Service

Commercial/Recreational Mobile Generator Sets

Models:

7.5EOR/EORZ
10EOR/EORZ
15EOR/EORZ
20EOR/EORZ
6EFOR/EFORZ
9EFOR/EFORZ
12.5EFOR/EFORZ
16.5EFOR/EFORZ

ISO 9001 KOHLER POWER SYSTEMS NATIONALLY REGISTERED

KOHLER® POWER SYSTEMS

TP-6073 4/06a

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

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

Table of Contents

Table of Contents, continued

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 equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

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.

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.

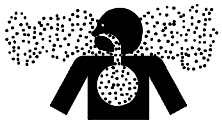
Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

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 or vehicle. Do not obstruct the exhaust outlet when parking your vehicle. The exhaust gases must discharge freely to prevent carbon monoxide from deflecting into the vehicle.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. 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.

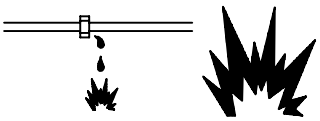
Copper tubing exhaust systems. Carbon monoxide can cause severe nausea, fainting, or death. Do not use copper tubing in diesel exhaust systems. Sulfur in diesel exhaust causes rapid deterioration of copper tubing exhaust systems, resulting in exhaust leakage.

Installing the exhaust tail pipe. Carbon monoxide can cause severe nausea, fainting, or death. Install the exhaust system tail pipe to prevent the drawing of discharged exhaust gases into the vehicle interior through windows, doors, air conditioners, and other openings. Do not use flexible tail piping because it could crack and allow lethal exhaust fumes to enter the vehicle.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the vehicle's occupants, install a carbon monoxide detector. Consult the coach builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

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.

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.

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/Electrical Shock

⚠ WARNING

Hazardous voltage. Moving rotor.
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 severe injury, death, or property damage.

Connect the generator set to the building's electrical system only through an approved device and after the building's main switch is opened.

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

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.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator. *(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)*

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. Connect the generator set to the building/campground electrical system only through an approved device and after the building/campground main switch is opened. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a transfer switch to prevent interconnection of the generator set power and other sources of power.

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)

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.

Checking the coolant level. Hot coolant can cause severe injury or death. Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

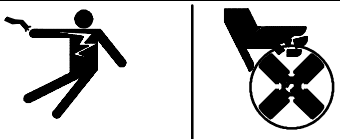
Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Combustible materials. Fire can cause severe injury or death. A hot exhaust system can ignite adjacent combustible materials. Do not locate electrical wiring, fuel lines, or combustible materials above the exhaust muffler. Exercise caution when parking your vehicle to prevent the exhaust system and hot exhaust gases from starting grass fires.

Combustible materials. Fire can cause severe injury or death. A hot generator set can ignite debris in the compartment. Keep the compartment and generator set clean and free of debris and combustible materials to minimize the possibility of fire. Do not block the fuel/oil drain opening in the generator set mounting tray. Cut a corresponding hole in the subfloor, if used, for the drain opening.

Moving Parts

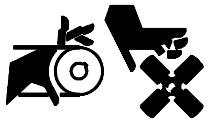
⚠ WARNING



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

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

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Tightening the hardware. Flying projectiles can cause severe injury or death. Loose hardware can cause the hardware or pulley to release from the generator set engine and can cause personal injury. Retorque all crankshaft and rotor hardware after servicing. Do not loosen the crankshaft hardware or rotor thrubolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor thrubolt counterclockwise can loosen the hardware.

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.

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

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

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.

NOTICE

This generator set does not comply with United States Coast Guard (USCG) requirements and must not be used for marine applications. For marine installations use only generator sets specified for marine use. USCG Regulation 33CFR183 requires that a generator set must be ignition protected when used in a gasoline-fueled environment.

Notes

This manual provides troubleshooting and repair instructions for the 7.5EOR/EORZ, 10EOR/EORZ, 15EOR/EORZ, 20EOR/EORZ, 6EFOR/EFORZ, 9EFOR/EFORZ, 12.5EFOR/EFORZ, and 16.5EFOR/EFORZ model generator sets, controllers, and accessories.

Refer to the engine service manual for generator set engine service information.

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This manual may be used for models not listed on the front cover.

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. Obtain service from an authorized service distributor/dealer to keep equipment in top condition.

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Service Assistance

For professional advice on generator 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 KohlerPowerSystems.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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North China Regional Office, Beijing
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Fax: (86) 10 6518 7955

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India Regional Office
Bangalore, India
Phone: (91) 80 3366208
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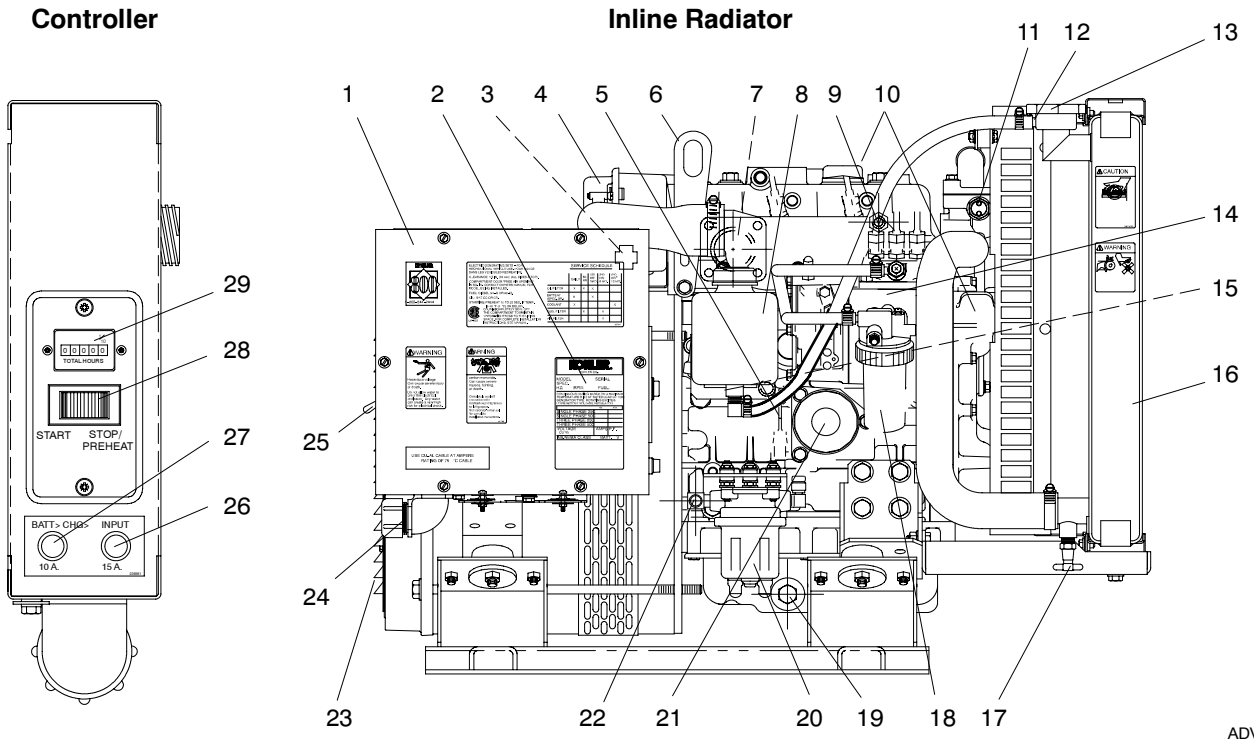
Japan, Korea
North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

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

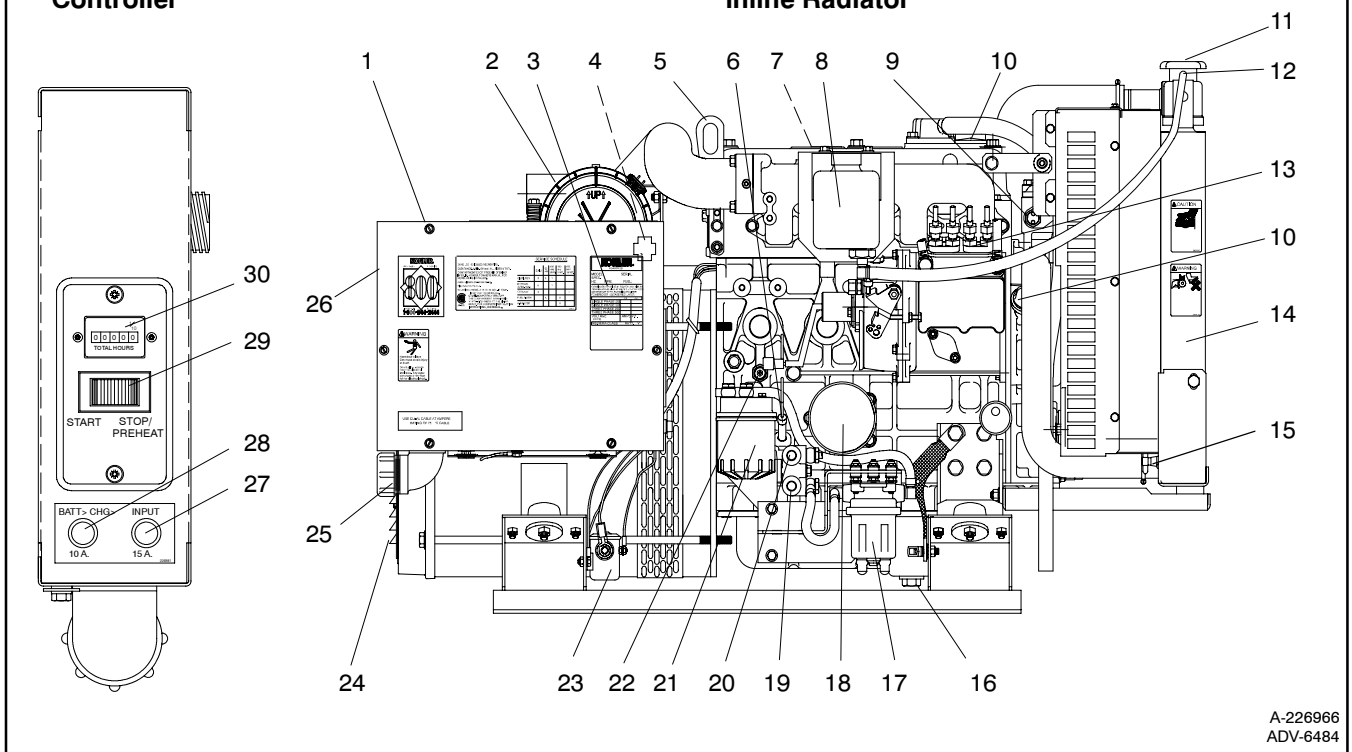
Notes

1.1 Service Views



1. Controller
2. Nameplate
3. Remote start connector
4. Air cleaner
5. Oil check
6. Lifting eye
7. Exhaust outlet
8. Coolant overflow bottle
9. Fuel return connection
10. Oil fill
11. High water temperature safety shutdown switch
12. Overflow tube
13. Pressure cap
14. Fuel injection pump
15. Low oil pressure safety shutdown switch
16. Radiator
17. Coolant drain
18. Fuel filter
19. Oil drain
20. Fuel pump
21. Oil filter
22. Fuel inlet connection
23. Cooling air inlet
24. Customer load access connector
25. Optional circuit breaker location
26. Input fuse
27. Battery charging fuse
28. Start/stop switch
29. Hourmeter

Figure 1-1 7.5–10 kW Service View (Inline Radiator Model Shown)



1. Controller
2. Air cleaner
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8. Coolant overflow bottle
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10. Oil fill
11. Pressure cap
12. Overflow tube
13. Fuel injection pump
14. Radiator
15. Coolant drain
16. Oil drain
17. Fuel pump
18. Oil filter
19. Fuel inlet connection
20. Fuel return connection
21. Fuel filter
22. Low oil pressure safety shutdown switch
23. Preheat relay
24. Cooling air inlet
25. Customer load access connector
26. Optional circuit breaker location
27. Input fuse
28. Battery charging fuse
29. Start/stop switch
30. Hourmeter

Figure 1-2 15–20 kW Service View (Inline Radiator Model Shown)

1.2 Engine Specifications

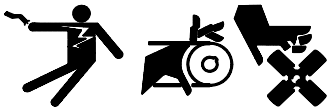
Component	7.5EOR/6EFOR, 7.5EORZ/6EFORZ	10EOR/9EFOR, 10EORZ/9EFORZ	15EOR/12.5EFOR, 15EORZ/12.5EFORZ	20EOR/16.5EFOR, 20EORZ/16.5EFORZ
Make	Yanmar	Yanmar	Yanmar	Yanmar
Model	3TNE74	3TNE82A	4TNE84	4TNE84-T
Cylinders, arrangement	3, inline	3, inline	4, inline	4, inline
Compression ratio	23.0:1	18.0:1	17.79:1	16.99:1
Combustion system	Swirl precombustion chamber	Direct injection	Direct injection	Direct injection
Displacement, L (cu. in.)	1.006 (61.39)	1.330 (81.14)	1.995 (121.74)	1.995 (121.74)
Rated horsepower	14.0/11.6	17.7/14.8	26.1/22.0	36.1/28.6
Rated rpm	1800/1500	1800/1500	1800/1500	1800/1500
Bore, mm (in.)	74 (2.91)	82 (3.23)	84 (3.31)	84 (3.31)
Stroke, mm (in.)	78 (3.07)	84 (3.31)	90 (3.54)	90 (3.54)
Connecting rod material	Forged carbon steel	Forged carbon steel	Forged carbon steel	Forged carbon steel
Cylinder block material	Cast iron	Cast iron	Cast iron	Cast iron
Cylinder head material	Cast iron	Cast iron	Cast iron	Cast iron
Piston rings	2 compression, 1 oil	2 compression, 1 oil	2 compression, 1 oil	2 compression, 1 oil
Crankshaft material	Heat treated, ductile iron casting	Heat treated, ductile iron casting	Heat treated, ductile iron casting	Heat treated, ductile iron casting
Main bearings: number, type	2, replaceable sleeve	2, replaceable sleeve	2, replaceable sleeve	2, replaceable sleeve
Injection pump	Yanmar YPES	Yanmar YPES	Yanmar YPES	Yanmar YPES
Governor	Mechanical	Mechanical	Mechanical	Mechanical
Lubrication system	Full pressure	Full pressure	Full pressure	Full pressure
Oil capacity, L (qt.)	2.3 (2.4)	5.2 (5.5)	5.8 (6.1)	5.8 (6.1)
Oil type	CC or CD	CC or CD	CC or CD	CC or CD
Oil pressure, kPa (psi)	172-241 (25-35)	172-241 (25-35)	172-241 (25-35)	245-343 (35-49)
Low oil pressure, kPa (psi)	49.0 (7.11)	49.0 (7.11)	49.0 (7.11)	49.0 (7.11)
High engine temperature, °C (°F)	110 ±3 (230 ±5.4)	110 ±3 (230 ±5.4)	110 ±3 (230 ±5.4)	110 ±3 (230 ±5.4)
Fuel pump	Electric	Electric	Electric	Electric
Maximum lift, m (ft.)	1 (3.28)	1 (3.28)	1 (3.28)	1 (3.28)
Fuel type	Diesel fuel ISO 8217 DMA, BS2869 A1 or A2	Diesel fuel ISO 8217 DMA, BS2869 A1 or A2	Diesel fuel ISO 8217 DMA, BS2869 A1 or A2	Diesel fuel ISO 8217 DMA, BS2869 A1 or A2
Battery voltage	12	12	12	12
Battery ground	Negative	Negative	Negative	Negative
Battery recommendation, min.	625 CCA at 0°F, 100 amp/hr.	625 CCA at 0°F, 100 amp/hr.	625 CCA at 0°F, 100 amp/hr.	625 CCA at 0°F, 100 amp/hr.
Starter motor	Gear reduction	Gear reduction	Gear reduction	Gear reduction
Cooling system	Liquid	Liquid	Liquid	Liquid
Cooling system capacity, L (qt.), engine block only	3.8 (4.0)	2.5 (2.6)	2.7 (2.85)	2.7 (2.85)

1.3 Generator Specifications

Component Specification	With Brushes				With Exciter			
	7.5EOR/ 6EFOR	10EOR/ 9EFOR	15EOR/ 12.5EFOR	20EOR/ 16EFOR	7.5EORZ/ 6EFORZ	10EORZ/ 9EFORZ	15EORZ/ 12.5EFORZ	20EORZ/ 16EFORZ
Main field (rotor) resistance, cold, ohms	5.0	3.6	3.0	3.0	5.0	5.7	3.0	3.0
Exciter field voltage/current readings at rated voltage, hot								
No load (63 Hz), volts/amps	—	—	—	—	19/0.9	12/0.8	8/1.4	8/1.4
Full load (60 Hz), volts/amps	—	—	—	—	32/1.5	33/2.2	16/2.4	16/2.4
Exciter field resistance, cold, ohms	—	—	—	—	4.8	4.8	5.8	5.8
Exciter armature resistance, cold, ohms	—	—	—	—	1.2	1.2	0.5	0.5
Stator output voltages with separately excited generator using a 12-volt battery, volts								
1-2, 3-4	115	120	120	120	81	115	—	—
1-4, 2-5, 3-6, 7-10, 8-11, 9-12, 7-8	—	—	—	—	—	—	70	70
55-66	122	129	128	128	105	155	90	90
B1-B2	13	14	14	14	10	15	9	9
Stator resistance, cold, ohms								
1-2, 3-4	0.3	0.2	0.1	0.1	0.3	0.2	—	—
1-4, 2-5, 3-6, 7-10, 8-11, 9-12, 7-8	—	—	—	—	—	—	0.04	0.04
55-66	2.1	1.9	1.3	1.3	2.1	1.9	1.3	1.3
B1-B2	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05

2.1 General Maintenance

⚠ 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 equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

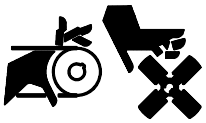
⚠ WARNING

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



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

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.

See the Safety Precautions and Instructions at the beginning of this manual before attempting to service, repair, or operate the generator set. Have an authorized distributor/dealer perform generator set service.

Engine Service. Perform generator set engine service at the intervals specified by the engine operation manual.

Generator Set Service. Perform generator set service at the intervals specified by the generator set operation manual.

If the generator set operates under dusty or dirty conditions, use *dry* compressed air to blow dust out of the alternator. With the generator set running, direct the stream of air in through the cooling slots at the alternator end.

Routine Maintenance. Refer to the following generator set service schedule, the engine service schedule, and the hourmeter located on the generator set controller to determine when to schedule routine maintenance. Service more frequently generator sets that are subject to extreme weather or dusty or dirty conditions.

Service Schedule. Perform maintenance on each item in the service schedule at the designated intervals for the life of the generator set. For example, an item requiring service every 100 hours or 3 months also requires service after 200 hours or 6 months, 300 hours or 9 months, and so on.

x:sm:004:001

2.2 Lubrication System

Use oil that meets the American Petroleum Institute (API) classification of CD, CC/CD, or CC. Using unsuitable oil or neglecting an oil change may result in engine damage and a shorter engine life. See Figure 2-1 for the recommended Society of Automotive Engineers (SAE) viscosity designation for various operating temperature ranges.

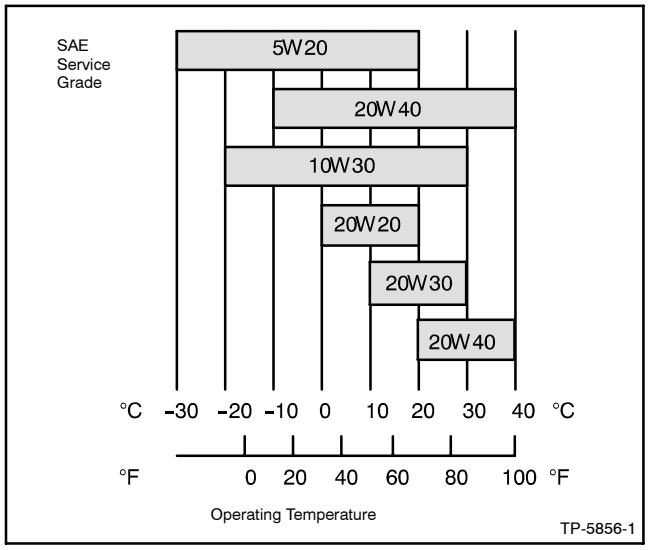
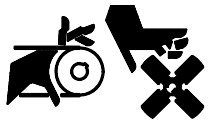


Figure 2-1 Engine Oil Selection

2.3 Battery Charging

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Do not operate generator set without all guards, screens, and covers in place.

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

The generator has a 40-amp, belt-driven battery charging alternator. See Figure 2-2. The alternator is attached to the engine block by a bracket and keeps the battery constantly charged. Observe battery polarity when connecting the battery to the generator set. Alternator maintenance consists only of maintaining belt tension.

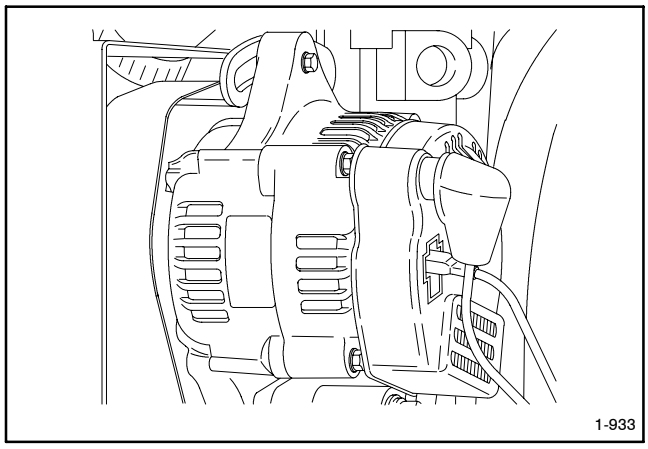
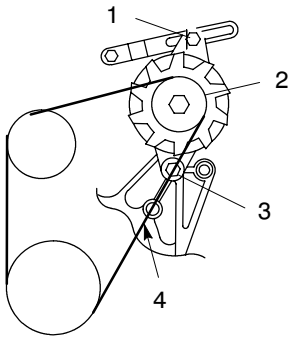


Figure 2-2 Battery-Charging Alternator

2.4 Belt Tension

Adjust the tension of the alternator/fan belt so that finger pressure deflects the belt about 10–15 mm (0.4–0.6 in.). See Figure 2-3. Use the following procedure.



1. Adjusting screw
2. Battery-charging alternator pulley
3. Pivot screw
4. Alternator belt tension test location

Figure 2-3 Belt Tension

Belt Tension Adjustment Procedure:

1. Place the generator set start/stop switch in the STOP position.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the belt guard.
5. Loosen the pivot and adjusting screws.
6. Tighten the adjusting screw while pulling the battery-charging alternator outward to achieve the specified tension.
7. Tighten the pivot screw.
8. Recheck and adjust the tension as necessary.
9. Install the belt guard.
10. Check that the generator set start/stop switch is in the STOP position.
11. Reconnect the generator set engine starting battery, negative (-) lead last.
12. Reconnect the power to the battery charger, if equipped.

2.5 Battery

Use a 12-volt battery with a minimum 625 CCA rating. Do not perform maintenance on a maintenance-free battery. Battery connections are shown on the wiring diagrams. Verify that battery connections are correct and fully tightened. Follow the battery manufacturer's recommendations for cleaning the battery.

Note: Reversed battery connections prevent generator set starting.

⚠ WARNING

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

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

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 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.

2.6 Storage Procedure

Perform the following storage procedure before taking a generator set out of service for three months or longer. Follow the engine manufacturer's recommendations, if available, for fuel system and internal engine component storage.

x:sm:002:001

2.6.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

1. Run the generator set for a minimum of 30 minutes to bring it to normal operating temperature.
2. Stop the generator set.
3. With the engine still warm, drain the oil from the crankcase.
4. Remove and replace the oil filter.
5. Refill the crankcase with oil suited to the climate.
6. Run the generator set for two minutes to distribute the clean oil.
7. Stop the generator set.
8. Check the oil level and adjust, if needed.

x:sm:002:002

2.6.2 Cooling System

Prepare the cooling system for storage as follows:

1. Check the coolant freeze protection using a coolant tester.
2. Add or replace coolant as necessary to ensure adequate freezing protection. Use the guidelines included in the engine operation manual.
3. Run the generator set for 30 minutes to redistribute added coolant.

x:sm:002:003

2.6.3 Fuel System

Prepare the fuel system for storage as follows:

Diesel-Fueled Engines

1. Fill the fuel tank with #2 diesel fuel.
2. Condition the fuel system with compatible additives to control microbial growth.
3. Change the fuel filter/separator and bleed the fuel system. See Section 4.

