Service

Marine Generator Sets

Models:

6EKOD
5EFKOD
9–11EKOZD
7–9EFKOZD

ISO 9001 KOHLER POWER SYSTEMS NATIONALLY REGISTERED

KOHLER®
Power Systems

TP-6774 2/14a

Product Identification Information

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

Generator Set Identification Numbers

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

Model Designation _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

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Notes

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

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

DANGER

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

WARNING

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

CAUTION

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

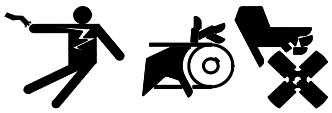
NOTICE

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

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

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

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

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

Engine Backfire/Flash Fire

WARNING

Fire.
Can cause severe injury or death.

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

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel injection system, 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 fuel system.

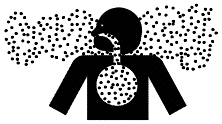
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner/silencer removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the generator set. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Catch fuels in an approved container. 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



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

The exhaust system must be leakproof and routinely inspected.

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

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

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

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. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. 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.

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

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

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

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

Hazardous Voltage/ Moving Parts

⚠ WARNING

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

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

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.

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

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

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.

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 turned off. 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.

Notice

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

Introduction

This manual provides troubleshooting and repair instructions for 6EKOD, 9-11EKOZD, 5EFKOD and 7-9EFKOZD model generator sets (4-lead and 12-lead), Advanced Digital Control, and accessories.

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

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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.

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Service Assistance

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

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

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Fax: (813) 3440-2727

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

Notes

1.1 General

This manual covers maintenance, troubleshooting, and repair of the alternating current marine generator sets listed in Figure 1-1. Consult the generator set nameplate for specific generator set ratings.

Models	Voltage	Hz	Ph
6EKOD	120 120/240	60	1
9/11EKOZD	120 120/240	60	1
11EKOZD	220/380 240/416 120/240 127/220	60	3
5EFKOD	115/230 230 240	50	1
7/9EFKOZD	115/230 230 240	50	1
9EFKOZD	230/400	50	3

Figure 1-1 Generator Model Coverage

The 6EKOD/5EFKOD (single-phase) models are powered by a three-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

The 9EKOZD/7EFKOZD (single-phase) models are powered by a three-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

The 11EKOZD/9EFKOZD (single- and three-phase) models are powered by a four-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

Heat exchanger cooling consists of a heat exchanger with a coolant recovery tank, thermostat, rubber impeller seawater pump, centrifugal type engine circulating pump, water-cooled exhaust manifold, and an exhaust mixer.

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

Read this manual, then carefully follow all service recommendations. See Figure 1-2 for identification and location of components.

