

Service

Marine Generator Sets



Models:

5E/4EF

7.3E/6EF

KOHLER[®]
POWER SYSTEMS

ISO 9001
KOHLER
POWER SYSTEMS
NATIONALLY REGISTERED

TP-5986 4/03b

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
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
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_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

x:in:007:001a

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Safety Precautions and Instructions

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.**

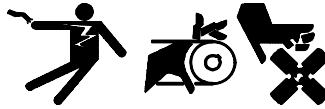
NOTICE

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

<p>Fire. Can cause severe injury or death.</p> <p>Do not smoke or permit flames or sparks near fuels or the fuel system.</p>


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 backfire flame arrester. A sudden backfire can cause severe injury or death. Do not operate the generator set with the backfire flame arrester removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel system. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Wipe up spilled fuels and engine oil.

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

<p>Carbon monoxide. Can cause severe nausea, fainting, or death.</p> <p>The exhaust system must be leakproof and routinely inspected.</p>

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

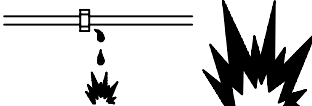
If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve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

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Consult the boat 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.

Operating the generator set. 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. Use the following precautions when installing and operating the generator set. Do not install the exhaust outlet where exhaust can be drawn in through portholes, vents, or air conditioners. If the generator set exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Never operate the generator set without a functioning carbon monoxide detector. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings. Avoid overloading the craft.

Fuel System

⚠ WARNING

<p>Explosion. Gasoline vapors can cause explosion and severe injury or death.</p> <p>Before starting the generator set, operate the blower 4 minutes and check the engine compartment for gasoline vapors.</p>

⚠ WARNING

<p>Explosive fuel vapors. Can cause severe injury or death.</p> <p>Use extreme care when handling, storing, and using fuels.</p>

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

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

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


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.

Installing the fuel system. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Do not modify the tank or the propulsion engine fuel system. Equip the craft with a tank that allows one of the two pickup arrangements described in the installation section. The tank and installation must conform to USCG Regulations.

Pipe sealant. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Use pipe sealant on all threaded fittings to prevent fuel leakage. Use pipe sealant that resists gasoline, grease, lubrication oil, common bilge solvents, salt deposits, and water.

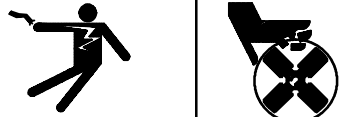
Ignition-protected equipment. Explosive fuel vapors can cause severe injury or death. Gasoline vapors can cause an explosion. USCG Regulation 33CFR183 requires that all electrical devices (ship-to-shore transfer switch, remote start panel, etc.) must be ignition protected when used in a gasoline and gaseous-fueled environment. The electrical devices listed above are not ignition protected and are not certified to operate in a gasoline and gaseous-fueled environment such as an engine room or near fuel tanks. Acceptable locations are the wheelhouse and other living areas sheltered from rain and water splash.


Hazardous Noise

⚠ CAUTION

<p>Hazardous noise. Can cause hearing loss.</p> <p>Never operate the generator set without a muffler or with a faulty exhaust system.</p>

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

<p>Hazardous voltage. Moving rotor. Can cause severe injury or death.</p> <p>Operate the generator set only when all guards and electrical enclosures are in place.</p>

⚠ CAUTION

<p>Welding the generator set. Can cause severe electrical equipment damage.</p> <p>Never weld components of the generator set without first disconnecting the battery, controller wiring harness, and engine electronic control module (ECM).</p>

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocutation is possible whenever electricity is present. Open 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.

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

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


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*)

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina 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 ship-to-shore transfer switch to prevent interconnection of the generator set power and shore 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.

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.	


⚠ WARNING	
	
Airborne particles. Can cause severe injury or blindness.	
Wear protective goggles and clothing when using power tools, hand tools, or compressed air.	

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 throbolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor throbolt 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.

Sound shield removal. Exposed moving parts can cause severe injury or death. The generator set must be operating in order to perform some scheduled maintenance procedures. Be especially careful if the sound shield has been removed, leaving the belts and pulleys exposed. *(Sound-shield-equipped models only)*

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

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Notes

This manual provides troubleshooting and repair instructions for 5E/4EF and 7.3E/6EF model generator sets, controllers, and accessories.

Refer to the engine service manuals (TP-6002 and TP-6008) for generator set engine service information.

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. Maintenance work must be performed by appropriately-skilled and suitably-trained maintenance personnel, familiar with generator set operation and service.

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

Africa, Europe, Middle East

London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Asia Pacific

Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

China

North China Regional Office, Beijing
Phone: (86) 10 6518 7950
(86) 10 6518 7951
(86) 10 6518 7952
Fax: (86) 10 6518 7955

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

India, Bangladesh, Sri Lanka

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

Japan, Korea

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

Latin America

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

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Routine Service Parts

The following table contains a list of recommended spare parts. Contact your Kohler generator distributor/dealer for a complete list of service parts for your generator set.

Part Description	Part Number
Battery Charging Fuse (25 amp)	262389
Input Fuse (10 amp)	223316
Oil Filter	359771
Seawater Pump Impeller Kit	359978
Spark Plug For Engine Model AS 04	359796
Spark Plug For Engine Model BS 04	359979
Spray Paint (White)	221335
Touch-Up Paint (White)	GM19490
Voltage Regulator Fuse (10 amp)	223316
Zinc Anode	267928

List of Related Literature

The following table identifies literature available for the generator sets covered in this manual. Only qualified persons should install or service the generator set.

Literature Type	Part Number
Installation Manual	TP-5982
Operation Manual (Generator)	TP-5985
Operation Manual (Engine)	TP-6001
Parts Catalog*	TP-5987
Service Manual (Generator)	TP-5986
Service Manual (Engine)	TP-6002
Service Manual Supplement (Engine)	TP-6008

* One manual combines Generator and Engine information.

Notes

1.1 General

The 7.3E/6EF and 5E/4EF units are powered by a two-cylinder, water-cooled, four-cycle gasoline engine with heat exchanger.

Kohler Co. develops all Kohler marine generator set ratings using accepted reference conditions of 25°C (77°F) and pressure of 99 kPa (29.2 in. Hg) dry barometer. ISO 3046 and ISO 8528-1 include reference conditions and output calculations. Obtain technical information bulletin (TIB-101) on ratings guidelines for complete ratings definitions.

1.2 Engine

Generator Model	7.3E/6EF	5E/4EF
Engine manufacturer	Kawasaki	
Engine model	FD501D	
Number of cylinders	2	
Cylinder block material	Aluminum	
Cylinder head material	Aluminum	
Piston rings	2 compression/1 oil	
Governor	Gear driven centrifugal	
Bore x stroke, mm (in.)	67 (2.64) x 62 (2.44)	
Displacement, L (CID)	0.4 (26.7)	
Compression ratio	9.3:1	
Horsepower, 60/50 Hz	16	13.8
RPM, 60/50 Hz	3600	3000
Lubrication system	Pressure; mechanical	
Lube oil capacity, L (U.S. qts) (w/filter)	1.36 (1.44)	
Low oil pressure shutdown, kPa (psi)	96.5 (14)	
Oil recommendation (API)	SC, SD, SE, SF, SG, SH, or SJ	
Battery voltage	12 volt (standard)	
Battery recommendation, minimum	260 CCA	
Battery charging	15 amps	
Starter motor	Bendix automotive type	

1.3 Fuel

Fuel recommendation	Unleaded 87 octane
Fuel pump	Electric
Fuel pump operating, kPa (psi)	13.8-24.1 (2.0-3.5)
Fuel filter inlet hose, mm (in.) ID	6.35 (0.25)

1.4 Cooling

Recommended coolant	50% ethylene glycol; 50% clean, softened water
Coolant capacity L (U.S. qts.) (approx.)	2.84 (3.0)
Thermostat, °C (°F)	91 (195)
Pressure cap rating, kPa (psi)	97 (14)
High temperature shutdown, °C (°F)	111 (232)
High exhaust temperature shutdown, °C (°F)	102 (215)
Inlet water line hose ID, (seawater pump inlet), mm (in.)	19 (0.75)
Outlet water line hose ID, (mixing elbow outlet), mm (in.)	51 (2.00)
Max. water pump inlet pressure, kPa (psi)	34.5 (5.0)

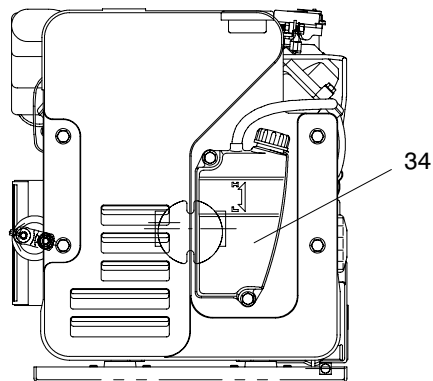
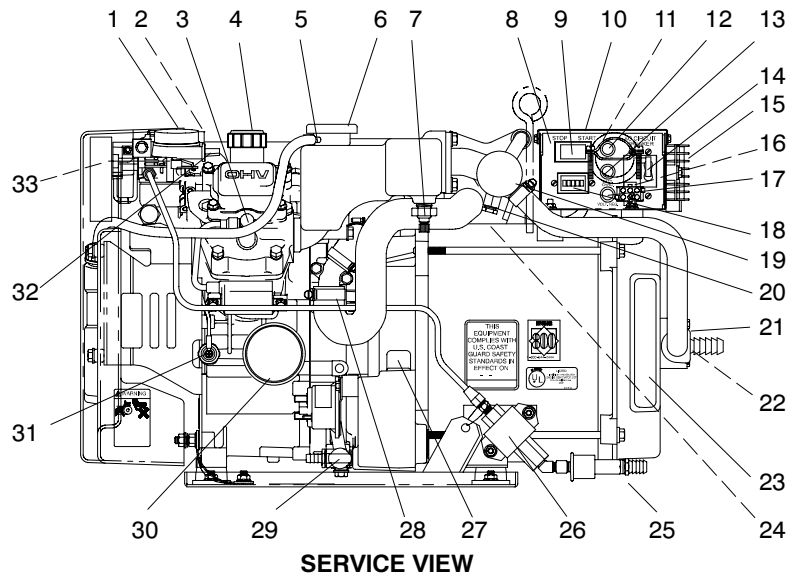
1.5 Generator

Component Specification	Value
Rotor field voltage/current readings at rated voltage (hot)	
No load (63 Hz) (volts/amps)	13/3.82
Full load (60 Hz) (volts/amps)	47/13.82
Cold main field (rotor) resistance (ohms)	3.4
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)	
1-2, 3-4, 33-44 (VAC)	145
55-66 (VAC)	190
B1-B2 (VAC)	14
Cold stator resistance	
1-2, 3-4, 33-44 (ohms)	0.16
55-66 (ohms)	1.70
B1-B2 (ohms)	0.05

1.6 Torque

Component	Torque Nm (in. lbs.)
Rotor bolt	23.1 (204)
Generator overbolts	13.6 (120)
Mounting plate to end bracket bolts	6.8 (60)
Lift eye bolts	19.0 (168)
Generator adapter to engine bolts	14.9 (132)
Engine oil drain boss (inside generator adapter)	47.5 (420)
Generator adapter to exhaust manifold	13.6 (120)
High exhaust temp. switch	13.6 (120)
Spark plugs	12-17 (106-150)
Bolts that hold the coverplate over the impeller	3.4 (30)

1.7 Service Views



ADV-6395-A
GY-250000-A

- | | |
|--|---|
| 1. Electric choke (on carburetor) | 18. Hourmeter |
| 2. Carburetor/choke linkage | 19. Heat exchanger |
| 3. Spark plug (also one on nonservice side) | 20. Anticorrosion zinc anode |
| 4. Oil fill | 21. Seawater drain (remove zinc anode) |
| 5. Overflow tube | 22. Seawater pump (water inlet) |
| 6. Pressure cap (coolant fill location after draining coolant) | 23. Cooling air inlet |
| 7. High water temp. switch | 24. High exhaust temp. switch on mixing elbow (nonservice side) |
| 8. Controller | 25. Fuel filter (fuel inlet) |
| 9. Start/Stop switch | 26. Fuel feed pump |
| 10. Nameplate (top) | 27. Oil check |
| 11. AC load lead connector (nonservice side) | 28. Coolant drain (remove hose clamp to drain coolant) |
| 12. Input fuse | 29. Oil drain valve |
| 13. Battery charging fuse | 30. Lube oil filter |
| 14. AC circuit breaker | 31. Low oil pressure switch |
| 15. Voltage regulator | 32. Antidieseling solenoid (on carburetor) |
| 16. Remote start connector (nonservice side) | 33. Air intake silencer/backfire flame arrestor |
| 17. Voltage regulator fuse | 34. Coolant overflow bottle (daily coolant check/fill location) |

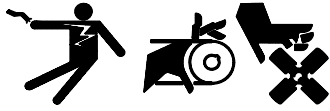
Figure 1-1 Service Views

Notes

Section 2 Scheduled Maintenance

2.1 General

⚠ WARNING

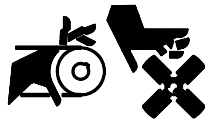


Accidental starting.
Can cause severe injury or death.

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



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.

Sound shield removal. Exposed moving parts can cause severe injury or death. The generator set must be operating in order to perform some scheduled maintenance procedures. Be especially careful if the sound shield has been removed, leaving the belts and pulleys exposed.
(Sound-shield-equipped models only)

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Note: See the generator set operation manual for the service schedule and other service not included in this manual.

2.2 Lubrication System

Use oil that meets the American Petroleum Institute (API) classification of SC, SD, SE, SF, SG, SH, or SJ. Using unsuitable oil or neglecting an oil change may result in engine damage that is not covered by the engine warranty. Figure 2-1 shows the recommended Society of Automotive Engineers (SAE) viscosity designation for given operating temperature ranges.

Do not mix different oil brands. Incompatibility could cause a breakdown of lubricating ingredients and reduce engine protection.

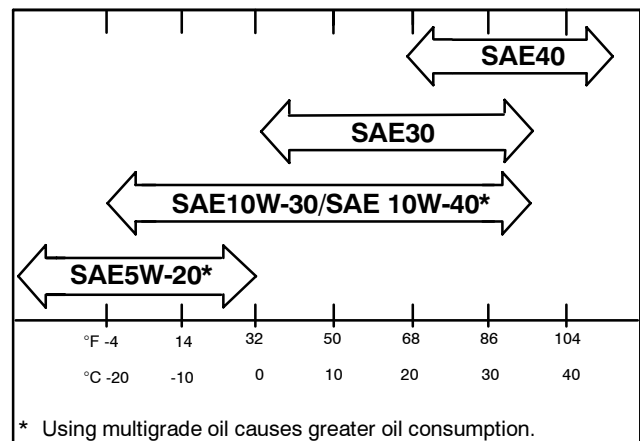


Figure 2-1 Recommended SAE Viscosity Grades

Notes

Section 3 Intake and Exhaust System

3.1 Backfire Flame Arrestor

At the interval specified in the service schedule, inspect, clean or replace the backfire flame arrestor. Check the wire mesh screen for accumulated oil or dirt that could clog the element and cause poor performance. See Figure 3-1.

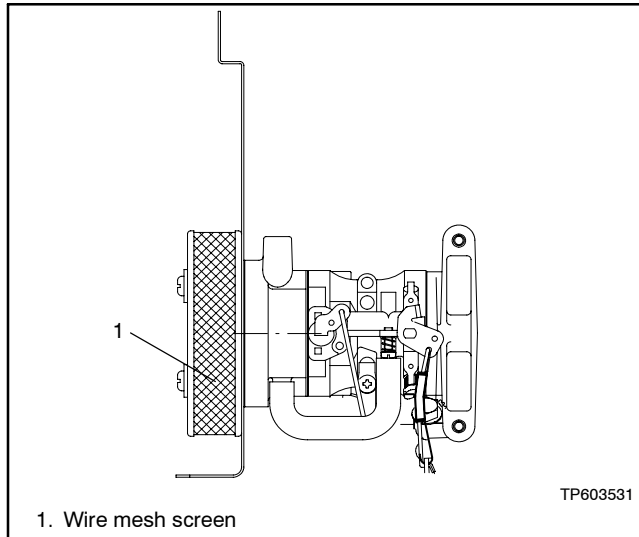
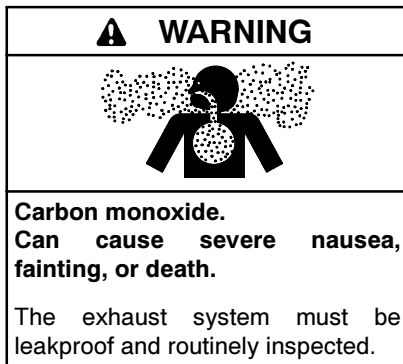


Figure 3-1 Air Intake

3.2 Exhaust



Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Consult the boat 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 silencer and piping condition and check for tight exhaust system connections.

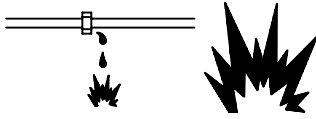
Inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust line, hose clamps, silencer, and outlet flapper) for cracks, leaks, and corrosion.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps 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(s) is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

Note: Never operate the generator set without a functioning carbon monoxide detector.

Notes

⚠ WARNING



**Explosive fuel vapors.
Can cause severe injury or death.**

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

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

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

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

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.

4.1 General

In most installations, both the generator set and the vehicle's engine operate from a common fuel tank with a dual dip tube arrangement. The generator set's dip tube may be shorter than the vehicle engine's dip tube. With this arrangement, fuel may not be available to the generator set when the fuel supply is low. See Figure 4-1 for fuel system schematic.