2.6.4 Exterior

1. Clean the exterior surface of the generator set.
2. Seal all engine openings except for the air intake with nonabsorbent adhesive tape.
3. To prevent impurities from entering the air intake and to allow moisture to escape from the engine, secure a cloth over the air intake.
4. Spread a light film of oil over unpainted metallic surfaces to inhibit rust and corrosion.

x:sm:002:006

2.6.5 Battery

Perform battery storage after all other storage procedures.

1. Place the generator set start/stop switch in the STOP position.
2. Disconnect the battery(ies), negative (–) lead first.
3. Clean the battery. Refer to section 2.5, Battery for the battery cleaning procedure.
4. Place the battery in a cool, dry location.
5. Connect the battery to a float/equalize battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.
6. Maintain a full charge to extend battery life.

x:sm:002:007

3.1 Air Cleaner Service

Replace the air cleaner element at the intervals shown in the service schedule. Service the air cleaner more often if the generator set operates under dusty or dirty conditions. A dirty air cleaner element can cause engine damage and increased fuel consumption. When servicing, clean the air cleaner breather pipe and remove dust and foreign matter from the air cleaner housing. See Section 1 for the air cleaner location and the following procedure.

Air Cleaner Service Procedure:

1. Place the generator set start/stop switch in the STOP position.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the air cleaner cover by releasing the air cleaner clips.
5. Remove the air cleaner element.
6. Tap the edges of the dry element on a hard surface to remove loose debris. Replace the element if it is damaged or very dirty.

   Note: Do not clean a dry-type element in liquid or with compressed air.

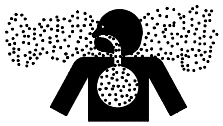
7. Wipe dirt or dust accumulation from the cover and the base. Check that the clamps are tight on the inlet/outlet connections.
8. Install the air cleaner element.
9. Position the cover over the base and tighten using the air cleaner clips.

   Note: 15 and 20 kW models require positioning the air cleaner cover with the arrow on the cover pointing up.

10. Check that the generator set start/stop switch is in the STOP position.
11. Reconnect the generator set engine starting battery, negative (-) lead last.
12. Reconnect the power to the battery charger, if equipped.

3.2 Exhaust System Inspection

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the vehicle's occupants, install a carbon monoxide detector. Consult the coach builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Exhaust System. Check for exhaust leaks and blockages. Check the muffler and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, exhaust line, exhaust clamps, and muffler) for cracks and corrosion.

- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace the exhaust clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Check the exhaust gas color. If the exhaust is blue or black, contact your local distributor/dealer.
- Visually inspect for exhaust leaks. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector is (1) in the vehicle, (2) functional, and (3) energized whenever the generator set operates.

x:op:001:002:a

Notes

4.1 Fuel Specifications

Use clean, good quality diesel fuel oil with a cetane number of 45 or greater. Clean fuel prevents diesel fuel injectors and pumps from clogging.

Fuel Recommendation	
United States	ISO 8217 DMA, BS 2869, Part 1 Class A1 or Part 2 Class A2
United Kingdom	BS 2869-1983, Part 2 Class A2
Germany	DIN 51 601-1978

Note: Avoid storing fuel for more than one month. Take special precautions to keep all dirt, water, and other contaminants out of the fuel to prevent the growth of microbes. Microbes form slime that clogs the fuel filter and lines.

Note: Do not run the generator set out of fuel because the fuel lines will draw in air and necessitate bleeding the fuel system before restarting the generator set.

4.2 Fuel Filter

The fuel filter removes impurities from the fuel. Fuel quality determines the element's useful life. Replace the fuel filter element according to the service schedule in the operation manual. Section 1 shows the location of the fuel filter. There are two types of fuel filtering systems—the spin-on fuel filter and the fuel filter element. Use the applicable procedure below to replace the fuel filter. See Figure 4-1 or Figure 4-2.

Fuel Filter Service Procedure:

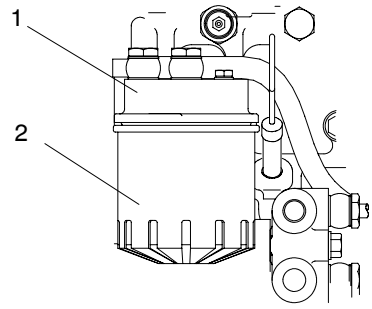
Note: The procedures to disable and enable the generator set apply to both spin-on filters and fuel filter elements.

Disable the Generator Set:

1. Place the generator set start/stop switch in the STOP position.
2. Disconnect the generator set engine starting battery, negative (-) lead first.
3. Close the fuel supply valve.

Spin-on Fuel Filter:

1. Loosen the fuel filter by turning it counterclockwise. Remove the fuel filter and use rags to clean up any spilled fuel oil. Dispose of the fuel filter in an approved manner.
2. Clean the contact surface of the fuel filter adapter.
3. Lightly lubricate the gasket surface of the new fuel filter with fresh fuel oil. Thread the filter onto the adapter until the gasket makes contact; hand-tighten the filter an additional one-half turn. Proceed to step 1, Enable the Generator Set.



1. Fuel filter adapter
2. Fuel filter

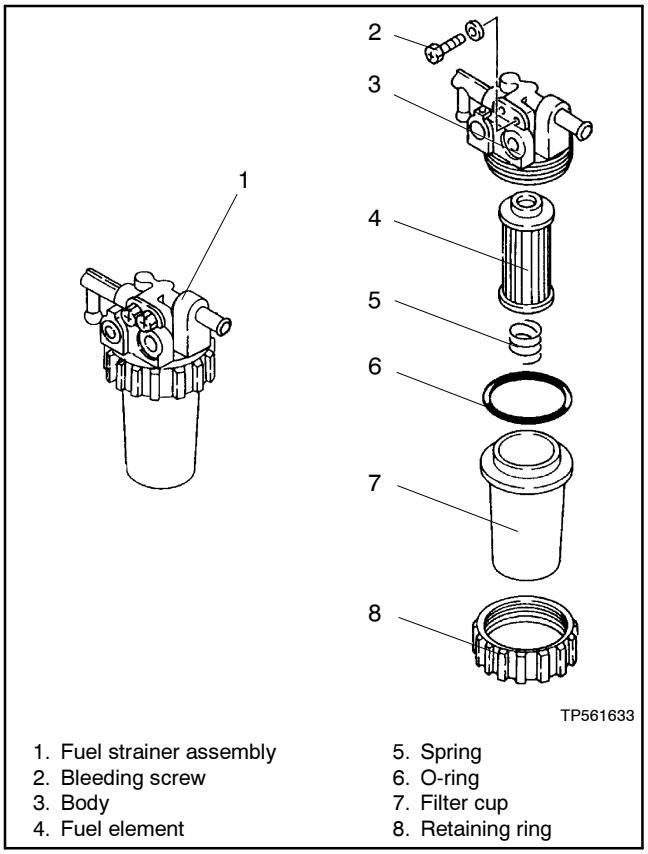
Figure 4-1 Spin-On Fuel Oil Filter

Fuel Filter Element:

1. Remove the retaining ring, filter cup, O-ring, spring, and fuel filter element. See Figure 4-2.
2. Replace the fuel filter element.
3. Reinstall the spring, O-ring, filter cup and retaining ring. Proceed to step 1, Enable the Generator Set.

Enable the Generator Set:

1. Open the fuel supply valve.
2. Reconnect the generator set engine starting battery, negative (-) lead last.
3. Bleed the fuel system. See Section 4.3.



1. Fuel strainer assembly
2. Bleeding screw
3. Body
4. Fuel element
5. Spring
6. O-ring
7. Filter cup
8. Retaining ring

Figure 4-2 Fuel Oil Filter Element

4.3 Fuel System Bleeding

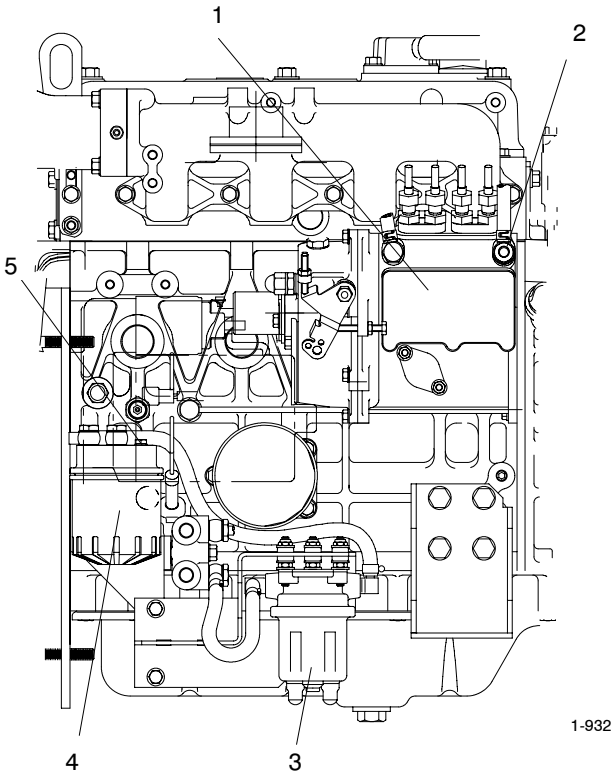
Bleed the air from the fuel system to prevent engine starting failures and/or erratic operation. One or more of the following causes air to collect in the fuel system:

- Operating the generator set until the fuel supply is emptied
- Air leaking from the suction side of the fuel system
- Replacing the fuel filter

Note: Connect the battery during the priming procedure to allow engine cranking. Do not allow the engine/generator to start. To prevent starting, *toggle* the start/stop switch by momentarily placing the start/stop switch in the START position for a few seconds and then placing the switch in the STOP position.

Procedure to Bleed the Fuel System:

1. Fill the fuel tank.
2. Loosen the fuel filter vent screw. See Figure 4-3.
3. Toggle the start/stop switch until fuel, free of air bubbles, flows from the vent screw. Tighten the screw.
4. Loosen the line connection (bleed point) at the fuel injection pump inlet.
5. Toggle the start/stop switch until fuel, free of air bubbles, flows from the vent screw at the line connection on the fuel injection pump inlet. Tighten the connection.



1. Fuel injection pump
2. Line connection at fuel injection pump inlet
3. Electric fuel pump
4. Fuel filter
5. Fuel filter vent screw

Figure 4-3 Bleeding the Fuel System, Typical

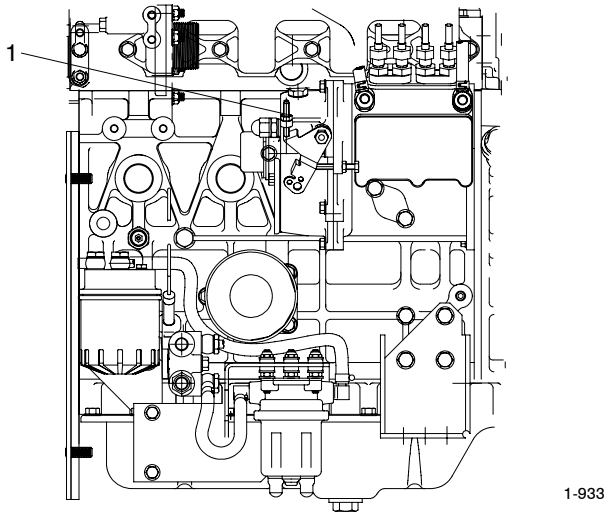
4.4 Governor

The centrifugal, mechanical-type governor maintains constant engine speed by automatically adjusting the fuel supply to the engine depending on load changes. The governor requires no regular service. The governor is factory-set during run-in and requires no further adjustment unless greatly varying load conditions are encountered or if poor governor control develops after extended usage.

60 Hz generator sets are designed to operate at 60–63 Hz, 1800 rpm under full load and 1890 rpm under no load.

50 Hz generator sets are designed to operate at 50–52.5 Hz, 1500 rpm under full load and 1575 rpm under no load.

To check speed, use a frequency meter. Loosen the locknut on the speed-adjusting screw. Turn the screw counterclockwise to increase speed (and frequency) or clockwise to decrease speed. Tighten the locknut to secure at a new setting. See Figure 4-4.



1. Locknut

Figure 4-4 Governor, Typical

Notes

5.1 General

The water-cooled engine uses a closed-loop cooling system that includes an engine water pump which circulates the cooling water and an engine thermostat that regulates cooling water flow to maintain a constant engine temperature.

The radiator cools hot water from the engine and returns it to the water pump for recirculation in the cooling passages of the engine. For a cooling system with a remote radiator, the belt guard replaces the radiator and its mounting provisions on the engine. Hoses then connect the water pump and thermostat port to the remote radiator.

5.2 Cooling System

The cooling system maintenance information applies to radiator-cooled models. Radiator-cooled models have a radiator with a pressure cap and coolant recovery tank.

⚠ 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.

Checking the coolant level. Hot coolant can cause severe injury or death. Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

Note: Engine damage. Bleed the air from the cooling system to prevent overheating and subsequent engine damage.

Note: Block heater damage. The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

x:sm:003:001

5.2.1 Coolant Level Check

Check the coolant level in the coolant recovery tank and maintain the coolant level between the high and low marks or approximately 1/4 full in tanks without marks.

Note: Periodically check the coolant level by removing the pressure cap. Do not rely solely on the level in the coolant recovery tank. Add fresh coolant until the level is just below the overflow tube opening of the filler neck.

x:sm:003:002

5.2.2 Cooling System Component Inspection

To prevent generator shutdown or damage caused by overheating:

- Keep the cooling air inlets clean and unobstructed.
- Inspect the radiator's exterior for obstructions. Remove dirt and foreign material using a soft brush or cloth to avoid damaging the radiator fins.
- Check the hoses and connections for leaks. Replace any cracked, frayed, or spongy hoses.
- Check the condition and tension of the radiator fan and water pump belt(s). Follow the belt tension procedure in this manual and/or the engine operation manual.
- Check the pressure cap seal and replace a cracked or deteriorated cap. Remove dirt and other debris from the pressure cap and filler neck. The pressure cap raises the boiling point of the coolant, enabling higher operating temperatures. Replace a leaking pressure cap with one rated for the same pressure. The pressure cap rating usually appears on the pressure cap.

x:sm:003:003

5.2.3 Procedure to Drain the Cooling System

For optimum protection, drain, flush, and refill the cooling system at the intervals listed in the service schedule.

Note: Dispose of all waste materials (oil, fuel, coolant, filters, and gaskets) in an environmentally safe manner.

1. Deenergize the block heater, if equipped.
2. Remove the pressure cap to allow the entire system to drain and prevent air pockets from restricting coolant flow through the engine block.
3. Open the radiator and/or engine block coolant drain valve(s) and allow the system to drain.
4. If the inside of the radiator has mineral deposits or the used coolant contains dirt or grease, refer to Section 5.2.4, Procedure to Flush and Clean the Cooling System. If the cooling system does not have mineral deposits, go to Section 5.2.5, Procedure to Refill the Cooling System.

x:sm:003:004

5.2.4 Procedure to Flush and Clean the Cooling System

Use the instructions in the engine operation manual when available to flush and clean the cooling system. Otherwise, use the following procedure and the cooling system cleaner manufacturer's instructions.

1. Flush the cooling system with clean water.
2. If the inside of the radiator still has mineral deposits, use a radiator cleaner to remove the remaining deposits following the manufacturer's instructions.
3. Drain, clean, and flush the coolant recovery tank.

x:sm:003:005

5.2.5 Procedure to Refill the Cooling System

See the generator set spec sheet for coolant capacity.

Note: Do not add coolant to a hot engine. Adding coolant to a hot engine can cause the cylinder block or cylinder head to crack. Wait until the engine has cooled.

1. Remove the pressure cap.
2. Close the radiator and/or engine block coolant drain valve(s) and tighten the cooling system hose clamps.
3. Open the air-bleed petcocks, if equipped. Close the air-bleed petcocks when coolant begins to flow from them.
4. Add coolant additives or water pump lubricants according to the engine manufacturer's recommendations in the engine operation manual.
5. Fill the cooling system with the recommended coolant/antifreeze mixture of 50% ethylene glycol and 50% clean, softened water to inhibit rust/corrosion and prevent freezing.

   Note: A coolant solution of 50% ethylene glycol provides freezing protection to –37°C (–34°F) and overheating protection to 129°C (265°F). A coolant solution containing less than 50% ethylene glycol may not provide adequate freezing and overheating protection. A coolant solution containing more than 50% ethylene glycol can cause engine or component damage. Do not use alcohol or methanol antifreeze or mix them with the specified coolant. Refer to the engine operation manual for recommendations regarding the coolant mixture to use in extreme temperatures.
6. Replace the pressure cap.
7. Fill the coolant recovery tank to the low mark or approximately 1/4 full for tanks without marks.
8. Operate the generator set until the thermostat opens when the upper cooling system hose warms.
9. Stop the engine and allow it to cool.
10. Remove the pressure cap.
11. Add coolant to bring the coolant level to just below the overflow tube opening of the filler neck.
12. Replace the pressure cap.
13. Maintain the coolant level in the coolant recovery tank between the high and low marks or approximately 1/4 full for tanks without marks.

    Note: Air pockets often form in the engine water jacket when the coolant system is refilled. Check the coolant level in the coolant recovery tank after each generator set operation and add coolant as necessary until the coolant level stabilizes. Then check the coolant at the interval specified in the service schedule.
14. Reenergize the block heater, if equipped.

x:sm:003:006

Notes

6.1 Controller Sequence of Operation

This section describes controller operation during generator set starting, running, and stopping. Use these data as starting points for identifying controller faults.

6.1.1 Start

Preheating. An intake-manifold-mounted heater preheats intake air during cold-weather starting. Energize the air heater (AH) relay by rocking the start/stop switch on the control panel to the STOP/PREHEAT position. The energized AH relay closes the normally open AH contacts, energizing the air heater.

After 15–20 seconds, release the start/stop switch to open the ground path to the AH relay, deenergizing the AH relay and the air heater. Do not energize the preheat feature for more than 30 seconds or damage to the preheat feature may occur.

Engine Startup. Rock the start/stop switch on the control panel to the START position to start the engine. If the engine doesn't start, check the 10-amp fuse. A blown fuse prevents the following starting sequence.

Setting the start/stop switch to the START position energizes the K2 relay (LED2 lights), closing the normally open contacts of K2. The closed K2 relay contacts energize the K3 relay, the K25 relay, and the fuel pump motor (FP).

Energizing the K3 relay (LED3 lights) closes a set of normally open K3 contacts, energizing the K20 relay. A set of normally open K20 contacts close to energize the starter relay (SR), causing the normally open SR contacts to close. The closed SR contacts energize the starter motor (SM). The starter motor gear engages the ring gear on the engine flywheel to begin cranking the engine. At the same time, the power supplied to the starter motor energizes the pull-in coil of the fuel supply solenoid (FS).

Energizing the K25 relay closes a set of normally open K25 contacts, energizing the hold coil of the fuel solenoid to complete the conditions necessary for engine startup.

Releasing the start/stop switch allows the switch to return to its neutral position. If the start/stop switch is released before the engine starts, the K1 relay does not energize, which stops the engine startup sequence.

6.1.2 Run

During engine startup, a set of normally open contacts of the K2 relay (which are closed during startup), two diodes, and two normally closed K1 contacts provide flashing current to the generator field. The combination of the flashing current and the rotation of the generator rotor induces an electrical current in the generator stator windings. The resulting generator output from the B1/B2 stator winding, rectified and regulated to 12 VDC, energizes the K1 relay (LED1 lights). After a 5- to 10-second delay, the same signal energizes the K5 relay (LED5 lights). Both relays remain energized during normal running.

The energized K1 relay performs the following functions using four different sets of K1 contacts (consult Section 10, Wiring Diagrams):

- It opens the two normally closed K1 contacts that supply flashing current to the generator exciter field. The voltage regulator, operating from an input supplied by generator stator winding 55, supplies field current for continued operation.
- It closes the normally open K1 contacts at the same time that the K1 contacts open between the start/stop switch and the K2 relay in the engine startup circuit. This keeps the K2 relay energized, maintaining the controller's operating power for the other relays and hourmeter.
- It opens the normally closed K1 contacts, deenergizing the K3 relay. As a result, K20 and the starter relays deenergize, disengaging and disrupting power to the starter motor. The K25 relay, the fuel pump, and the fuel solenoid energize during engine starting and remain energized to keep the engine running and to supply excitation to the battery-charging alternator (BCA).
- It closes the normally open K1 contacts, activating the hourmeter, oil pressure gauge, water temperature gauge, and battery voltage gauge on an optional remote panel.

6.1.3 Stop

Rock the start/stop switch on the controller front panel to the STOP position and release the switch to stop the generator set. Release the switch to prevent energizing the AH relay and unnecessarily heating the intake manifold. In the STOP position, the start/stop switch provides a ground through two blocking diodes energizing the K4 relay (LED4 lights). The normally open K4 contacts close, latching the energized K4 relay.

At the same time, normally closed K4 contacts open, deenergizing FP and the K25 relay. The normally open K25 contacts open, deenergizing the FS and disrupting fuel flow. Turning off the fuel supply and the fuel pump shuts off the engine.

When the engine shuts off, generator output decays and deenergizes relays K1 and K5 (LED1 and LED5 go out). The normally open K1 contacts open, deenergizing the K2 relay (LED2 goes out). When the K2 relay deenergizes, the normally open K2 contacts open, interrupting the power to the remaining controller relay circuits, including the K4 relay. Relay K4 unlatches, returning the controller circuits to a normal prestart condition.

6.1.4 Automatic Safety Shutdowns

The engine has two switches that monitor critical operating conditions:

- The High Engine Temperature (HET) switch closes when engine coolant temperature approaches an unsafe level.
- The Low Oil Pressure (LOP) switch closes when oil pressure is insufficient, indicating inadequate engine lubrication.

During normal running, closing either switch shuts down the engine. During startup, normally open contacts of the K5 relay disable this shutdown for 5–10 seconds after the engine starts to allow monitored conditions to stabilize.

Closing the normally open K5 contacts enables the engine safety switches. If either switch closes, the K4 relay energizes (LED4 lights). Energizing relay K4 causes the normally open K4 contacts to close, latching the energized K4 relay.

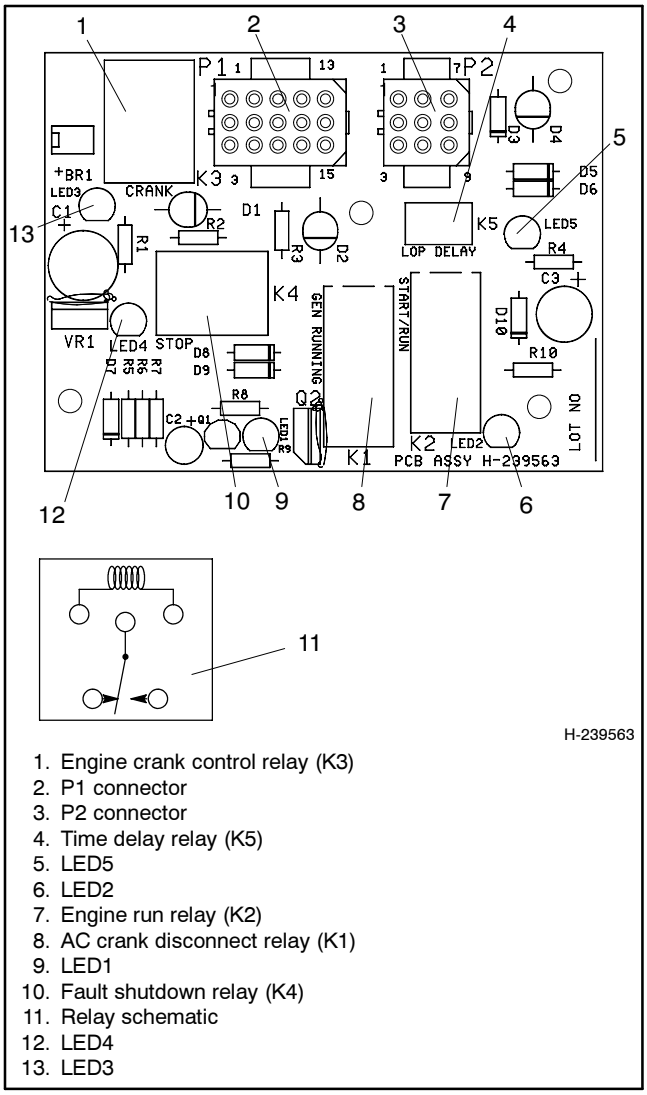
At the same time the K4 contacts close, the normally closed K4 contacts open, deenergizing FP and the K25 relay. The normally open K25 contacts open, deenergizing FS and disrupting fuel flow. Turning off the fuel supply and the fuel pump shuts off the engine.