1.2 Engine

Generator Model	6EKOD/ 5EFKOD (1 Phase)	9EKOZD/ 7EFKOZD (1 Phase)	11EKOZD/ 9EFKOZD (1 Phase)	11EKOZD/ 9EFKOZD (3 Phase)
Number of cylinders	3		4	
Type	4 cycle, naturally aspirated			
Engine block material	Cast iron with re-borable integral liners			
Cylinder head material	Aluminum			
Governor	Centrifugal, mechanical			
Engine firing order (#1 cylinder on flywheel end or alternator end)	1-3-2		1-3-4-2	
Direction of rotation (as viewed from flywheel)	Counterclockwise			
Combustion system	Indirect injection			
Bore x stroke, mm (in.)	75 x 77.6 (2.95 x 3.05)			
Displacement L (CID)	1.028 (62.7)		1.372 (83.7)	
Compression ratio	24.5:1			
Max. power at rated rpm, HP 60/50 Hz	10.1/8.4	14.5/11.9	19.6/15.4	
RPM 60/50 Hz	1800/1500			
Lubrication system	Pressurized oil system with oil pump			
Lube oil capacity, w/filter L (U.S. qts.)	2.5 (2.6)		3.4 (3.6)	
Oil recommendation (API)	CD or CF class			
Fuel recommendation (API)	Cetane No. 51 min. Fuel with low sulphur content: API CF4, CG4 or Fuel with high sulphur content API CF, CD, CE			
Fuel shutoff solenoid	Electric			
Fuel pump	Electric			
Max. recommended fuel pump lift, m (ft.)	0.9 (3)	1.2 (4)		
Battery voltage	12 volts			
Battery charging module	10-amp			
Battery recommendation (minimum)	650 CCA @ 0°F			
Starter motor	2.5 kW, 12 volt			
Recommended coolant	50% ethylene glycol; 50% clean, softened water			
Coolant capacity, approx. L (U.S. qts.) add 0.24 L (8 oz.) for coolant recovery tank	3 (3.2)		4.3 (4.5)	
Thermostat, opening temp. °C (°F)	83-87 (181-188)			
High exhaust temperature shutdown, °C (°F)	102 ± 2.8 (215 ± 5)			
Seawater inlet water line hose ID, mm (in.)	19 (0.75) with or without sound shield			
Water cooled exhaust outlet hose ID, mm (in.)	51 (2) with or without sound shield			
Fuel inlet size	1/4 NPT with or without sound shield			
Fuel return size	1/4 NPT with or without sound shield			
Fuel injection pressure, bar	128-137			
Intake/exhaust valve clearance (cold), mm (in.)	0.20 (0.008)			
Fuel pump static pressure, psi	4-8 (12-volt pump)			
Pressure cap's overpressure valve opening pressure, bar	0.7			

1.3 Generator, 4 Lead

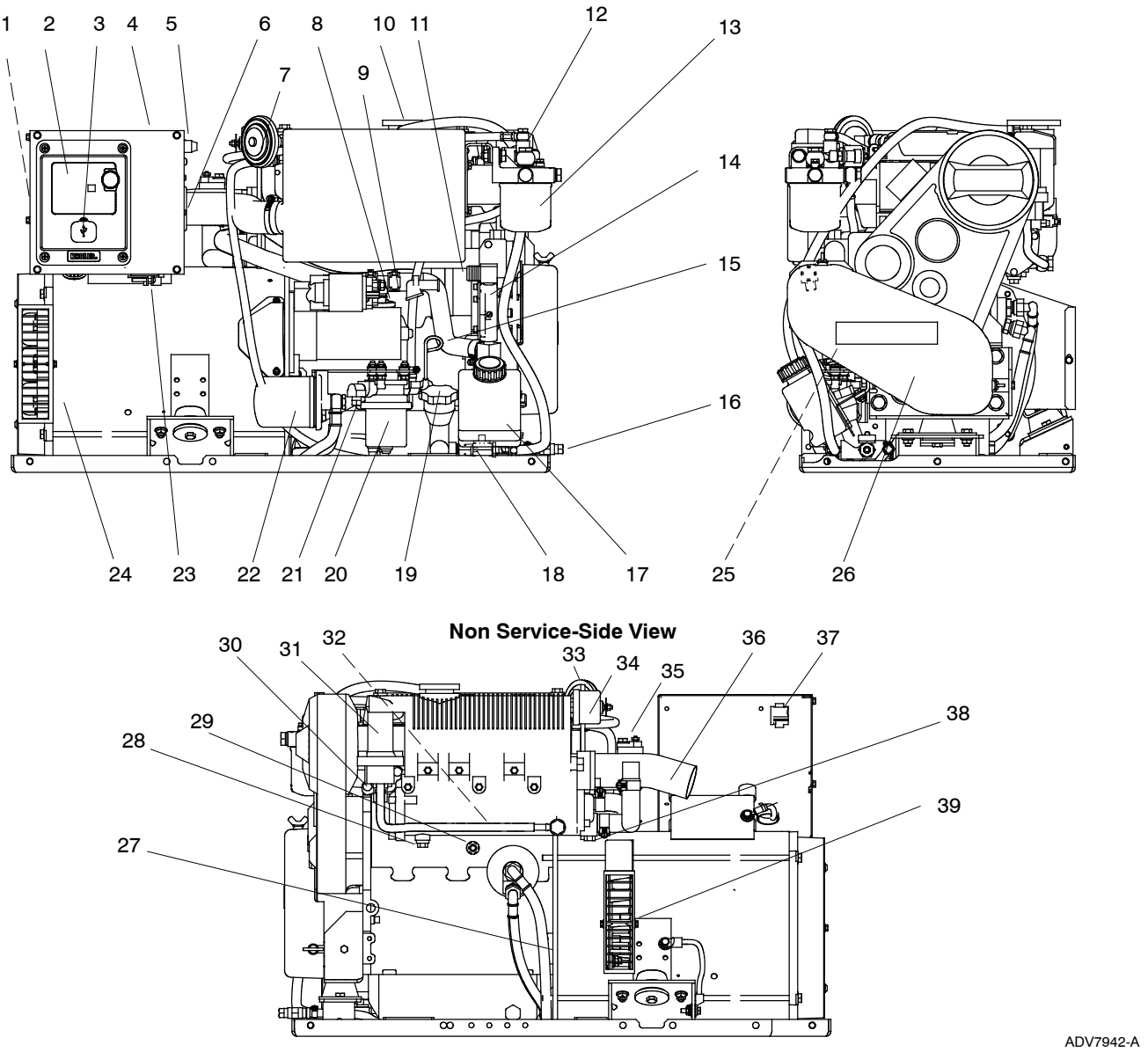
Component Specification	6EKOD 5EFKOD
Main field (rotor) resistance (cold)—ohms @ 20°C (68°F)	4.4–5.0
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)	
1–2, 3–4—volts	130
55–66—volts	155
Cold stator resistance	
1–2, 3–4—ohms	0.19
55–66—ohms	2.7

