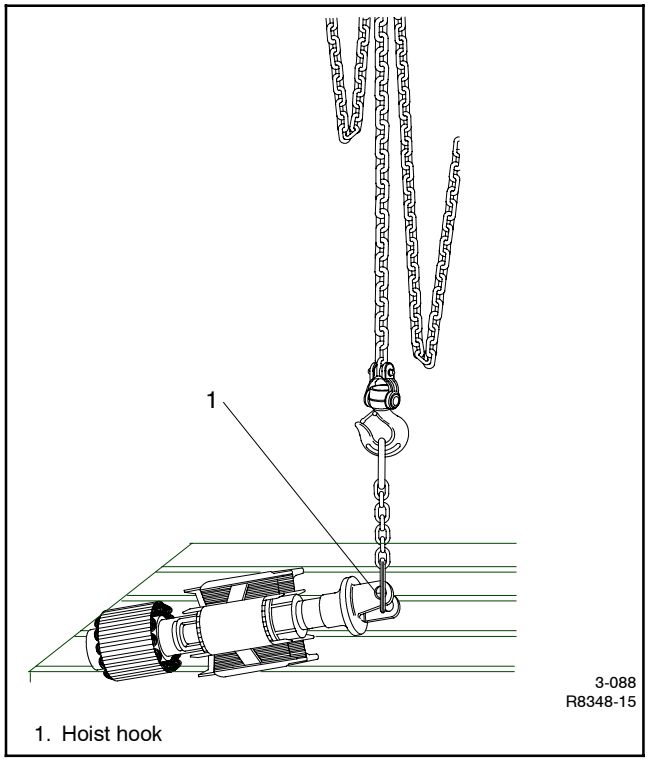


Figure 4-13 Supporting Alternator Assembly

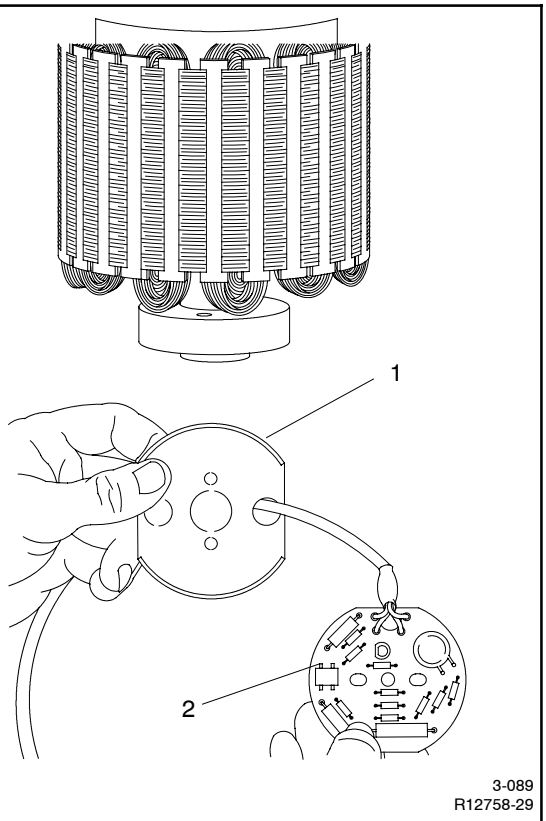
10. Fasten the lifting eye and hoist hook to the rotor flange. See Figure 4-14. Hoist the rotor to a vertical position taking care not to damage windings, laminations, or bearing.



1. Hoist hook

Figure 4-14 Hoisting Rotor

11. While the rotor is suspended, install the photo transistor board, insulator board, and magnetic actuator. Place the photo transistor board lead through the magnetic actuator as shown in Figure 4-15. Push the lead through the hole in the rotor shaft and then through the exciter laminations ending near the SCR assembly.



1. Magnetic actuator
2. Photo transistor board

Figure 4-15 Installing Photo Transistor Board (20–300 kW models shown)

⚠ WARNING

Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Installing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. Ensure that the foil side of the photo transistor circuit board, the end of the shaft, and the threaded holes are clean and free of metal particles and chips. Metal debris may short-circuit the photo transistor circuit board and cause hazardous voltage in the generator set. Do not reconnect the generator set to the load until the AC voltmeter shows the correct output.

12. Attach the photo transistor circuit board and magnetic actuator to the end of rotor shaft with two mounting screws. See Figure 4-16. Cut off excess lead wire, leaving enough wire to reach the SCR assembly. Strip 50–75 mm (2–3 in.) of gray insulator jacket from the lead. Cut off all exposed uninsulated wire. Strip about 0.6 mm (1/4 in.) of insulation on red and black leads and crimp on #8 electrical terminals (part no. X-283-7).