When the engine shuts off, generator output decays and deenergizes relays K1 and K5 (LED1 and LED5 go out). The normally open K1 contacts open, deenergizing the K2 relay (LED2 goes out) and opening the normally open K2 contacts, interrupting power to the remaining controller relay circuits, including relay K4. Relay K4 unlatches, returning the controller circuits to a normal prestart condition.

6.2 Controller Circuit Board

It is possible to check some controller circuit board components (relays) without removing them from the board. Check these relays before installing a new board and attempting startup. Use a high quality multimeter and follow the manufacturer's instructions. To obtain accurate readings when testing, remove all the circuit board connectors and conformal coating (transparent insulation) from the component terminals. Use the chart in Figure 6-2

The controller circuit board has LEDs to indicate the presence of relay coil power and aid in circuit board and generator fault detection. See Figure 6-1. When the K1-K5 relays energize, the corresponding LEDs light. The LEDs do not indicate whether the relay coil is functional or not. This conclusion can only be reached through analyzing the fault.



1. Engine crank control relay (K3)
2. P1 connector
3. P2 connector
4. Time delay relay (K5)
5. LED5
6. LED2
7. Engine run relay (K2)
8. AC crank disconnect relay (K1)
9. LED1
10. Fault shutdown relay (K4)
11. Relay schematic
12. LED4
13. LED3

Figure 6-1 Controller Circuit Board H-239563

Component	Ohmmeter Connections	Procedure	Results
K1 Relay Coil	K1 coil terminals (see relay schematic)	Ohmmeter on R x 10 scale	If functional, approximately 270 ohms. Low resistance (continuity), shorted coil. High resistance, open coil.
K2 Relay Coil	K2 coil terminals (see relay schematic)	Ohmmeter on R x 10 scale	If functional, approximately 270 ohms. Low resistance (continuity), shorted coil. High resistance, open coil.
K3 Relay Coil	K3 coil terminals (see relay schematic)	Ohmmeter on R x 10 scale	If functional, approximately 400 ohms. Low resistance (continuity), shorted coil. High resistance, open coil.
K4 Relay Coil	K4 coil terminals (see relay schematic)	Ohmmeter on R x 10 scale	If functional, approximately 125 ohms. Low resistance (continuity), shorted coil. High resistance, open coil.
K5 Relay Coil	K5 coil terminals (see relay schematic)	Ohmmeter on R x 10 scale	If functional, approximately 510 ohms. Low resistance (continuity), shorted coil. High resistance, open coil.

Figure 6-2 Relay Testing

6.3 Troubleshooting Flowchart

Use the flow chart (Figure 6-3) to aid in troubleshooting the generator set. If the prescribed remedy does not correct the problem, replace the circuit board.

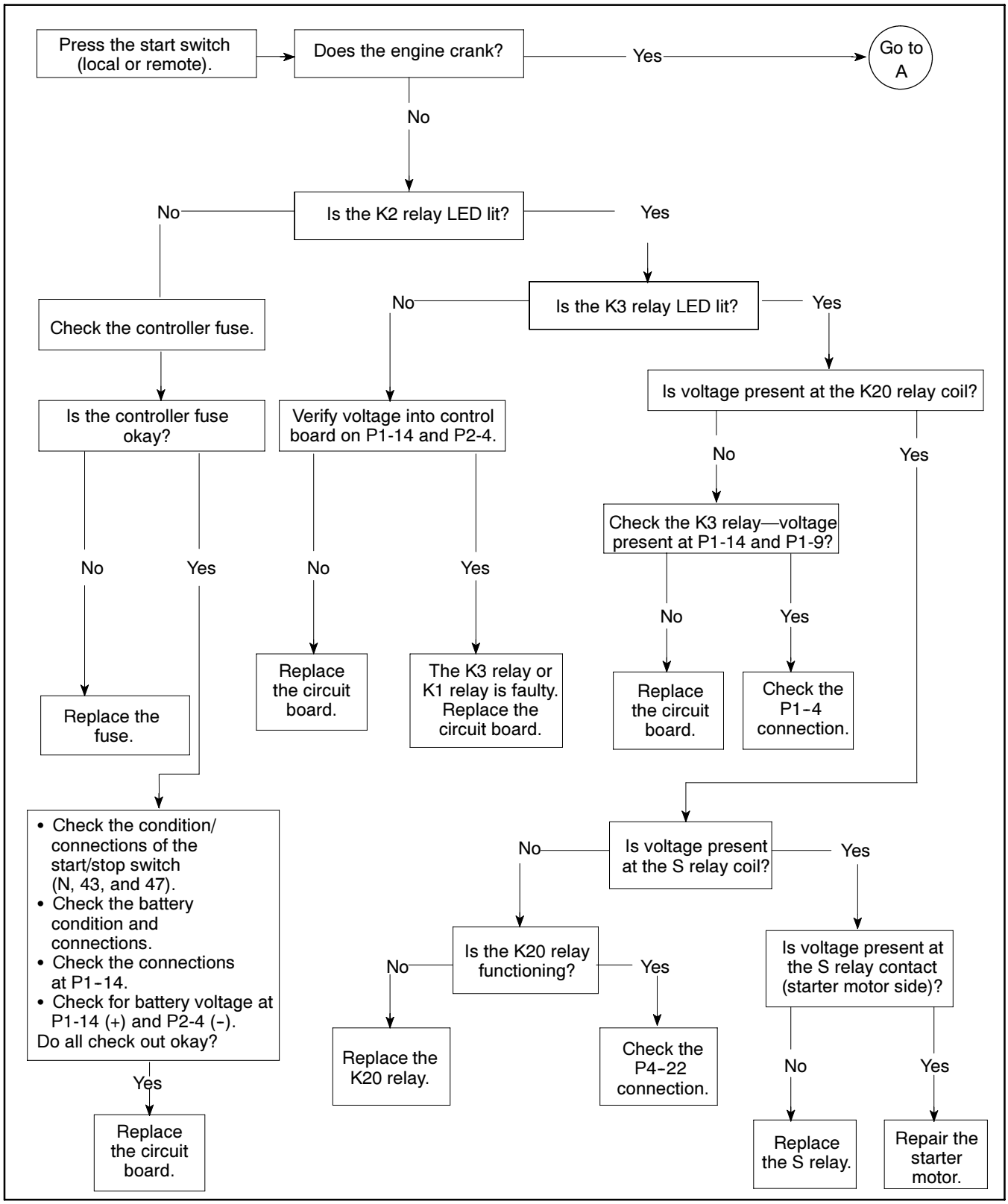


Figure 6-3 Troubleshooting the Relay Controller Circuit Board (1 of 4)

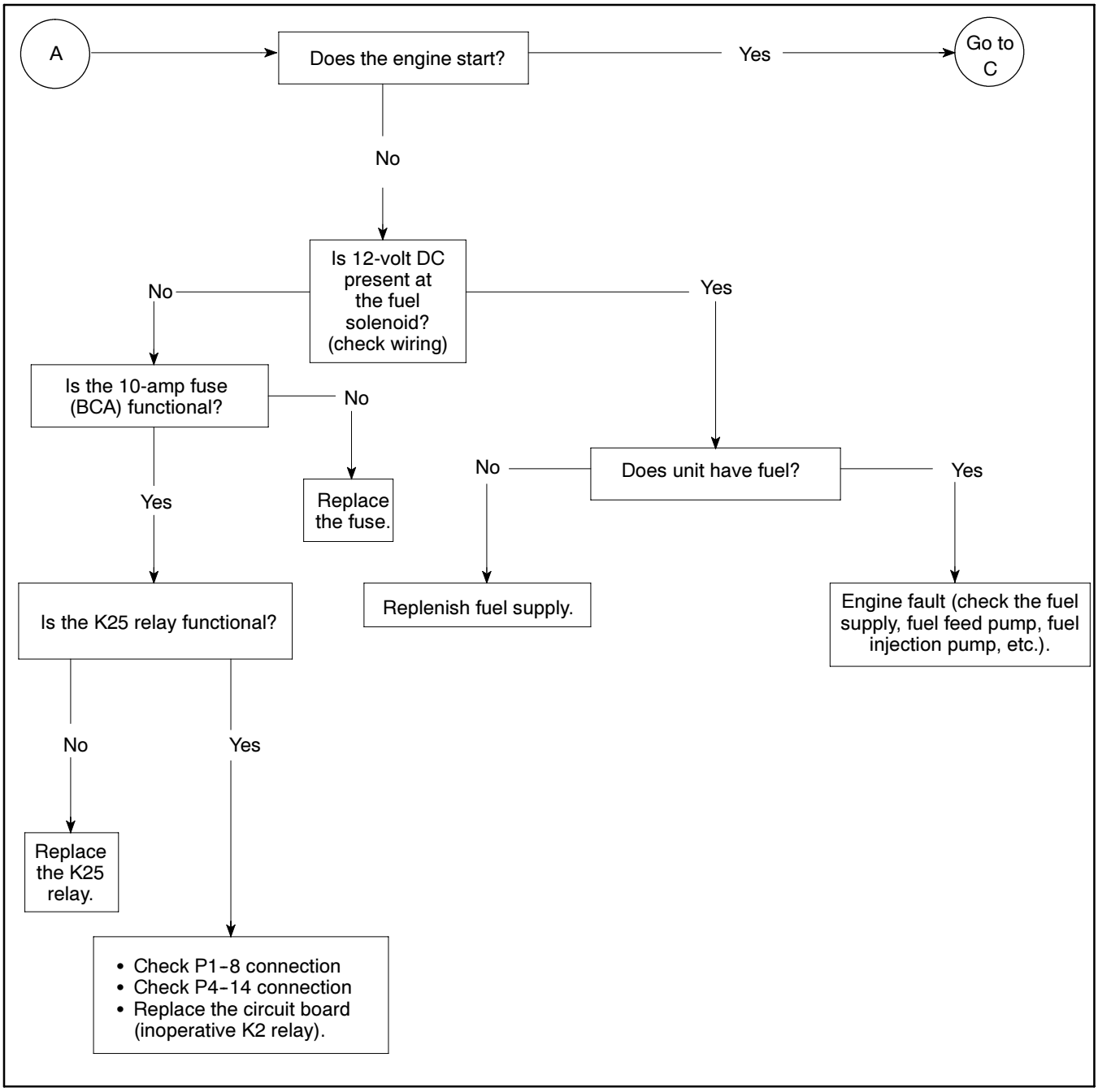


Figure 6-4 Troubleshooting the Relay Controller Circuit Board (2 of 4)

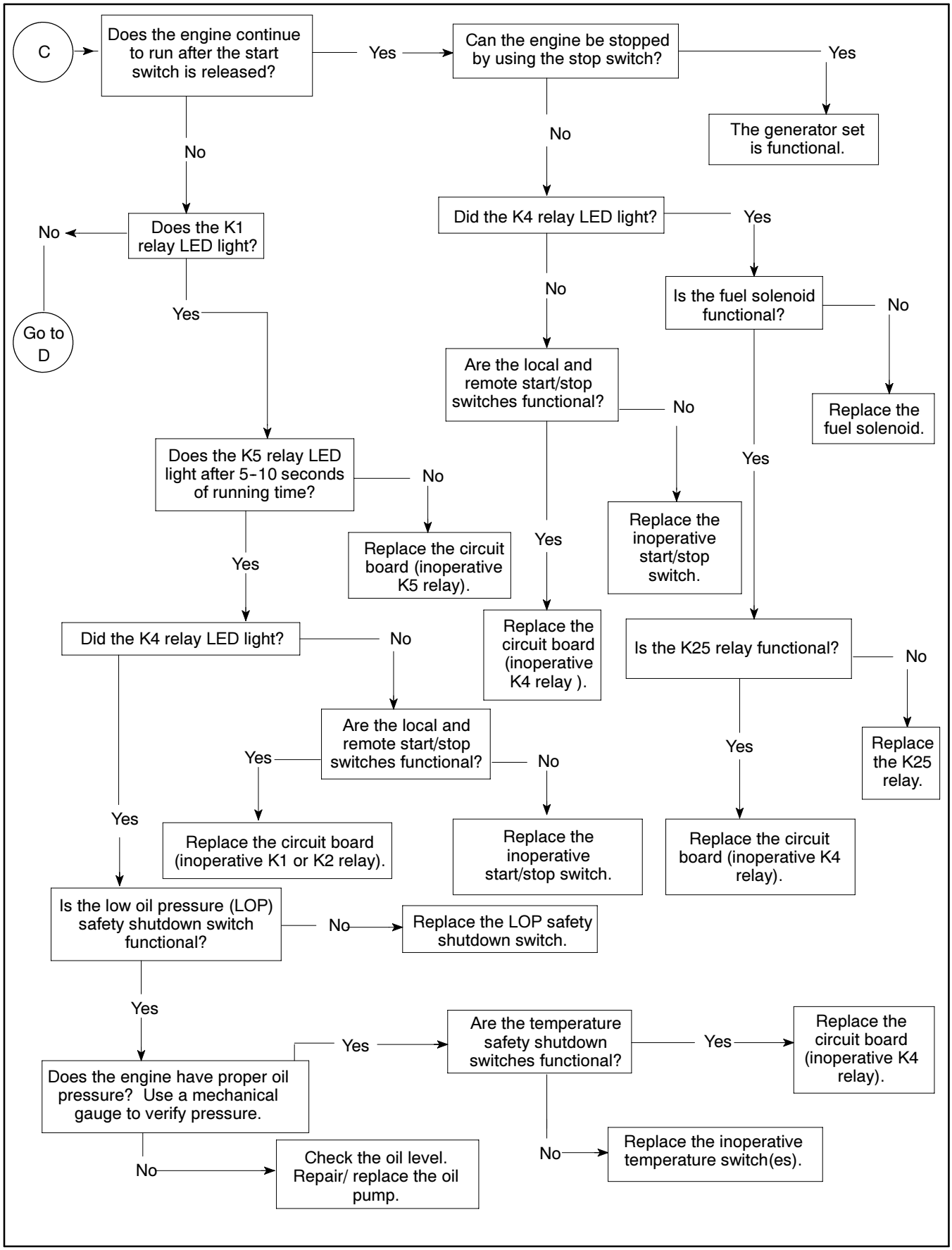


Figure 6-5 Troubleshooting the Relay Controller Circuit Board (3 of 4)

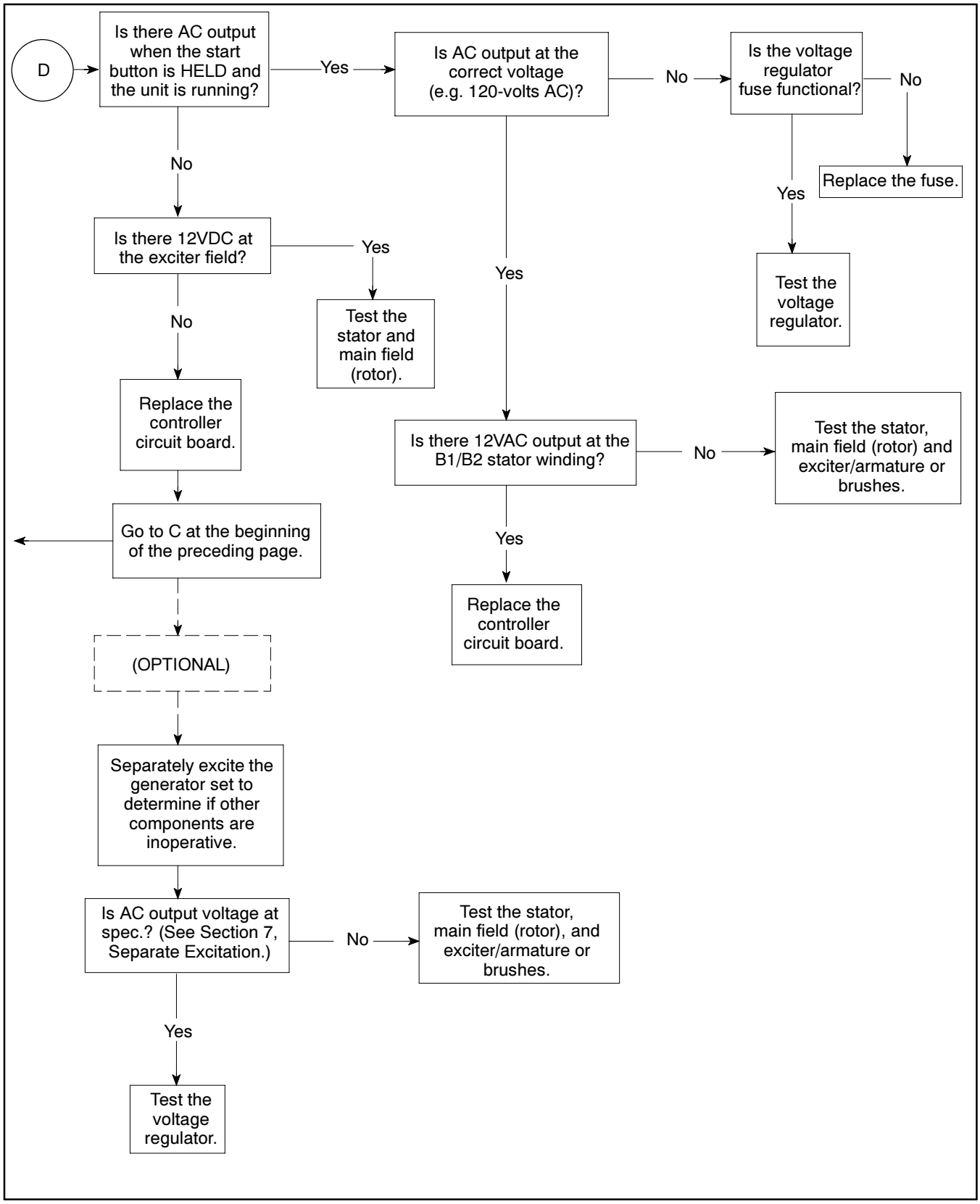
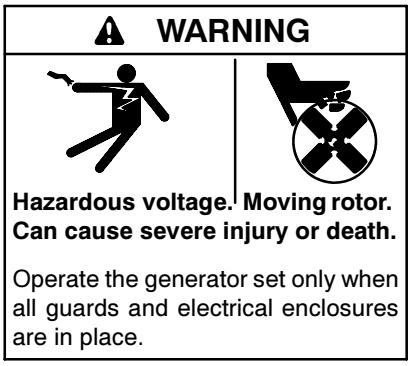


Figure 6-6 Troubleshooting the Relay Controller Circuit Board (4 of 4)

Notes

7.1 General

Before beginning the troubleshooting procedures, read all the safety precautions at the beginning of this manual. The following tests include additional safety precautions; OBSERVE THESE PRECAUTIONS!



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

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.

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.

7.2 General Troubleshooting

To determine the cause of no- or low-AC output , refer to the following steps and the troubleshooting flow chart (Figure 7-1).

1. Check the condition of the voltage regulator 8-amp fuse.
2. If the fuse is functional, separately excite the generator (see Section 7.3) The separate excitation test duplicates the role of the voltage regulator in providing the excitation current to the rotor.

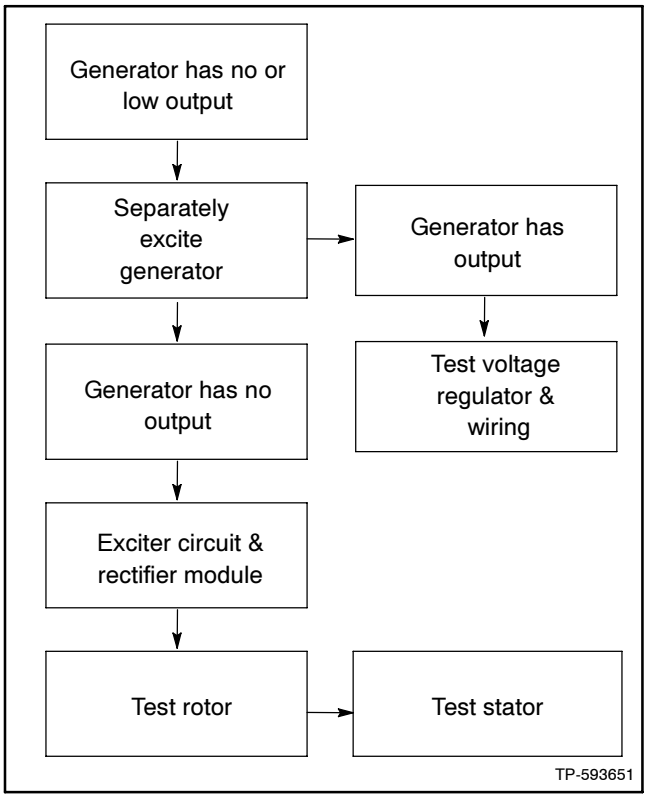


Figure 7-1 General Troubleshooting

7.3 Separate Excitation

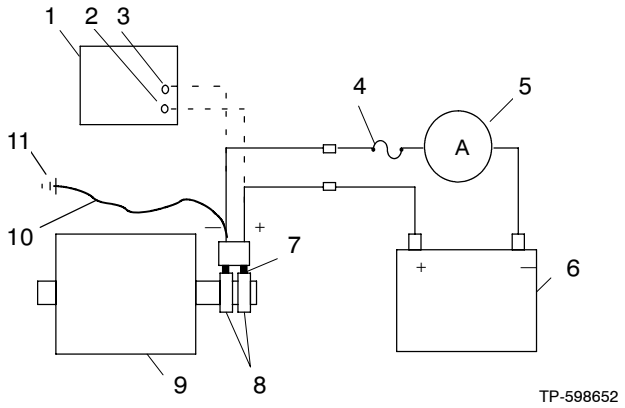
Separately exciting the generator can determine the presence of an inoperative voltage regulator or whether a running fault exists in the rotor and/or stator. A generator component that appears functional while static (stationary) may exhibit a running open or short circuit while dynamic (moving). Centrifugal forces acting on the windings during rotation or insulation breakdown as temperatures increase can cause short circuits.

Excitation Procedure:

1. Disconnect all of the leads from the voltage regulator.
2. Disconnect the P6 (F1, F2) connector.
3. Connect a separate excitation circuit as shown in Figure 7-2 or Figure 7-3. Connect an ammeter and a 10-amp fuse in series with F1. Note and record the ammeter reading.
4. Divide the battery voltage by the specified rotor (brushed units) or exciter field resistance (cold) to determine the exciter current. Disconnect the resistor leads and determine the exciter current value using an ohmmeter. See Section 1.3, Specifications, for the normal values.

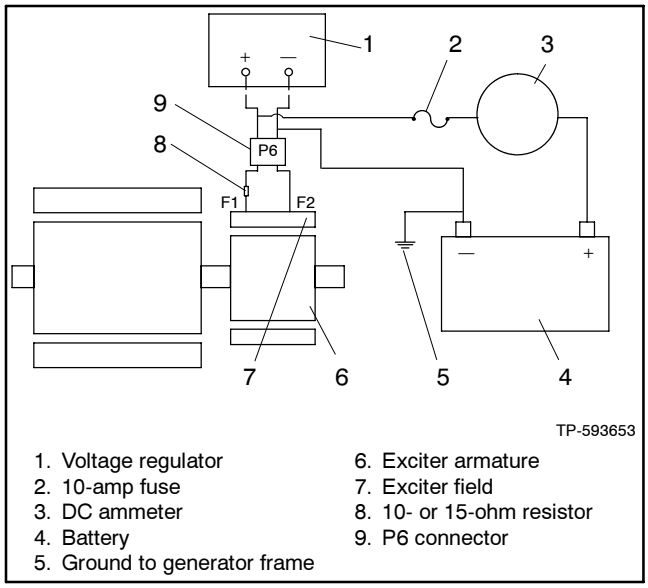
$$\text{Rotor or Exciter Current} = \frac{\text{Battery Voltage}}{\text{Rotor or Exciter Field Resistance}}$$

$$\text{Example}: \frac{12\ \text{VDC}}{3.5\ \text{ohms}} = 3.4\ \text{amps}$$



1. Voltage regulator
2. (+) Terminal—(P10-1)
3. (-) Terminal—(P10-2)
4. 10-amp fuse
5. DC ammeter
6. 12-volt battery (DC)
7. Brushes
8. Collector rings
9. Main field (rotor)
10. Jumper lead
11. Engine ground

Figure 7-2 Separate Excitation Connections, Brushed Units



1. Voltage regulator
2. 10-amp fuse
3. DC ammeter
4. Battery
5. Ground to generator frame
6. Exciter armature
7. Exciter field
8. 10- or 15-ohm resistor
9. P6 connector

Figure 7-3 Separate Excitation Connections Exciter Units

5. Start the engine and check that the ammeter remains stable. An increasing meter reading indicates a shorted rotor or exciter field or inoperative F1 resistor. A decreasing meter reading to zero or unstable reading suggests a running open in the rotor or exciter or F1 resistor. If the ammeter is stable, continue with step 6.
6. Check for AC output across the stator leads and compare the output to the values in Section 1.3, Specifications. If the output varies considerably from those listed, a faulty stator, rotor, rectifier module, or armature is the likely cause.