Component Specification	9EKOZD/ 7EFKOZD	11EKOZD/ 9EFKOZD
Hot exciter field voltage/amperage readings at rated voltage		
No load (63 Hz)—volts/amps	12/0.8	5/0.9
Full load (60 Hz)—volts/amps	33/2.2	14/2.3
Exciter field resistance (cold)—ohms @ 20°C (68°F)	4.8	4.8
Exciter armature resistance (cold)—ohms (line-to-line)	1.18	1.18
Main field (rotor) resistance (cold)—ohms @ 20°C (68°F)	5.7	5.7
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)		
1–2, 3–4—volts	115	184
55–66—volts	155	193
Cold stator resistance		
1–2, 3–4—ohms	0.19	0.28
55–66—ohms	1.9	1.3

1.4 Generator, 12 Lead

Component Specification	11EKOZD/ 9EFKOZD
Hot exciter field voltage/amperage readings at rated voltage	
No load (63 Hz)—volts/amps	7/1.3
Full load (60 Hz)—volts/amps	20/3.3
Exciter field resistance (cold)—ohms @ 20°C (68°F)	4.8
Exciter armature resistance (cold)—ohms (line-to-line)	1.18
Main field (rotor) resistance (cold)—ohms @ 20°C (68°F)	5.7
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)	
1–4, 2–5, 3–6, 7–10, 8–11, 9–12—volts	160
55–66—volts	192
Cold stator resistance	
1–4, 2–5, 3–6, 7–10, 8–11, 9–12—ohms	0.34
55–66—ohms	0.88