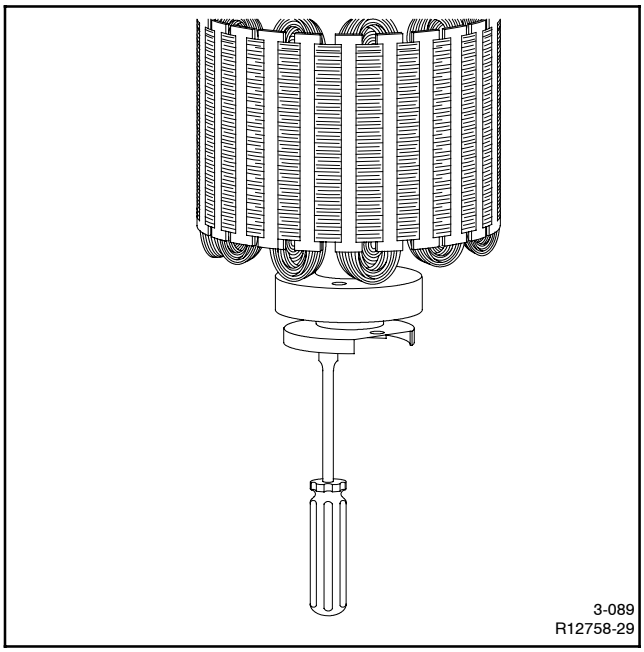
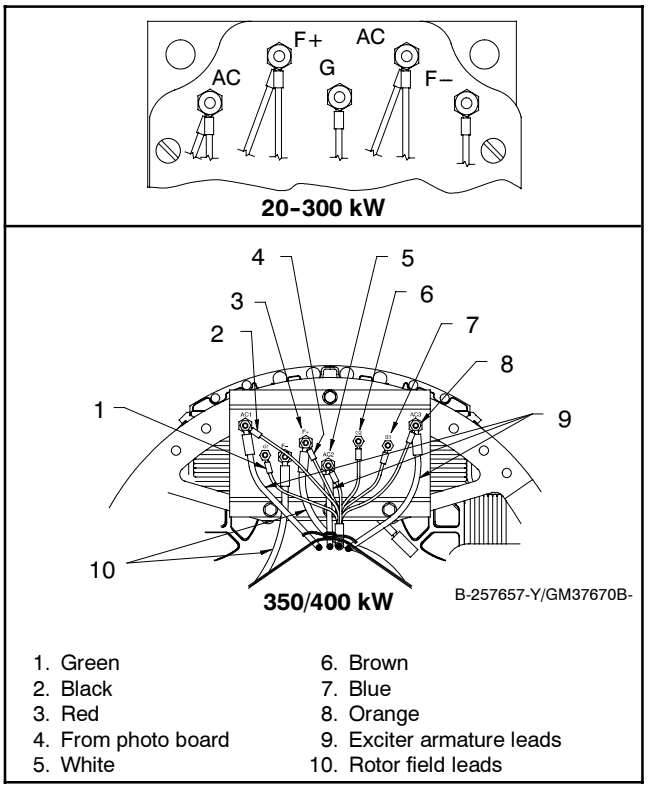


Figure 4-16 Mounting Photo Transistor Board and Magnetic Actuator (20–300 kW models shown)

Before connecting to the SCR studs, secure the leads with tie wraps. Reconnect the photo transistor circuit board white lead to SCR AC stud, red lead to F+ stud, green lead to G stud, and black lead to the remaining AC stud. Secure the leads with stop nuts. See Figure 4-17 for SCR connections and respective wiring diagram as needed. Torque connections to specifications.



1. Green
2. Black
3. Red
4. From photo board
5. White
6. Brown
7. Blue
8. Orange
9. Exciter armature leads
10. Rotor field leads

Figure 4-17 SCR Connections

13. **350/400 kW only.** Remove the photo transistor circuit board *screws*. Attach service tool Y-5718, or equivalent, to rotor shaft and attach photo transistor circuit board to service tool. The service tool positions the photo transistor circuit board so that it will pass through the end bracket hole when installing the rotor assembly.

14. Suspend the rotor over the alternator assembly. Lower the rotor field into the stator. Be extremely careful while lowering the rotor to avoid damaging the photo transistor circuit board, exciter armature, field magnets, stator windings, or rotor laminations. See Figure 4-18. Carefully align rotor bearing into end bracket. Check for an outer race measurement of 6.35 mm (1/4 in.) from bracket to bearing. Make sure the photo transistor board and magnetic actuator have clearance below the end bracket.