If there is no generator output during normal operation, but output is available when the generator set is separately excited, the voltage regulator is probably inoperative.

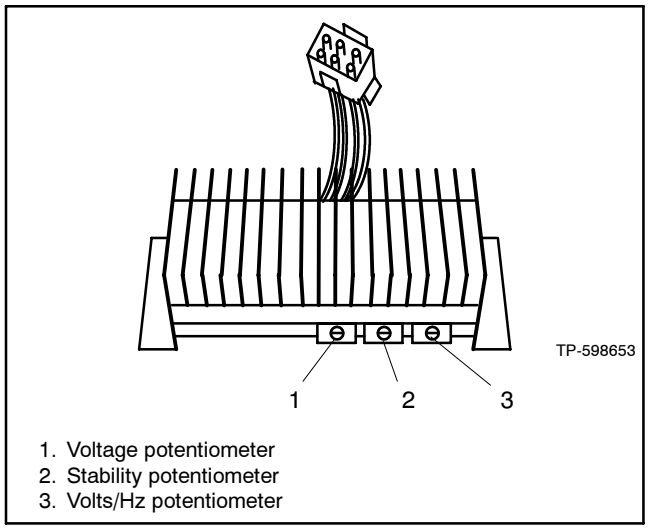
Note: See Section 1, Specifications, for the stator output voltages (with separately excited generator). These specifications are based on a battery voltage of 12. Should the battery voltage vary (11–14 volts), the resulting stator output values will also vary.

7.4 PowerBoost™ IIIE Voltage Regulators (7.5 and 10 kW Models)

The generator set is equipped with a PowerBoost™ IIIE voltage regulator. See Figure 7-4.

The voltage regulator monitors the output voltage to the generator exciter field.

If the regulator's 8-amp fuse blows, the generator set will shut down. Verify that the regulator fuse is functional before proceeding with the test.



1. Voltage potentiometer
2. Stability potentiometer
3. Volts/Hz potentiometer

Figure 7-4 PowerBoost™ IIIE Voltage Regulator

7.4.1 PowerBoost™ IIIE Voltage Regulator Test

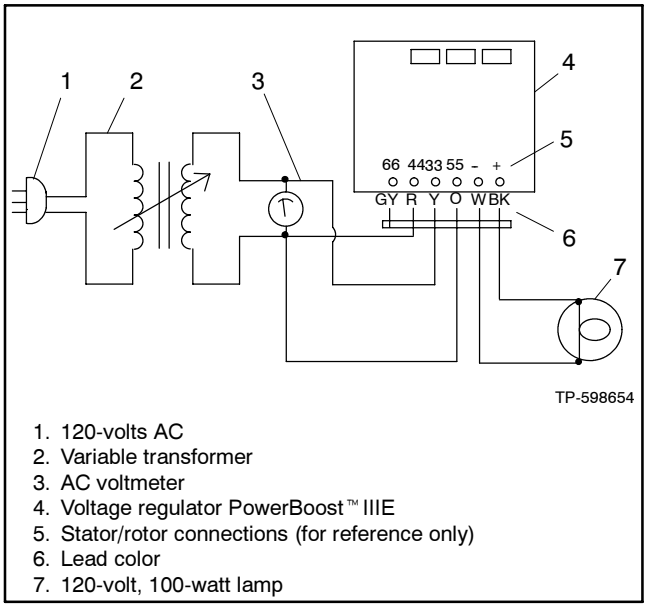
When the frequency drops below 57.5/47.5 Hz, the AC voltage should decline. Perform the following test to check the regulator output.

Use the following components to test the voltage regulator:

- Variable transformer, 0–140 volts (0.5-amp minimum)
- Plug, 120-volts AC
- Lamp, 120-volt, 100-watt
- AC voltmeter
- Insulated copper wire, #14 AWG (minimum)

PowerBoost™ IIIE Voltage Regulator Test Procedure:

1. Connect the components as shown in Figure 7-5.
2. Turn the variable transformer setting to zero. Plug in the variable transformer.
3. Turn the variable transformer on. Slowly increase the variable transformer voltage to 100 volts. The test lamp should light. If the lamp does not light, turn the voltage adjustment potentiometer (pot) clockwise. If the lamp still does not light, the voltage regulator is inoperative. Replace the voltage regulator. An inoperative voltage regulator causes a generator no/low-output condition.
4. Slowly increase the voltage to 120 volts. The lamp should go out and stay out as the voltage increases. If the lamp remains lit, turn the voltage adjustment pot counterclockwise. If the lamp still remains lit, replace the voltage regulator. An inoperative voltage regulator causes a generator high voltage output condition.
5. Turn the variable transformer to zero and unplug the AC cord.



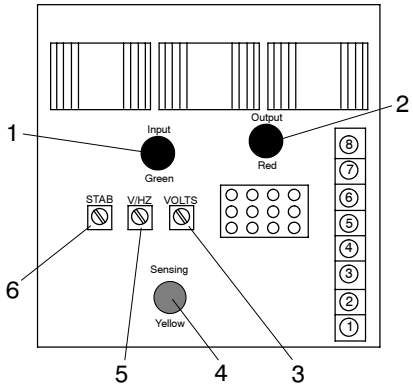
1. 120-volts AC
2. Variable transformer
3. AC voltmeter
4. Voltage regulator PowerBoost™ IIIE
5. Stator/rotor connections (for reference only)
6. Lead color
7. 120-volt, 100-watt lamp

Figure 7-5 PowerBoost™ IIIE Voltage Regulator Test

7.5 PowerBoost™ V Voltage Regulators (15 and 20 kW Models)

The generator set is equipped with a PowerBoost™ V voltage regulator. See Figure 7-6. The PowerBoost™ V voltage regulator monitors output voltage magnitude to control the current to the generator exciter field. The voltage regulator has an underfrequency unloading feature that is referred to as volts-per-Hz (V/Hz). To determine if the voltage regulator is functioning, reduce the engine speed (Hz) and watch for a corresponding drop in the AC voltage. The AC voltage should remain constant until the engine speed drops below 57.5 Hz on 60 Hz models or 47.5 Hz on 50 Hz models.

When the frequency drops below either 57.5 or 47.5 Hz, the AC voltage should decline. Perform the following test to check the regulator output.



1. LED1 (green input)
2. LED2 (red output)
3. Voltage potentiometer
4. LED3 (yellow sensing)
5. Volts/Hz potentiometer
6. Stability potentiometer

Figure 7-6 PowerBoost™ V Voltage Regulator

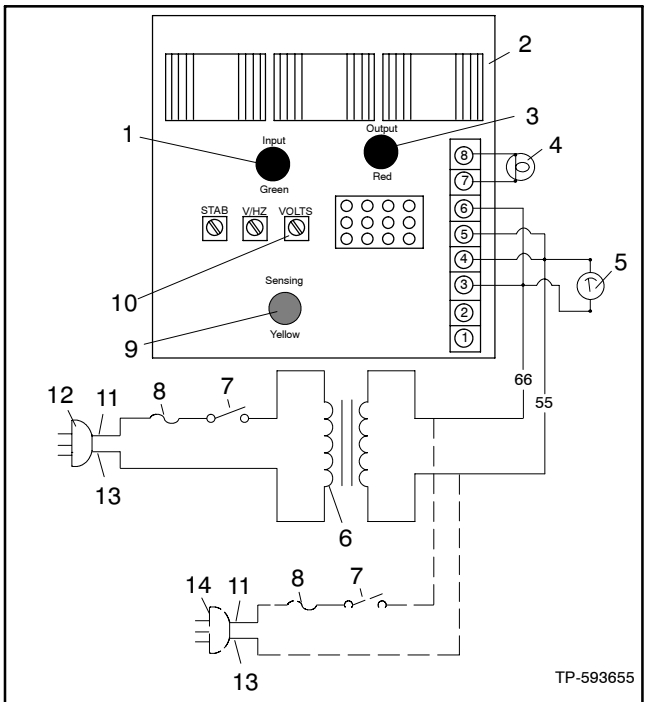
7.5.1 PowerBoost™ V Voltage Regulator Test

Use the following components to test the voltage regulator:

- Step-up transformer, 1:2, 120 volts to 240 volts (1.0-amp minimum)
- Lamp, 250-volt, 100-watt
- AC voltmeter (250-volt minimum)
- Fuse,1-amp
- Switch,1 single-pole single-throw (SPST) (1-amp minimum)
- Plug, 120-volt AC (200–240 volt AC plug optional)
- Insulated copper wire, #14 AWG (minimum)

PowerBoost™ V Voltage Regulator Test Procedure:

1. Connect the components as shown in Figure 7-7. If a 200–240 volt power source is available, the step-up transformer is not required.
2. Turn the volts potentiometer fully counterclockwise.
3. Plug the power cord into the outlet.
4. Turn the power supply on. The AC voltmeter should indicate a power supply voltage of 200–240 volts. The lamp should be off. If the lamp is lit, replace the voltage regulator.
5. Slowly turn the volts adjustment potentiometer clockwise. The lamp should light. Replace the voltage regulator if the lamp does not light.



1. LED1 (input)
2. PowerBoost™ V voltage regulator
3. LED2 (output)
4. 250-volt, 100-watt lamp
5. AC voltmeter 250 volt (minimum)
6. 1:2 step-up transformer
7. Single-pole single-throw switch
8. 1-amp fuse
9. LED3 (sensing)
10. Volts potentiometer
11. Black wire
12. 100–120 VAC
13. White wire
14. 200–240 VAC (optional)

Figure 7-7 PowerBoost™ V Voltage Regulator Test

7.6 Voltage Regulator Adjustment

The factory sets the voltage regulator and, under normal circumstances, the regulator requires no further adjustment. However, if the voltage regulator has been replaced or tampered with, or if voltage/frequency reconnection has been done, readjust the voltage regulator according to the following procedure. The following paragraphs and Figure 7-8 and Figure 7-9 identify and describe the voltage regulator.

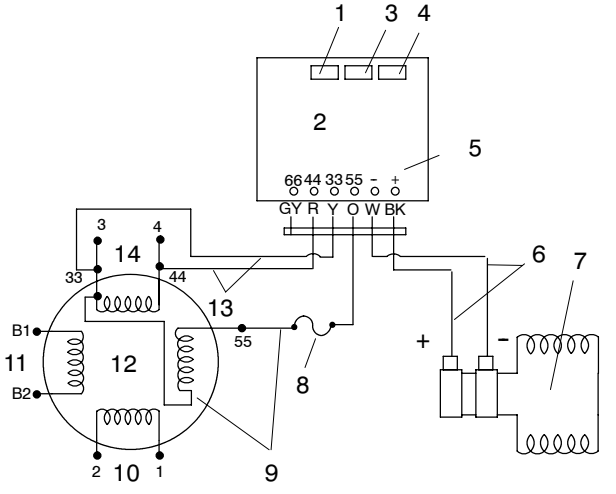
Note: The voltage regulator is located inside the generator set controller.

Note: The 7.5 and 10 kW models have the volts/Hz feature disabled by turning the volts/Hz pot out (fully counterclockwise).

Voltage Adjustment Potentiometer adjusts the generator output.

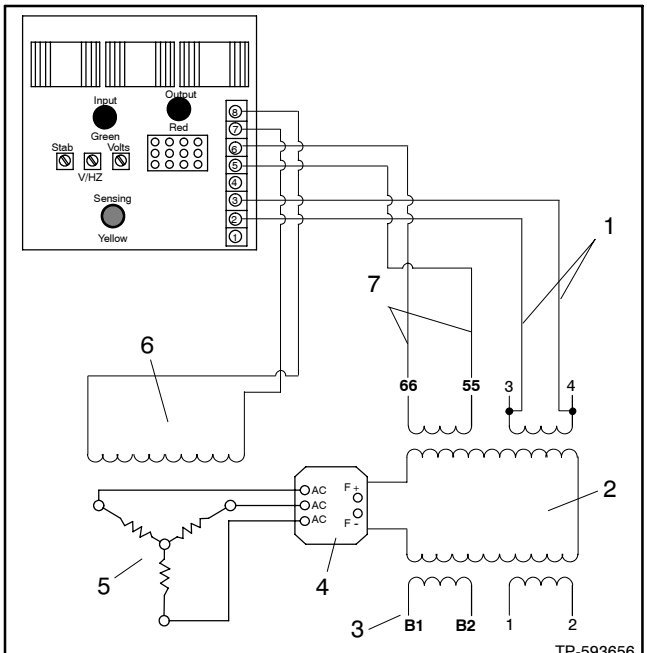
Stability Potentiometer fine tunes the regulator circuitry to reduce light flicker.

Volts/Hz Potentiometer determines the engine speed (Hz) at which the generator output begins to drop.



1. Voltage adjustment pot
2. PowerBoost™ IIIE voltage regulator
3. Stabilizer pot
4. Volts/Hz pot
5. Stator/rotor connections (for reference only)
6. DC output
7. Rotor
8. 10-amp fuse
9. AC power input (aux.)
10. Main (2 and 1)
11. Control
12. Stator
13. Sensing
14. Main (3 and 4)

Figure 7-8 PowerBoost™ IIIE Voltage Regulator Connection



1. Sensing leads
2. Main field (rotor)
3. Stator windings
4. Rectifier
5. Armature
6. Exciter field
7. Voltage regulator power supply leads

Figure 7-9 PowerBoost™ V Voltage Regulator Connection

Voltage Regulator Adjustment Procedure:

1. Place the generator set controller start/stop switch in the STOP position.

2. Turn the volts/Hz and the stability potentiometers fully counterclockwise. Connect the voltmeter to the AC circuit or an electrical outlet.

3. Start the generator set and rotate the voltage adjustment potentiometer clockwise (increase voltage) or counterclockwise (decrease voltage) until the desired output voltage is achieved.

4. Rotate the stability potentiometer clockwise until the test lamp flickers minimally.

5. Readjust the voltage adjustment potentiometer until the desired output voltage is achieved.

6. Adjust the engine speed to the specified cut-in frequency as measured on the frequency meter. The factory setting is 57.5–58 Hz for 60 Hz models and 47.5–48 Hz for 50 Hz models.

7. Rotate the volts/Hz potentiometer clockwise until the voltage level as measured on the voltmeter begins to drop. When the regulator is set to these specifications, the generator set will attempt to maintain normal output until the engine speed drops below the frequency set in step 6 as load is applied. See Figure 7-10.

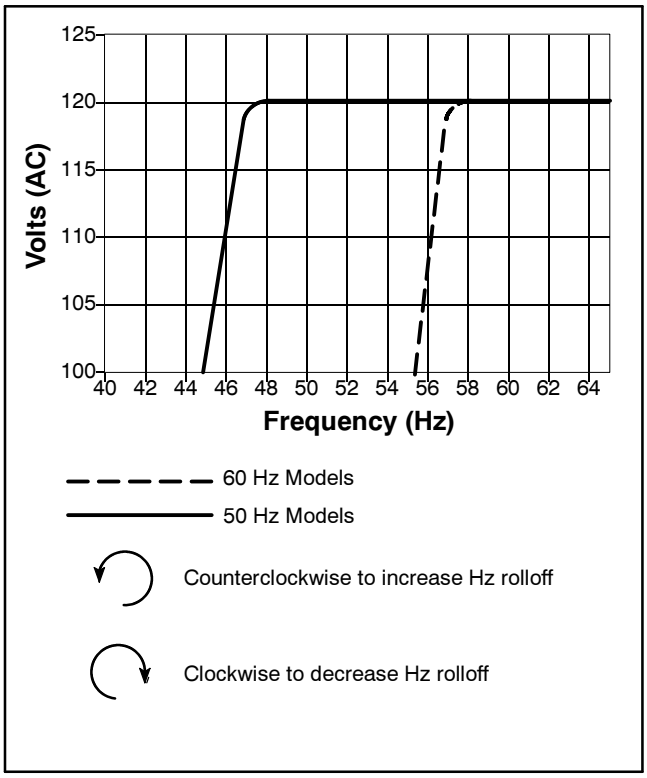


Figure 7-10 Volts/Hz Rolloff Chart

8. Readjust the engine speed to 1800 rpm for 60 Hz models and 1500 rpm for 50 Hz models.

9. Readjust the voltage adjustment potentiometer until the desired output is achieved.

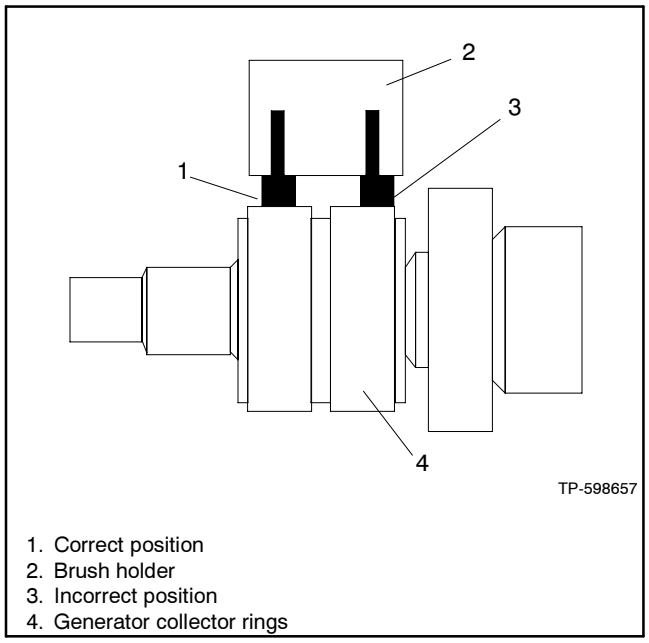
10. Readjust the stability potentiometer until the lamp flickers minimally.

11. Place the generator set controller start/stop switch in the STOP position.

7.7 Brushes (EOR/EFOR Models)

The brushes provide a current path from the voltage regulator to the collector rings. Because the brushes carry a low current, inspect them every 3000 hours. Abrasive dust on the collector rings could shorten the life of the brushes. Excessive arcing at the brushes could damage the voltage regulator. Weak springs, damaged collector rings, sticking brushes, a loose holder, or poor brush contact can cause arcing at the brushes. See Figure 7-12 for brush component identification.

The brushes must be free to move within the holder and be held in contact by the springs. When properly positioned, spring pressure on the brush surface will cause the brush to wear evenly. The brushes must ride 100% on the collector rings or arcing will occur and cause burned rings or failure of the voltage regulator. Figure 7-11 shows the correct positioning of the brushes. Add or remove alignment shims as necessary to center the brushes on the collector rings.



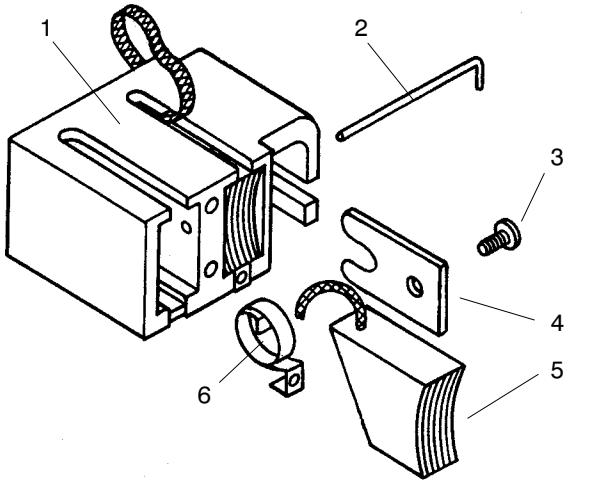
1. Correct position
2. Brush holder
3. Incorrect position
4. Generator collector rings

Figure 7-11 Brush Positioning

Replace brushes if they show excessive or uneven wear.

Use a retainer wire (such as a paper clip) to contain the brushes during disassembly and reassembly. Push the brushes into the brush holder until the retainer wire can be inserted into the brush keeping hole.

Replace brushes when they are worn to half of their original size.



1. Brush holder
2. Retainer (paper clip)
3. Mounting screw
4. Alignment shim(s)
5. Brush
6. Spring

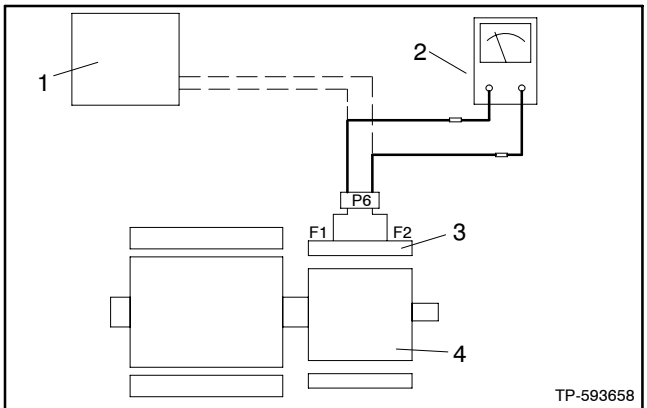
Figure 7-12 Brush Holder

7.8 Exciter Field (EORZ and EFORZ Models)

Direct current from the battery magnetizes the exciter field. When the exciter armature rotates within the magnetized exciter field windings, an electrical current develops within the exciter armature. Test the exciter field according to the following procedure.

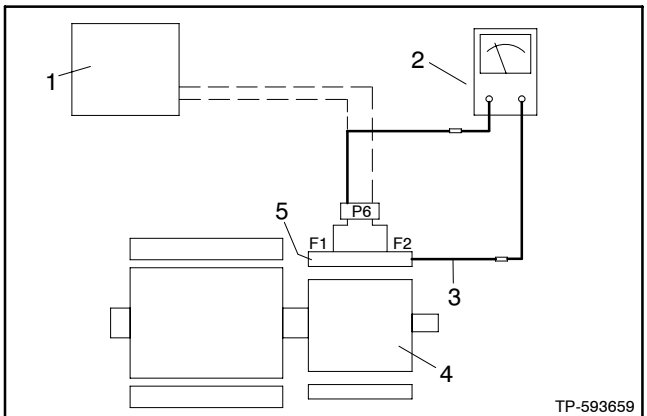
Exciter Field Test Procedure:

1. Place the start/stop switch in the STOP position.
2. Disconnect the generator set engine starting battery, negative (-) lead first.
3. Disconnect the P6 and P7 connectors (F1/F2 leads).
4. Check the exciter field resistance by connecting an ohmmeter across the exciter field F1 and F2 leads. See Section 1.3, Specifications, for the resistance reading for a cold exciter field. A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the exciter field if the ohmmeter readings indicate a inoperative exciter field (Refer to Section 9 for removal). If the resistance test is inconclusive, perform a megohmmeter test on the exciter field as described in the next step.
5. Check the exciter field for a short to ground condition. Use a megohmmeter to apply 500 volts DC to the F1 or F2 lead and the exciter field frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. A reading of approximately 1.5 mOhms and higher indicates the field winding is functional. A reading of less than approximately 1.5 mOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter field.