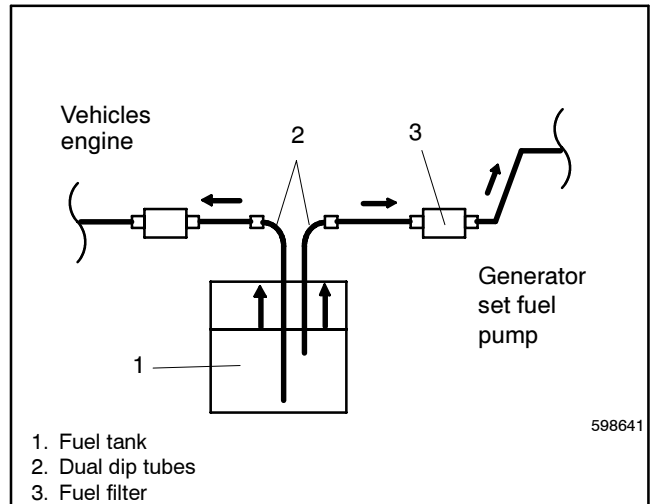


Figure 4-1 Fuel System Schematic Typical

4.2 Float Bowl Vent System

The float bowl vent system prevents fuel from overflowing into the bilge. In the event of an overflowing float bowl due to a sticking float valve, the float bowl vent tube redirects the unused fuel back into the intake per USCG regulations. Check for fuel leakage at the backfire flame arrestor for troubleshooting an overflowing float bowl.

4.3 Fuel Pump and Filter

Electric fuel pumps draw gasoline from the fuel tank, through a filter, and supply clean gasoline at the proper pressure and quantity to the generator set engine carburetor.

4.4 Fuel Pump Troubleshooting

The fuel pump transfers fuel from a source to the carburetor.

Fuel Pump Test Procedure

1. Connect the inlet side of the pump to a fuel source.
2. Disconnect the outlet hose from the fuel filter and place the end in a container to catch the fuel.
3. Disconnect the P9 connector.
4. Connect the positive (70) terminal of the fuel pump to the positive (+) terminal of a 12-volt battery.
5. Connect the negative (N) terminal of the fuel pump to the negative (-) terminal of the battery. The pump should operate and fuel should discharge from the pump outlet. If the pump does not operate, replace the pump.

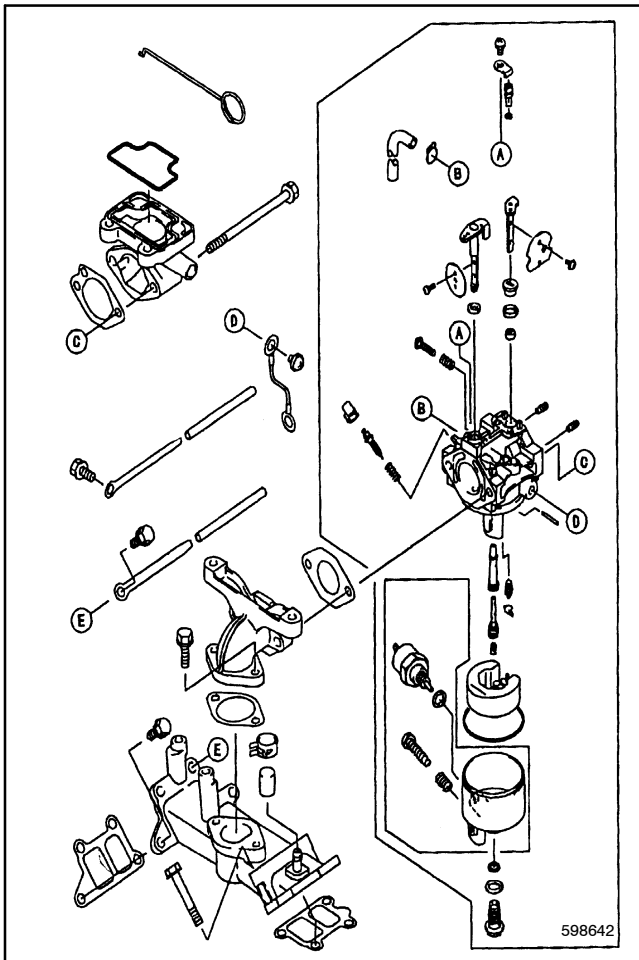


Figure 4-2 Fuel System Exploded View

4.5 Carburetor Troubleshooting

This section is for fuel-related problems only. Use for basic carburetor troubleshooting.

Note: When troubleshooting the fuel system, it is important to have an adequate fuel supply.

A lean or rich fuel condition can reduce power output and cause poor acceleration.

Symptoms of a Lean Condition:

- Hard starting
- Stalling
- Rough idle
- Surging above idle

Symptoms of a Rich Condition:

- Hard starting
- Stalling
- Rough idle
- Percolation
- Flooding
- Leaking carburetor

4.5.1 Hard Starting

A flooded engine, improperly adjusted or inoperative choke, dirty carburetor (lean condition), or improper idle fuel mixture can cause hard starting.

4.5.2 Stalling

Improper idle air/fuel mixture or a dirty carburetor can cause stalling. Clogged idle air bleeds, idle air passages, or an idle discharge port can cause stalling because of a lean condition. Clean or adjust the carburetor.

4.5.3 Flooding

Flooding occurs from a float level set too high, improperly adjusted fuel pressure, improperly installed fuel pump, a sticking choke plate or float, or a fuel inlet needle held off its seat either by improper seating or dirt particles. A punctured or leaking float admitting fuel becomes gas-logged causing a heavy float, high fuel level, and flooding.

If flooding occurs, disassemble the carburetor, observe the operation and condition of components, and repair or replace components as necessary.

4.5.4 Hunting

A low fuel level because of an improperly adjusted float, a clogged main jet, restricted main jet passages, or an improperly sized main jet for the application can cause hunting. Clean, adjust, or replace inoperative components.

An incorrect throttle linkage adjustment, a binding throttle linkage, a sticking throttle shaft, or a loose throttle shaft in the throttle body or bore can cause inconsistent idle speed.

4.5.5 Leaking Carburetor

Loose fuel connections, a cracked carburetor body, a sticking fuel inlet needle, or an inoperative float can cause a leaking carburetor. Adjust, repair, or replace the affected components.

4.6 Governor 60 Hz to 50 Hz Conversion

Governors are adjusted at the factory and further adjustments should not be necessary.

Note: Never tamper with the governor settings to increase the generator output. Overspeeding can cause equipment parts to exceed design limitations, resulting in component failure.

Governor 60 Hz to 50 Hz Conversion Procedure

1. Change the spring to the 50 Hz position. See Figure 4-3.
2. Adjust the generator frequency using a frequency meter. Set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation.
3. Replace the governor speed adjusting bolt. The 50 Hz bolt is X-6284-7 and is 65 mm long. The 60 Hz bolt is M933-5050-60 and is 50 mm long.
4. Adjust the voltage regulator volt/Hz rolloff point. Refer to Section 7.2.2.

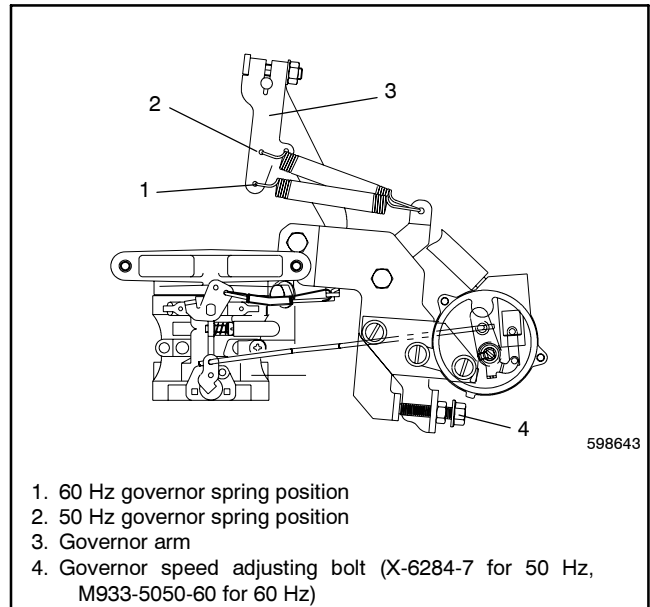


Figure 4-3 Governor 60 Hz to 50 Hz Conversion

Notes

5.1 General

The heat exchanger cooling system consists of a heat exchanger with a coolant recovery tank, a thermostat, a rubber impeller seawater pump, a centrifugal-type

engine circulating pump, a water-cooled exhaust manifold, and an exhaust mixer. See Figure 5-1 for cooling system components.

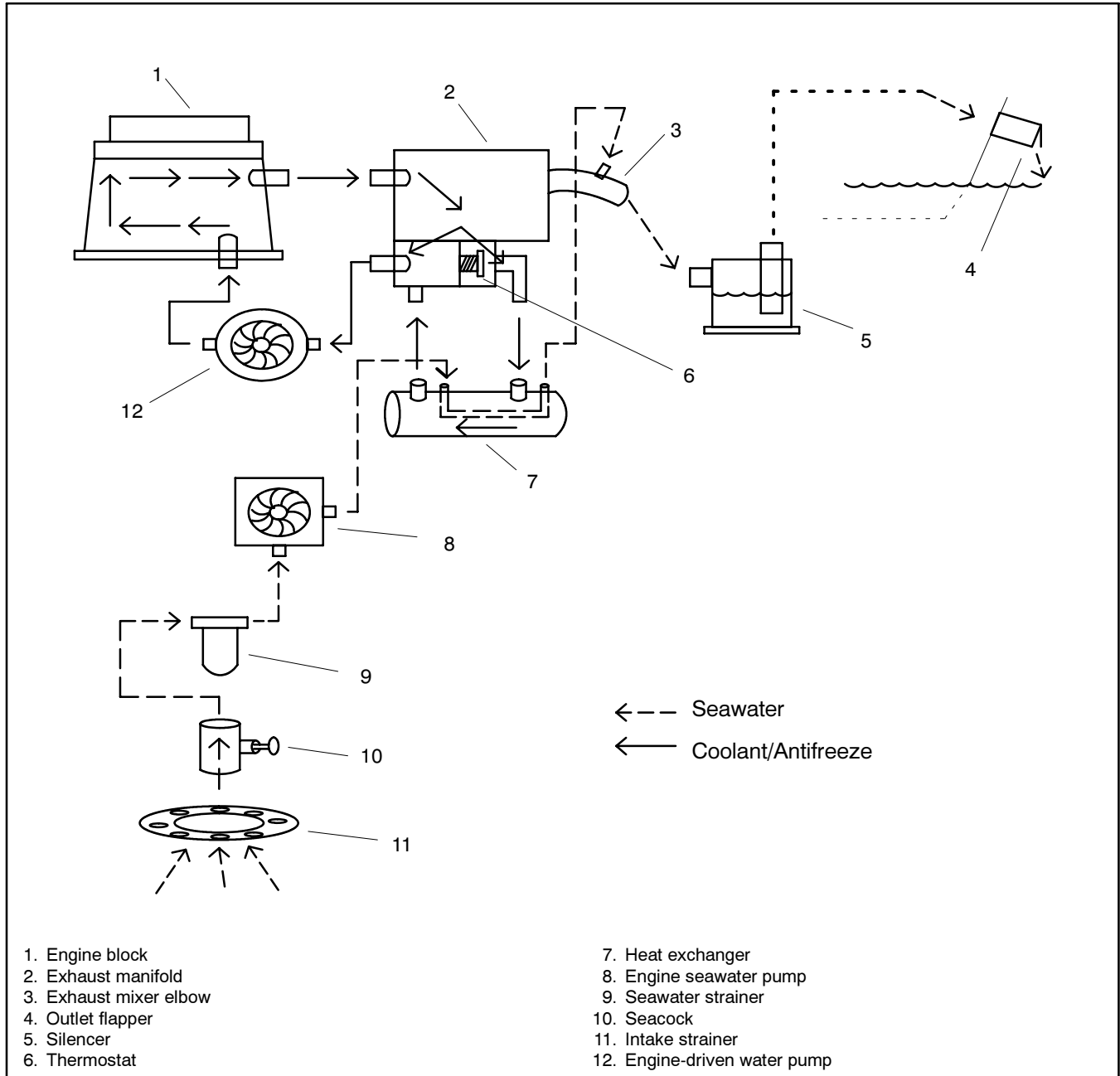
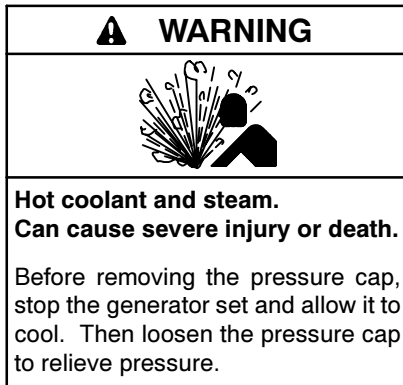


Figure 5-1 Cooling System Components

5.2 Closed Heat Exchanger

In a closed cooling system, the seawater circulates through separate chambers within the heat exchanger to cool the engine water. The seawater then mixes with the engine exhaust and ejects out of the exhaust outlet. The cooling capacity for the 5/7.3E and 4/6EF is 2.84 L (3.0 qts.). The capacity of the recovery tank is an additional 0.24 L (8.0 oz.).



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.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

5.3 Check and Fill Coolant

Keep the coolant recovery tank approximately 1/4 full. Before filling the cooling system, close all petcocks and tighten all hose clamps. Use a solution of 50% ethylene glycol and 50% clean, softened water to inhibit rust and corrosion and to prevent freezing. Add additional coolant mixture, as necessary, to the coolant recovery tank. Periodically check the coolant level on closed systems 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.

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.

Note: Coolant solution. 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 with less than 50% ethylene glycol may not provide adequate freezing and overheating protection. A coolant solution with 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. Consult the engine manufacturer's operation manual for engine coolant specifications.

5.4 Flush and Clean Cooling System

For optimum protection, drain, flush, and refill the cooling system at the interval listed in the operation manual's service schedule.

Pay special attention to the coolant level. Check the coolant level as described earlier.

Flush and Clean Procedure

1. Remove the hose clamp at the coolant hose. See Section 1 for location.
2. Remove the pressure cap to simplify draining.
3. Drain, clean, and flush the coolant recovery tank.
4. Flush the system with clean water.
5. Replace the hose clamp to secure the coolant hose.
6. Fill the cooling system with the recommended coolant.
7. Bleed the air from the cooling system.
8. Replace the pressure cap.

5.5 Impeller

This model uses a direct-driven seawater pump located on the generator end. Check and change the seawater pump impeller at the interval specified in the service schedule. Follow the instructions included with the impeller kit. If the instructions are not included with the kit, use the following procedure.

Impeller Inspection/Replacement Procedure

1. Close the seacock.
2. Remove the seawater pump coverplate. See Figure 5-2.
3. Remove the impeller.
4. Inspect the impeller for damaged, cracked, broken, missing or flattened vanes. The impeller vanes should be straight and flexible. See Figure 5-3. Replace the impeller if it is damaged.

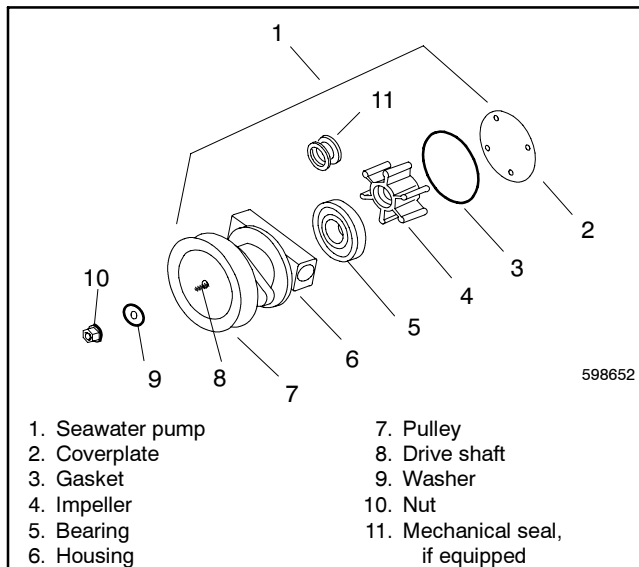


Figure 5-2 Seawater Pump, Typical

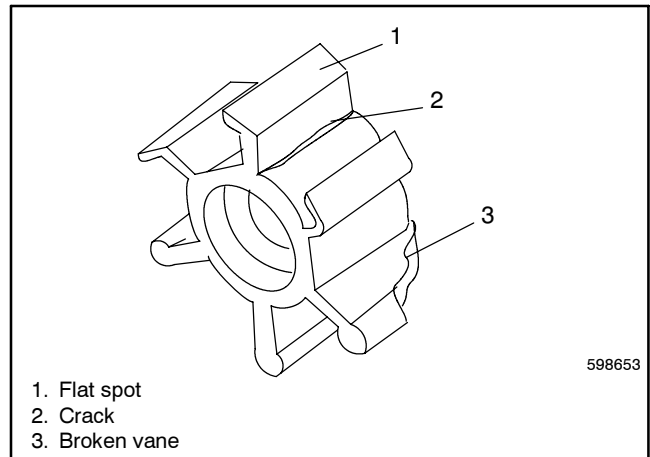


Figure 5-3 Worn Impeller

Note: Impeller pieces can cause blockage and overheating. Locate and remove all missing impeller pieces from the cooling system.

5. Lubricate the impeller with soapy water before installation.
6. While installing the impeller, always rotate the drive shaft and the impeller together in the same direction as the engine rotation.
7. Inspect the coverplate and gasket for corrosion and/or damage. Replace components as necessary.
8. Lubricate the gasket with petroleum jelly and install the gasket and coverplate to the seawater pump housing.
9. Open the seacock.
10. Start the generator set and check for leaks.
11. Stop the generator set and repair leaks or replace components as necessary.

5.6 Siphon Break

A siphon break prevents seawater entry into the engine when the engine exhaust manifold outlet is less than 23 cm (9 in.) above waterline. Check the siphon break at the interval listed in the service schedule. Use the following procedure and Figure 5-4 to ensure correct functioning of the siphon break.

Siphon Break Inspection Procedure

1. Stop the generator set.
2. Remove the retaining cap and the reed valve for inspection. See Figure 5-4.
3. Use a light detergent to clean the reed valve.

4. Check that the reed valve opening is clear.
5. Replace the siphon break if it is cracked or if the reed valve material has hardened or deteriorated.
6. Install the reed valve downward into the mounting base.
7. Install the retaining cap and finger-tighten only. Do not overtighten.
8. Restart the generator set and inspect the reed assembly for leaks. Replace the reed valve if leakage occurs.

Note: Consult the installation manual for a complete explanation of the dimensions and other installation considerations.