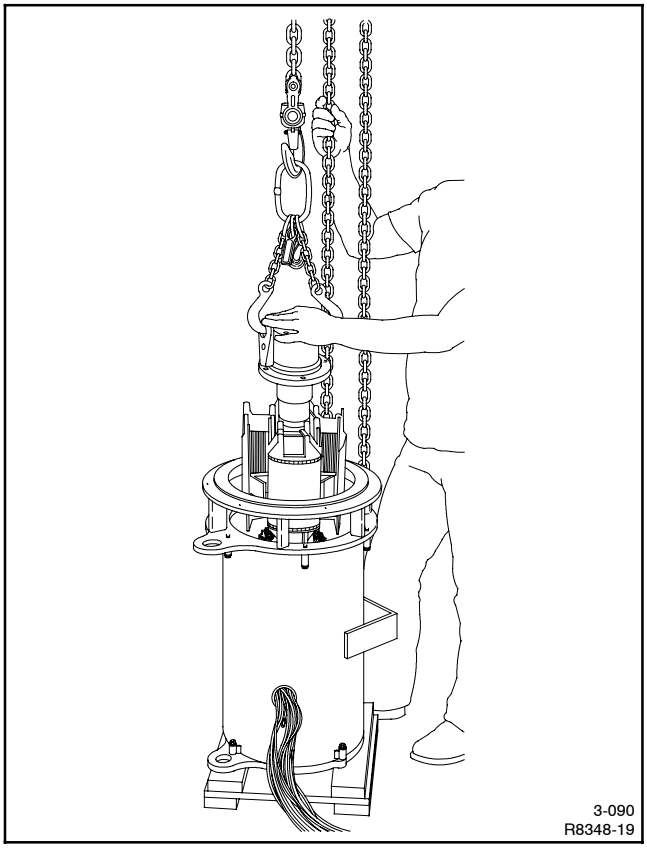
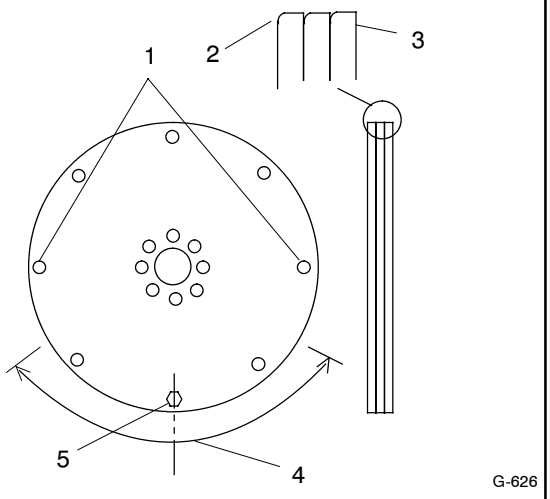


Figure 4-18 Installing Rotor

15. Place the fan over the rotor flange and torque bolts to specifications.

16. Align the individual drive disks with the hex holes together and with the hole burr sides facing the same direction. Temporarily place two alignment pins (not supplied) or bolts in the outer holes at opposite ends and 90° from the hex hole before installing the drive disk to the rotor shaft. The pins help maintain concentric alignment of the individual drive disks during installation. See Figure 4-19.

    Note: User-supplied pins should be no smaller than 0.025 mm (0.001 in.) of disc hole.



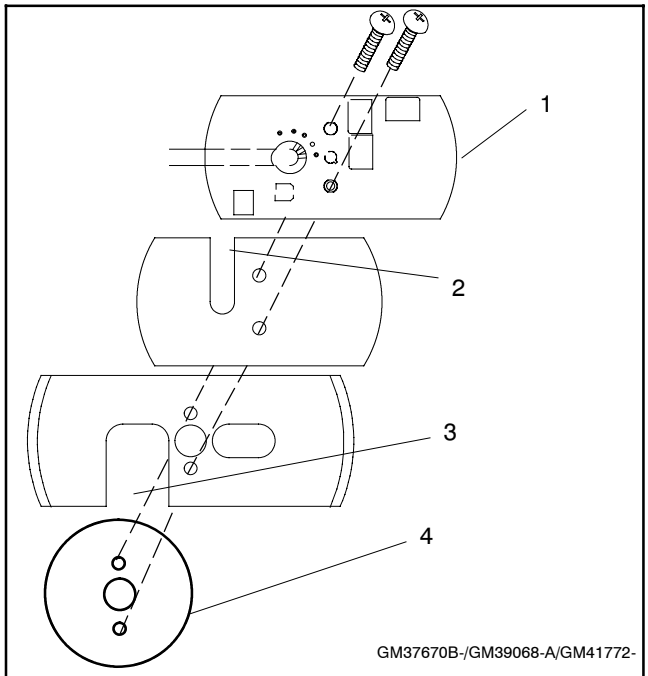
1. Install alignment pins or bolts here
2. Rolled corner
3. Burr side
4. 120° total; position drive disk hex hole at stator bottom position or within 60° CW or CCW from stator bottom position
5. Hex hole

Figure 4-19 Aligning and Mounting Drive Disks

17. Attach the drive disc(s) to the end of the rotor shaft with the hole burr side toward the alternator fan and with the hex hole at the stator bottom position or within 60° clockwise (CW) or counterclockwise (CCW) of the bottom position as viewed when the stator is installed on the skid. Torque the drive disc(s) mounting bolts to specifications. Remove the two alignment pins or bolts.