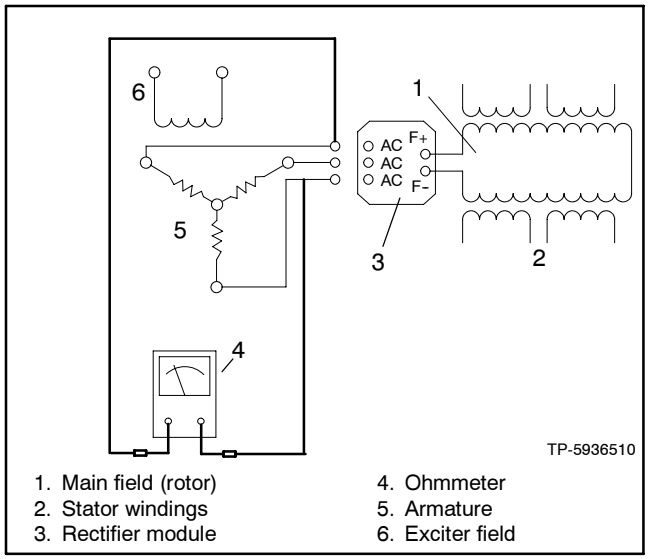
1. Voltage regulator
2. Ohmmeter
3. Exciter field
4. Exciter armature

Figure 7-13 Exciter Field Resistance Test



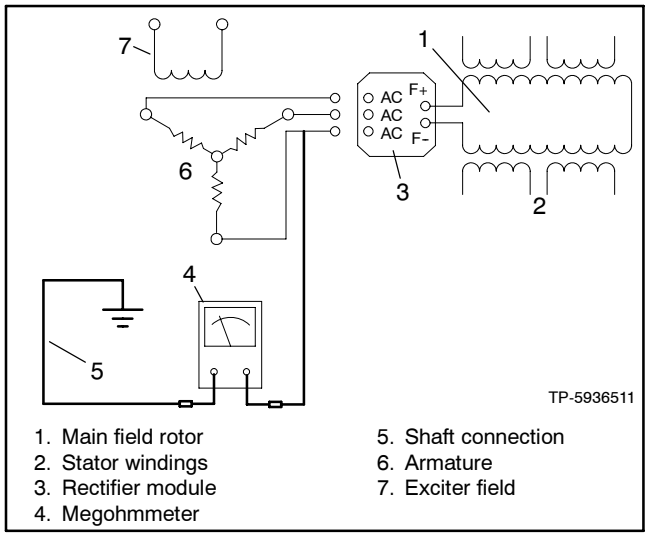
1. Voltage regulator
2. Ohmmeter
3. Frame connection
4. Exciter armature
5. Exciter field

Figure 7-14 Megohmmeter Connections on the Exciter Field



1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Ohmmeter
5. Armature
6. Exciter field

Figure 7-15 Exciter Armature Ohmmeter Test



1. Main field rotor
2. Stator windings
3. Rectifier module
4. Megohmmeter
5. Shaft connection
6. Armature
7. Exciter field

Figure 7-16 Megohmmeter Connections on Exciter Armature

7.9 Exciter Armature (EORZ and EFORZ Models)

The exciter armature supplies excitation current to the generator main field through the rectifier module. Test the exciter armature as described in the following steps.

Exciter Armature Test Procedure:

1. Disassemble the alternator. Refer to Section 9.

2. With the alternator disassembled, disconnect the armature leads from the rectifier module AC terminals. Refer to Section 9.

3. With an ohmmeter on the R x 1 scale, check the resistance across the exciter armature leads. See Figure 7-15. See Section 1.3, Specifications, for the armature resistance. No continuity indicates an open armature winding. If the resistance test is inconclusive, perform a megohmmeter test on the exciter armature as described in the next step.

   Note: Consider the exciter armature good if the resistance reading (continuity) is low and there is no evidence of a shorted winding (heat discoloration).

4. Check the exciter armature winding for a short to ground condition. Use a megohmmeter to apply 500 volts DC to either armature lead and the armature frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. See Figure 7-16. A reading of approximately 1.5 mOhms and higher indicates the exciter armature is functional. A reading of less than approximately 1.5 mOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter armature.

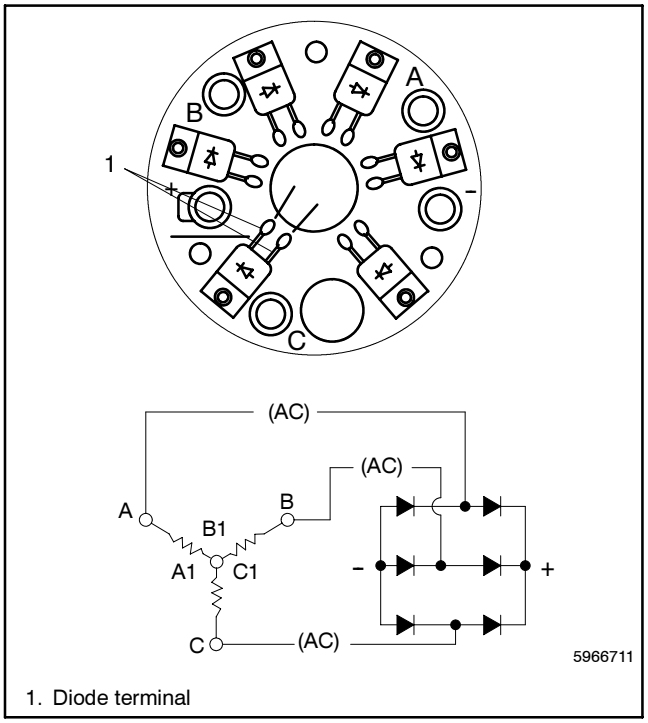
7.10 Rectifier Module (EORZ and EFORZ Models)

The rectifier module converts the AC from the exciter armature to DC, which magnetizes the generator main field. Test the rectifier module as described in the following steps.

Rectifier Module Test Procedure:

1. Disconnect the exciter armature and the main field leads from the rectifier module.

2. Use an ohmmeter on the R x 100 scale to check the resistance between the rectifier diodes as shown in Figure 7-17. The ohmmeter should show a low resistance in one direction and, upon reversing the ohmmeter leads, a high resistance in the other direction. Replace the rectifier module if any of the diodes tests differently than described.



1. Diode terminal

Figure 7-17 Testing the Rectifier Module

7.11 Rotor

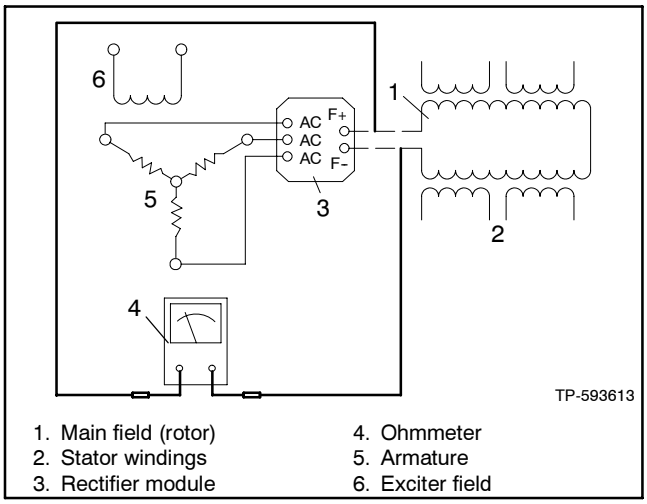
The generator set rotor (magnetized by DC from the rectifier module) rotating within the stator windings induces AC in the stator windings. Test the generator set rotor (main field) as described in the following steps. Disassemble the generator set before performing this test. See Section 9.

Generator Set Rotor Test Procedure:

1. With the generator set disassembled, disconnect the generator set rotor (main field) windings at the rectifier module terminals F+ and F–.

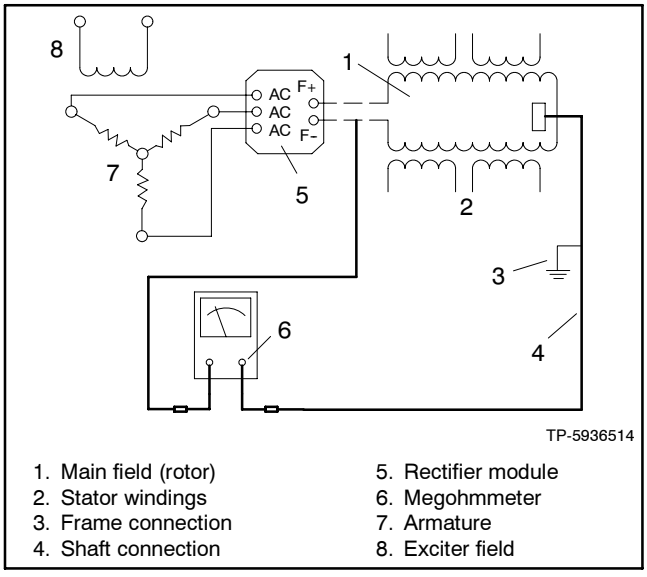
2. Check the main field resistance by connecting an ohmmeter across the main field F+ and F– leads. See Figure 7-18. See Section 1.3 for the resistance reading. A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the main field if the ohmmeter readings indicate the main field is inoperative. If the resistance test is inconclusive, perform a megohmmeter test on the main field as described in the next step.

3. Check the main field for a short to ground condition by using a megohmmeter. Apply 500 volts DC to either field lead and the main field frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. See Figure 7-19. A reading of 1.5 mOhms and higher indicates the main field is functional. A reading of less than 1.5 mOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the main field.



1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Ohmmeter
5. Armature
6. Exciter field

Figure 7-18 Ohmmeter Connections on the Rotor



1. Main field (rotor)
2. Stator windings
3. Frame connection
4. Shaft connection
5. Rectifier module
6. Megohmmeter
7. Armature
8. Exciter field

Figure 7-19 Megohmmeter Connections on the Main Field

7.12 Stator

The stator produces electrical output (AC) as the magnetized main field rotates within the stator windings. The stator consists of a series of coils of wire laid in a laminated steel frame. The stator leads supply voltage to the AC load and exciter regulator.

Leads 1, 2, 3, and 4 are the generator set output leads. Leads 55 and 66 are the voltage regulator supply and sensing leads. The output of leads B1 and B2 is rectified by BR1 to supply the control voltage. BR1 is located on the controller circuit board.

Before testing the stator, inspect it for heat discoloration and visible damage to the housing lead wires and exposed and varnished areas of the frame laminations. Be sure the stator is securely fastened in the stator housing.

Test the condition of the stator according to the following procedure. See Figure 7-20.

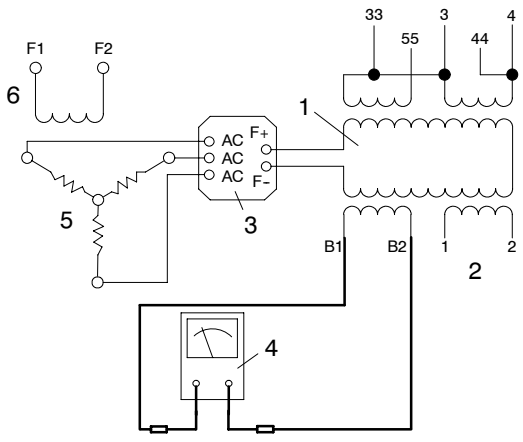
Stator Test Procedure:

1. Place the generator set start/stop switch in the STOP position.

2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Check the generator output lead connections. See the installation manual for voltage reconnection and Section 10 of this manual for the wiring diagram.

4. Disconnect all the stator leads to isolate the windings. To check the stator continuity, set the ohmmeter on the R x 1 scale. Check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 7-20 through Figure 7-22. Perform the stator tests on all the stator windings.



1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Ohmmeter
5. Armature
6. Exciter field

Figure 7-20 Stator Ohmmeter Connections

Between Leads	Continuity
1 and 2	Yes
3 and 4	Yes
55 and 66	Yes
B1 and B2	Yes
1 and 3, 4, 33, 44	No
1 and 55, B1, and B2	No
4 and B1 and B2	No
55 and B1 and B2	No
Any stator lead and ground	No

Figure 7-21 Stator Continuity, 4-Lead

Between leads	Continuity
1 and 4	Yes
2 and 5	Yes
3 and 6	Yes
7 and 10	Yes
8 and 11	Yes
9 and 12	Yes
55 and 66	Yes
B1 and B2	Yes
1 and 2, 5, 3, 6, 7, 10, 8, 11, 9, 12	No
1 and 55, 66, B1, and B2	No
Any stator lead and ground	No

Figure 7-22 Stator Continuity, 12-Lead

5. Contact the ohmmeter leads and readjust the ohmmeter to zero ohms. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads 1-2, 3-4, etc. See Section 1, Specifications, for the stator resistance values. If the stator resistance test is inconclusive, perform a megohmmeter test on the stator as described in the next step.

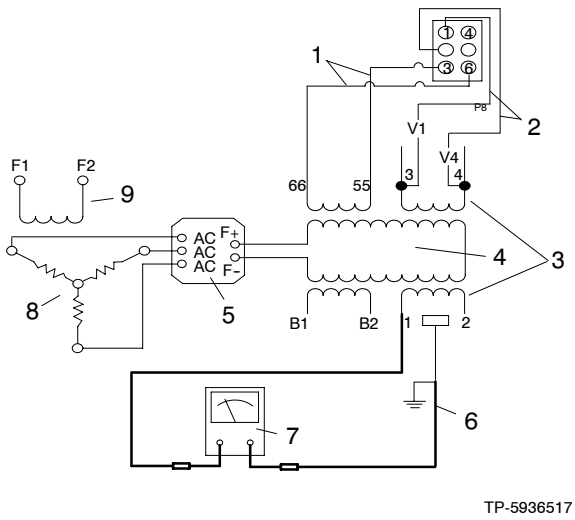
   Note: Consider the stator functional if the resistance reading (continuity) is low and there is no evidence of shorted windings (heat discoloration).

   Note: When taking an ohmmeter reading using lead 55, make the connection before the inline fuse.

   Note: The stator resistance varies directly with increased temperature.

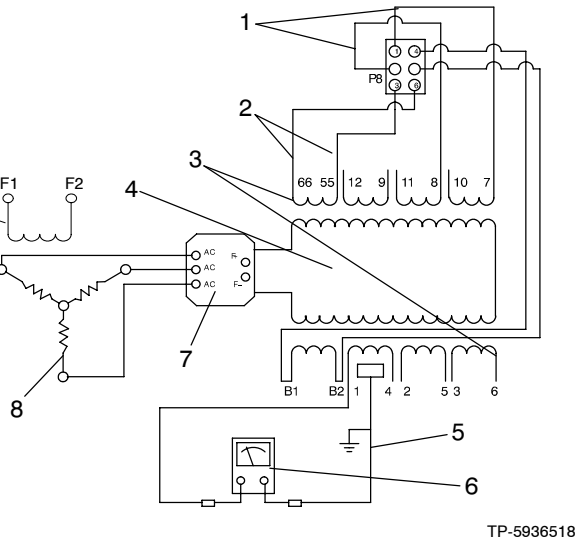
6. If any of the stator readings varies during the previous checks, replace the stator.

7. Check the stator for a short to ground condition using a megohmmeter. See Figure 7-23 and Figure 7-24. Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. Repeat the test on the other leads until all the stator windings have been tested. A reading of 1.5 mOhms and higher indicates the stator is functional. A reading of less than 1.5 mOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the stator.



1. Voltage regulator power supply leads
2. Sensing leads (208-240 volts nominal)
3. Stator windings
4. Main field (rotor)
5. Rectifier module
6. Frame connection
7. Megohmmeter
8. Armature
9. Exciter field

Figure 7-23 Megohmmeter Connections on the Stator (4-Lead)



1. Voltage regulator power supply leads
2. Sensing leads (208-240 volts nominal)
3. Stator windings
4. Main field (rotor)
5. Frame connection
6. Megohmmeter
7. Rectifier module
8. Armature
9. Exciter field

Figure 7-24 Megohmmeter Connections on the Stator, (12-Lead)

8.1 Engine/Generator Components

⚠ WARNING

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

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

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.

With the generator set battery connected, check the wiring harness and some generator set components with a voltmeter as described in Figure 8-1. Place the controller or remote start/stop switch in the prescribed position and check for 12-volt DC at each component. The presence of 12-volt DC confirms that the switch and the power supply are functioning satisfactorily.

Component	Voltmeter Connections	Remarks	Results
Hourmeter	None (see remarks)	Disconnect the hourmeter leads and apply 12-volt DC to hourmeter. **NOTE:** Hourmeter is polarity sensitive.	If functional, the hourmeter operates.
B1 and B2 stator auxiliary winding	Disconnect the B1/B2 leads. Connect the AC voltmeter to the leads. **NOTE:** Voltage is measured momentarily because the unit stops running after the start switch is released.	Voltmeter setting 20 volts AC or greater. Start the generator set by holding the start/stop switch in the START position and allow the generator set to reach its rated speed. Take the reading and then stop the generator set.	Reading of 12–15 volts indicates the B1/B2 winding is functional.

Figure 8-1 Engine/Generator Component Testing with Voltmeter

To further check generator set components, disconnect the battery and remove the wiring harness plugs from the controller circuit board. Use an ohmmeter to check continuity and to isolate inoperative components as described in Figure 8-2. Also refer to the corresponding wiring diagram in Section 10.

Note: Before performing ohmmeter checks, disconnect the generator set battery to prevent damage to the ohmmeter.

Component	Ohmmeter Connections	Remarks	Results
Controller switch	P2-6 and P2-4	Ohmmeter on R x 1 scale. Place the rocker switch in the START position.	If functional, zero ohms (continuity). Any resistance other than zero or very low ohms, replace the switch.
	P2-6 and P2-5	Ohmmeter on R x 1 scale. Place the rocker switch in the STOP position.	If functional, zero ohms (continuity). Any resistance other than zero or very low ohms, replace the switch.
K20 relay coil	P1-4 and P1-9	Ohmmeter on R x 1 scale.	If functional, 85 ohms. Low resistance, shorted K20 relay coil and/or wiring. High resistance, open K20 relay and/or wiring.
K25 relay coil	P1-8 and P1-9		If functional, 85 ohms. Low resistance, shorted K25 relay coil and/or wiring. High resistance, open K25 relay and/or wiring.
Starter solenoid ('S' relay)	P4-22 and battery (-) cable. **NOTE:** Disconnect J4 and P4 to perform this test.		If functional, approx. 0.20–0.35 ohms at 27°C (80°F).
Controller 15-amp fuse and wiring	Battery positive (+) cable and P1-14 **NOTE:** Connect J4 and P4 to perform this test.		If functional, zero or very low ohms. No reading (infinity), open circuit or fuse blown.
Air heater relay (AHR)	P4-8 and P4-1		If functional, approx. 16–20 ohms at 27°C (80°F).
P1 ground connection	P1-9 and ground.	Ohmmeter on R x 1 scale.	If functional, zero ohms (continuity). Any other reading indicates a poor ground connection.
Low oil pressure (LOP) safety shutdown switch	P1-15 and engine block (ground). **NOTE:** J4 and P4 must be connected to perform this test.	Ohmmeter on R x 1 scale. This test is not conclusive until the temperature shutdown switches are checked.	If functional, zero ohms (continuity). Then, disconnect the LOP switch lead and isolate the terminal. The meter reading should show an open circuit.
High engine temperature (HET) safety shutdown switch	P1-15 and engine block (ground). **NOTE:** LOP switch lead should be removed and isolated. **NOTE:** J4 and P4 must be connected to perform this test.	Ohmmeter on R x 1 scale.	If functional, open circuit. Any continuity suggests that temperature switch(es) are inoperative. Disconnect individual leads to determine which switch is inoperative.

Figure 8-2 Engine/Generator Set Component Testing with Ohmmeter

8.2 Remote Start Panels (Optional)

Kohler Co. offers three remote panels. The first has a start/stop switch. The second has a start/stop switch and two gauges. The third has a start/stop switch and four gauges. Test the switch, gauge, and gauge sender functions if difficulty with remote operation occurs. Disconnect the J3/P3 connector before testing.

8.2.1 Sender Tests

To test the water temperature sender, connect an ohmmeter to controller sockets P3-1 and P3-2. See Figure 8-3 for the resistance generated by different temperatures. Start the generator set to change temperature. Stop the generator set after completing the test.

To test the oil pressure sender, connect an ohmmeter to controller sockets P3-1 and P3-3. See Figure 8-4 for the resistances generated by different pressures. Start the generator set to change pressure. Stop the generator set after completing the test.

Generally, senders can be presumed functional if they change their resistance values as their respective pressure/temperature change.

8.2.2 Panel Tests

Test the panels with an ohmmeter as described in Figure 8-5 or with a voltmeter as described in Figure 8-6. Refer to Figure 8-3 and Figure 8-4 for desired resistance values.

2-Meter and 4-Meter Panels	
Temperature	**Resistance**
60°C (140°F)	134.0 ±10 ohms
90°C (194°F)	51.5 ±4 ohms
100°C (212°F)	38.0 ±3 ohms

Figure 8-3 Water Temperature Sender Resistance

2-Meter and 4-Meter Panels	
Pressure	**Resistance**
0 kPa (0 psi)	9 ±4 ohms
103 kPa (15 psi)	48 ±4 ohms
207 kPa (30 psi)	84 ±4 ohms
310 kPa (45 psi)	120 ±5 ohms

Figure 8-4 Oil Pressure Sender Resistance

Component	Voltmeter Connections	Remarks	Results
Start/stop switch	P3-1 and P3-5 (plug side). Place the remote rocker switch in the START position.	Ohmmeter on R x 1 scale	If functional, ohmmeter indicates continuity.
	P3-1 and P3-6 (plug side). Place the remote rocker switch in the STOP position.		

Figure 8-5 Remote Panel Testing with Ohmmeter

Component	Voltmeter Connections	Remarks	Results
Remote switch “ON” light, gauge lights, DC voltmeter, and hourmeter, if equipped	Red test lead to P3-4 (socket side) and black test to P3-1 (socket side). Place the controller start/stop switch in the START position. STOP the generator set when the test is completed.	Voltmeter setting 12 volts or greater. Generator set does not need to be running, just cranking for this test. **NOTE:** If the hourmeter is not illuminated connect it to a 12-volt battery. **NOTE:** Hourmeter is polarity sensitive.	If 12 volts DC is present and the hourmeter does not function after the P3 plug is connected to controller, replace the hourmeter.

Figure 8-6 Remote Panel Testing with Voltmeter

Notes

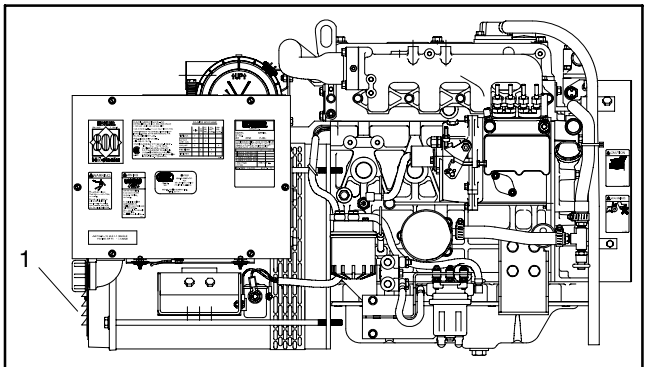
9.1 Disassembly

Disconnect all of the external connections—battery cables at the battery (negative (-) lead first), AC-output leads in the controller, remote start panel at the controller P3 connector, fuel line at the fuel pump filter inlet, and exhaust. Observe all of the safety precautions listed at the beginning of this manual during the disassembly/reassembly procedures.

Note: The voltage regulator is located in the controller box. Remove the controller cover to service the voltage regulator. Adjustments are possible without removing the voltage regulator from the controller.

Generator Disassembly Procedure:

1. Place the generator set start/stop switch in the STOP position.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery(ies), negative (-) lead first.
4. Remove the end panel from the alternator end of the generator set. See Figure 9-1.



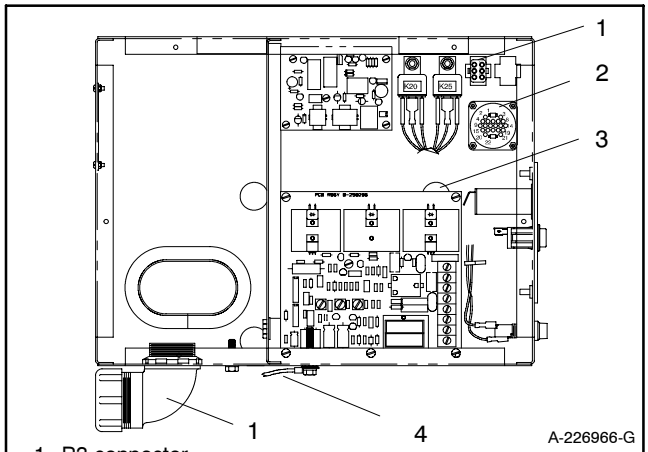
1. Generator set end panel

Figure 9-1 End Panel

5. Remove the six screws and lift off the controller cover.
6. Disconnect the P4 (22-pin) connector from J4 and the P3 (remote start) connector from J3.
7. Remove the bolt from the bottom of the controller and disconnect the ground strap.

Note: It is possible to connect the output leads in various positions for different volt configurations. Mark leads 1, 2, 3, and 4 for correct reconnection.