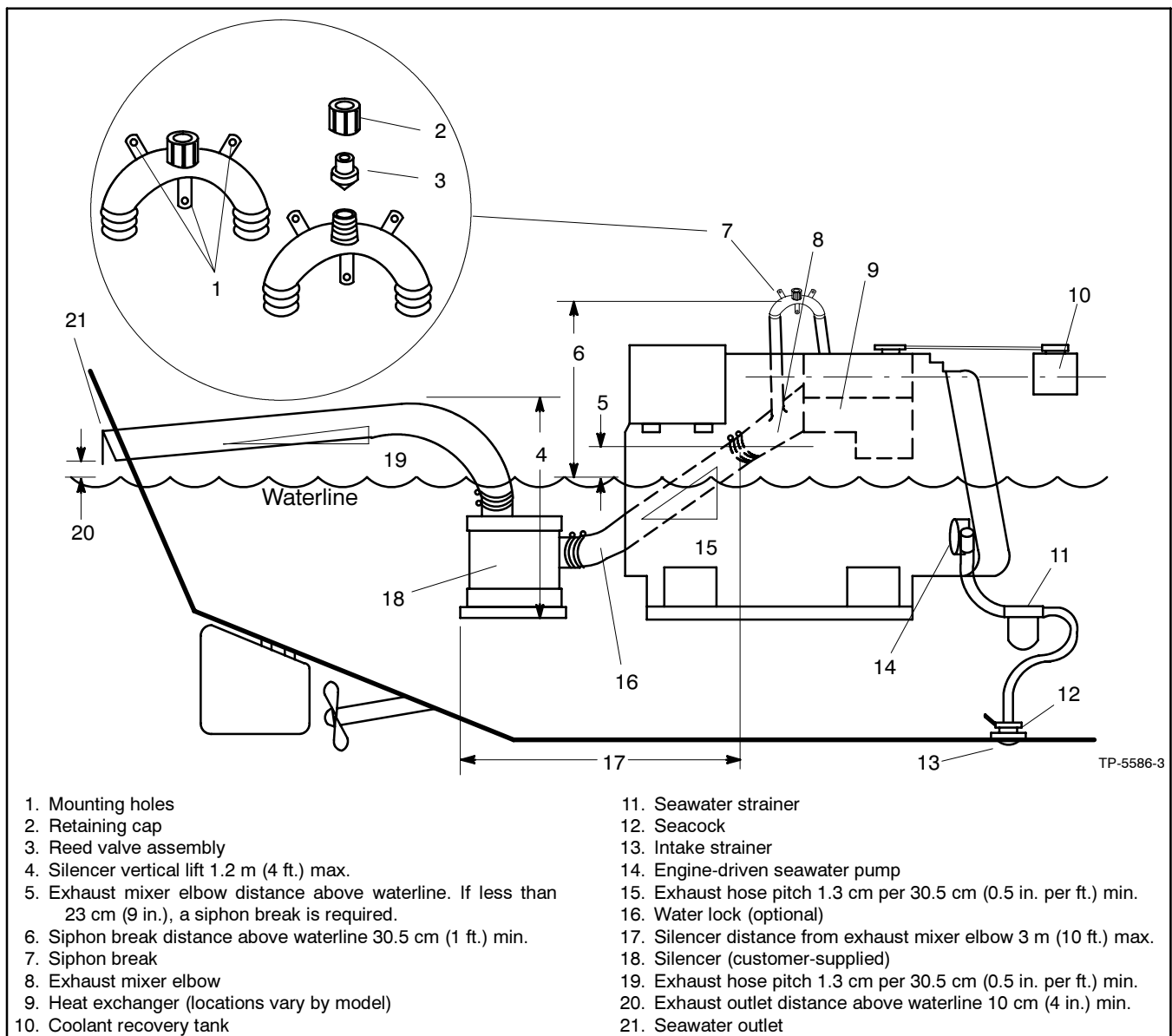


Figure 5-4 Siphon Break, Plastic "U" Type

5.7 Anticorrosion Zinc Anode

The heat exchanger contains an anticorrosion zinc anode (plug) to prevent electrolytic corrosion by seawater.

Check and replace the zinc anode at intervals recommended by the operation manual's service schedule.

Anticorrosion Zinc Anode Replacement Procedure

1. With the generator set cooled, close the seacock, remove the zinc plug from the heat exchanger, and drain the coolant into a container.
2. Remove the corrosion on the zinc anode. Replace the anode when the percent of the zinc remaining is less than 50% of the length and diameter shown in Figure 5-5.
3. Clean the threaded opening of the heat exchanger and coat the threads of the zinc anode with pipe sealant suitable for marine applications.

4. Install the zinc anode into the heat exchanger.
5. Open the seacock.
6. Refill the cooling system.
7. Start the generator set and check for leaks at the zinc anode location. The pump is operating if cooling water flows from the exhaust outlet. If water is not discharging at the exhaust outlet, stop the generator set. For seawater pump priming, see the Prestart Checklist in the operation manual.

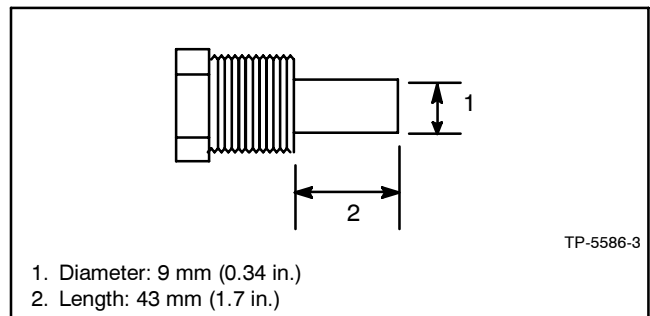


Figure 5-5 Anticorrosion Zinc Anode (Plug)

5.8 Generator Storage

Perform the generator storage procedure while the craft is afloat. Follow the procedure below when storing your generator set for 3 months or more.

Generator Storage Procedure

1. Add fuel stabilizer to the fuel tank of gasoline-powered generator sets. Follow the fuel stabilizer manufacturer's recommendation.
2. Start and run the generator set until it reaches operating temperature; about 30 minutes.
3. Stop the generator set.
4. Change the oil and oil filter. See the operation manual.
5. Drain the seawater from the heat exchanger by removing the seawater zinc anode. See Section 1.7, Service Views, for location.
6. Close the seacock and remove the hose at the seacock. Place the hose in a container having approximately 3.7–7.5 L (1–2 gal.) of marine antifreeze. Kohler Co. recommends using an environmentally friendly potable antifreeze such as Peak® RV/marine propylene glycol/water mix or equivalent.
7. With a container at the exhaust outlet, run the generator set until coolant discharges at the exhaust outlet or until depleting the coolant mixture. Do not allow the coolant mixture to flow into waterways.
8. Stop the generator set.
9. Connect the hose to the seacock. Leave the seacock closed.
10. Check the coolant level of the heat exchanger and add coolant if necessary.
Note: Use antifreeze with the lowest available temperature rating.
11. Clean the exterior of the generator set and spread a light film of oil or silicon spray over any exposed surfaces which may be subject to rust or corrosion.
12. Remove the spark plugs.
13. Pour one tablespoon of engine oil into each spark plug hole.
14. Toggle the generator set start/stop switch to crank the engine two or three revolutions to lubricate the cylinders.
15. Reinstall the spark plugs and torque them to specifications.
16. Disconnect and remove the battery. Place the battery in a dry location for the storage period. Recharge the battery once a month to maintain a full charge.
17. Cover the entire unit with a breathable dust cover.

Section 6 Controller Troubleshooting

6.1 Sequence of Operation

This section describes the controller sequence of operation during the generator start, run, stop, and fault shutdown modes and describes the relay testing procedures. Use this section as a starting point for controller fault identification. Use the LEDs on the controller circuit board to assist in the troubleshooting process. An illuminated LED indicates that the respective relay is receiving power; the LED does not indicate whether that relay is energized or working properly.

6.1.1 Start

Close the start/stop switch between N and 47 (local or remote).

The K2 relay energizes and LED2 is illuminated. The normally-open K2 contacts close to energize the K3 relay (LED3 lights), fuel pump (FP), choke heater (CHTR), antidiessel solenoid (ADS), ignition (IGN), and hourmeter (HR).

Flashing of the main field occurs when the K2 contacts close.

The normally-open K3 contacts close to energize the K20 relay. The normally-open K20 contacts close, energizing the starter relay and the starter motor.

Note: The normally-closed LOP contacts open when the engine builds oil pressure. This may take a few seconds after engine cranking is initiated.

6.1.2 Run

The bridged rectifier (BR1) receives AC voltage (12-15 volts) through the B1 and B2 windings of the stator.

The K1 relay energizes (LED1 lights).

The normally-open K1 contacts close to maintain voltage to the K2 relay, allowing the function of the fuel pump (FP), choke heater (CHTR), antidiessel solenoid (ADS), ignition (IGN), hourmeter (HR), and the remote panel gauges.

The normally-closed K1 contacts open, ending the flashing by preventing battery voltage to the main field (+) and (-).

The K6 relay energizes. The normally-open K6 contacts close, latching itself on. The normally-closed K6 contacts open, preventing inadvertent starter engagement by disabling the the K3 relay.

The K3 relay is deenergized (LED3 Off). The K3 contacts open, deenergizing the K20 relay. The K20 contacts open, deenergizing the starter relay and starter motor.

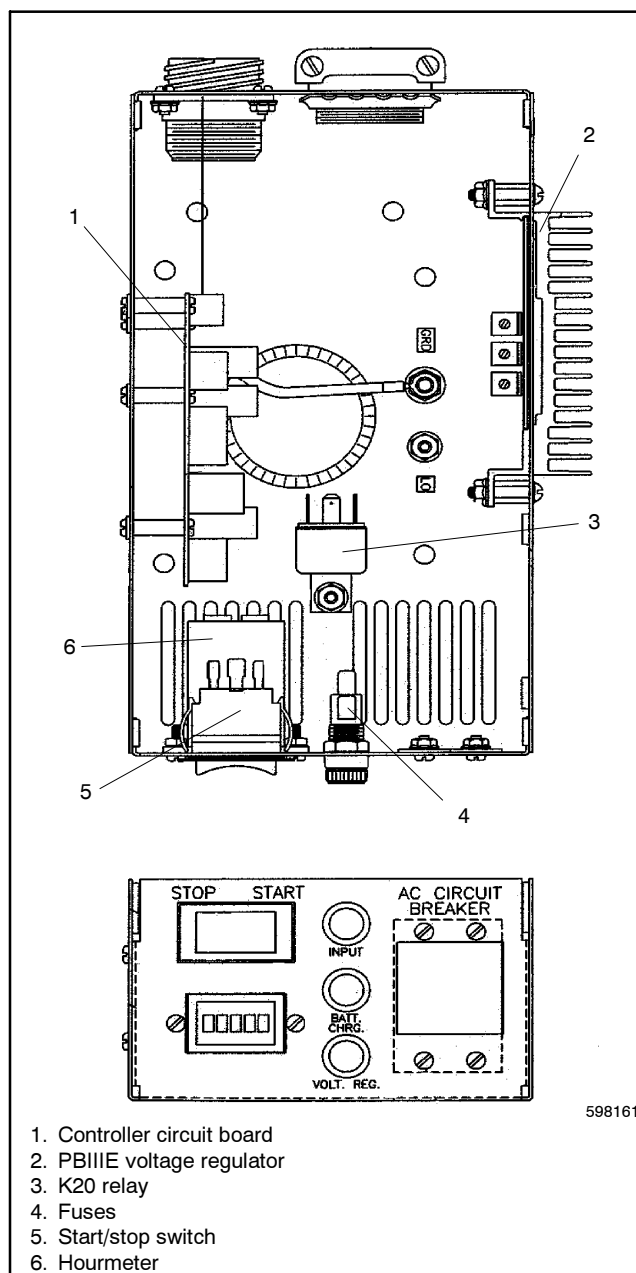


Figure 6-1 Controller

At the same time the K1 relay is energized, the time delay for the K5 relay starts. After 5–10 seconds, the K5 relay is energized (LED 5 lights).

The normally-open K5 contacts close to permit the function of the engine safety shutdown switches.

6.1.3 Stop

Close the start/stop switch between N and 43 (local or remote).

The K4 relay energizes (LED4 lights).

The normally-closed K4 contacts open, disabling the fuel pump (FP), choke heater (CHTR), antidiethyl solenoid (ADS), and ignition (IGN).

The normally-open K4 contacts close, latching the circuit to the K4 relay until the generator set comes to a complete stop.

6.2 Engine Safety Shutdown Switches

6.2.1 Low Oil Pressure (LOP) Shutdown

When low oil pressure occurs, the LOP shutdown switch contacts close energizing the K4 relay (LED4 lights).

The generator shuts down, as described in Section 6.1.3.

Note: During cranking, the low oil pressure shutdown switch deactivates until the K5 relay energizes. This delay allows the engine to reach normal operating oil pressure.

6.2.2 Loss of Coolant Switch (LCS) Shutdown

When the coolant level is low, the LCS contacts close, energizing the K4 relay (LED4 lights). The generator shuts down, as described in Section 6.1.3.

6.2.3 High Engine Temperature Switch (HET) Shutdown

When the engine temperature exceeds 110°C (230°F), the HET contacts close, energizing the K4 relay (LED4 lights). The generator shuts down, as described in Section 6.1.3.

6.2.4 Controller Circuit Board

The controller circuit board has light emitting diodes (LEDs) that indicate the presence of relay coil power. When any of the relays K1–K5 receive power, the corresponding LED lights.

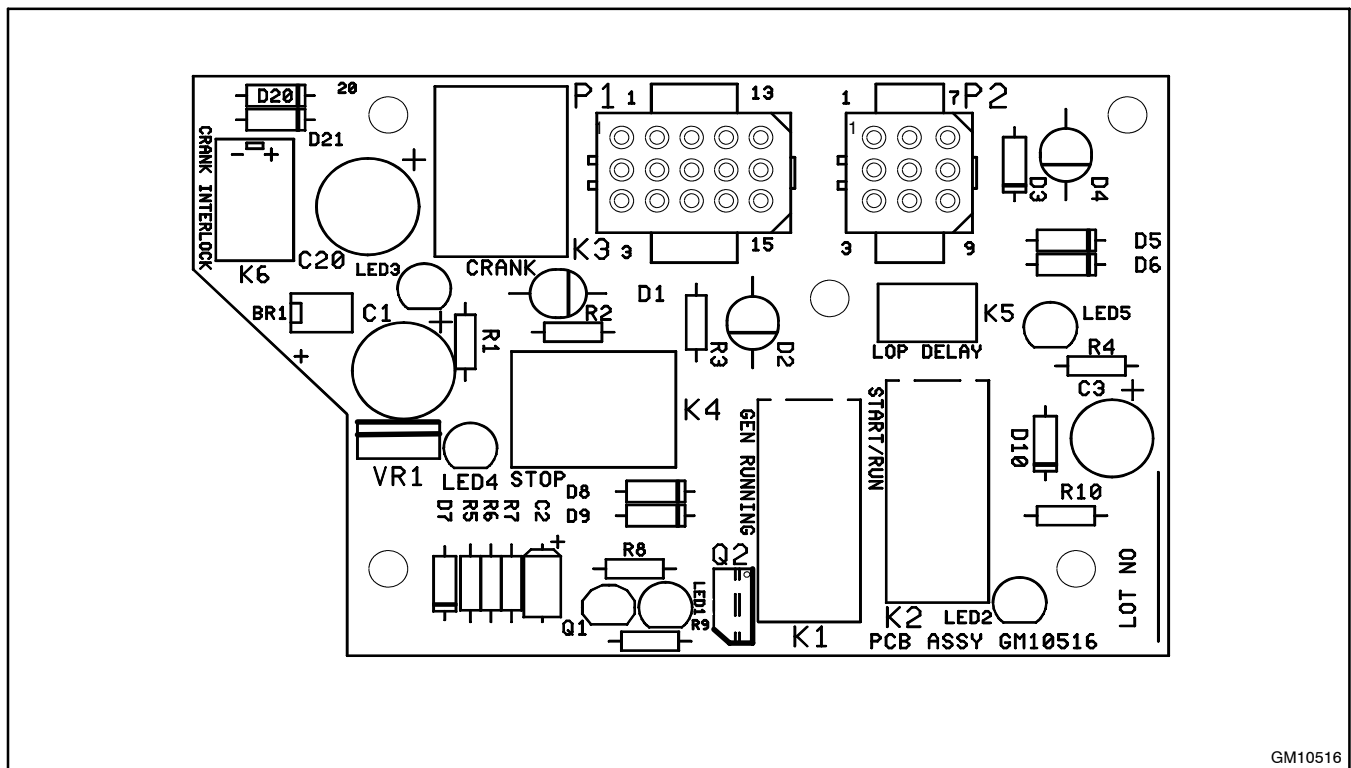


Figure 6-2 GM10516 Controller Circuit Board

6.2.5 Troubleshooting

Use the following flowchart as an aid in troubleshooting the main circuit board and the entire generator set. If the prescribed remedy does not correct the problem, the

circuit board may have to be replaced. Use this chart for component testing only. Always check the continuity of the wires between components.