18. Attach the hoist to adapter eye and place the alternator assembly in a horizontal position. Take care not to damage the rotor or stator. Place the hoisting eyes of alternator to the top.

19. **350/400 kW only.** Remove the photo transistor circuit board service tool. Attach the photo transistor circuit board, insulator, and magnetic actuator to the rotor shaft using two screws. Position the insulator notch *opposite* the magnetic actuator cutout. See Figure 4-20.

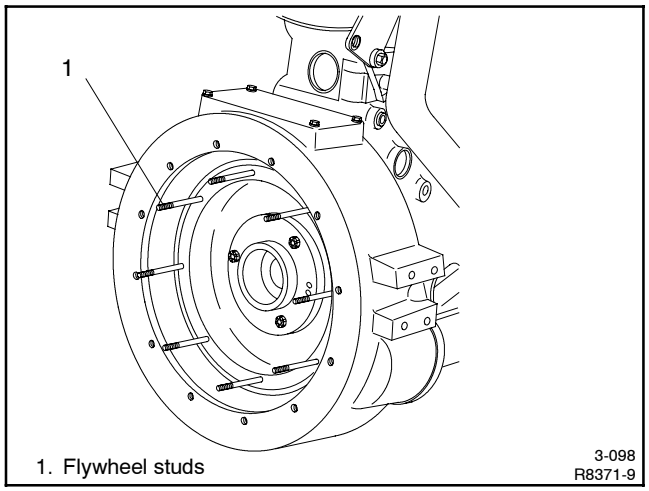


1. Photo transistor circuit board
2. Insulator notch (opposite of the magnetic actuator cutout)
3. Magnetic actuator cutout
4. Rotor shaft

Figure 4-20 Photo Transistor Circuit Board Mounting (350/400 kW models shown)

20. **UA alternator only.** Remove the vent/sight hole screw from the end bracket located 180° from the grease fitting. Use a grease gun and fill with Chevron SRI2 or equivalent lithium-based grease until grease is visible at the vent/sight hole. Wipe excess grease from the end bracket. Replace the vent/sight hole screw and torque to specifications.

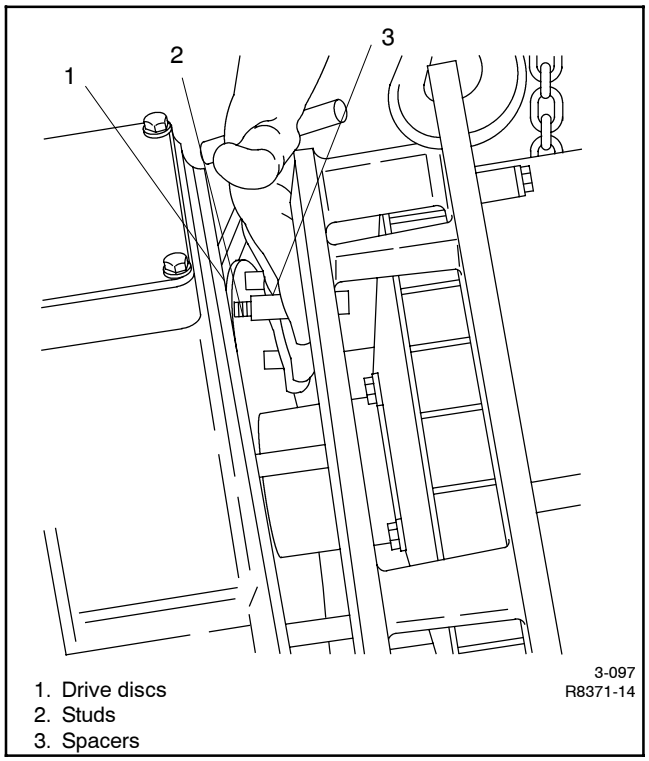
21. If studs are used, apply Loctite® No. 271 red to stud threads and install into flywheel as shown in Figure 4-21. Install studs completely into flywheel. Apply Loctite® No. 242 blue to stud threads on nut side.



1. Flywheel studs

Figure 4-21 Flywheel Studs

22. Place hoist hooks into the end bracket and adapter eye. Raise the alternator assembly and align the studs with the drive discs by turning the flywheel. Move the alternator as necessary to work the drive discs over studs. When the drive discs are about 25 mm (1 in.) over the studs, install spacers if so equipped. See Figure 4-22.



1. Drive discs
2. Studs
3. Spacers

Figure 4-22 Installing Spacers

23. Move the alternator as necessary to align the alternator adapter and the flywheel housing. Fasten and final tighten the adapter to the flywheel housing using bolts and hardened lock washers. See Figure 4-23. Torque bolts to specifications.