1.5 Service Views

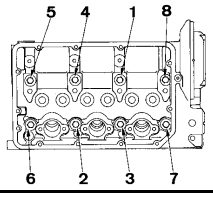


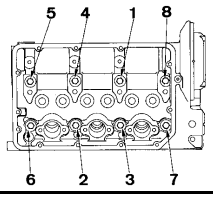
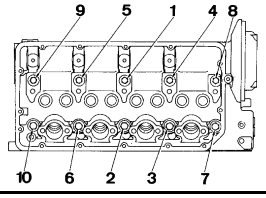
1. Battery charging module
2. ADC IId controller
3. USB port
4. Nameplate (on top of controller)
5. Fuses (F1, F2, and F3)
6. AC circuit breaker panel
7. Closed breather
8. Battery positive (+) connection
9. Seawater pressure switch
10. Coolant fill/coolant overflow tube
11. Seawater inlet
12. Fuel solenoid
13. Fuel filter
14. Seawater pump
15. Oil check/dipstick
16. Fuel return
17. Coolant overflow bottle
18. Oil drain valve
19. Oil fill
20. Fuel feed pump
21. Fuel inlet
22. Oil filter
23. Customer load lead connection
24. Alternator cooling air inlet
25. V-belt
26. Belt guard
27. Battery negative (-) connection
28. Seawater drain
29. Engine coolant drain
30. Coolant temperature sensor
31. Thermostat assembly
32. Heat exchanger internal to exhaust manifold
33. Lifting eye
34. Oil pressure sender
35. High exhaust temperature switch
36. Mixing elbow (water outlet/exhaust outlet)
37. Customer interface
38. Anticorrosion zinc anode
39. Air outlet

Figure 1-2 Service Views—Typical

1.6 Torque Specifications

Follow the general torque specification found in Appendix C of this manual unless noted below.

Generator Model	6EKOD/ 5EFKOD (1 Phase)
Overbolts	23 Nm (17 ft. lbs.)
Drive discs to rotor hub	45 Nm (34 ft. lbs.)
Rotor fan to flywheel	23 Nm (17 ft. lbs.)
Back plate to engine block	23 Nm (17 ft. lbs.)
Locator plate to engine block	23 Nm (17 ft. lbs.)
Flywheel mounting bolts	80 Nm (59 ft. lbs.)
Brush holder to brush holder bracket	4 Nm (35 in. lbs.)
Brush bracket to end bracket	6.5 Nm (50 in. lbs.)
Thermostat housing	23 Nm (17 in. lbs.)
Exhaust manifold	25 Nm (18 in. lbs.)
Cylinder head Follow the numerical order shown in the diagram and tighten the bolts in 3 phases: 1st phase: 50 Nm (37 ft. lbs.) 2nd phase: Rotate the wrench clockwise 90° 3rd phase: Rotate the wrench again clockwise 90°	

Generator Model	9EKOZD/ 7EFKOZD (1 Phase)	11EKOZD/ 9EFKOZD (1 Phase)	11EKOZD/ 9EFKOZD (3 Phase)
Overbolts	23 Nm (17 ft. lbs.)		
Drive discs to rotor hub	45 Nm (34 ft. lbs.)		
Rotor fan to flywheel	23 Nm (17 ft. lbs.)		
Back plate to engine block	23 Nm (17 ft. lbs.)		
Locator plate to engine block	23 Nm (17 ft. lbs.)		
Flywheel mounting bolts	80 Nm (59 ft. lbs.)		
Exciter armature to rotor shaft	38 Nm (28 ft. lbs.)		
Thermostat housing	23 Nm (17 ft. lbs.)		
Exhaust manifold	25 Nm (18 ft. lbs.)		
Cylinder head Follow the numerical order shown in the diagram and tighten the bolts in 3 phases: 1st phase: 50 Nm (37 ft. lbs.) 2nd phase: Rotate the wrench clockwise 90° 3rd phase: Rotate the wrench again clockwise 90°			

Notes

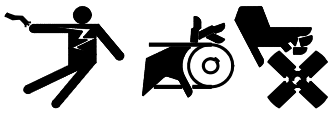
2.1 General

Schedule routine maintenance using the service schedule located in the generator set operation manual and the runtime hours shown on the ADC IId. If the generator set will be subject to extreme operating conditions, service the unit accordingly.

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

Note: High-mineral content seawater (salt water) can cause rapid destruction of metals. Wipe up all salt water spillage on and around the generator set and keep metal surfaces free from accumulated salt deposits.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

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

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.