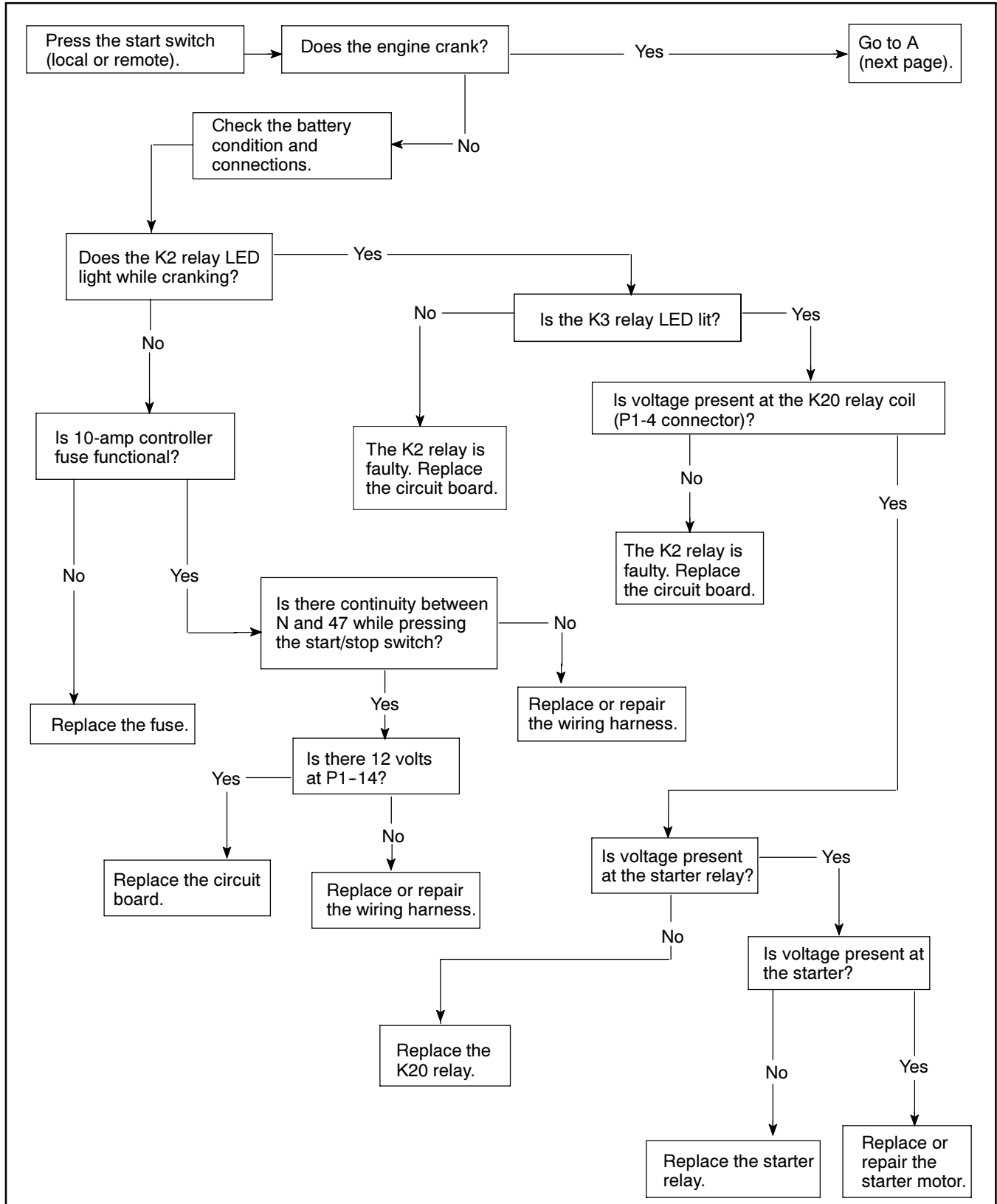


Figure 6-3 Troubleshooting Relay Controller Circuit Board (1 of 4)

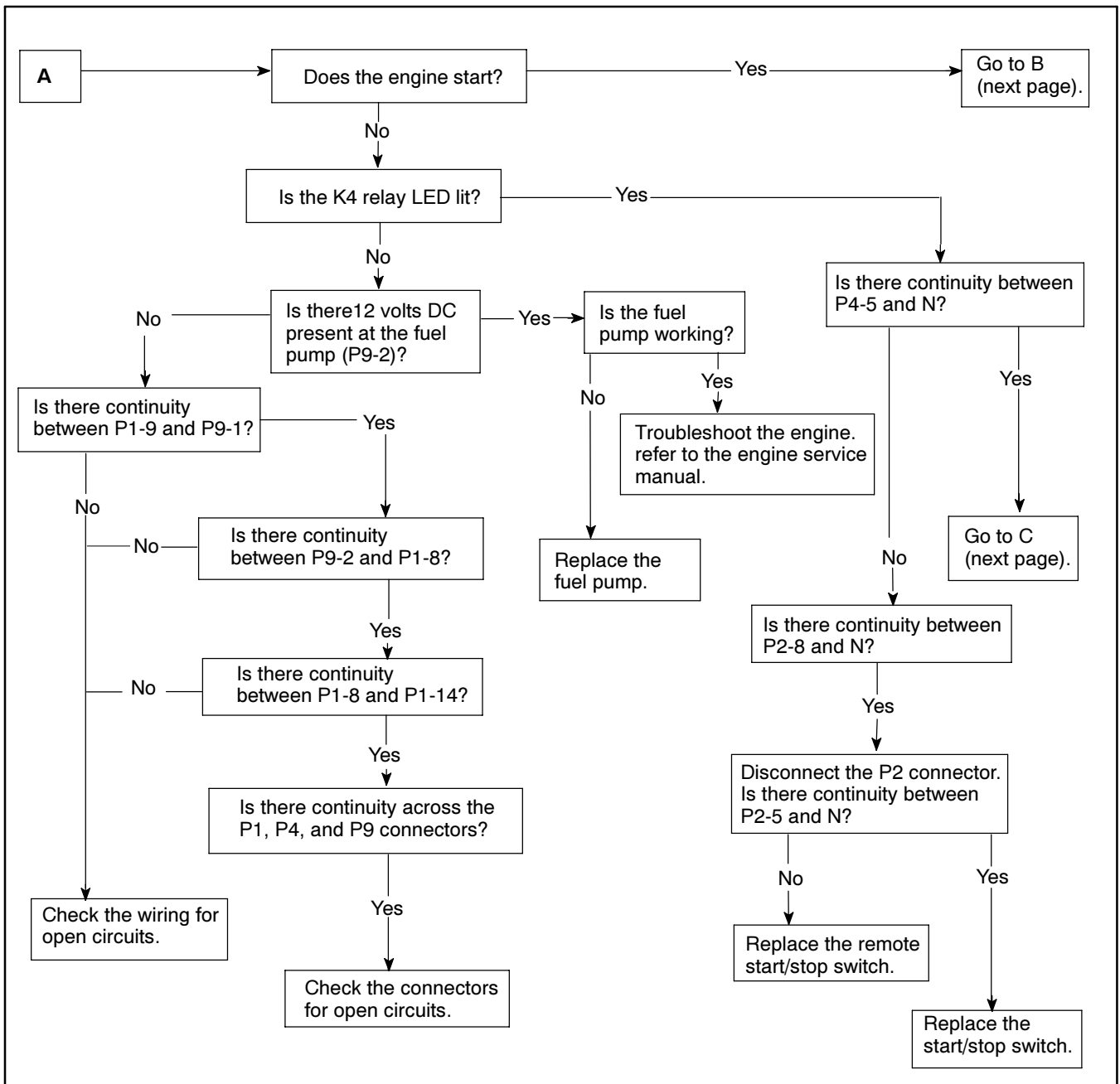


Figure 6-4 Troubleshooting Relay Controller Circuit Board (2 of 4)

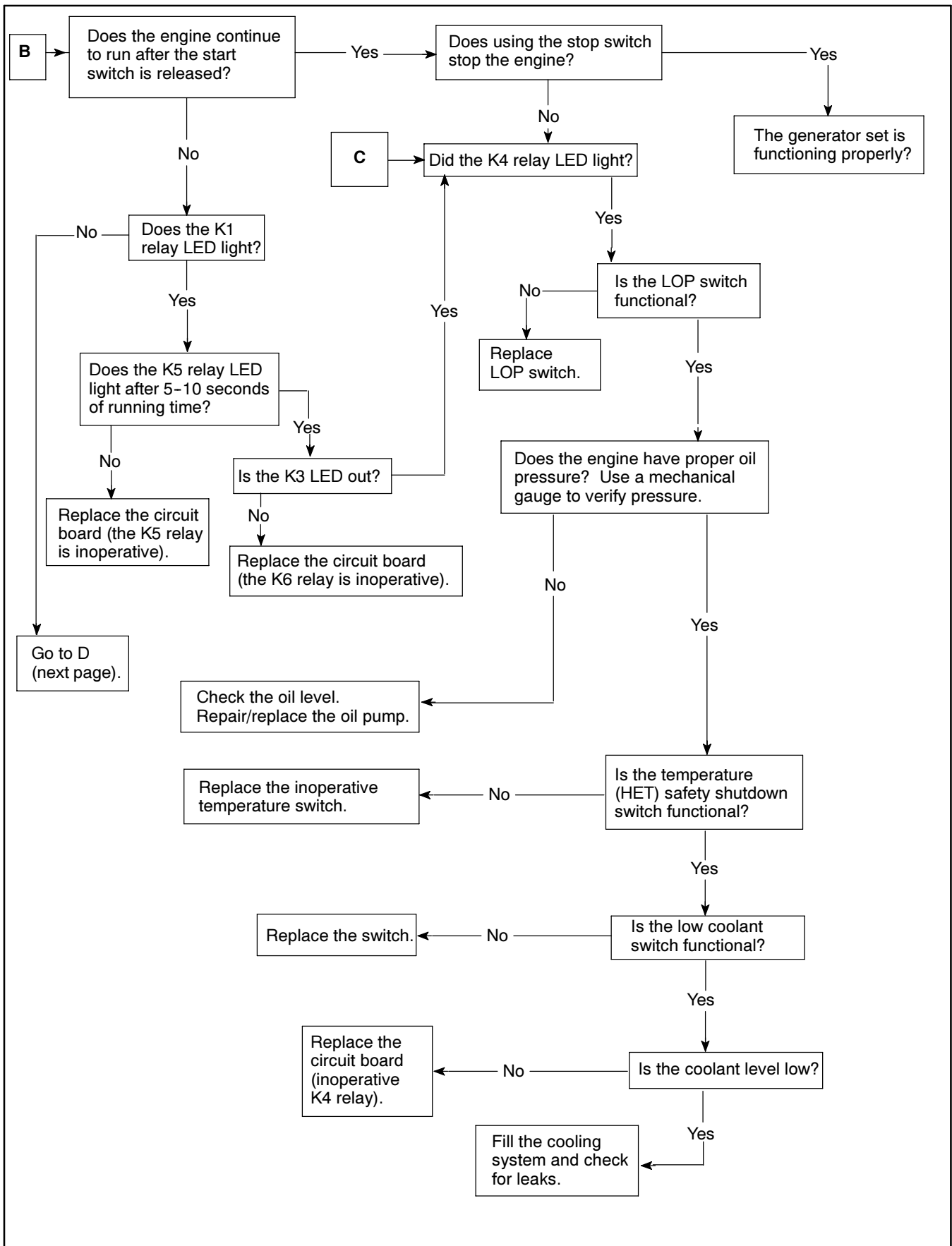


Figure 6-5 Troubleshooting Relay Controller Circuit Board (3 of 4)

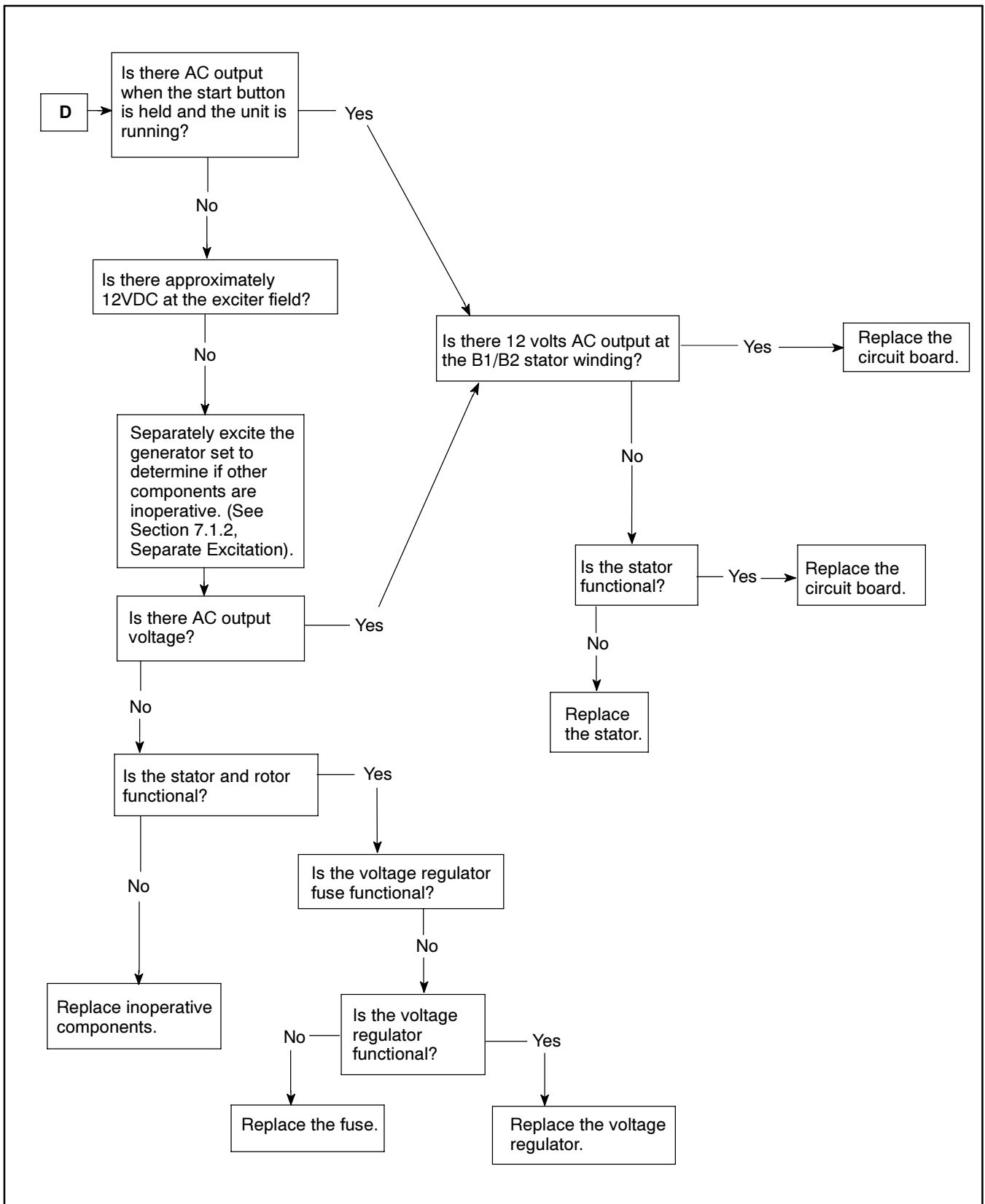
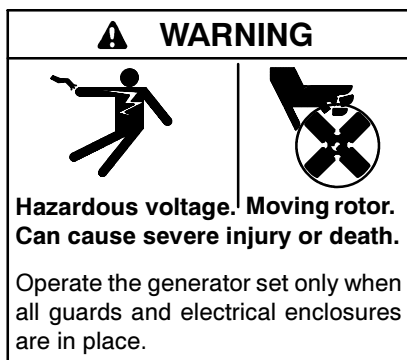


Figure 6-6 Troubleshooting Relay Controller Circuit Board (4 of 4)

Section 7 Generator Troubleshooting

7.1 General

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



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)

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocutation is possible whenever electricity is present. Open 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.

7.1.1 Troubleshooting

To determine the cause of no- or low-AC output, refer to the following steps and the troubleshooting flowchart (Figure 7-1). Verify the operation of the alternator components before replacing the controller board or voltage regulator.

General Troubleshooting

1. Check the condition of the voltage regulator's 10-amp fuse.
2. If the fuse is functional, separately excite the generator. See Section 7.1.2. The separate excitation test duplicates the role of the voltage regulator by providing excitation current to the rotor.

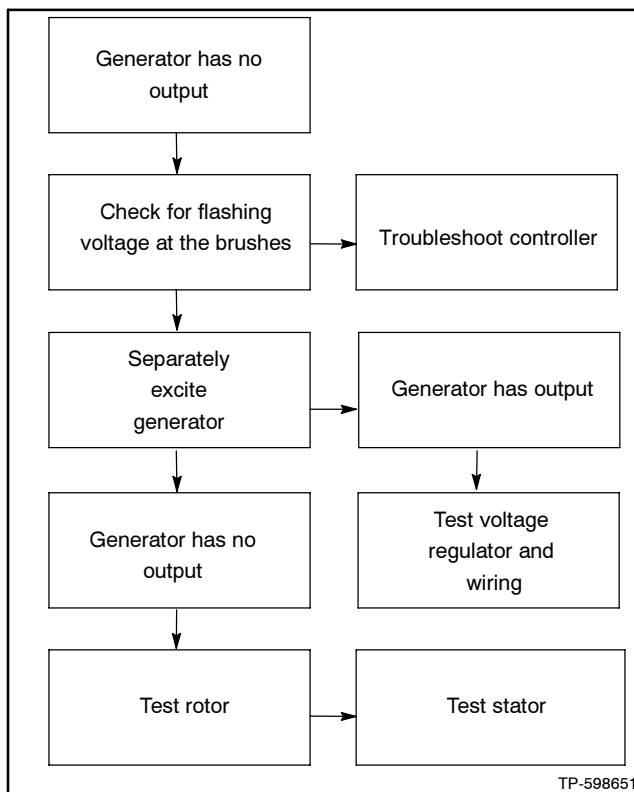


Figure 7-1 General Troubleshooting

7.1.2 Separate Excitation

By separately exciting the generator to determine the presence of a faulty voltage regulator, it is possible to determine if 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.

Note: It is not necessary to separately excite the generator if there is AC output with flashing voltage.

Separate Excitation Procedure

1. Disconnect all of the leads from the voltage regulator.
2. Disconnect the P10 (F1, F2) connector.
3. Connect a separate excitation circuit as shown in Figure 7-2. Connect an ammeter and a 10-amp fuse in series with F1. Note and record the ammeter reading.
4. The approximate ammeter reading should equal battery voltage divided by the specified rotor resistance (cold). See Section 1, Specifications, for the correct values.

Example:

$$\frac{12 \text{ Volts (Battery Voltage)}}{3.4 \text{ Ohms Rotor Resistance}} = 3.5\text{-amp Ammeter reading}$$

5. Start the engine and check that the ammeter remains stable. An increasing meter reading indicates a shorted rotor. A decreasing meter reading to zero, or unstable reading, suggests a running open in the rotor. If the ammeter is stable, continue with step 6.
6. With a jumper wire, ground the negative (-) lead from the rotor to the engine block. An increased current reading or a fluctuating reading indicates a grounded rotor winding. Replace the rotor if the ammeter reading fluctuates. If the ammeter is stable, continue with step 7.

7. Remove the jumper wire and reverse the positive (+) and negative (-) leads on the rotor. Repeat step 5. If the ammeter is stable, ground the negative (-) lead at its new location on the rotor to the engine block. Replace the rotor if the ammeter reading fluctuates.
8. Check for AC output across the stator leads and compare the measured output to the values in Section 1, Specifications. If the output varies considerably from those listed, a faulty stator, rotor, rectifier module, or armature is likely.

If there is no generator output during normal operation but output is available when the generator set is separately excited, the voltage regulator may be 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 volts. Should the battery voltage vary, the resulting stator output values will also vary.