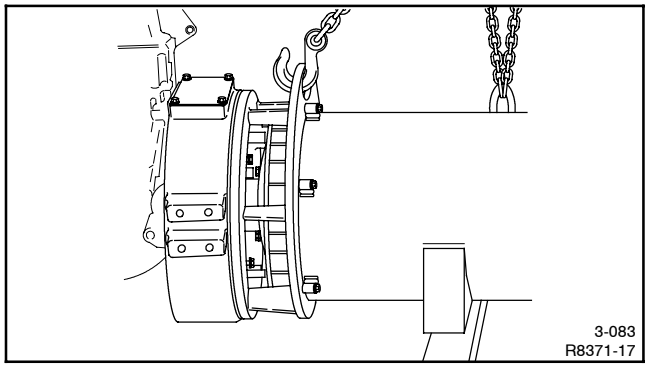


Figure 4-23 Aligning Adapter and Flywheel Housing

24. Install the hardware attaching the drive discs to the flywheel. Do not final tighten at this time.

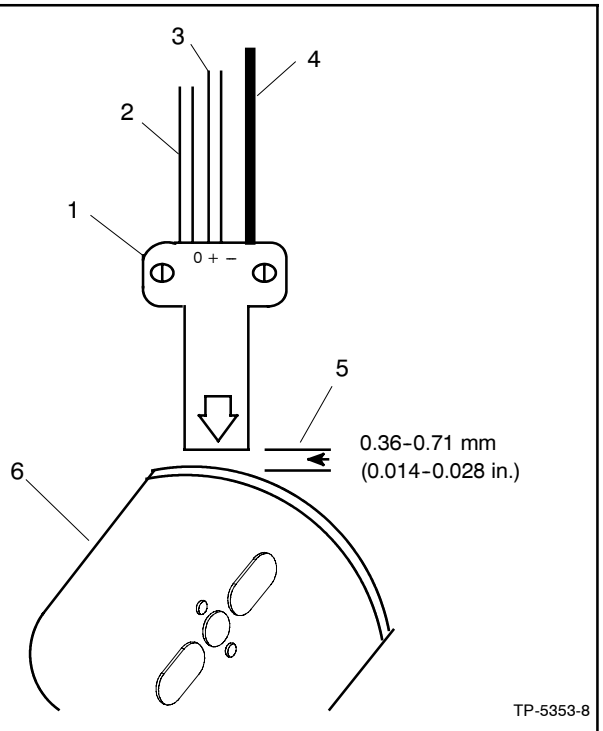
    Note: Some models mount drive discs to flywheel using bolts. Some applications use hardened washers.

25. Hoist the alternator and engine slightly to remove the wood block(s) from under the flywheel housing. Align the alternator assembly and skid. Lower the alternator and tighten the vibromount mounting bolts.

26. Remove the chains or slings used for suspending the alternator. Final tighten the drive discs to the flywheel. Torque hardware to specifications.

Loctite® is a registered trademark of Loctite Corporation.

27. Install the speed sensor to the end bracket. Adjust the air gap. See Figure 4-24.



1. Speed sensor
2. Wire 16: white/clear
3. Wire 24: red
4. Wire 2: black
5. Air Gap: 0.36–0.71 mm (0.014–0.028 in.)
6. Magnetic actuator

Figure 4-24 Speed Sensor Air Gap

28. Replace the alternator (rodent) guard on the end bracket (if equipped).

29. Replace the LED circuit board cover to the end bracket.

30. Install the fan guard.

31. Reinstall the junction box and controller.

32. Reconnect all controller-to-engine and engine-to-alternator harnesses and wiring. Refer to the wiring diagrams as required.

33. Replace the junction box panels.

34. Reconnect the fuel, cooling, and exhaust systems disconnected during disassembly. Reconnect the output leads or load circuit cables at the alternator. Open the fuel supply valve.

35. Reconnect the starting batteries, negative lead last. Connect any AC-powered accessories such as the battery charger, block heater, fuel transfer pump, etc.

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	advanced digital control; analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
Ah	amp-hour
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
APDC	Air Pollution Control District
API	American Petroleum Institute
approx.	approximate, approximately
AQMD	Air Quality Management District
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CAN	controller area network
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cUL	Canadian Underwriter's Laboratories
CUL	Canadian Underwriter's Laboratories
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dB(A)	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
DFMEA	Design Failure Mode and Effects Analysis
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
ECM	electronic control module, engine control module
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lb.	foot pounds (torque)
ft./min.	feet per minute
ftp	file transfer protocol
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temp., high engine temp.
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard

k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
KBus	Kohler communication protocol
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
kWth	kilowatt-thermal
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/hr.	cubic meters per hour
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCCB	molded-case circuit breaker
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
ms	millisecond
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MTU	Motoren-und Turbinen-Union
MW	megawatt
mW	milliwatt
µF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips® head Crimptite® (screw)
PHH	Phillips® hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
psig	pounds per square inch gauge
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTU	remote terminal unit
RTV	room temperature vulcanization
RW	read/write
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SNMP	simple network management protocol
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec	specification
specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
THD	total harmonic distortion
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix F, General Torque Specifications, and other torque specifications in the service literature.