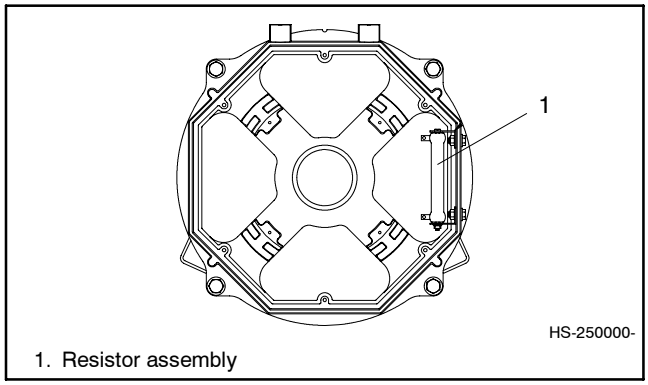
8. Disconnect the generator output leads 1, 2, 3, and 4 from the circuit breaker and neutral stud (L0).
9. Remove the controller mounting hardware. See Figure 9-2.



1. P3 connector
2. P4 connector
3. Mounting hardware location
4. Ground strap
5. Conduit elbow

Figure 9-2 Controller Removal

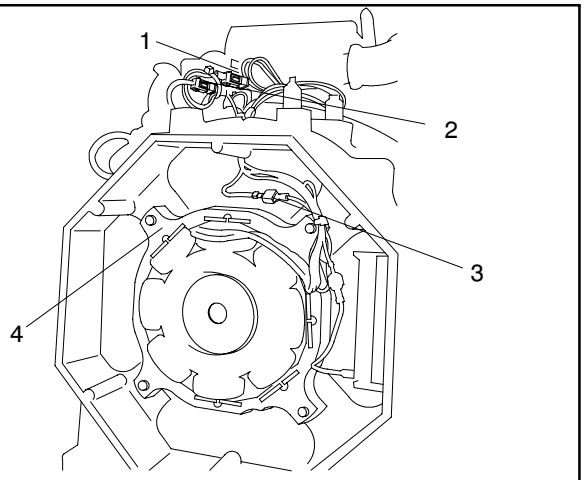
10. Lift the controller from the generator set while guiding the leads through the conduit elbow on the bottom of the controller box.
11. Remove the tie wraps from the wire harness as necessary.
12. **7.5 and 10 kW models:** Disconnect the F1 connectors from the resistor leads. See Figure 9-3 for the resistor assembly location.



1. Resistor assembly

Figure 9-3 Resistor Assembly (7.5 and 10 kW)

13. Disconnect the P7 (FP and FN) and P6 (F1 and F2) connectors. See Figure 9-4.



1. P7 connector
2. P6 connector
3. F1 connector
4. Exciter field

Figure 9-4 Exciter Field Removal

14. **Brush-equipped models:** Pull the brush leads outward to raise the brushes in the holder and install a brush retainer. See Section 7.7

15. **Exciter-equipped models:**

    a. Remove the four bolts to remove the exciter field. See Figure 9-4.

    b. Remove the three bolts and spacers from the rectifier board.

    c. Disconnect the main field rotor leads from the rectifier board positive/negative terminals. Remove the retaining bolt and washer.

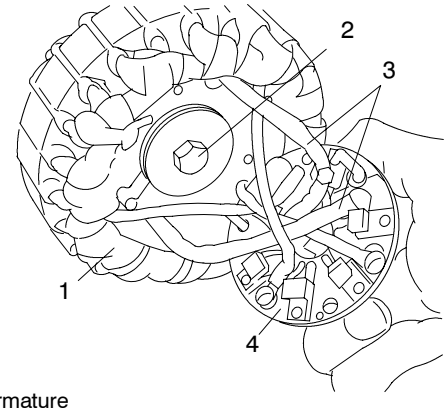
    d. Remove the armature from the shaft, guiding the rotor leads through the armature bores. See Figure 9-5.

16. Remove the tie wraps and disconnect the P5 (33, 44, 55, F1, and F2) wire connector.

17. Attach the hoist hook to the generator hoisting eye.

    Note: The hoist capacity rating should be one-half ton or greater.

18. Remove the two alternator end vibromounts. See Figure 9-6.

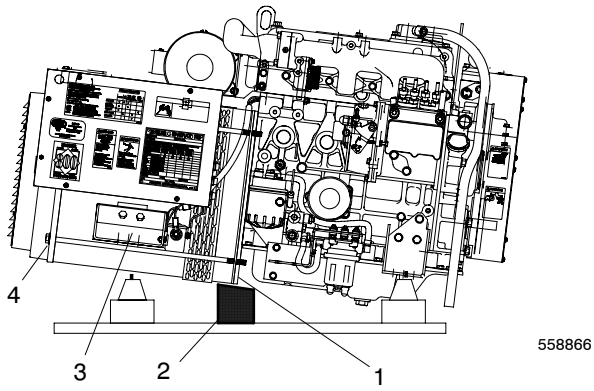


1. Armature
2. Armature retaining bolt
3. Rotor leads
4. Rectifier board

Figure 9-5 Armature Removal

19. Raise the alternator end and place a wood block under the locator plate. Lower the alternator until the wood block supports the locator plate. See Figure 9-6.

20. Remove the four overbolts from the end bracket. See Figure 9-6.

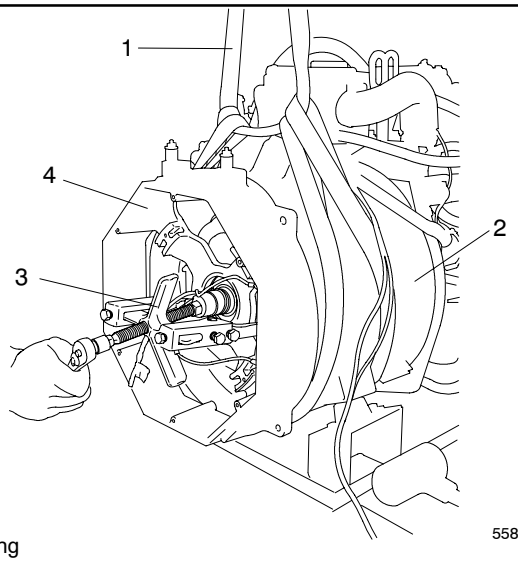


1. Backplate
2. Wood block
3. Vibromounts
4. Overbolts

Figure 9-6 Supporting the Generator

21. Install a sling on the stator housing. See Figure 9-7.

22. Use a two-jaw puller to pull the end bracket/stator assembly from the bearing on the rotor shaft. See Figure 9-7.



1. Sling
2. Fan guard
3. Two-jaw puller
4. End bracket

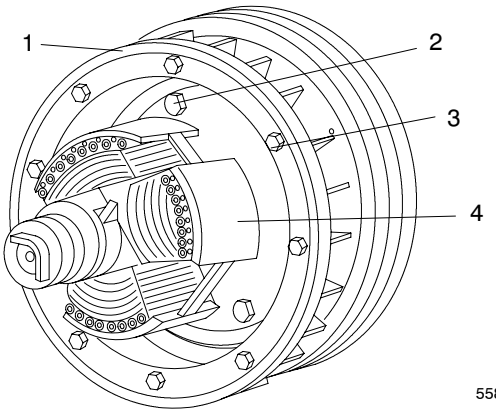
Figure 9-7 Stator Assembly Removal

23. Remove the stator assembly from the rotor. Remove or rotate the fan guard, if necessary, to clear the vibromounts.

24. Remove the eight fan bolts and remove the fan and fan spacer. See Figure 9-8.

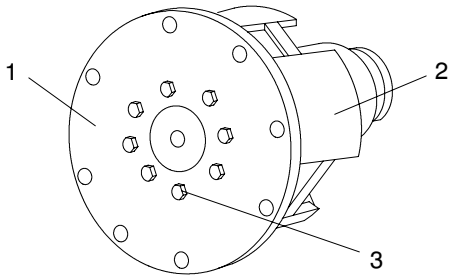
25. Remove the eight drive disc bolts to remove the drive disc/rotor assembly from the engine flywheel. See Figure 9-8.

26. Clamp the rotor in a soft-jaw vise. Remove the eight bolts and remove the drive disc assembly from the rotor. See Figure 9-9.



1. Fan
2. Drive disc/rotor bolts
3. Fan bolts
4. Rotor assembly

Figure 9-8 Disc/Rotor and Fan Assembly



1. Drive disc
2. Rotor
3. Bolt

Figure 9-9 Drive Disc

9.2 Reassembly

1. Clamp the rotor in a soft-jaw vise. Install the drive disc on the rotor with disc studs facing the rotor. Tighten the eight bolts to 38 Nm (28 ft. lbs). See Figure 9-9.

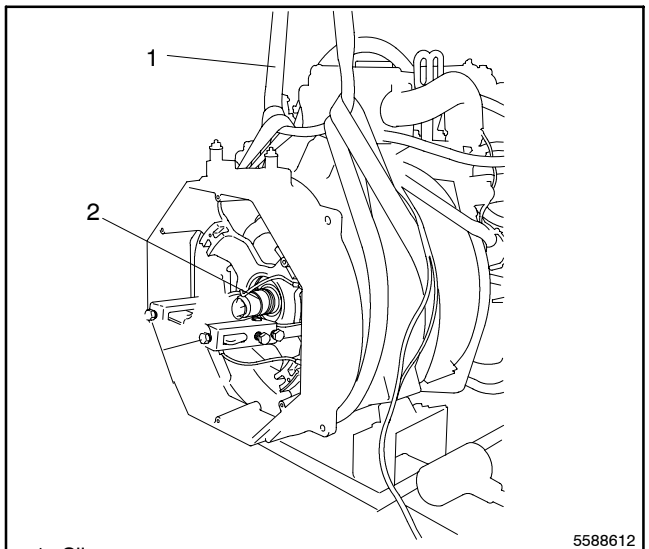
   Note: 7.5 kW models: Apply antiseize compound to the end of the rotor shaft.

2. Install the rotor/drive disc assembly on the engine flywheel using six washers and bolts. Tighten the bolts to 37 Nm (27 ft. lbs). See Figure 9-8.

3. Install the fan to the drive disc using four spacers, washers, and locknuts.

   Note: Install the fan with the flange side facing away from the flywheel. Space the studs so that they allow the fan installation in one position only.

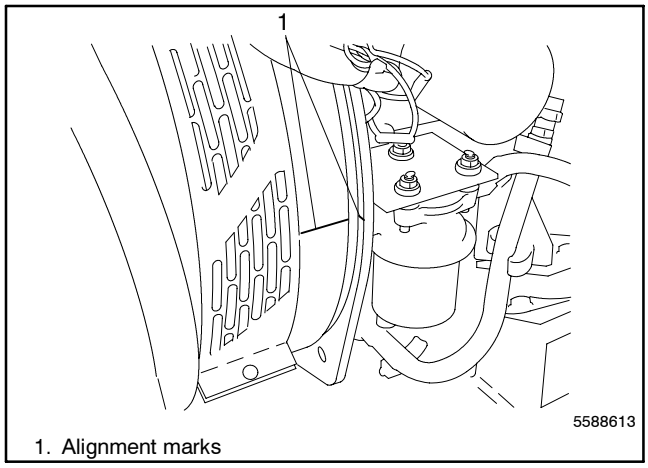
4. Inspect the O-ring in the end bracket bearing bore and replace the O-ring if damaged. Use a sling to support the stator assembly while installing the stator over the rotor. Be careful not to damage the rotor. See Figure 9-10.



1. Sling
2. O-ring

Figure 9-10 Stator Installation

5. Install the four overbolts (**7.5 kW models:** the two long bolts in the lower holes). Check that the alignment marks on the stator housing and locator plate match. See Figure 9-11. Tighten the overbolts to 34 Nm (25 ft. lbs.).



1. Alignment marks

Figure 9-11 Alignment Marks

6. Use the hoist to raise the alternator end. Remove the wood block from under the locator plate. Lower the generator set and install a bolt, a large washer, two small washers, and a locknut in each vibromount. Tighten the mounting bolts.

7. Apply antiseize compound to the keyed end of the rotor shaft.

8. **Exciter-equipped models:**

   a. Bring the rotor leads through the bores in the armature while installing the armature on the shaft. Check the keyway of the shaft and the key of the armature for damage. Install the armature retaining bolt and washer. Torque the armature retaining bolt to 38 Nm (28 ft. lbs.).

   b. Use screws and lock washers to install the rotor leads to the rectifier board at the positive (+) and negative (–) terminals.

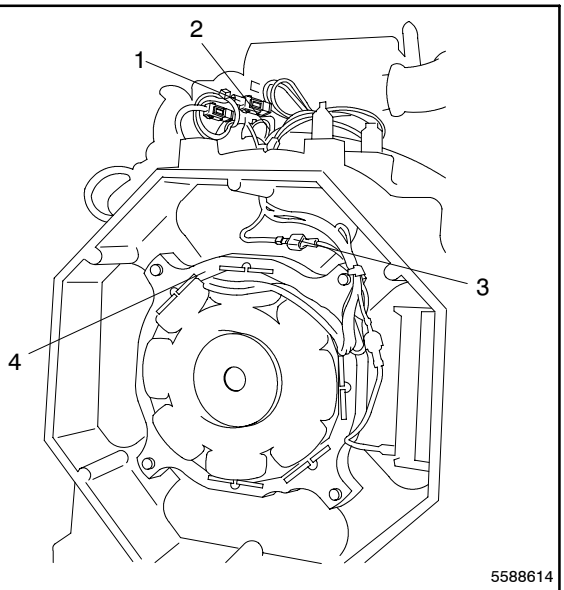
      Note: Position the lock washers against the rectifier board.

   c. Install three spacers and bolts to mount the rectifier board to the armature.

   d. Install the exciter field using four bolts and washers. The field leads are at the top.

9. Connect the P6, P7, and F1 connectors. See Figure 9-12.

10. **Brush-equipped models:** Remove the brush retainer from the brush holder.



1. P7 connector
2. P6 connector
3. F1 connector
4. Exciter field

Figure 9-12 Installing Exciter Field

11. Install tie wraps to secure the wires as necessary.

12. Route output leads 1, 2, 3, and 4 through the conduit elbow on the top of the controller box. Check that the grommet is intact and there are no sharp edges exposed that could damage the wiring. Install the box to the generator set with the original mounting hardware. Connect the stator leads to the circuit breaker and neutral stud (LO) as marked during disassembly.

    Note: Check the generator set's nameplate to verify the original voltage configuration. See Section 10, Wiring Diagrams.

13. Connect the P4 (22-pin) connector. Connect the ground strap using a bolt, washer, and lock washer (install the lock washer against the ground strap).

14. Install the controller cover.

15. Install the end panel with the louvered openings down.

16. Reconnect all of the external connections—the exhaust line, the fuel line to the fuel pump filter inlet, the remote start panel to the controller P3 connector, the AC output leads in controller, and the battery cables to the battery (negative (-) lead last).

Notes

Refer to the following wiring diagrams for suggested connection of generator sets. Follow the National Electrical Code (NEC) in all cases.

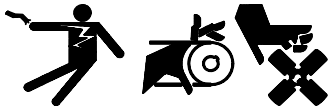
⚠ WARNING

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

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

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

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

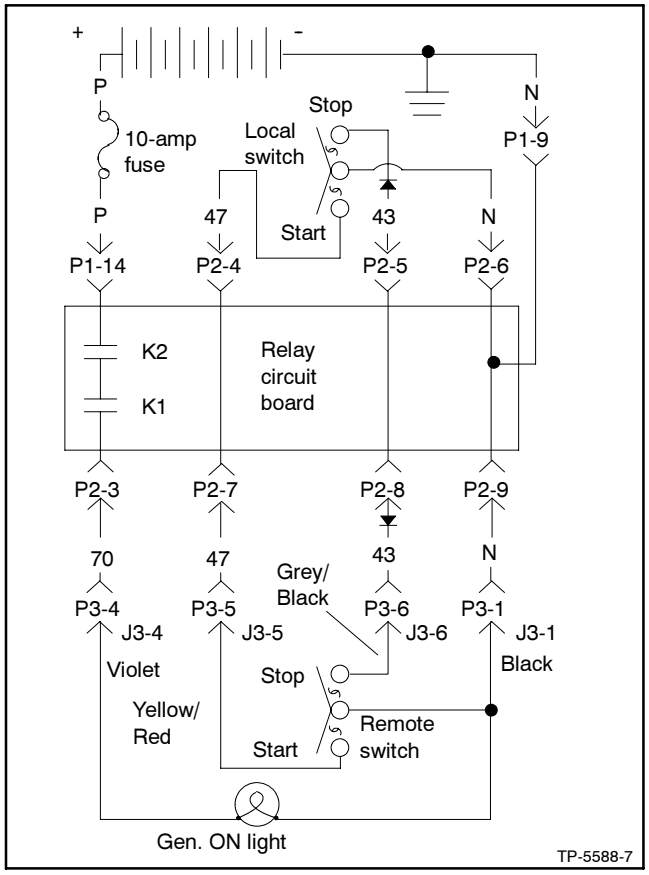
Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

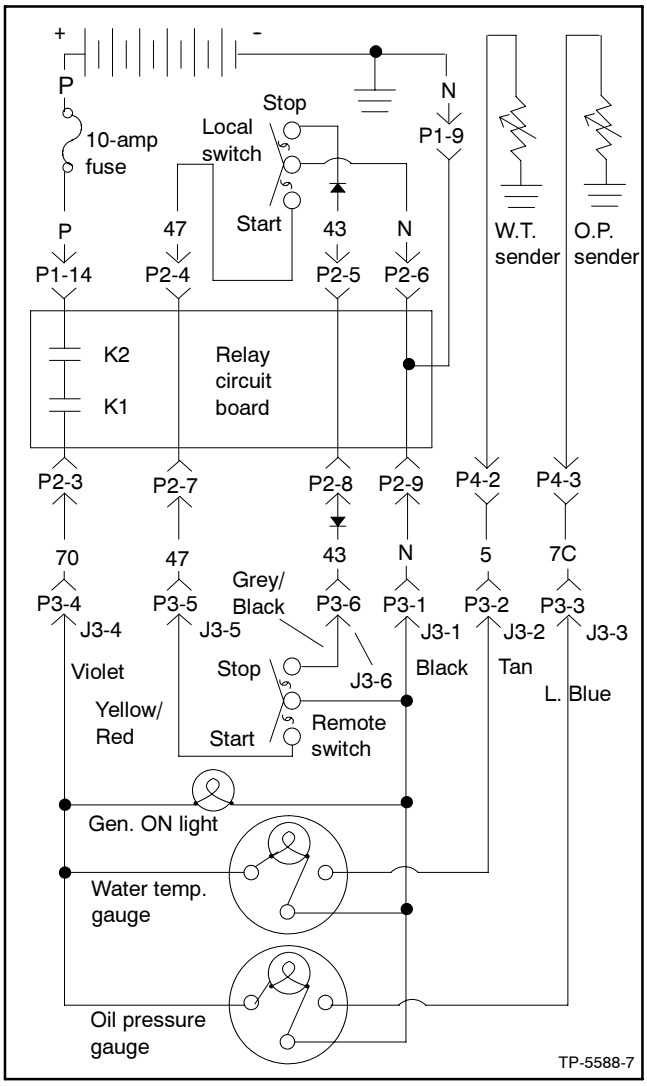
NOTICE

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.

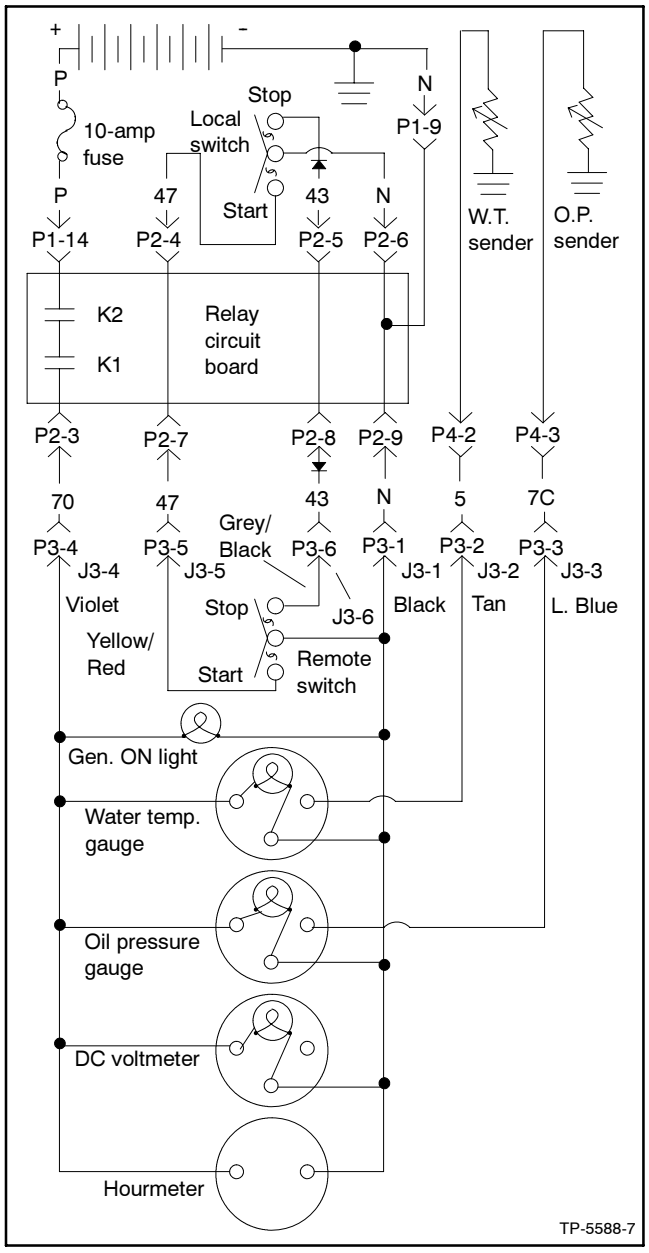
10.1 Remote Start Panel



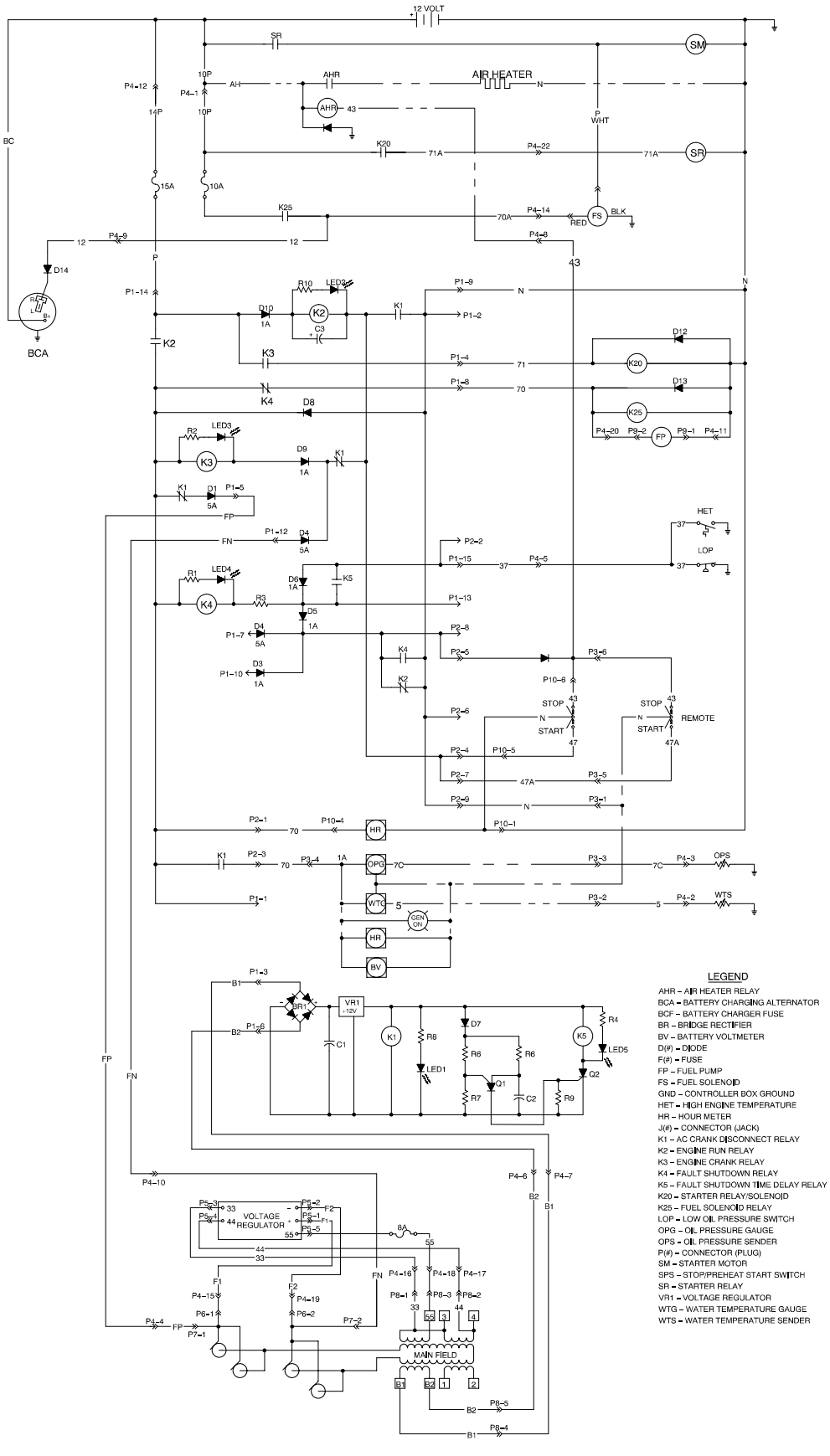
10.2 Remote Start and Two-Meter Panel



10.3 Remote Start and Four-Meter Panel



10.4 7.5/10EOR & 6/9EFOR with Brushes, Schematic Wiring Diagram



LEGEND

AHR – AIR HEATER RELAY
BCA – BATTERY CHARGING ALTERNATOR
BCF – BATTERY CHARGER FUSE
BR – BRIDGE RECTIFIER
BV – BATTERY VOLTMETER
D(#) – DIODE
F(#) – FUSE
FP – FUEL PUMP
FS – FUEL SOLENOID
GND – CONTROLLER BOX GROUND
HET – HIGH ENGINE TEMPERATURE
HR – HOUR METER
J(#) – CONNECTOR (JACK)
K1 – AC CRANK DISCONNECT RELAY
K2 – ENGINE RUN RELAY
K3 – ENGINE CRANK RELAY
K4 – FAULT SHUTDOWN RELAY
K5 – FAULT SHUTDOWN TIME DELAY RELAY
K20 – STARTER RELAY/SOLENOID
K25 – FUEL SOLENOID RELAY
LOP – LOW OIL PRESSURE SWITCH
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDER
P(#) – CONNECTOR (PLUG)
SM – STARTER MOTOR
SPS – STOP/PREHEAT START SWITCH
SR – STARTER RELAY
VR1 – VOLTAGE REGULATOR
WTG – WATER TEMPERATURE GAUGE
WTS – WATER TEMPERATURE SENDER