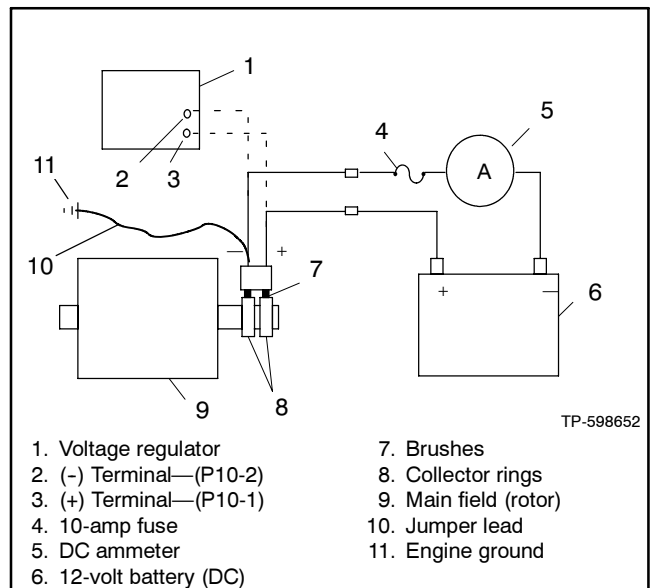


Figure 7-2 Separate Excitation Connections

7.2 PowerBoost™ III E Voltage Regulators

The generator set is equipped with a PowerBoost™ III E voltage regulator. See Figure 7-3.

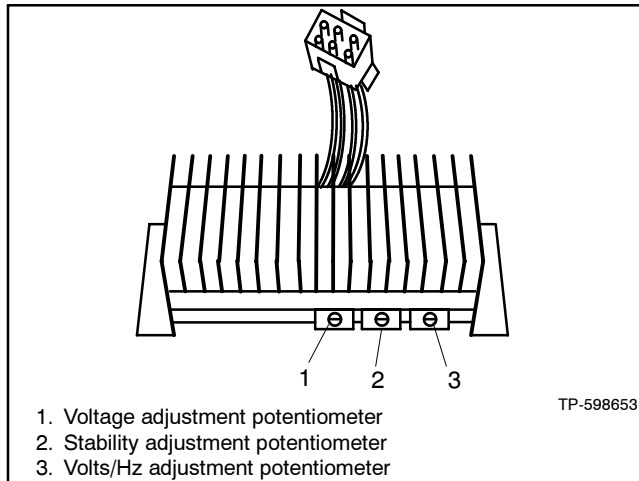


Figure 7-3 PowerBoost™ III E Voltage Regulator

The voltage regulator monitors the output voltage of the generator set.

The 10-amp regulator fuse protects the alternator stator windings (power supply) 55-33 from excessive current draw because of an inoperative voltage regulator or a downstream short. If the regulator's 10-amp fuse blows, the generator set will shut down. Verify that the regulator fuse is functional before proceeding with the test.

7.2.1 Voltage Regulator Test

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 volts, 100 watts
- AC voltmeter
- Insulated copper wire, #14 AWG, minimum

Regulator Test Procedure

1. Connect the components as shown in Figure 7-4.
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. A voltage regulator which tests bad causes a generator high voltage output condition.
5. Turn the variable transformer to zero and unplug the AC cord.

Note: For applications requiring fine voltage adjustment, connect a remote rheostat to voltage regulator terminal 66.

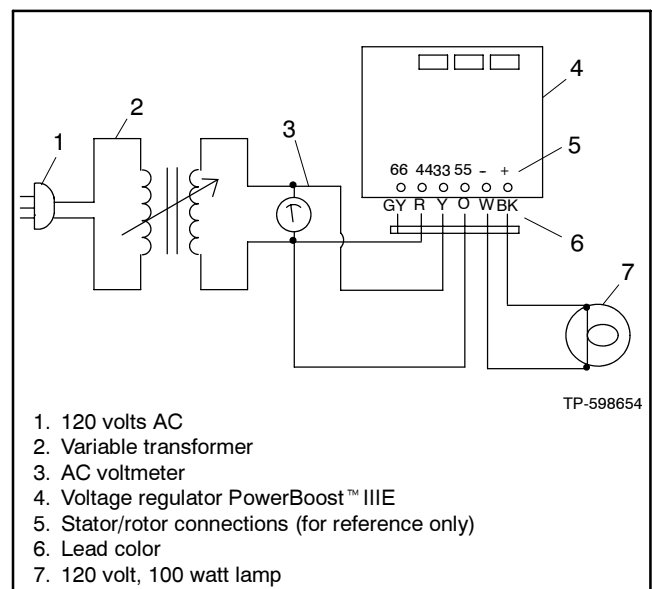


Figure 7-4 PowerBoost™ III E Voltage Regulator Test

7.2.2 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. See Figure 7-5. The following paragraphs describe the voltage regulator components.

Voltage Adjustment Pot adjusts the generator output within the range of 100–130 volts.

Stabilizer Pot fine-tunes regulator circuitry to minimize AC voltage fluctuation.

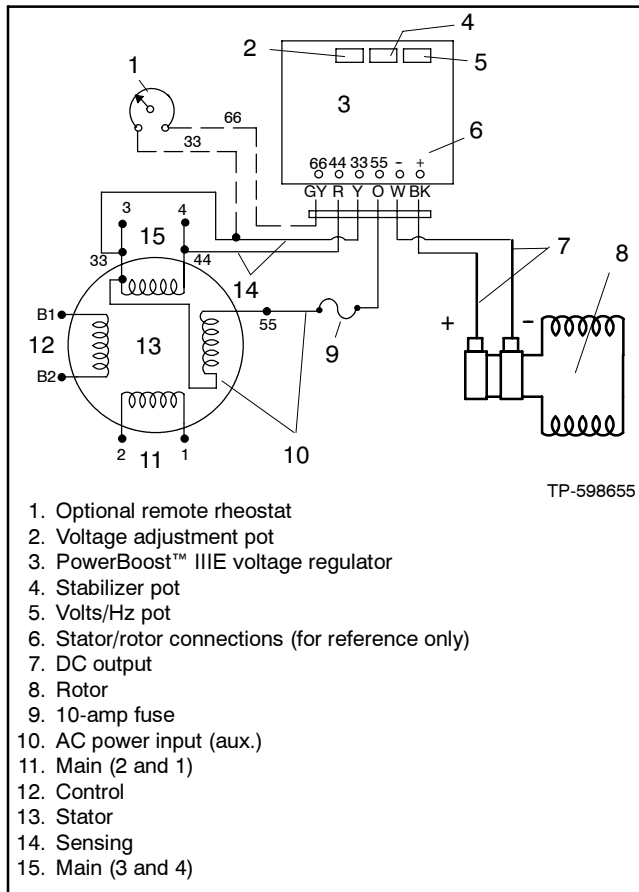


Figure 7-5 PowerBoost™ IIIIE Voltage Regulator

Volts/Hz Pot feature allows the voltage to drop if the load imposed on the generator causes the engine speed to fall below a predetermined RPM or frequency. This reduction of voltage results in a decrease of starting kW (load) allowing the governor to recover the engine speed.

Voltage Regulator Adjustment Procedure

1. Stop the generator set.
2. Turn the remote rheostat, if equipped, to the midpoint. Turn the voltage and stabilizer pots fully counterclockwise. Connect the voltmeter to the AC circuit or an electrical outlet.
3. Start the generator set.
4. Adjust the generator frequency using a frequency meter. Set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation.
5. Rotate the voltage adjustment pot clockwise to increase the voltage or counterclockwise to decrease the voltage to achieve the desired output voltage.
6. Connect a 120-volt light bulb to the AC plug on the generator set.
7. Rotate the stability pot clockwise until the light bulb flickers minimally.
8. Readjust the voltage adjustment pot to achieve the desired output voltage.
9. Disconnect the 120-volt light bulb.
10. Turn the volts/Hz pot completely clockwise to decrease the Hz rolloff point. See Figure 7-6.

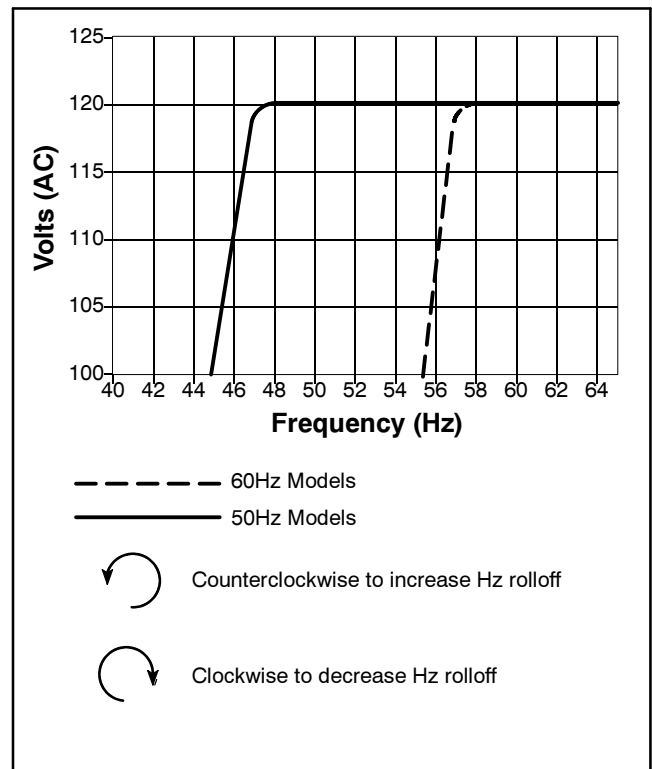


Figure 7-6 Volts/Hz Rolloff Chart

11. Set engine speed to 47.5 Hz for 50 Hz generator sets and 57.5 Hz for 60 Hz generator sets for the desired cut-in frequency.
12. Slowly turn the volts/Hz pot counterclockwise until the frequency matches that of the engine frequency (47.5 or 57.5 Hz) or until the voltage just begins to drop.
13. Reset the engine speed to the normal frequency (50 Hz or 60 Hz).
14. Recheck the AC voltage output and stability as described in steps 5-7.
15. Stop the generator set.

7.3 Rotor

The two-pole rotor creates the magnetic field needed to sustain alternating current in the stator windings. Before testing, inspect the rotor for visible damage to pole shoes, insulation, exposed coil windings, and collector ring surfaces. Check the rotor bearing for noisy operation, excessive wear, radial or axial movement, and/or heat discoloration. Replace or repair as necessary.

Collector rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly machined appearance. Wipe the collector rings with a dry, lint-free cloth. Use a commutator stone to remove the grooves on the collector rings. Do not use emery or carborundum paper or cloth. Remove all carbon dust from the generator. Remove the black or pitted surface of the collector rings using a lathe.

Check the rotor for continuity and resistance. Lift the brushes and measure the rotor resistance between the two collector rings. See Section 1.5.

Note: When checking rotor resistance with the rotor installed, brushes must not be in contact with rotor collector rings. Use a brush retainer on brushes for accurate resistance readings.

Note: Use the values in Section 1 as a reference for rotor resistance readings. Take readings at room temperature or about 21°C (70°F). Rotor resistance will vary directly with increase in temperature.

To check whether the rotor is shorted to ground, touch one ohmmeter lead to either collector ring and the other lead to the rotor poles or shaft. The meter should register no continuity.

Repair or replace the rotor if the previous tests detect any faults.

7.4 Stator

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. See Figure 7-7 for coil lead description.

Stator Leads	Description
1-2	Output coil
3-4	Output coil
33-44	Control wires from 3 and 4
55-33	Voltage regulator power source
B1-B2	Controller power source

Figure 7-7 Stator Coil Lead Description

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

The stator produces electrical output (AC) as the magnetized main field rotates within the stator windings. Test the condition of the stator according to the following procedure.

Leads 1, 2, 3, and 4 are the generator output leads. Leads 33, 44, and 55 are the voltage regulator supply and sensing leads. The output of leads B1 and B2 is the control voltage for the controller.

Stator Test Procedure

1. Place the generator 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 Section 10, Wiring Diagrams and Voltage Reconnection.
4. Disconnect all of 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 7-8. Perform the stator tests on all the stator windings.

Note: When taking an ohmmeter reading using lead 55, make the connection prior to the in-line fuse.

5. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads 1-4, 2-5, 3-6, etc. See Section 1, Specifications, for the stator resistance values.
6. Perform a megohmmeter test on the stator as described in step 7.

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

Note: The stator resistance varies directly with increased temperature.

If the stator readings vary considerably during the previous checks, repair or replace the stator.

7. Check the stator for a grounded condition using a megohmmeter. Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the instructions of the megohmmeter manufacturer when performing this test. Repeat the test on the other leads until all the stator windings have been tested. A reading of approximately 3-5 megohms and higher indicates the stator is functional. A reading of less than approximately 3-5 megohms indicates deterioration of the winding insulation and possible current flow to ground. Replace the stator.

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, 55	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 7-8 Stator Continuity

7.5 Brushes

The brushes provide a current path from the voltage regulator to the collector rings. Because the brushes carry a low current, inspect them every 1000–1500 hours. Abrasive dust on the collector rings could, however, 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.

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. Brushes must ride 100% on the collector rings or arcing will occur and cause burned rings or failure of the voltage regulator. Figure 7-9 shows the correct positioning of the brushes. Add or remove spacers as necessary to center brushes on collector rings. Replace brushes if they show excessive or uneven wear.

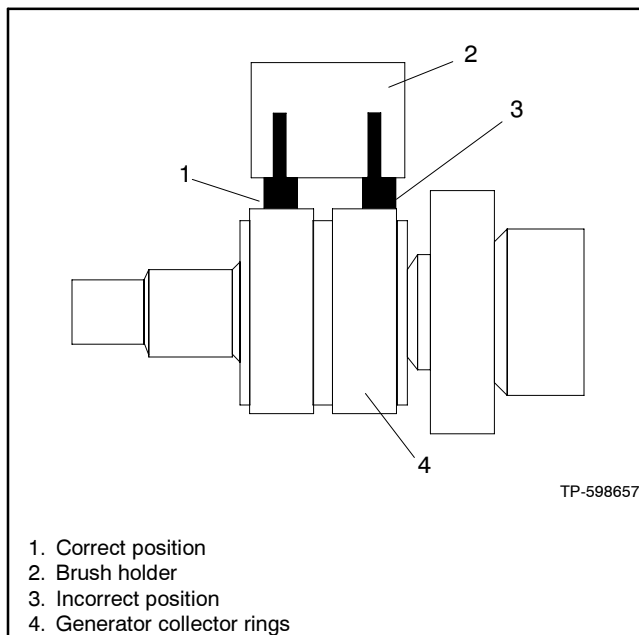


Figure 7-9 Brush Positioning

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. See Figure 7-10. Replace brushes when they are worn to half of their original size.

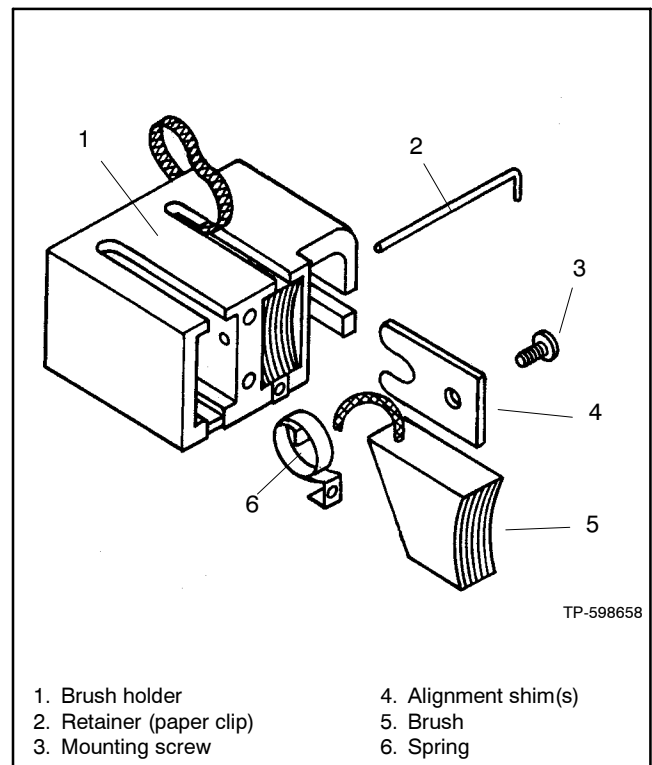


Figure 7-10 Brush Holder

Notes

Section 8 Component Troubleshooting

8.1 Engine/Generator Components

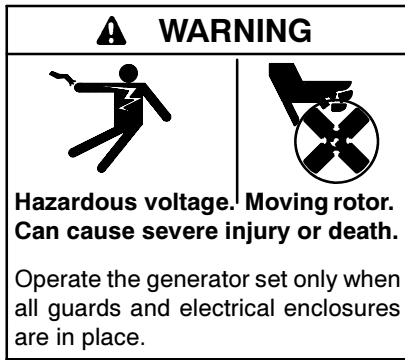
See Figure 8-1 through Figure 8-3 for engine/generator component testing.

With the generator set battery connected, check the wiring harness and the engine/generator components

listed in the following tables. Check each component using a multimeter to verify that the switches function and that voltage is present at each component.

Component	Voltmeter Connections	Procedure	Results
Hourmeter and wiring	Connect the red test lead to the hourmeter positive (+) terminal. Connect the black test lead to the hourmeter negative (-) terminal.	Set the voltmeter to 12 volts DC or greater. Start the generator set.	A 12 volt DC reading indicates the wiring harness is functional.
	None (see Procedure)	Disconnect the hourmeter leads and apply 12 volts DC to the hourmeter. The hourmeter is polarity sensitive.	If functional, hourmeter operates.
Stator auxiliary winding B1 and B2	Connect the AC voltmeter leads to the B1 and B2 windings at connector P11. Stop the generator set.	Set the voltmeter setting 20 volts AC or greater. Crank the generator set and allow the set to reach rated its speed.	A reading of 12-15 volts AC indicates a functional B1/B2 winding.

Figure 8-1 Engine/Generator Component Testing, Relay Controller



To further check the generator set components, disconnect the battery and remove the wiring harness plugs from the controller circuit board. Use an ohmmeter to check the continuity of the components and to isolate inoperative components. Refer to Figure 8-2 and Figure 8-3.

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

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.