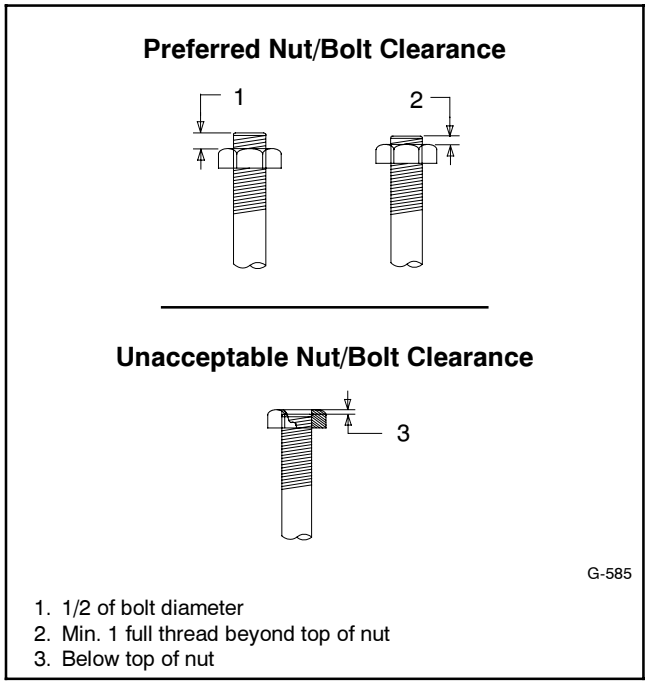


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.

2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.

3. Follow these SAE washer rules after determining exit hole type:

   a. Always use a washer between hardware and a slot.

   b. Always use a washer under a nut (see 2 above for exception).

   c. Use a washer under a bolt when the female thread is fixed (weld nut).