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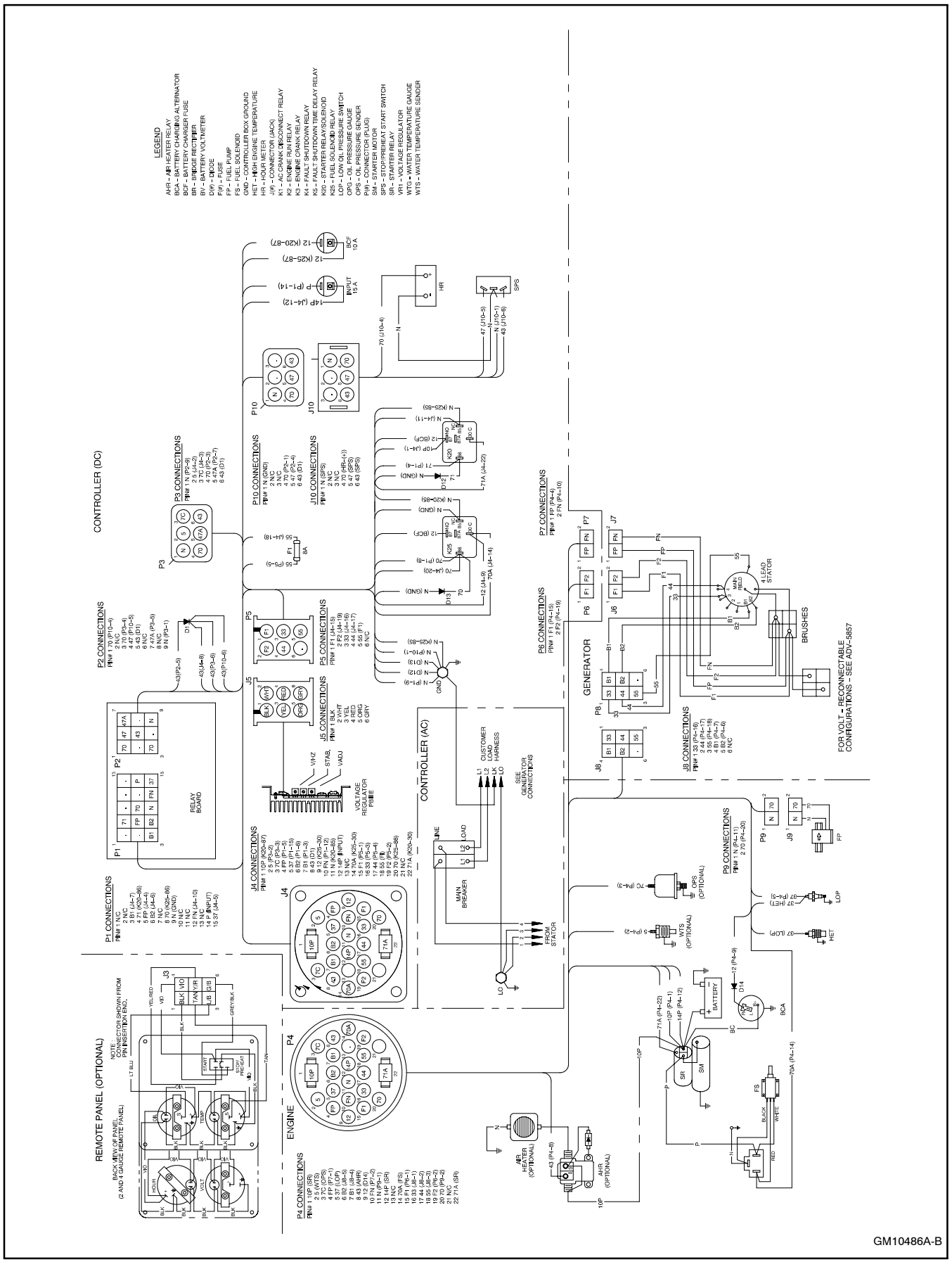
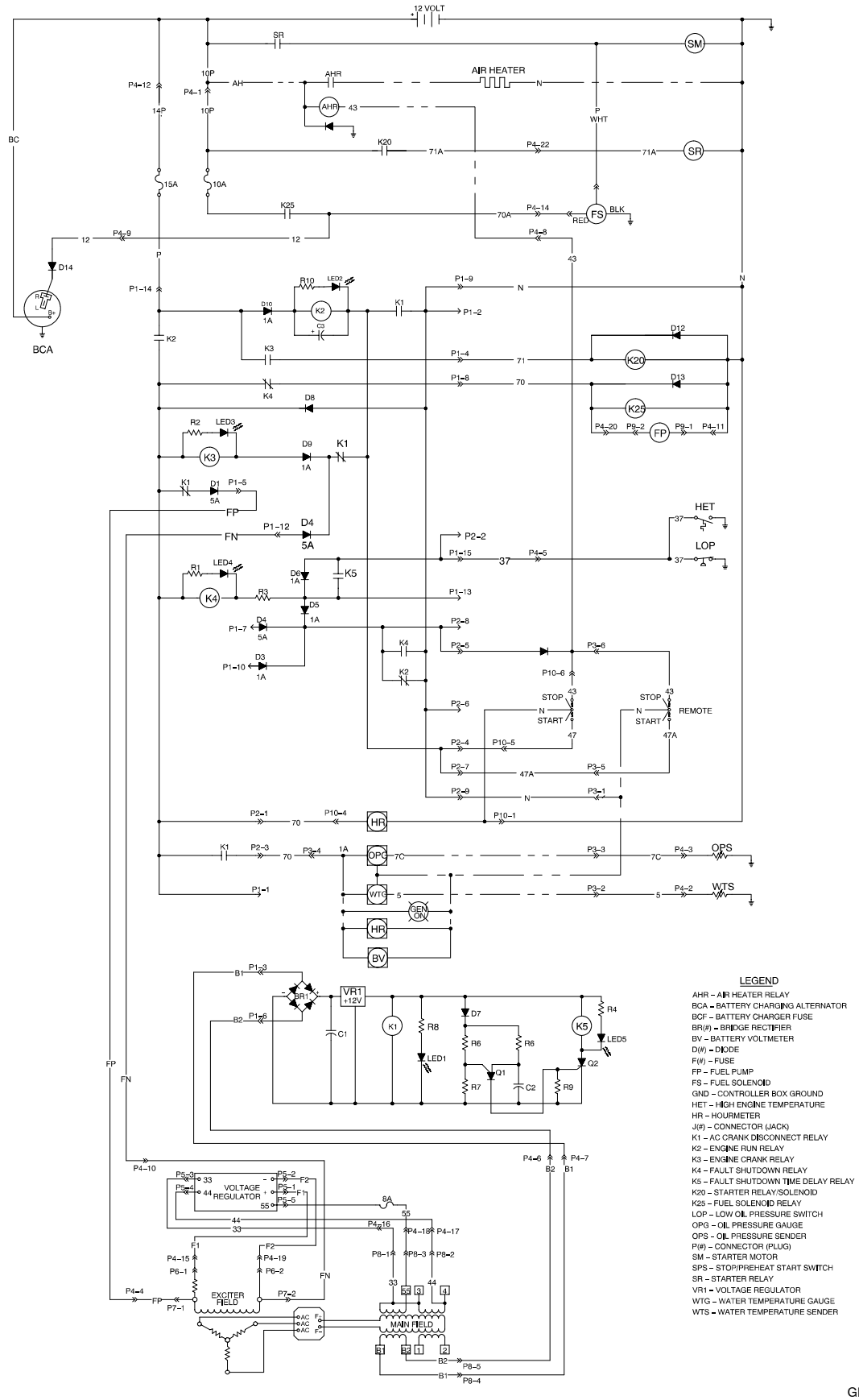
10.5 7.5/10EOR & 6/9EFOR with Brushes, Point-to-Point Wiring Diagram



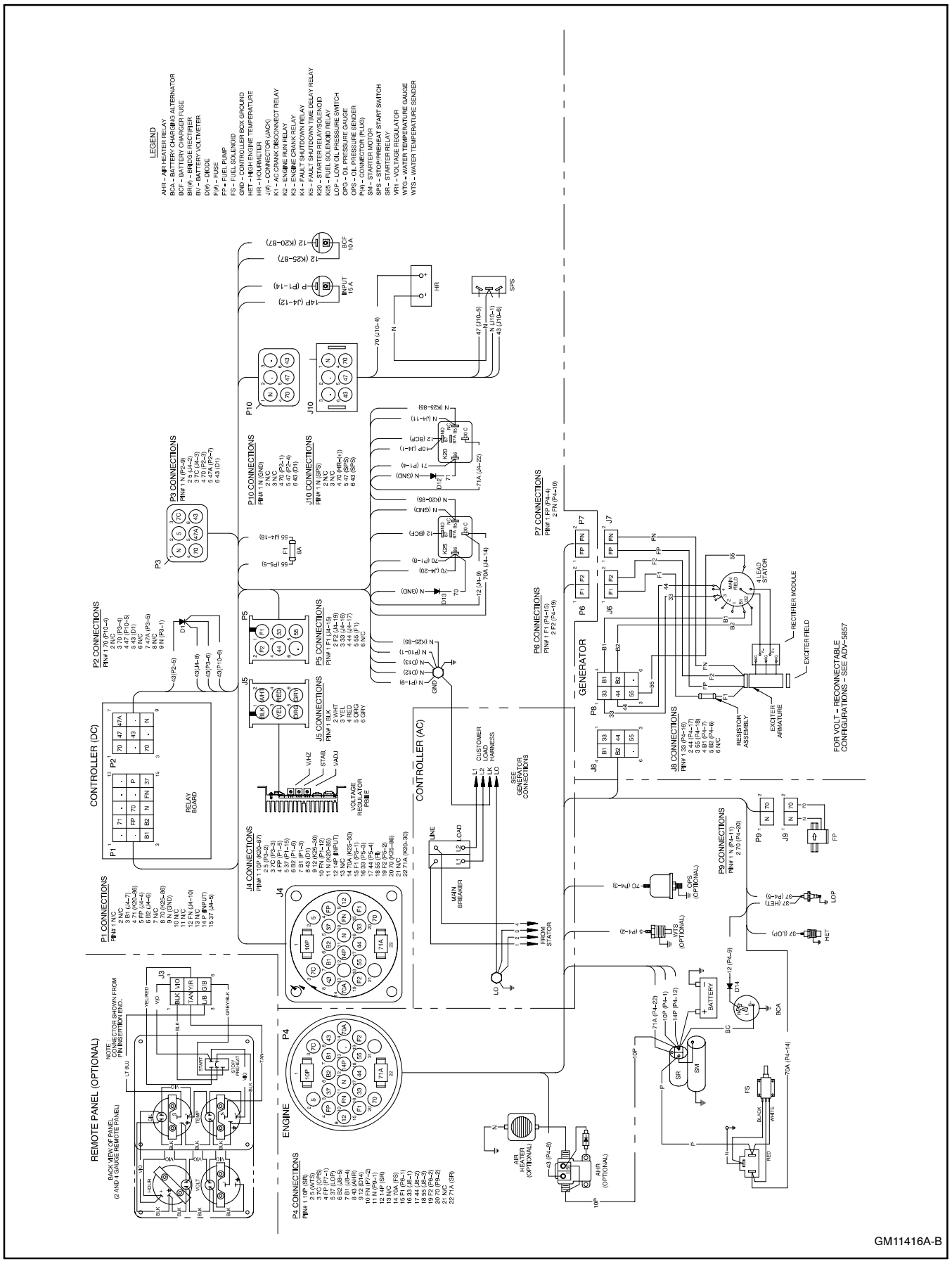
10.6 7.5/10EORZ & 6/9EFORZ with Exciter, Schematic Wiring Diagram



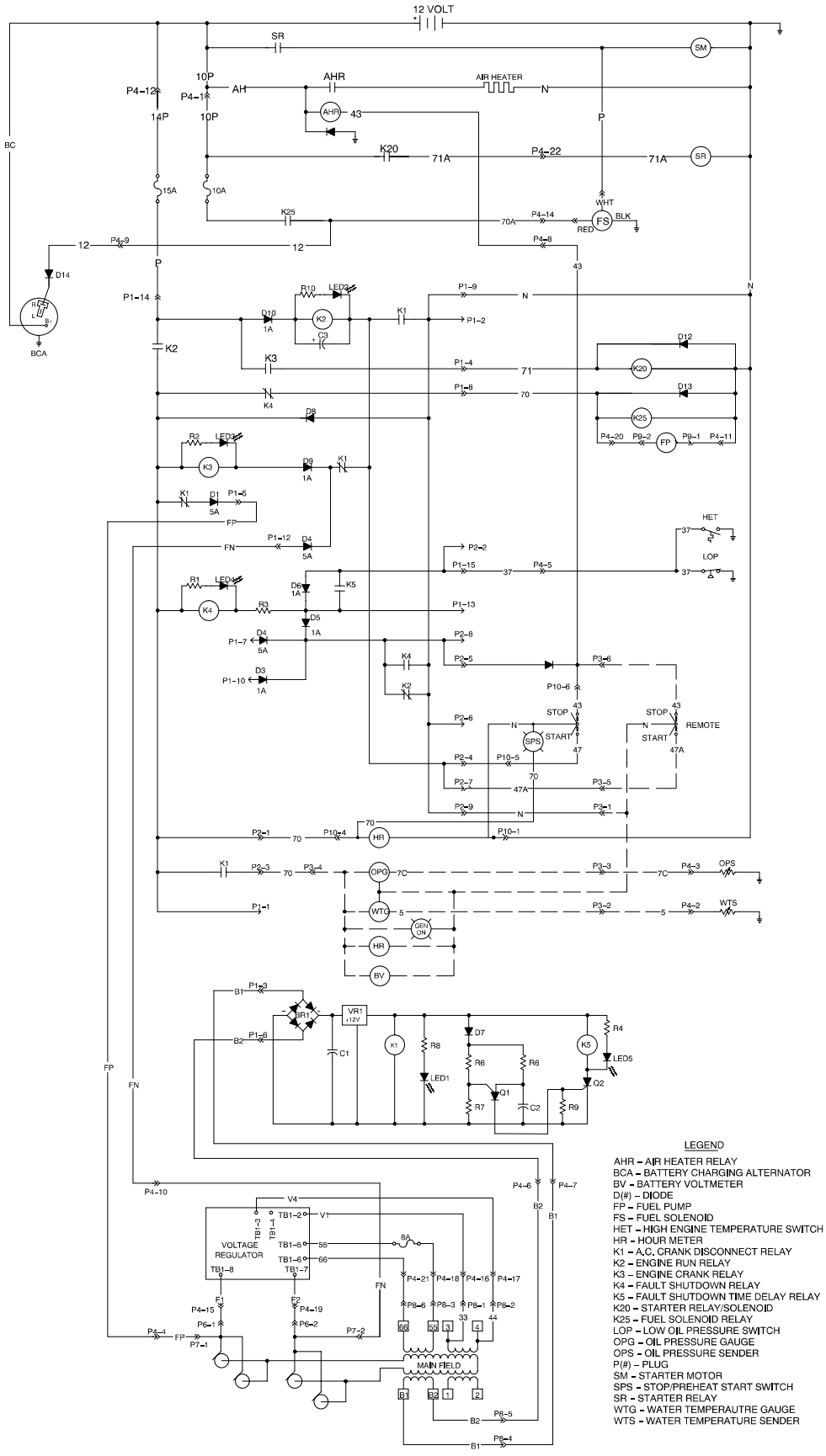
LEGEND

AHR – AIR HEATER RELAY
BCA – BATTERY CHARGING ALTERNATOR
BCF – BATTERY CHARGER FUSE
BR(#) – BRIDGE RECTIFIER
BV – BATTERY VOLTMETER
D(#) – DIODE
F(#) – FUSE
FP – FUEL PUMP
FS – FUEL SOLENOID
GND – CONTROLLER BOX GROUND
HET – HIGH ENGINE TEMPERATURE
HR – HOURMETER
J(#) – CONNECTOR (JACK)
K1 – AC CRANK DISCONNECT RELAY
K2 – ENGINE RUN RELAY
K3 – ENGINE CRANK RELAY
K4 – FAULT SHUTDOWN RELAY
K5 – FAULT SHUTDOWN TIME DELAY RELAY
K20 – STARTER RELAY/SOLENOID
K25 – FUEL SOLENOID RELAY
LOP – LOW OIL PRESSURE SWITCH
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDER
P(#) – CONNECTOR (PLUG)
SM – STARTER MOTOR
SPS – STOP/PREHEAT START SWITCH
SR – STARTER RELAY
VR1 – VOLTAGE REGULATOR
WTG – WATER TEMPERATURE GAUGE
WTS – WATER TEMPERATURE SENDER

10.7 7.5/10EORZ & 6/9EFORZ with Exciter, Point-to-Point Wiring Diagram



10.8 15/20EOR & 12.5/16.5EFOR with Brushes, Schematic Wiring Diagram



LEGEND

AHR – AIR HEATER RELAY
BCA – BATTERY CHARGING ALTERNATOR
BV – BATTERY VOLTMETER
D(#) – DIODE
FP – FUEL PUMP
FS – FUEL SOLENOID
HET – HIGH ENGINE TEMPERATURE SWITCH
HR – HOUR METER
K1 – A.C. CRANK DISCONNECT RELAY
K2 – ENGINE RUN RELAY
K3 – ENGINE CRANK RELAY
K4 – FAULT SHUTDOWN RELAY
K5 – FAULT SHUTDOWN TIME DELAY RELAY
K20 – STARTER RELAY/SOLENOID
K25 – FUEL SOLENOID RELAY
LOP – LOW OIL PRESSURE SWITCH
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDER
P(#) – PLUG
SM – STARTER MOTOR
SPS – STOP/PREHEAT START SWITCH
SR – STARTER RELAY
WTG – WATER TEMPERAUTRE GAUGE
WTS – WATER TEMPERATURE SENDER

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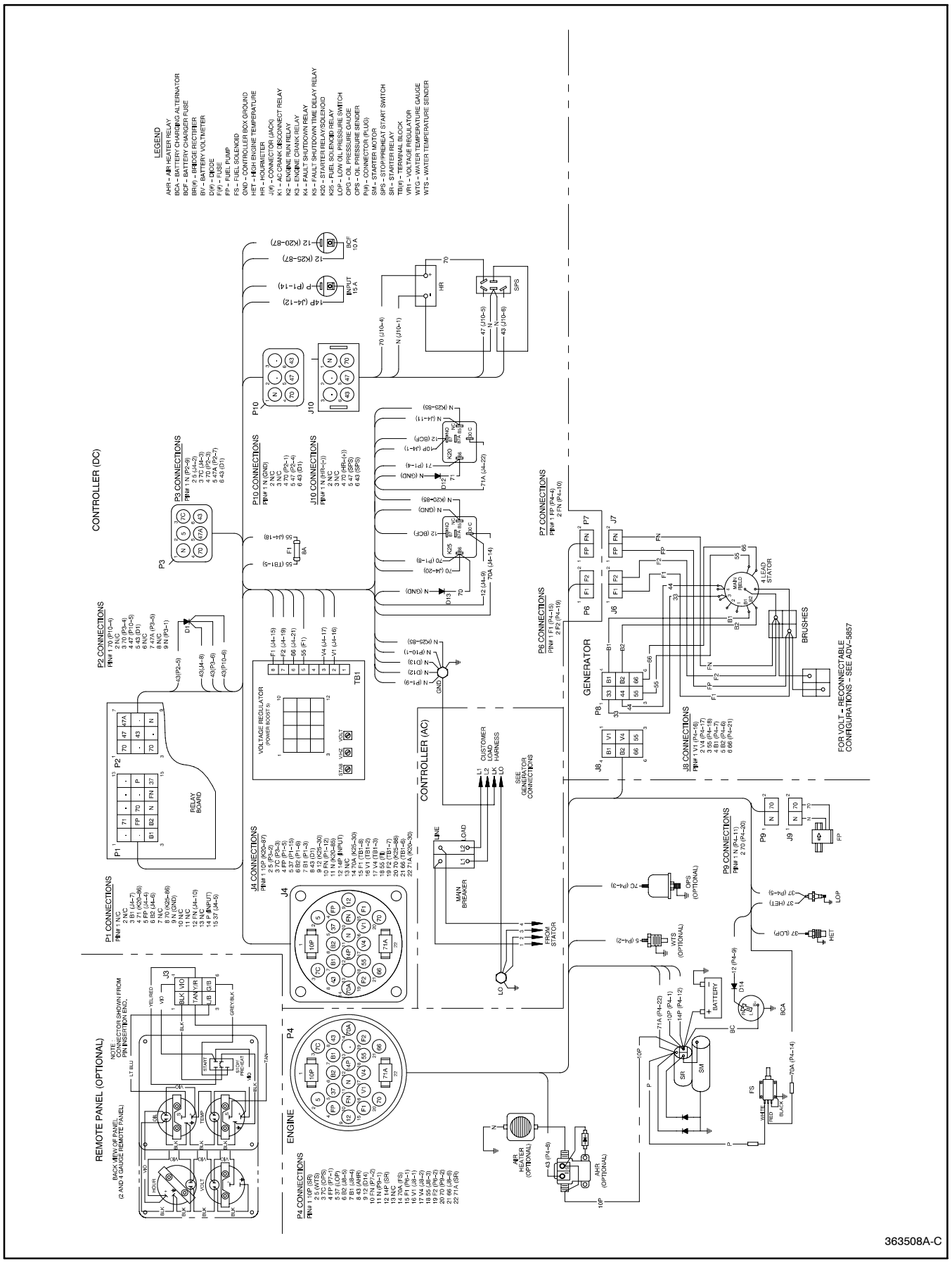
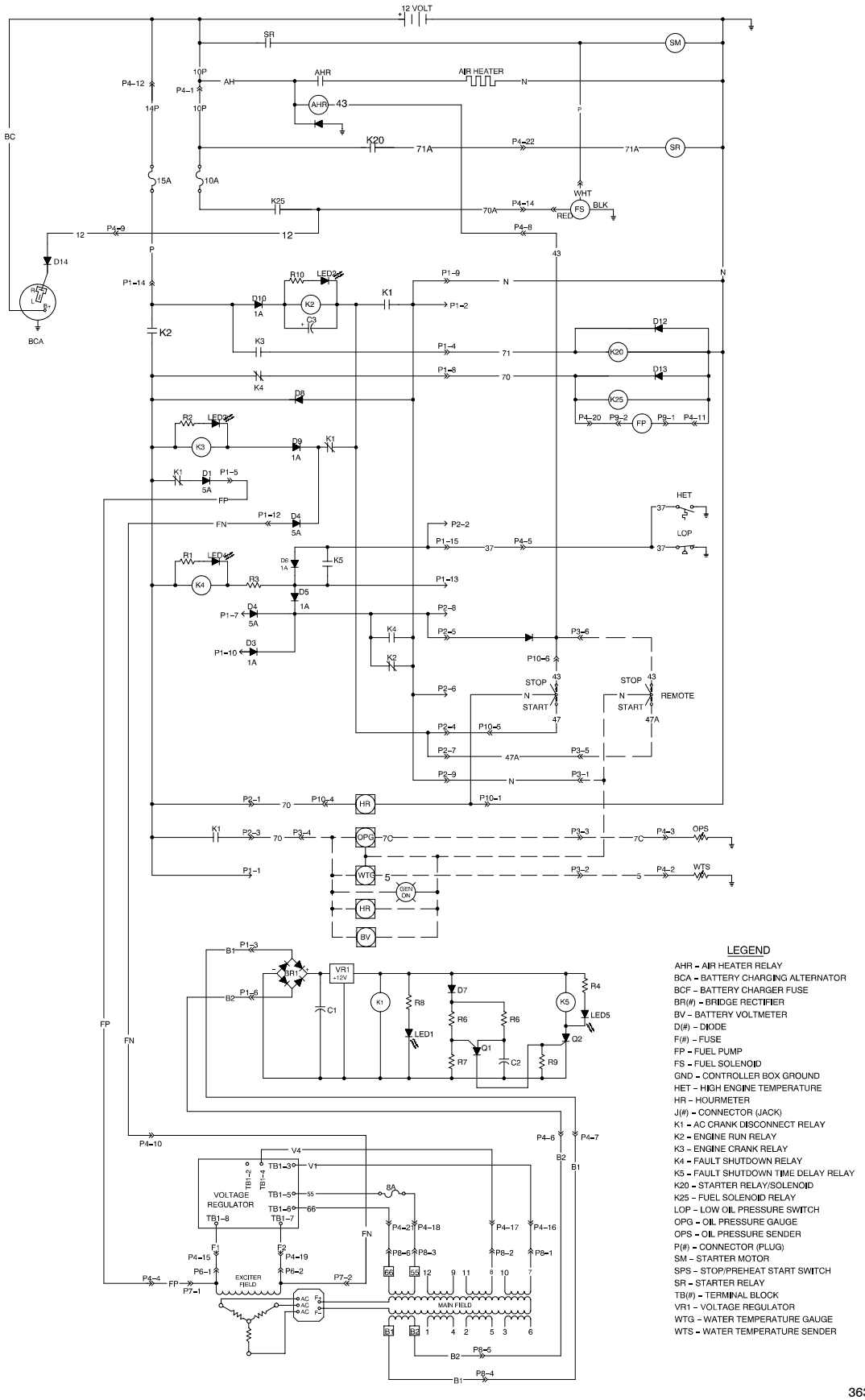
10.9 15/20EOR & 12.5/16.5EFOR w/ Brushes, Point-to-Point Wiring Diagram