Component	Ohmmeter Connections	Procedure	Results
Start/stop switch	Connect the ohmmeter to the P2-6 and P2-4 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the START position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
	Connect the ohmmeter to the P2-6 and P2-5 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the STOP position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
K20 relay coil and wiring	Connect the ohmmeter to the P1-4 and P1-9 leads.	Place the ohmmeter on the R x 1 scale.	If functional, 85 ohms. Low resistance, shorted C relay coil and/or wiring. High resistance, open C relay and/or wiring.
Starter solenoid (S relay)	Connect the ohmmeter to the P4-22 lead and the battery positive (+) cable. Note: The J4 and P4 leads must be disconnected to perform this test.	Place the ohmmeter on the R x 1 scale.	If functional, approximately 0.5–0.6 ohms at 27°C (80°F)
Controller 10-amp circuit breaker and wiring	Connect the ohmmeter to the battery positive (+) cable and the P1-14 lead. Note: The J4 and P4 leads must be connected to perform this test.	Place the ohmmeter on the R x 1000 scale.	If functional, zero or very low ohms. No reading (infinity), open circuit or circuit breaker tripped.

Figure 8-2 Engine/Generator Component Testing, Relay Controller

Component	Ohmmeter Connections	Procedure	Results
Main field (rotor)	Disconnect the P10 and P11 connectors and connect the ohmmeter to P10-1 and P10-2 leads.	Place the ohmmeter on the R x 1 scale.	If functional, see Section 1, Specifications. Low resistance, rotor windings shorted. High resistance, rotor windings open.
B1/B2 stator windings	Connect the ohmmeter to the P11-1 and P11-2 leads. Note: Disconnect P11 and J11 to perform this test.	Place the ohmmeter on the R x 1 scale.	If functional, see Section 1, Specifications. Low resistance, B1/B2 windings shorted. High resistance, B1/B2 windings open.
P1 ground connection	Connect the ohmmeter to the P1-9 and ground.	Place the ohmmeter on the R x 1 scale.	If functional, zero ohms (continuity). Any other reading indicates a poor ground connection.
Low oil pressure (LOP) safety shutdown switch	Connect the ohmmeter to the P13-1 and engine block (ground).	Place the ohmmeter on the R x 1000 scale. This test is not conclusive until the temperature shutdown switches are checked.	If functional, zero ohms (continuity). Then, disconnect LOP switch lead and isolate terminal. Meter reading should show an open circuit.
High exhaust temperature (HET), low coolant (LCS) safety shutdown switches	Connect the ohmmeter to the P1-15 and engine block (ground). Note: Remove and isolate the LOP switch lead.	Place the ohmmeter on the R x 1000 scale.	If functional, open circuit. Any continuity suggests an inoperative temperature switch(es). Disconnect individual leads to inoperative switch.

Figure 8-3 Engine/Generator Component Testing, Relay Controller

8.2 Remote Panels (Optional)

Kohler Co. offers three remote panels for connection to the generator set.

- A panel with a start/stop switch
- A panel with a start/stop switch and two gauges (engine oil pressure and water temperature)
- A panel with a start/stop switch and four gauges (DC voltmeter, engine oil pressure, water temperature, and hourmeter)

If difficulty with the remote operation occurs, test the switch, gauges, and gauge senders using the following procedures. See Sections 10.6, 10.7, or 10.8 to identify the location for the appropriate panel.

Troubleshooting Remote Start Panels

Generally, if the sender changes its resistance values as its respective pressure/temperature changes, it is working correctly. An inoperative sender will either be open or shorted. Refer to Figure 8-4 and Figure 8-5 for resistance values.

2-Meter and 4-Meter Panels Temperature	
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 8-4 Water Temperature Sender Resistance

2-Meter and 4-Meter Panels Pressure	
0 kPa (0 psi)	10 ohms
345 kPa (50 psi)	80 ohms
690 kPa (100 psi)	135 ohms

Figure 8-5 Oil Pressure Sender Resistance

Refer to Figure 8-6 for troubleshooting information on the remote start panels.

Component	Ohmmeter Connections	Procedure	Results
Remote start/stop switch	Remote switch: yellow/red wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Press the rocker switch to the START position.	Continuity, the switch is functional.
	Remote switch: grey/black wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Press the rocker switch to the STOP position.	Continuity, the switch is functional.
Generator set ON light, gauge lights, DC voltmeter, and hourmeter	Connect the red test lead to P3-4 and black test lead to P3-1.	If 12 volts DC is present and the component does not function after the J3 is connected to the controller P3, replace the component. Place the controller rocker switch to the START position. Stop the generator set when the test is complete.	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, test by connecting it to a 12-volt battery. Note: The hourmeter is polarity sensitive.
Water temperature gauge	Connect the red test lead to P3-4 (socket side) and black test lead to P3-2 (socket side).	Start the generator set for the test. If 0.5-12-volts DC is present and the gauge does not function after the J3 is connected to controller, replace the gauge.	Voltmeter setting 12 volts or greater.
Oil pressure gauge	Connect the red test lead to P3-4 (socket side) and black test lead to P3-3 (socket side).	Start the generator set for the test. If 0.5-12-volts DC is present and the gauge does not function after the J3 is connected to the controller, replace the gauge.	Voltmeter setting 12 volts or greater.
Note: Check continuity of gauge wiring and extension harness before replacing components.			

Figure 8-6 Remote Start Panels Troubleshooting

Section 9 Generator Disassembly/Reassembly

9.1 Disassembly

Disconnect 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, water line at the seawater pump, fuel line at the fuel pump filter inlet, and exhaust line at the mixing elbow. Observe all of the safety precautions listed during the disassembly/reassembly procedures.

Disassembly Procedure

1. Place the start/stop switch in the STOP position.
2. Disconnect the generator set engine starting battery, the negative (-) lead first.
3. Remove the controller cover.
4. Disconnect the P4 (22-pin) connector from J4.
5. Disconnect the controller ground strap (generator side).

Note: It is possible to connect the output leads in various positions for different voltage configurations. Mark the leads for correct reconnection.

6. Disconnect the generator output leads 1, 2, 3, and 4 from the circuit breaker and the neutral stud (L0).
7. Disconnect the P11 (FP and FN) and P10 (F1 and F2) connectors.
8. Remove the fuel inlet hose.
9. Close the seacock and remove the water inlet hose from the water pump.
10. Remove the sound shield enclosure, if equipped.
11. If the generator set is not equipped with a sound shield enclosure, lift the controller from the rubber mounts while guiding the leads through the bottom opening of the controller box.
12. Remove the fuel pump and line from the generator.
13. Remove the alternator coverplate. See Figure 9-1.

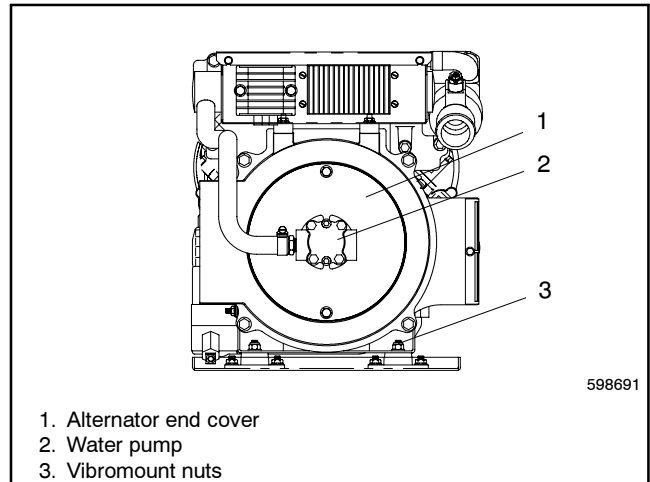


Figure 9-1 Alternator end cover

14. Push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holes. Refer to Section 7.5.
15. Remove the brush holder and carefully pull the leads out of the stator housing. See Figure 9-3.
16. Remove the generator side vibromount nuts. See Figure 9-1.
17. Tilt the generator set up and brace it with a block of wood. Figure 9-2.

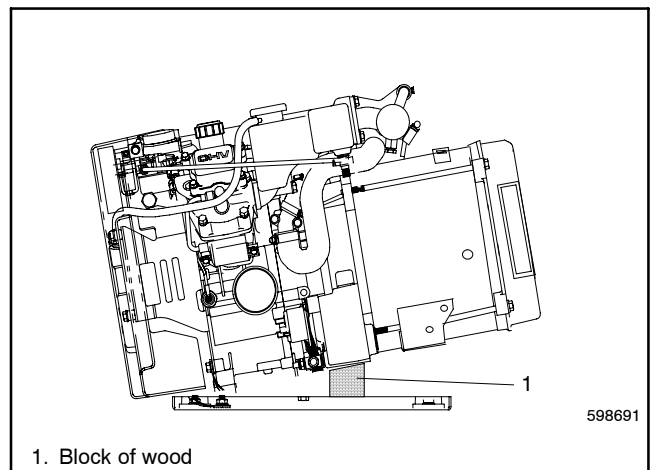


Figure 9-2 Raising the Generator

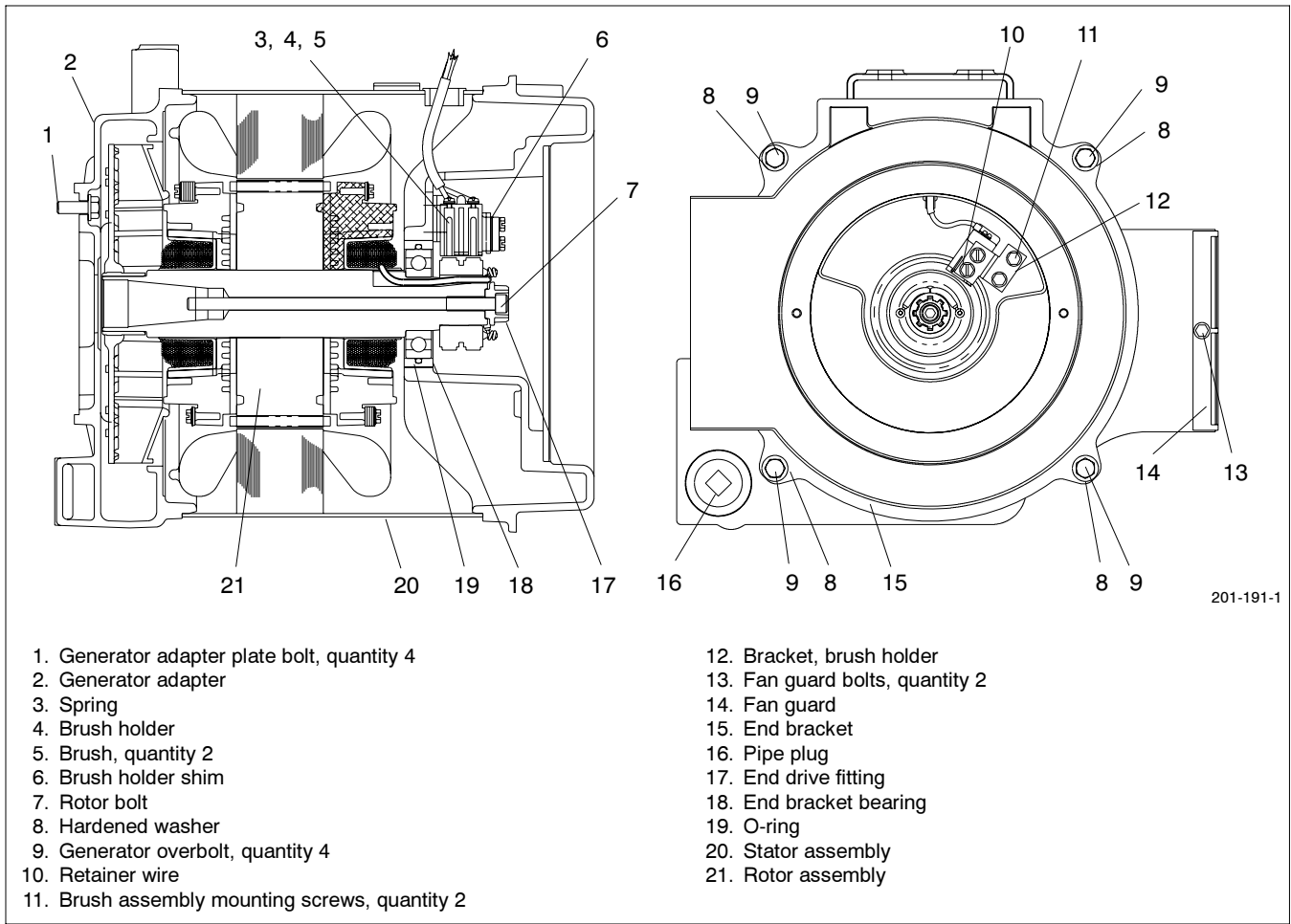


Figure 9-3 Alternator Assembly Components

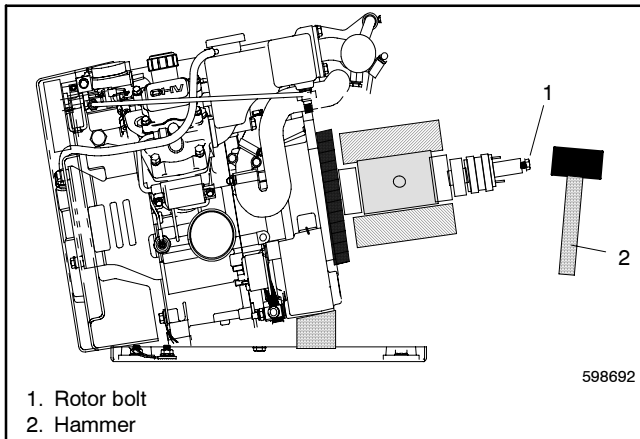


Figure 9-4 Removing the Rotor

18. Remove the end bracket overbolts. See Figure 9-3. Use a rubber mallet to separate the end bracket from the stator housing.
19. Carefully remove the stator assembly from the generator adaptor plate.
20. Remove the rotor bolt and end drive fitting.
21. Reinstall the rotor bolt (without end fitting), finger tighten, and back off two turns.
22. Strike the bolt with a hammer until the rotor is freed from the engine tapered drive shaft. Do not damage through bolt threads or bolt head. See Figure 9-4.

9.2 Collector Ring and Bearing Replacement

1. Unsolder the collector ring leads from the collector ring terminals.
2. Remove the collector rings with a three-jaw puller.
3. Remove the bearing with a three-jaw puller.
4. Press the new bearing onto the rotor shaft.
5. Align the collector ring keyway with the keyway on the rotor shaft. See Figure 9-6.
6. Press the new collector rings onto the rotor shaft.

Note: The new collector rings must be turned down to a finish of 32 micro inches using a lathe and commutator stones. Turn down the collector rings on the rotor shaft.

7. Solder the leads onto the collector ring terminals. The connection is not to exceed 9.65 mm (0.38 in.) beyond the collector rings. See Figure 9-6.
8. Test to ensure continuity at the collector rings.

9.3 Reassembly

1. Apply antiseize compound to the tapered shaft of the engine.
2. Align the rotor onto the engine shaft and secure with the end drive fitting and rotor bolt. Torque the rotor to 23.1 Nm (204 in. lbs.).
3. Carefully slide the stator assembly over the rotor.
4. Replace the end bracket o-ring.
5. Install the end bracket and torque the overbolts to 13.6 Nm (120 in. lbs.).
6. Feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws.
7. Remove the brush retainer and check the brush alignment. See Section 7.5.
8. Install the coverplate and torque the coverplate bolts to 6.8 Nm (60 in. lbs.).

9. Install the sound shield enclosure.
10. Install the fuel line and fuel pump.
11. Reconnect the water inlet hose to the water pump.
12. Guide the leads from the stator through the bottom opening of the controller. Secure the controller.
13. Reconnect the leads from the stator to the controller using the reverse procedure of that listed in Section 9.1. Refer to Section 10, Wiring Diagrams.
14. Connect the generator set starting battery, the positive (+) lead first.
15. Test the generator operation.