4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

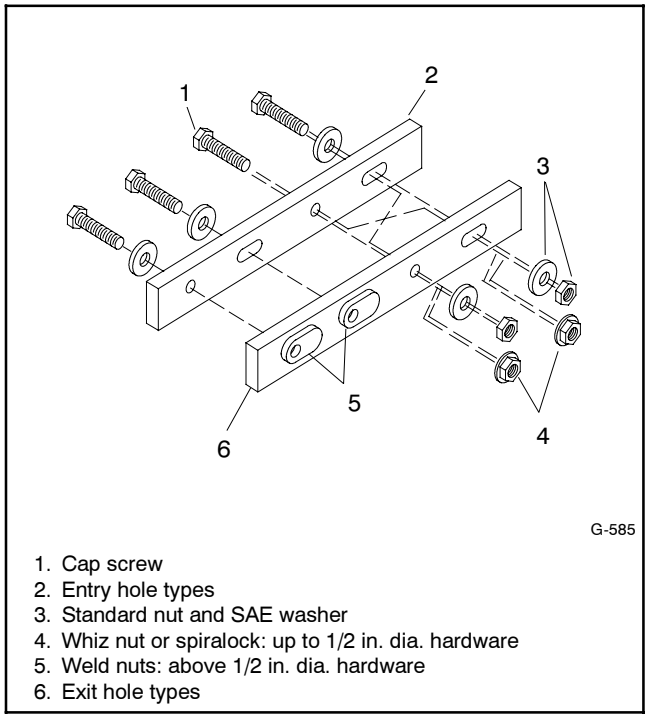


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

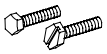
American Standard Fasteners Torque Specifications								
Size	Torque Measurement	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 2 or 5
		Grade 2		Grade 5		Grade 8		
8-32	Nm (in. lb.)	1.8	(16)	2.3	(20)	—		See Note 3
10-24	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
10-32	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
1/4-20	Nm (in. lb.)	6.8	(60)	10.8	(96)	14.9	(132)	
1/4-28	Nm (in. lb.)	8.1	(72)	12.2	(108)	16.3	(144)	
5/16-18	Nm (in. lb.)	13.6	(120)	21.7	(192)	29.8	(264)	
5/16-24	Nm (in. lb.)	14.9	(132)	23.1	(204)	32.5	(288)	
3/8-16	Nm (ft. lb.)	24	(18)	38	(28)	53	(39)	
3/8-24	Nm (ft. lb.)	27	(20)	42	(31)	60	(44)	
7/16-14	Nm (ft. lb.)	39	(29)	60	(44)	85	(63)	
7/16-20	Nm (ft. lb.)	43	(32)	68	(50)	95	(70)	
1/2-13	Nm (ft. lb.)	60	(44)	92	(68)	130	(96)	
1/2-20	Nm (ft. lb.)	66	(49)	103	(76)	146	(108)	
9/16-12	Nm (ft. lb.)	81	(60)	133	(98)	187	(138)	
9/16-18	Nm (ft. lb.)	91	(67)	148	(109)	209	(154)	
5/8-11	Nm (ft. lb.)	113	(83)	183	(135)	259	(191)	
5/8-18	Nm (ft. lb.)	128	(94)	208	(153)	293	(216)	
3/4-10	Nm (ft. lb.)	199	(147)	325	(240)	458	(338)	
3/4-16	Nm (ft. lb.)	222	(164)	363	(268)	513	(378)	
1-8	Nm (ft. lb.)	259	(191)	721	(532)	1109	(818)	
1-12	Nm (ft. lb.)	283	(209)	789	(582)	1214	(895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)								
Size (mm)	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 5.8 or 8.8	
	Grade 5.8		Grade 8.8		Grade 10.9			
M6 x 1.00	6.2	(4.6)	9.5	(7)	13.6	(10)	See Note 3	
M8 x 1.25	15	(11)	23	(17)	33	(24)		
M8 x 1.00	16	(11)	24	(18)	34	(25)		
M10 x 1.50	30	(22)	45	(34)	65	(48)		
M10 x 1.25	31	(23)	47	(35)	68	(50)		
M12 x 1.75	53	(39)	80	(59)	115	(85)		
M12 x 1.50	56	(41)	85	(63)	122	(90)		
M14 x 2.00	83	(61)	126	(93)	180	(133)		
M14 x 1.50	87	(64)	133	(98)	190	(140)		
M16 x 2.00	127	(94)	194	(143)	278	(205)		
M16 x 1.50	132	(97)	201	(148)	287	(212)		
M18 x 2.50	179	(132)	273	(201)	390	(288)		
M18 x 1.50	189	(140)	289	(213)	413	(305)		
M20 x 2.50	245	(181)	374	(276)	535	(395)		
M20 x 1.50	264	(195)	402	(297)	576	(425)		
M22 x 2.50	332	(245)	507	(374)	725	(535)		
M22 x 1.50	351	(259)	535	(395)	766	(565)		
M24 x 3.00	425	(314)	649	(479)	928	(685)		
M24 x 2.00	447	(330)	682	(503)	976	(720)		
M27 x 3.00	—		937	(692)	1341	(990)		
M27 x 2.00	—		985	(727)	1409	(1040)		
M30 x 3.50	—		1278	(943)	1829	(1350)		
M30 x 2.00	—		1349	(996)	1931	(1425)		

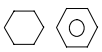
Notes:

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- Length In Inches (Screws and Bolts)
- Threads Per Inch
- Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M6-1.25 x 20

- Length In Millimeters (Screws and Bolts)
- Distance Between Threads In Millimeters
- Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14	1/2-20	Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (Partial Thread)

Part No.	Dimensions
M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60*
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Hex Head Bolts (Partial Thread), continued

Part No.	Dimensions
M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200

Hex Head Bolts (Full Thread)

M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Hex Head Bolts (Full Thread), continued

Part No.	Dimensions
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100

Flat Head Machine Screws

M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

* This metric hex bolt's hardness is grade 10.9.