10.1015/20EORZ & 12.5/16.5EFORZ w/Exciter, Schematic Wiring Diagram



LEGEND

AHR – AIR HEATER RELAY
BCA – BATTERY CHARGING ALTERNATOR
BCF – BATTERY CHARGER FUSE
BR(#) – BRIDGE RECTIFIER
BV – BATTERY VOLTMETER
D(#) – DIODE
F(#) – FUSE
FP – FUEL PUMP
FS – FUEL SOLENOID
GND – CONTROLLER BOX GROUND
HET – HIGH ENGINE TEMPERATURE
HR – HOURMETER
J(#) – CONNECTOR (JACK)
K1 – AC CRANK DISCONNECT RELAY
K2 – ENGINE RUN RELAY
K3 – ENGINE CRANK RELAY
K4 – FAULT SHUTDOWN RELAY
K5 – FAULT SHUTDOWN TIME DELAY RELAY
K20 – STARTER RELAY/SOLENOID
K25 – FUEL SOLENOID RELAY
LOP – LOW OIL PRESSURE SWITCH
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDER
P(#) – CONNECTOR (PLUG)
SM – STARTER MOTOR
SPS – STOP/PREHEAT START SWITCH
SR – STARTER RELAY
TB(#) – TERMINAL BLOCK
VR1 – VOLTAGE REGULATOR
WTG – WATER TEMPERATURE GAUGE
WTS – WATER TEMPERATURE SENDER

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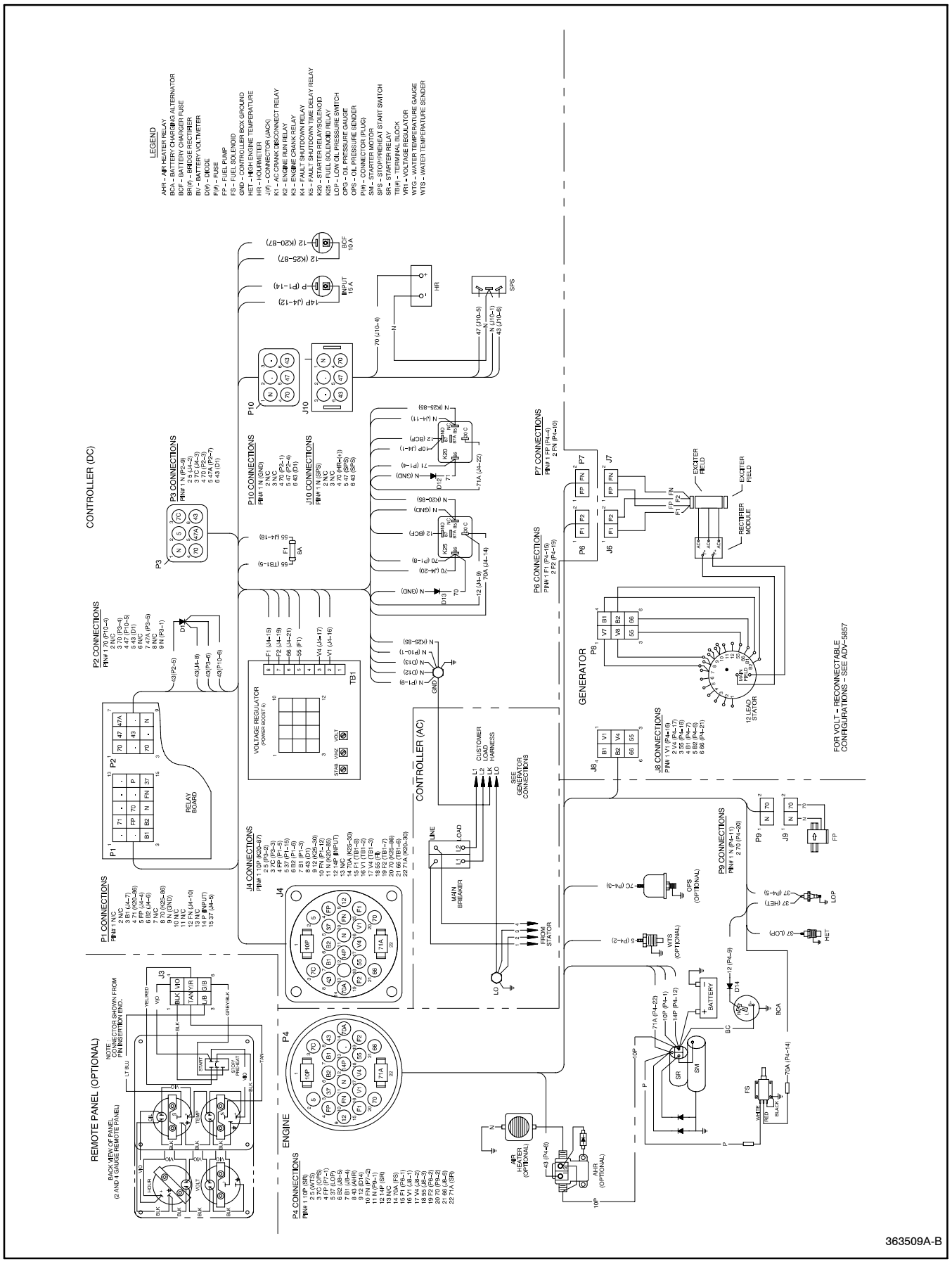
10.11 15/20EORZ & 12.5/16.5EFORZ w/Exciter, Point-to-Point Wiring Diagram



10.12 Four-Lead Reconnection

The following drawing illustrates the reconnection of four-lead generator sets. In all cases, follow the National Electrical Code (NEC) guidelines.

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.

100-120 Volt Configurations

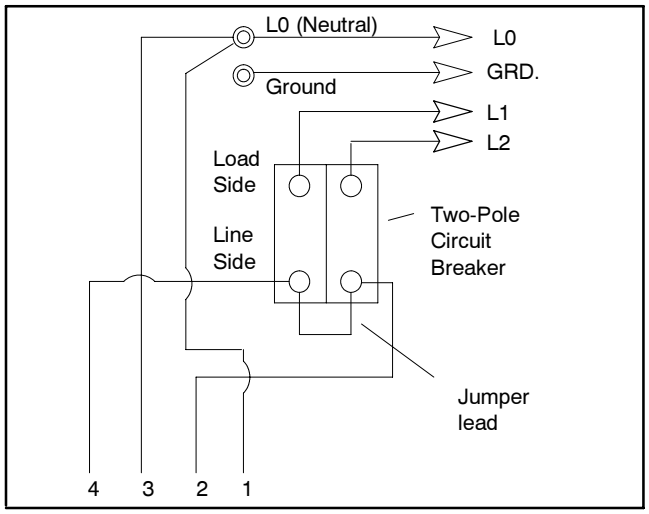


Figure 10-1 100-120 Volt, 3-Wire Configuration

If the installation requires a factory two-pole circuit breaker, do not connect the load-side terminals of the circuit breaker together; see Figure 10-1. If the installation requires a 100-120 volt, 2-wire system, use a single-pole circuit breaker. See Figure 10-2. When connecting stator phase leads together, size the output lead (L1) to handle the amperage. Use a jumper lead on the *line* side of the circuit breaker to balance the load of the generator set.

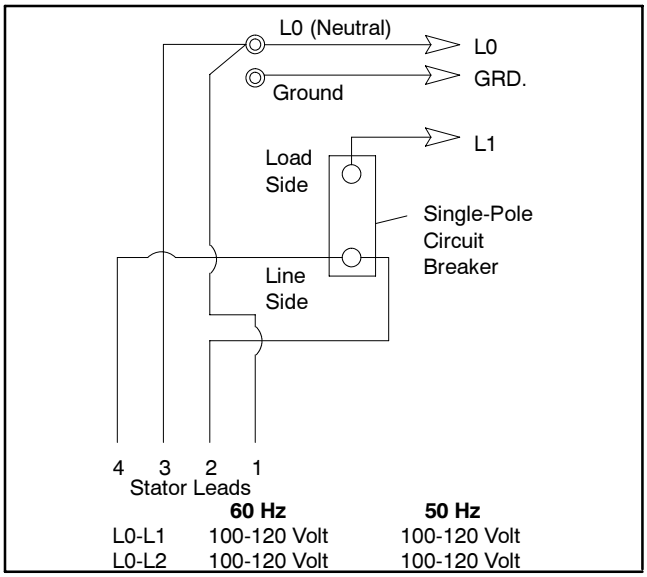


Figure 10-2 100-120 Volt 2-Wire Configuration

100-120/200-240 Volt Configurations

The 100-120/200-240 volt configuration does not use a jumper lead. If the unit was originally wired for straight 100-120 volt, 3 wire, remove the jumper lead (see Figure 10-1 for location). Select a two-pole circuit breaker. Application of two single-pole circuit breakers does not conform to NEC requirements for supplying a 200-240 volt load—even if the breakers are mechanically attached together. Leads L1 and L2 are for different phases—**never** connect them together.

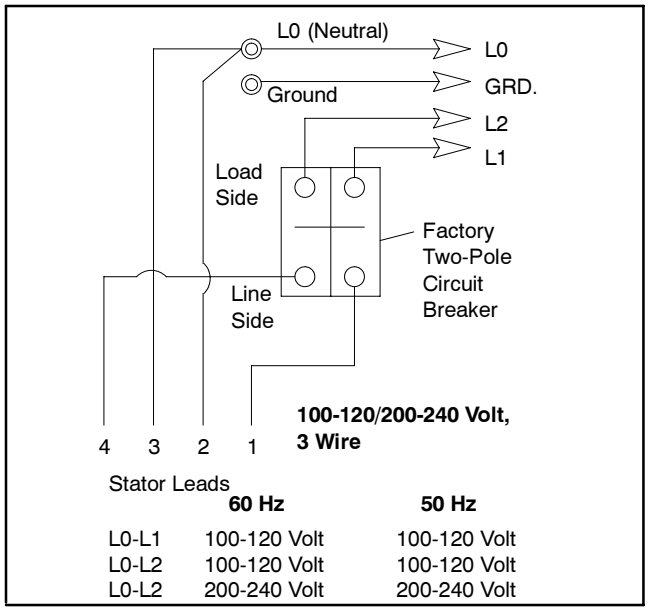


Figure 10-3 100-120/200-240 Volt 3-Wire Configuration

200-240 Volt Configurations

The 200-240 volt configuration does not use a jumper lead. If the unit was originally wired for straight 100-120 volt, 3 wire, remove the jumper lead (see Figure 10-1 for location).

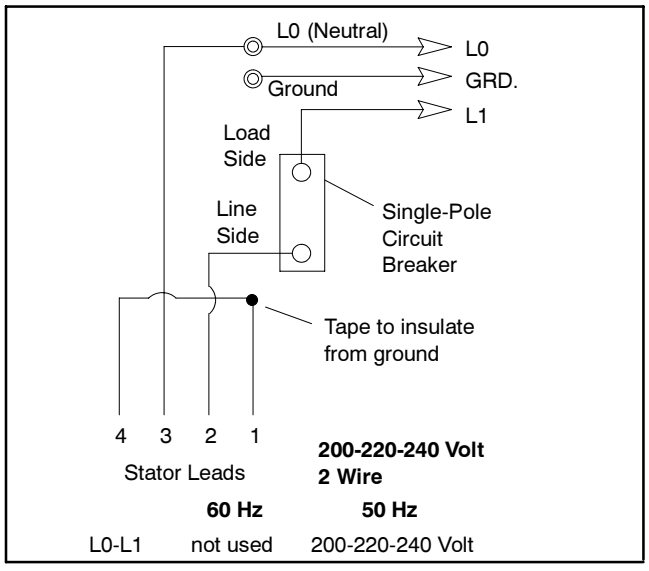


Figure 10-4 200-220-240 Volt 2-Wire Configuration

10.13 Twelve-Lead Reconnection

The reconnection procedure that follows details voltage reconnections only. If the generator set requires frequency changes, adjust the governor and voltage regulator. See the generator set service manual for information regarding frequency adjustment.

In all cases, follow National Electrical Code (NEC) guidelines.

Reconnect the stator leads of the generator set to change output phase or voltage. Refer to the following procedure and connection schematics. Follow all safety precautions at the front of this manual and in the text during reconnection procedure.

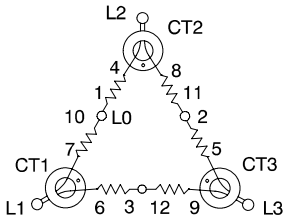
NOTICE

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.

Twelve-Lead Reconnection Procedure

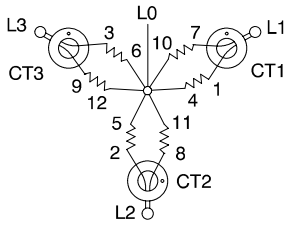
1. Move generator set start/stop switch to the STOP position.
2. Disconnect engine starting battery, negative (-) lead first. Disconnect power to battery charger, if equipped.
3. Use Figure 10-5 to determine generator set voltage configuration. Note original voltage and reconnect as needed.

3 PHASE DELTA, 4 WIRE



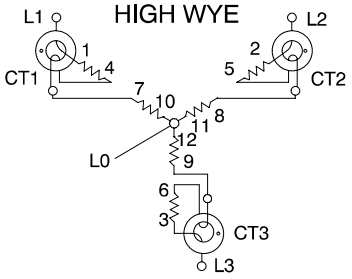
110/220 VOLT 50 HZ
120/240 VOLT 60 HZ

3 PHASE WYE, 4 WIRE
LOW WYE



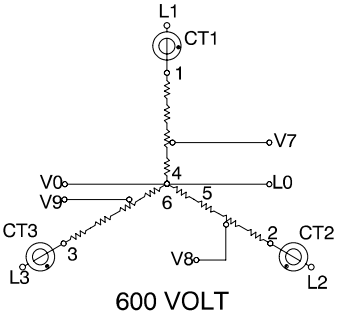
190–208 VOLT 50 HZ
208–240 VOLT 60 HZ

3 PHASE WYE, 4 WIRE
HIGH WYE



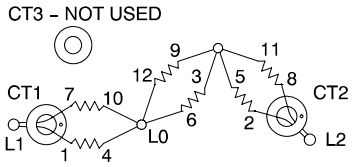
380–416 VOLT 50 HZ
416–480 VOLT 60 HZ

3 PHASE WYE 4 WIRE



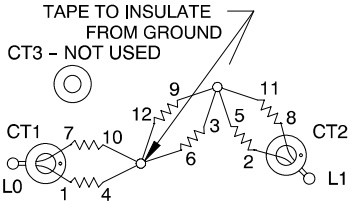
600 VOLT

SINGLE PHASE, 3 WIRE
SOME SETS NOT RATED FOR
SINGLE PHASE – SEE MANUALS



110/220 VOLT 50 HZ
120/240 VOLT 60 HZ

SINGLE PHASE, 2 WIRE
(MARINE ONLY)



220 VOLT 50 HZ
240 VOLT 60 HZ

Reconnection Notes

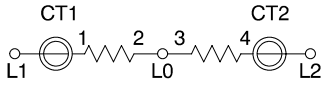
Note: Position the current transformers with the dot or HI side CT mark toward the generator set. Some generator sets have no current transformers.

Note: Phase Rotation: A = L1, B = L2, and C = L3.

Note: All 12-lead generator sets are reconnectable. The 6-lead, 600-volt generator set is not reconnectable. Some specially wound stators made for a single voltage are also not reconnectable.

EM-250000-G

SINGLE PHASE, 3 WIRE



(NOT RECONNECTABLE)

60 HZ 120/240V 1 PH. 3 WIRE
50 HZ 110/220V OR 115/230V
1 PH. 3 WIRE

Figure 10-5 Generator Reconnection

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	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
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
API	American Petroleum Institute
approx.	approximate, approximately
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
A/V	audiovisual
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
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
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)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
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)
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. lbs.	foot pounds (torque)
ft./min.	feet per minute
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 temperature
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. lbs.	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)

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
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/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
MCCB	molded-case circuit breaker
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
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
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
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
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
RTV	room temperature vulcanization
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
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, 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
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 General Torque Specifications and other torque specifications in the service literature.

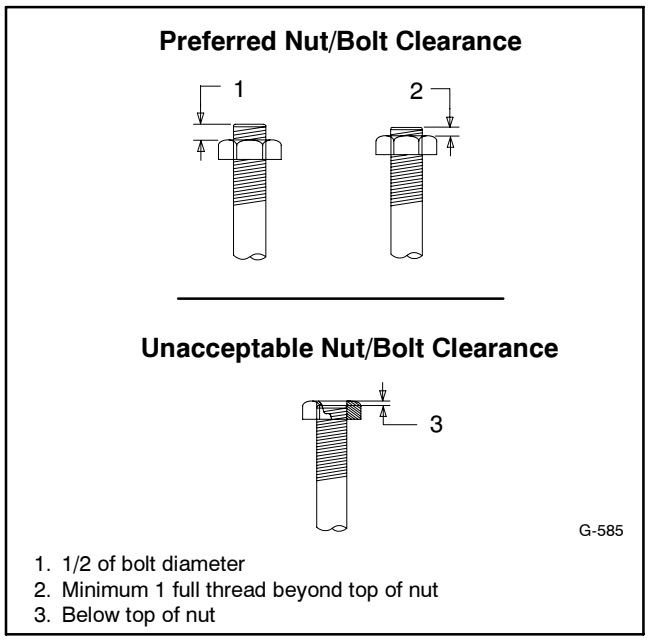


Figure 1 Acceptable Bolt Lengths

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 the diagram below.
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 the diagram below, which depicts the preceding hardware configuration possibilities.

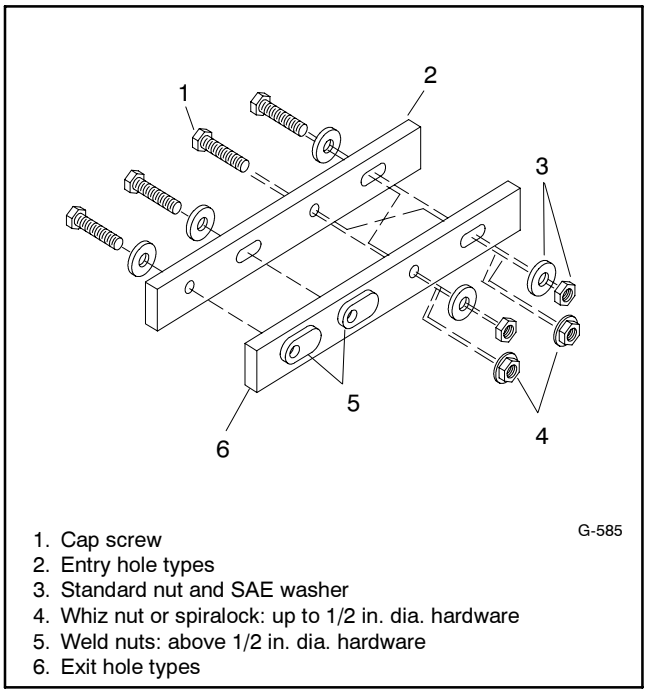


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

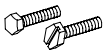
American Standard Fasteners Torque Specifications

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

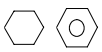
Metric Fasteners Torque Specifications, Measured in ft. lbs. (Nm)

Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum
	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	4 (5.6)	7 (9.9)	10 (14)	4 (5.6)
M8 x 1.25	10 (13.6)	18 (25)	26 (35)	10 (13.6)
M8 x 1.00	16 (21)	18 (25)	26 (35)	16 (21)
M10 x 1.50	20 (27)	35 (49)	50 (68)	20 (27)
M10 x 1.25	29 (39)	35 (49)	50 (68)	29 (39)
M12 x 1.75	35 (47)	61 (83)	86 (117)	—
M12 x 1.50	48 (65)	65 (88)	92 (125)	—
M14 x 2.00	55 (74)	97 (132)	136 (185)	—
M14 x 1.50	74 (100)	103 (140)	142 (192)	—
M16 x 2.00	85 (115)	148 (200)	210 (285)	—
M16 x 1.50	104 (141)	155 (210)	218 (295)	—
M18 x 2.50	114 (155)	203 (275)	288 (390)	—
M18 x 1.50	145 (196)	225 (305)	315 (425)	—

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)

M8-1.25 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		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
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
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
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 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
M931-10090-60	M10-1.50 x 90
M931-10100-60	M10-1.50 x 100
M931-12045-60	M12-1.75 x 45
M931-12050-60	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
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
M931-16090-60	M16-2.00 x 90
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
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

Hex Head Bolts (full thread)

Part No.	Dimensions
M933-04006-60	M4-0.70 x 6
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
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
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
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
M933-10012-60	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
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
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M933-12030-60	M12-1.75 x 30
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
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M933-16040-60	M16-2.00 x 40
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04020-20	M4-0.70 x 20
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12

Flat Head Machine Screws

M965A-05016-20	M5-0.80 x 16

Hex Nuts

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

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 bolt's hardness is grade 10.9.

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