Min. diameter mm (in.)	57.15 (2.250)
Max. finish	32 micro inches
Max. eccentricity mm (in.)	0.08 (0.003)
Max. out-of-round mm (in.)	0.01 (0.0002)

Figure 9-5 Collector Ring Dimensions

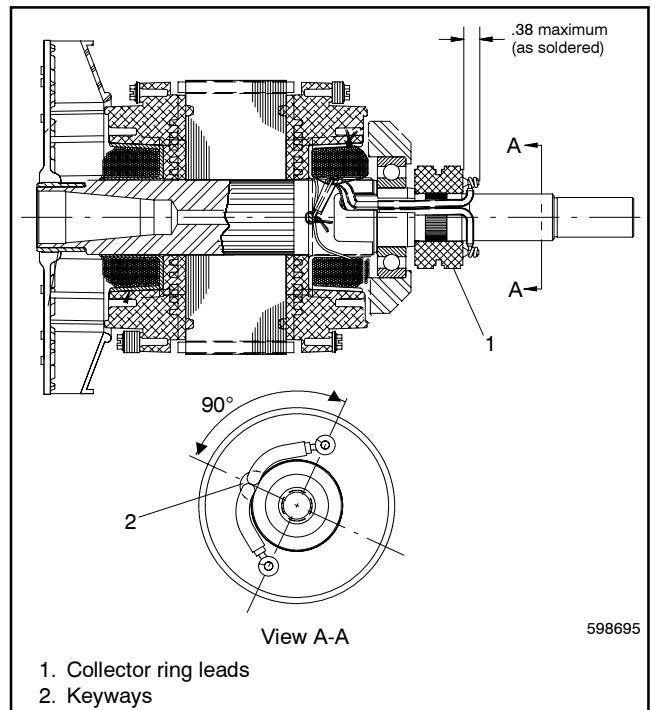
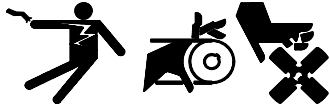


Figure 9-6 Rotor Assembly

Notes

Section 10 Wiring Diagrams and Voltage Reconnection

WARNING

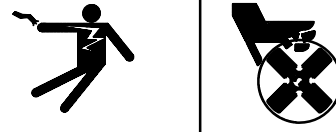


**Accidental starting.
Can cause severe injury or death.**

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

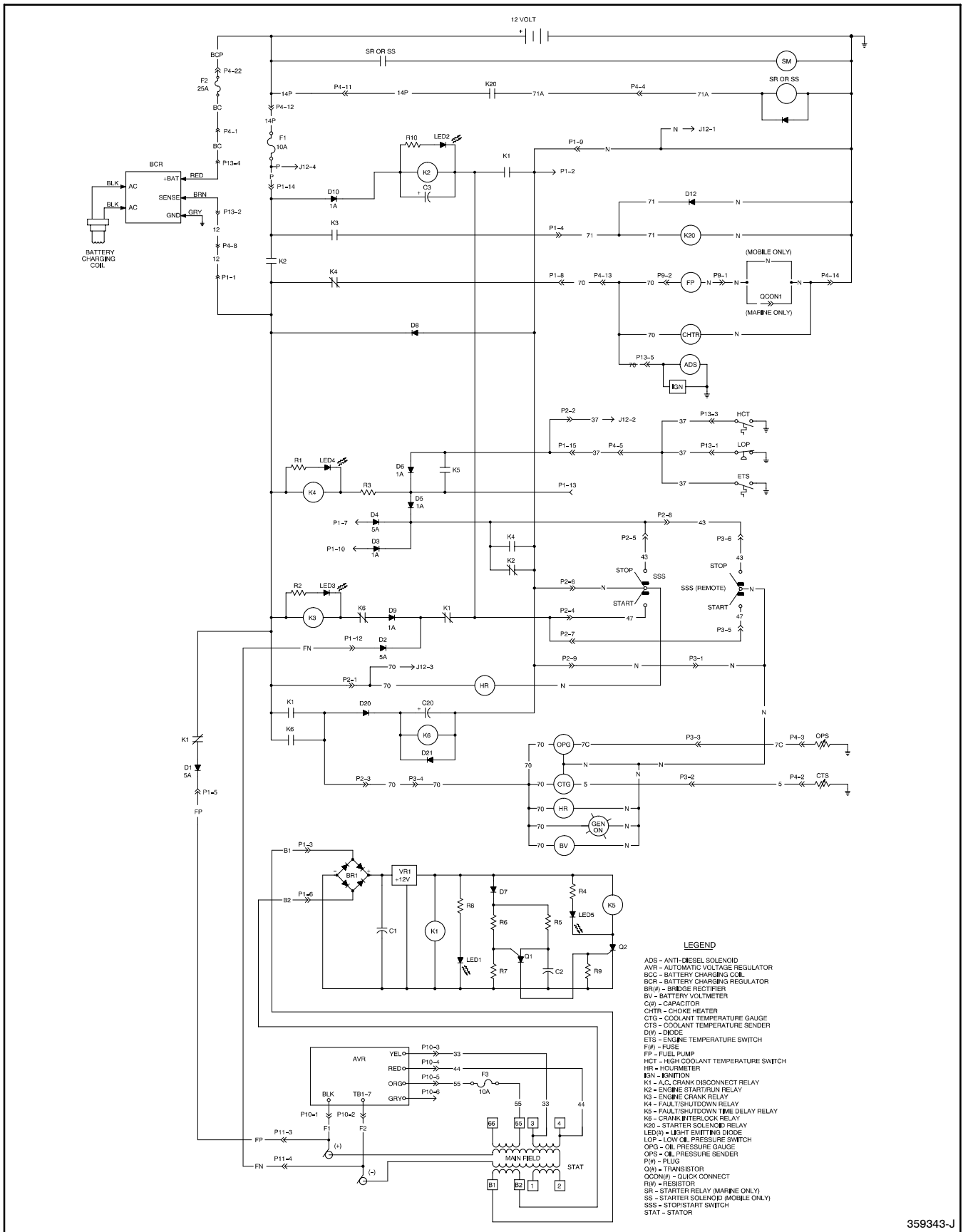


**Hazardous voltage. Moving rotor.
Can cause severe injury or death.**

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

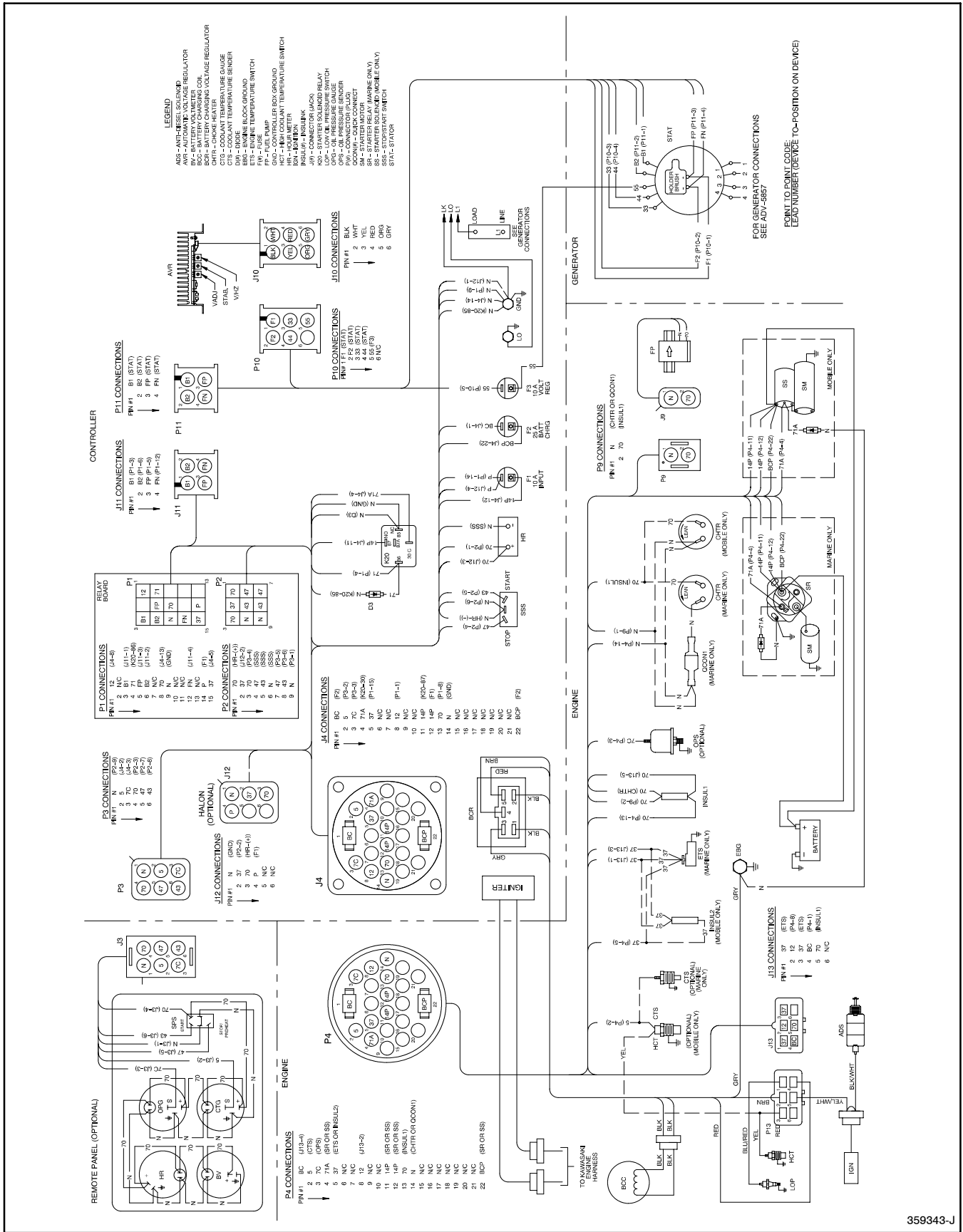
Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocutation is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer 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.

10.1 Schematic Wiring Diagram

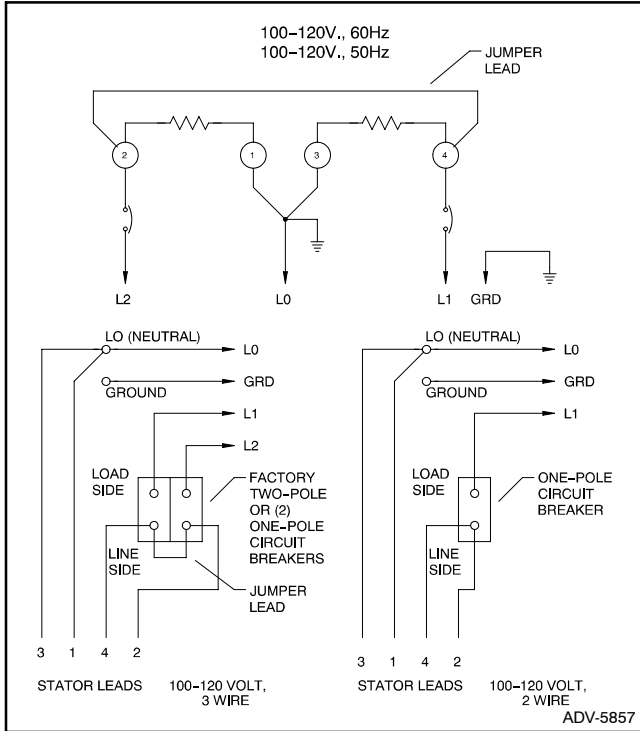


- LEGEND**
- ADS - ANTI-DESEL SOLENOID
 - AVR - AUTOMATIC VOLTAGE REGULATOR
 - BCG - BATTERY CHARGING COIL
 - BCR - BATTERY CHARGING REGULATOR
 - BR# - BRIDGE RECTIFIER
/>
 - BV - BATTERY VOLTMETER
 - C# - CAPACITOR
 - CHTR - CHOKE HEATER
 - CTS - COOLANT TEMPERATURE SENDER
 - CTS - COOLANT TEMPERATURE SENDER
 - D# - DIODE
 - ETS - ENGINE TEMPERATURE SWITCH
 - F# - FUSE
 - FP - FUEL PUMP
 - HCT - HIGH COOLANT TEMPERATURE SWITCH
 - HR - HOURMETER
 - IGN - IGNITION
 - K1 - A2C, CRANK DISCONNECT RELAY
 - K2 - ENGINE START/RUN RELAY
 - K3 - ENGINE CRANK RELAY
 - K4 - FAULT/SHUTDOWN RELAY
 - K5 - FAULT/SHUTDOWN TIME DELAY RELAY
 - K6 - CRANK INTERLOCK RELAY
 - K20 - STARTER SOLENOID RELAY
 - LED# - LIGHT EMITTING DIODE
 - OPG - OIL PRESSURE GAUGE
 - OPG - OIL PRESSURE SENDER
 - P# - PLUG
 - Q# - TRANSISTOR
 - QCON# - QUICK CONNECT
 - R# - RESISTOR
 - SR - STARTER RELAY (MARINE ONLY)
 - SS - STARTER SOLENOID (MOBILE ONLY)
 - SSS - STOP/START SWITCH
 - STAT - STATOR

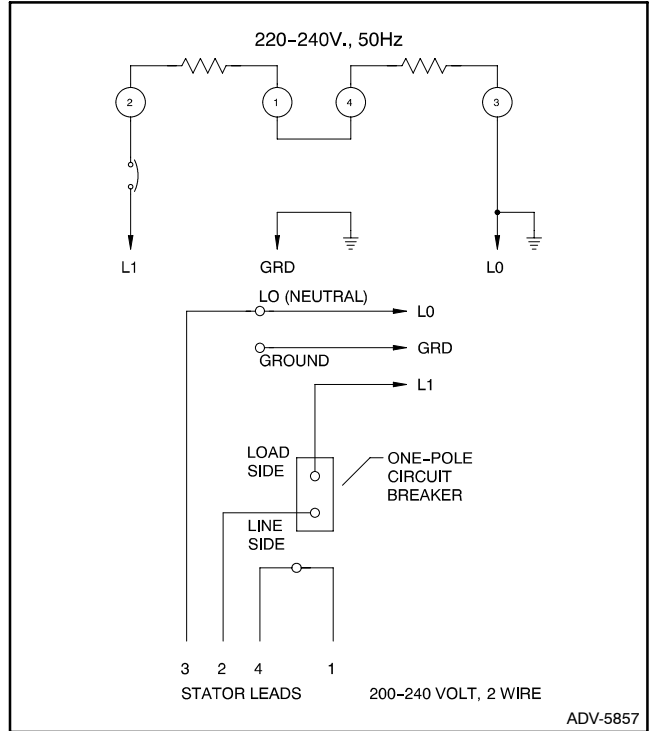
10.2 Point-to-Point Wiring Diagram



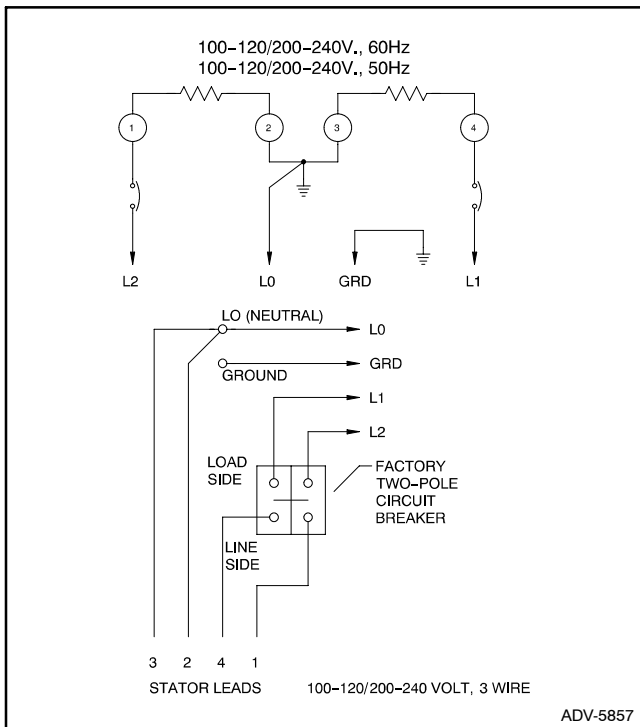
10.3 Reconnection Diagram 100-120 V, 60 & 50 Hz



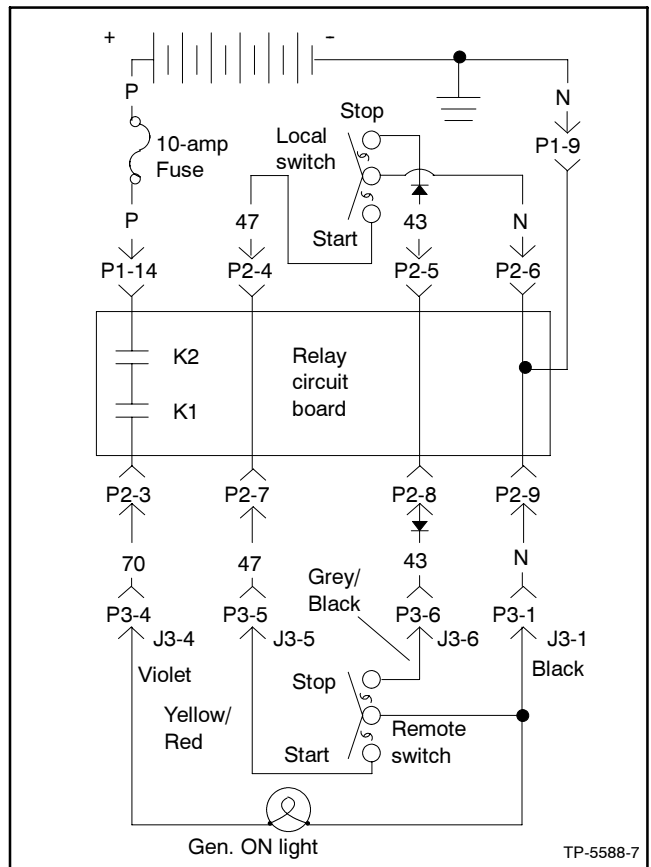
10.5 Reconnection Diagram 220-240 V, 50 Hz



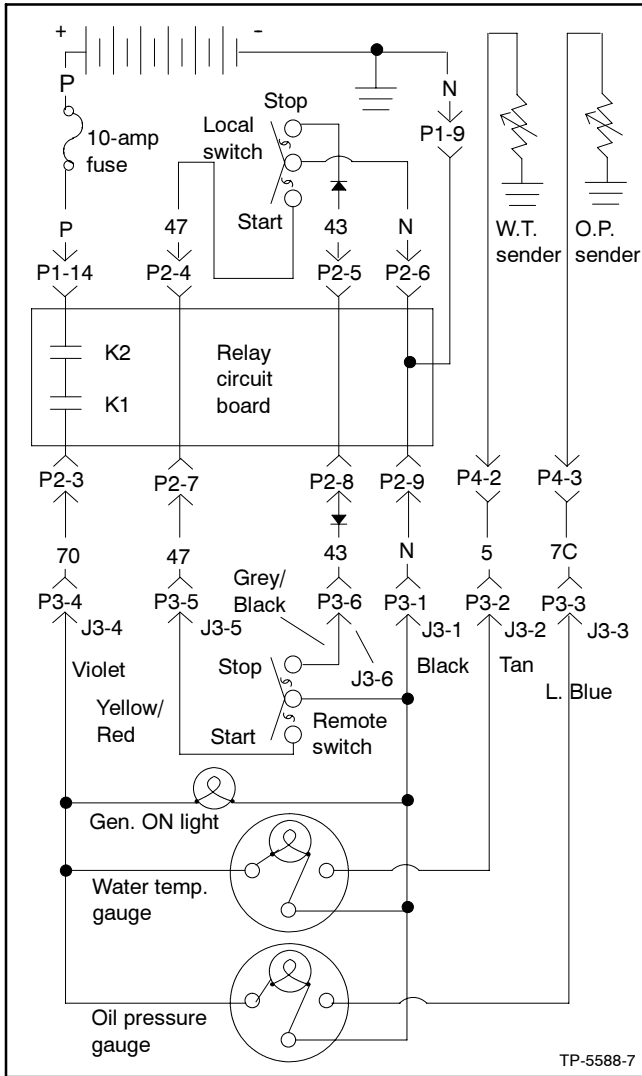
10.4 Reconnection Diagram 100-120/200-240 V, 60 & 50 Hz