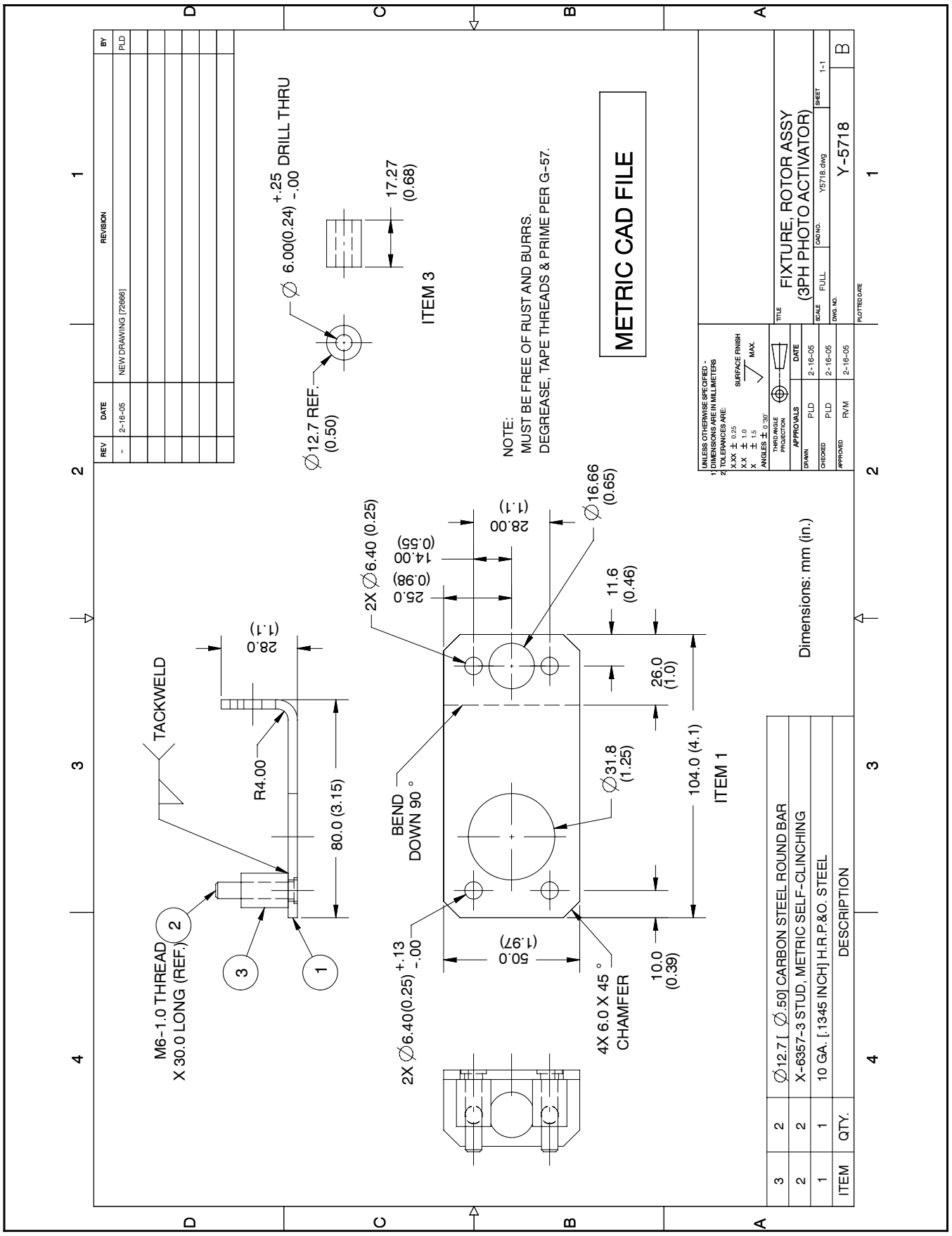
Metric, continued

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-04-B	M4-0.70	Brass
M934-05-50	M5-0.80	Standard
M934-06-60	M6-1.00	Standard
M934-06-64	M6-1.00	Std. (green)
M6923-06-80	M6-1.00	Spiralock
M982-06-80	M6-1.00	Elastic Stop
M934-08-60	M8-1.25	Standard
M6923-08-80	M8-1.25	Spiralock
M982-08-80	M8-1.25	Elastic Stop
M934-10-60	M10-1.50	Standard
M934-10-60F	M10-1.25	Standard
M6923-10-80	M10-1.50	Spiralock
M6923-10-62	M10-1.50	Spiralock†
M982-10-80	M10-1.50	Elastic Stop
M934-12-60	M12-1.75	Standard
M934-12-60F	M12-1.25	Standard
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-60	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M934-18-80	M18-2.5	Standard
M982-18-60	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-60	M22-2.50	Standard
M934-24-80	M24-3.00	Standard
M982-24-60	M24-3.00	Elastic Stop
M934-30-80	M30-3.50	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

† This metric hex nut's hardness is grade 8.


METRIC CAD FILE
NOTE:
MUST BE FREE OF RUST AND BURRS.
DEGREASE, TAPE THREADS & PRIME PER G-57.
ITEM 3
ITEM 1
TACKWELD
M6-1.0 THREAD
X 30.0 LONG (REF.)
R4.00
80.0 (3.15)
28.0
(1.1)
BEND
DOWN 90 °
2X ∅6.40 (0.25)
25.0
(0.98)
14.00
(0.55)
28.00
(1.1)
∅16.66
(0.65)
11.6
(0.46)
26.0
(1.0)
∅31.8
(1.25)
104.0 (4.1)
50.0
(1.97)
10.0
(0.39)
4X 6.0 X 45 °
CHAMFER
2X ∅6.40(0.25) +.13 -.00
∅12.7 REF.
(0.50)
∅ 6.00(0.24) +.25 -.00 DRILL THRU
17.27
(0.68)
Dimensions: mm (in.)
REV DATE REVISION BY
- 2-16-05 NEW DRAWING [72666] PLD
UNLESS OTHERWISE SPECIFIED -
1) DIMENSIONS ARE IN MILLIMETERS
2) TOLERANCES ARE:
X.XX ± 0.25
X.X ± 1.0
X ± 1.5
ANGLES ± 0 30'
SURFACE FINISH MAX.
THIRD ANGLE PROJECTION
APPROVALS DATE
DRAWN PLD 2-16-05
CHECKED PLD 2-16-05
APPROVED RVM 2-16-05
TITLE FIXTURE, ROTOR ASSY (3PH PHOTO ACTIVATOR)
SCALE FULL CAD NO. Y5718.dwg SHEET 1-1
DWG. NO. Y-5718 B
PLOTTED DATE
ITEM QTY. DESCRIPTION
3 2 ∅12.7 [∅.50] CARBON STEEL ROUND BAR
2 2 X-6357-3 STUD, METRIC SELF-CLINCHING
1 1 10 GA. [.1345 INCH] H.R.P.&O. STEEL

Notes

Notes

Notes

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TP-6353 3/12b