2.2 Lubrication System

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

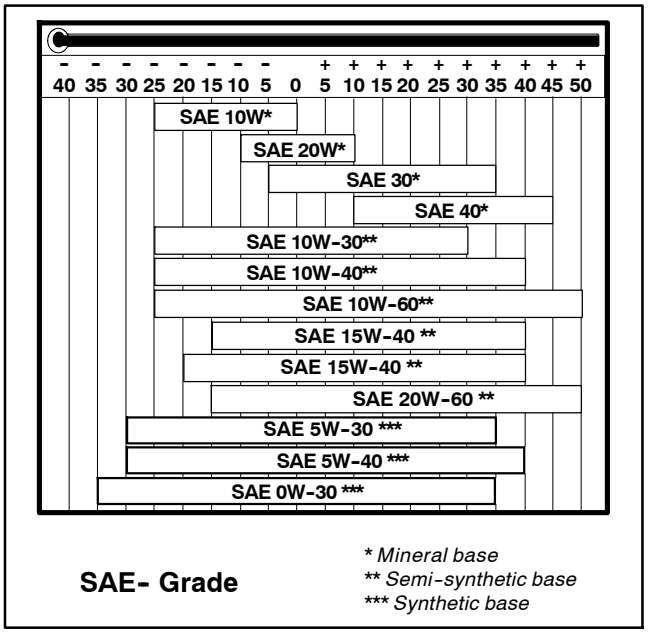
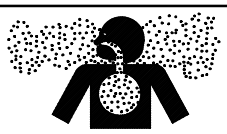


Figure 2-1 Engine Oil Selection

Note: Failure to observe the oil specifications may cause inadequate lubrication/oil pressure and cold-starting difficulties.

3.1 Exhaust System Inspection

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

At the interval specified in the service schedule, inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust hose, hose clamps, silencer, and outlet flapper) for cracks, leaks, and corrosion.

Ensure that the carbon monoxide detector(s) is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

For your safety: Never operate the generator set without a functioning carbon monoxide detector(s) for your safety and the safety of others on your vessel.

Exhaust System Inspection Points

Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

- 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 and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect the exhaust system for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.

3.2 Servicing Mixing Elbow

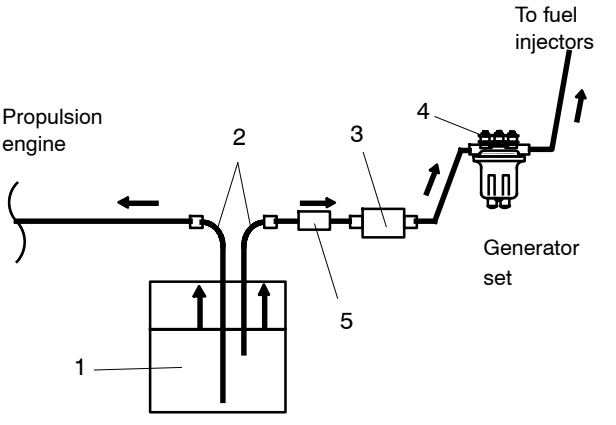
The mixing elbow combines high-temperature exhaust with cooling seawater. See the operation manual for mixing elbow scheduled maintenance.

1. Check the mixing elbow for carbon buildup and corrosion inside the pipe.
2. Clean or replace the mixing elbow as necessary.
3. Inspect the exhaust manifold mounting threads for cracking and corrosion.

Notes

4.1 General

In most installations, both the generator set and the propulsion engine operate from a common fuel tank with a dual dip tube arrangement. The generator set's dip tube is shorter than the propulsion 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 a fuel system schematic.