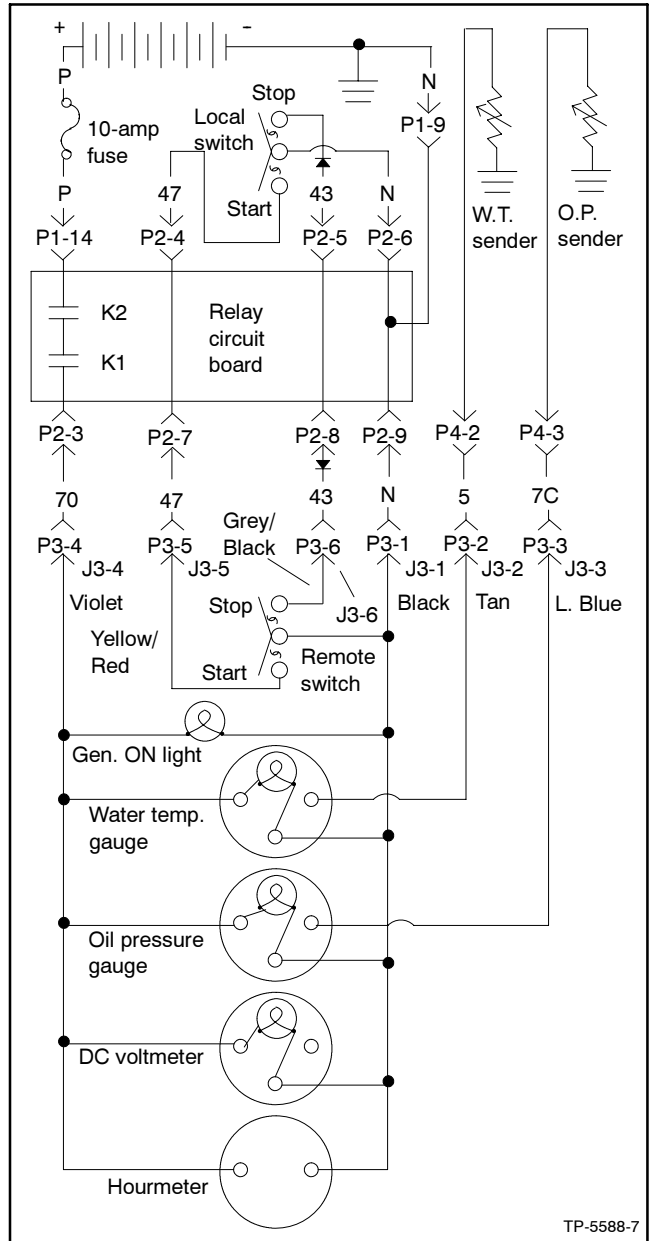
10.6 Remote Start Panel



10.7 Remote Start and Two-Meter Panel



10.8 Remote Start and Four-Meter Panel



Notes

Appendix A Abbreviations

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

A, amp	ampere	CG	center of gravity	fglass.	fiberglass
ABDC	after bottom dead center	CID	cubic inch displacement	FHM	flat head machine (screw)
AC	alternating current	CL	centerline	fl. oz.	fluid ounce
A/D	analog to digital	cm	centimeter	flex.	flexible
ADC	analog to digital converter	CMOS	complementary metal oxide substrate (semiconductor)	freq.	frequency
adj.	adjust, adjustment			FS	full scale
ADV	advertising dimensional drawing	cogen.	cogeneration	ft.	foot, feet
AHWT	anticipatory high water temperature	Com	communications (port)	ft. lbs.	foot pounds (torque)
AISI	American Iron and Steel Institute	conn.	connection	ft./min.	feet per minute
ALOP	anticipatory low oil pressure	cont.	continued	g	gram
alt.	alternator	CPVC	chlorinated polyvinyl chloride	ga.	gauge (meters, wire size)
Al	aluminum	crit.	critical	gal.	gallon
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	CRT	cathode ray tube	gen.	generator
		CSA	Canadian Standards Association	genset	generator set
AO	anticipatory only	CT	current transformer	GFI	ground fault interrupter
API	American Petroleum Institute	Cu	copper	GND, ⊕	ground
approx.	approximate, approximately	cu. in.	cubic inch	gov.	governor
AR	as required, as requested	cw.	clockwise	gph	gallons per hour
AS	as supplied, as stated, as suggested	CWC	city water-cooled	gpm	gallons per minute
ASE	American Society of Engineers	cyl.	cylinder	gr.	grade, gross
ASME	American Society of Mechanical Engineers	D/A	digital to analog	GRD	equipment ground
assy.	assembly	DAC	digital to analog converter	gr. wt.	gross weight
ASTM	American Society for Testing Materials	dB	decibel	H x W x D	height by width by depth
ATDC	after top dead center	dBA	decibel (A weighted)	HC	hex cap
ATS	automatic transfer switch	DC	direct current	HCHT	high cylinder head temperature
auto.	automatic	DCR	direct current resistance	HD	heavy duty
aux.	auxiliary	deg., °	degree	HET	high exhaust temperature
A/V	audiovisual	dept.	department	hex	hexagon
avg.	average	dia.	diameter	Hg	mercury (element)
AVR	automatic voltage regulator	DI/EO	dual inlet/end outlet	HH	hex head
AWG	American Wire Gauge	DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)	HHC	hex head cap
AWM	appliance wiring material	DIP	dual inline package	HP	horsepower
bat.	battery	DPDT	double-pole, double-throw	hr.	hour
BBDC	before bottom dead center	DPST	double-pole, single-throw	HS	heat shrink
BC	battery charger, battery charging	DS	disconnect switch	hsg.	housing
BCA	battery charging alternator	DVR	digital voltage regulator	HVAC	heating, ventilation, and air conditioning
BCI	Battery Council International	E, emer.	emergency (power source)	HWT	high water temperature
BDC	before dead center	EDI	electronic data interchange	Hz	hertz (cycles per second)
BHP	brake horsepower	EFR	emergency frequency relay	IC	integrated circuit
blk.	black (paint color), block (engine)	e.g.	for example (<i>exempli gratia</i>)	ID	inside diameter, identification
blk. htr.	block heater	EG	electronic governor	IEC	International Electrotechnical Commission
BMEP	brake mean effective pressure	EGSA	Electrical Generating Systems Association	IEEE	Institute of Electrical and Electronics Engineers
bps	bits per second	EIA	Electronic Industries Association	IMS	improved motor starting
br.	brass	EI/EO	end inlet/end outlet	in.	inch
BTDC	before top dead center	EMI	electromagnetic interference	in. H ₂ O	inches of water
Btu	British thermal unit	emiss.	emission	in. Hg	inches of mercury
Btu/min.	British thermal units per minute	eng.	engine	in. lbs.	inch pounds
C	Celsius, centigrade	EPA	Environmental Protection Agency	Inc.	incorporated
cal.	calorie	EPS	emergency power system	ind.	industrial
CARB	California Air Resources Board	ER	emergency relay	int.	internal
CB	circuit breaker	ES	engineering special, engineered special	int./ext.	internal/external
cc	cubic centimeter	ESD	electrostatic discharge	I/O	input/output
CCA	cold cranking amps	est.	estimated	IP	iron pipe
ccw.	counterclockwise	E-Stop	emergency stop	ISO	International Organization for Standardization
CEC	Canadian Electrical Code	etc.	et cetera (and so forth)	J	joule
cfh	cubic feet per hour	exh.	exhaust	JIS	Japanese Industry Standard
cfm	cubic feet per minute	ext.	external	k	kilo (1000)
		F	Fahrenheit, female	K	kelvin
				KA	kiloampere
				KB	kilobyte (2 ¹⁰ bytes)

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

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, spirallock 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.

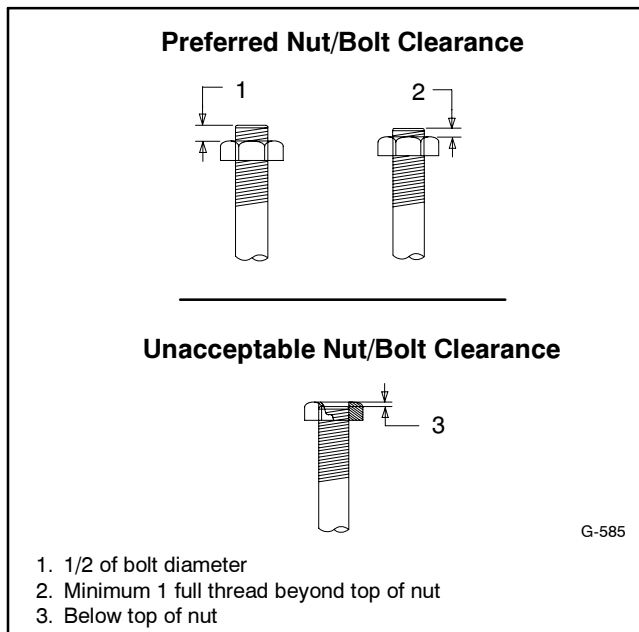


Figure 1 Acceptable Bolt Lengths

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 spirallock 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.

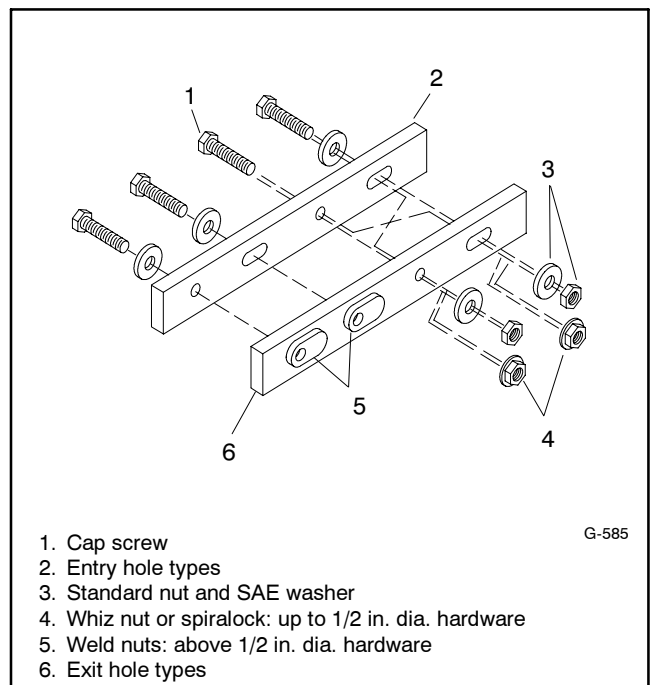


Figure 2 Acceptable Hardware Combinations

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 or 5
		Grade 2	Grade 5	Grade 8	
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 or 8.8
	Grade 5.8	Grade 8.8	Grade 10.9	
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	

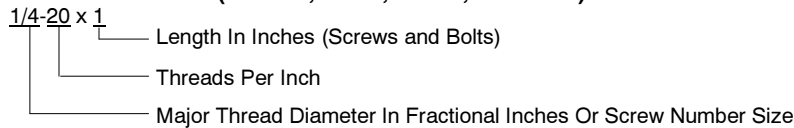
Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

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

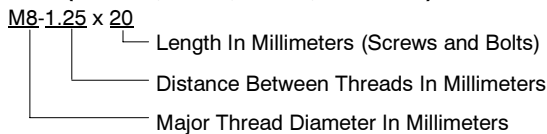
Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

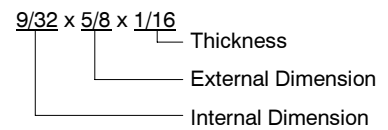
American Standard (Screws, Bolts, Studs, and Nuts)



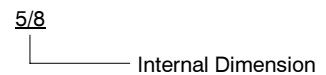
Metric (Screws, Bolts, Studs, and Nuts)



Plain Washers



Lock Washers



Appendix E Common Hardware List

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

American Standard

Part No.	Dimensions	Part No.	Dimensions	Part No.	Dimensions	Type
Hex Head Bolts (Grade 5)						
X-465-17	1/4-20 x .38	X-6238-14	3/8-24 x .75	X-6009-1	1-8	Standard
X-465-6	1/4-20 x .50	X-6238-16	3/8-24 x 1.25	X-6210-3	6-32	Whiz
X-465-2	1/4-20 x .62	X-6238-21	3/8-24 x 4.00	X-6210-4	8-32	Whiz
X-465-16	1/4-20 x .75	X-6238-22	3/8-24 x 4.50	X-6210-5	10-24	Whiz
X-465-18	1/4-20 x .88	X-6024-5	7/16-14 x .75	X-6210-1	10-32	Whiz
X-465-7	1/4-20 x 1.00	X-6024-2	7/16-14 x 1.00	X-6210-2	1/4-20	Spiralock
X-465-8	1/4-20 x 1.25	X-6024-8	7/16-14 x 1.25	X-6210-6	1/4-28	Spiralock
X-465-9	1/4-20 x 1.50	X-6024-3	7/16-14 x 1.50	X-6210-7	5/16-18	Spiralock
X-465-10	1/4-20 x 1.75	X-6024-4	7/16-14 x 2.00	X-6210-8	5/16-24	Spiralock
X-465-11	1/4-20 x 2.00	X-6024-11	7/16-14 x 2.75	X-6210-9	3/8-16	Spiralock
X-465-12	1/4-20 x 2.25	X-6024-12	7/16-14 x 6.50	X-6210-10	3/8-24	Spiralock
X-465-14	1/4-20 x 2.75	X-129-15	1/2-13 x .75	X-6210-11	7/16-14	Spiralock
X-465-21	1/4-20 x 5.00	X-129-17	1/2-13 x 1.00	X-6210-12	1/2-13	Spiralock
X-465-25	1/4-28 x .38	X-129-18	1/2-13 x 1.25	X-6210-15	7/16-20	Spiralock
X-465-20	1/4-28 x 1.00	X-129-19	1/2-13 x 1.50	X-6210-14	1/2-20	Spiralock
X-125-33	5/16-18 x .50	X-129-20	1/2-13 x 1.75	X-85-3	5/8-11	Standard
X-125-23	5/16-18 x .62	X-129-21	1/2-13 x 2.00	X-88-12	3/4-10	Standard
X-125-3	5/16-18 x .75	X-129-22	1/2-13 x 2.25	X-89-2	1/2-20	Standard
X-125-31	5/16-18 x .88	X-129-23	1/2-13 x 2.50	Washers		
X-125-5	5/16-18 x 1.00	X-129-24	1/2-13 x 2.75	Part No.	ID	OD
X-125-24	5/16-18 x 1.25	X-129-25	1/2-13 x 3.00	X-25-46	.125	.250
X-125-34	5/16-18 x 1.50	X-129-27	1/2-13 x 3.50	X-25-9	.156	.375
X-125-25	5/16-18 x 1.75	X-129-29	1/2-13 x 4.00	X-25-48	.188	.438
X-125-26	5/16-18 x 2.00	X-129-30	1/2-13 x 4.50	X-25-36	.219	.500
230578	5/16-18 x 2.25	X-463-9	1/2-13 x 5.50	X-25-40	.281	.625
X-125-29	5/16-18 x 2.50	X-129-44	1/2-13 x 6.00	X-25-85	.344	.687
X-125-27	5/16-18 x 2.75	X-129-51	1/2-20 x .75	X-25-37	.406	.812
X-125-28	5/16-18 x 3.00	X-129-45	1/2-20 x 1.25	X-25-34	.469	.922
X-125-22	5/16-18 x 4.50	X-129-52	1/2-20 x 1.50	X-25-26	.531	1.062
X-125-32	5/16-18 x 5.00	X-6021-3	5/8-11 x 1.00	X-25-15	.656	1.312
X-125-35	5/16-18 x 5.50	X-6021-4	5/8-11 x 1.25	X-25-29	.812	1.469
X-125-36	5/16-18 x 6.00	X-6021-2	5/8-11 x 1.50	X-25-127	1.062	2.000
X-125-40	5/16-18 x 6.50	X-6021-1	5/8-11 x 1.75			
X-125-43	5/16-24 x 1.75	273049	5/8-11 x 2.00	Thick.	Bolt/	Screw
X-125-44	5/16-24 x 2.50	X-6021-5	5/8-11 x 2.25	X-25-46	.022	#4
X-125-30	5/16-24 x .75	X-6021-6	5/8-11 x 2.50	X-25-9	.049	#6
X-125-39	5/16-24 x 2.00	X-6021-7	5/8-11 x 2.75	X-25-48	.049	#8
X-125-38	5/16-24 x 2.75	X-6021-12	5/8-11 x 3.75	X-25-36	.049	#10
X-6238-2	3/8-16 x .62	X-6021-11	5/8-11 x 4.50	X-25-40	.065	1/4
X-6238-10	3/8-16 x .75	X-6021-10	5/8-11 x 6.00	X-25-85	.065	5/16
X-6238-3	3/8-16 x .88	X-6021-9	5/8-18 x 2.50	X-25-37	.065	3/8
X-6238-11	3/8-16 x 1.00	X-6239-1	3/4-10 x 1.00	X-25-34	.065	7/16
X-6238-4	3/8-16 x 1.25	X-6239-8	3/4-10 x 1.25	X-25-26	.095	1/2
X-6238-5	3/8-16 x 1.50	X-6239-2	3/4-10 x 1.50	X-25-15	.095	5/8
X-6238-1	3/8-16 x 1.75	X-6239-3	3/4-10 x 2.00	X-25-29	.134	3/4
X-6238-6	3/8-16 x 2.00	X-6239-4	3/4-10 x 2.50		.134	1
X-6238-17	3/8-16 x 2.25	X-6239-5	3/4-10 x 3.00			
X-6238-7	3/8-16 x 2.50	X-6239-6	3/4-10 x 3.50			
X-6238-8	3/8-16 x 2.75	X-792-1	1-8 x 2.25			
X-6238-9	3/8-16 x 3.00	X-792-5	1-8 x 3.00			
X-6238-19	3/8-16 x 3.25	X-792-8	1-8 x 5.00			
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					

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No. Dimensions Hex Head Bolts (Partial Thread)

M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150

M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150

M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M960-10330-60	M10-1.25 x 330

M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Part No. Dimensions Hex Head Bolts (Partial Thread), continued

M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150

M931-20065-60	M20-2.50 x 65
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160

M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160

M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Hex Head Bolts (Full Thread)

M933-04006-60	M4-0.70 x 6
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M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50

M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50

M933-07025-60	M7-1.00 x 25
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M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*

M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35
M961-10040-60	M10-1.25 x 40

M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M961-12030-82F	M12-1.50 x 30
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*

Part No. Dimensions Hex Head Bolts (Full Thread), continued

M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50

M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45
M933-16045-82	M16-2.00 x 45
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70

M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60

M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55

M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12

M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100

M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100

M7985A-06100-20	M6-1.00 x 100
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Flat Head Machine Screws

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

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

Metric, continued

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

Washers

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

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

TP-5986 4/03b

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