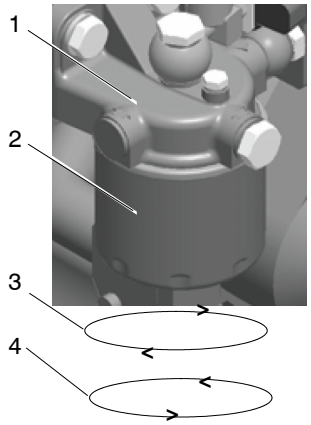
1. Fuel tank
2. Dual dip tubes
3. Fuel filter
4. Fuel feed pump
5. Water trap

Figure 4-1 Fuel System Schematic, Typical

4.2 Fuel Filter

Clean the fuel filter with fresh fuel oil and compressed air. The filter's useful life will be determined largely by the quality and condition of the fuel used. Under normal conditions, replace the fuel filter element at the specified interval in the generator set's operation manual. Use the following procedure to replace the fuel filter.

1. Press the start/stop button to stop the generator set.
2. Press the power button to turn the controller off.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Close the fuel supply valve.
5. Loosen the fuel filter by turning it counterclockwise. Remove the fuel filter and use rags to clean up spilled fuel oil. Dispose of the fuel filter and rags in an approved manner.
6. Clean the contact surface of the fuel oil filter adapter.
7. Lightly lubricate the gasket surface of the new fuel filter with fresh fuel oil. Thread the filter on the adapter until the gasket makes contact; hand-tighten the filter an additional one-half turn. Wash hands after any contact with fuel oil.
8. Open the fuel supply valve.
9. Reconnect the generator set engine starting battery, negative (–) lead last.
10. Bleed the system. See Section 4.2.1, Fuel System Bleed.



1. Fuel filter adapter
2. Fuel filter
3. Removal (counterclockwise)
4. Installation (clockwise)

Figure 4-2 Spin-On Fuel Oil Filter

4.2.1 Fuel System Bleed

Bleed air from the fuel system in order to reduce rough running or vapor lock. Trapped air in the fuel system can cause difficult starting and erratic engine operation.

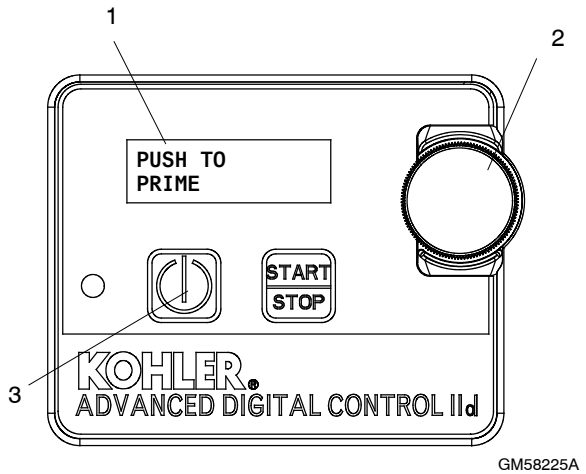
Prime the fuel system under the following conditions:

- Before starting the engine for the first time.
- After running out of fuel and adding fuel to the tank.
- After fuel system maintenance such as changing the fuel filter, draining the fuel/water separator, or replacing a fuel system component.

Fuel System Bleed Procedure (Preferred)

Note: To prevent damage to the starter motor, do not crank the engine to prime the fuel system. Use the following procedure.

1. Push the power button on the Advanced Digital Control IId to the ON position.
2. When the run time hours appear on the LCD digital display, rotate the pushbutton/rotary selector dial until "PUSH TO PRIME" appears on the LCD digital display.
3. Push the pushbutton/rotary selector dial.
4. Rotate the pushbutton/rotary selector dial to "CONFIRM PRIME: Yes".
5. Push the pushbutton/rotary selector dial to begin the fuel priming procedure. A 30 second priming sequence begins automatically. If necessary, push the control knob to stop the priming procedure before the 30 seconds are up.



1. LCD digital display
2. Pushbutton/rotary selector dial
3. Power button

Figure 4-3 Advanced Digital Control IId

Typically, running the Prime function on the ADC IId is all that is required. If rough operation continues, use the following procedure to open the air bleed valve on the fuel filter.

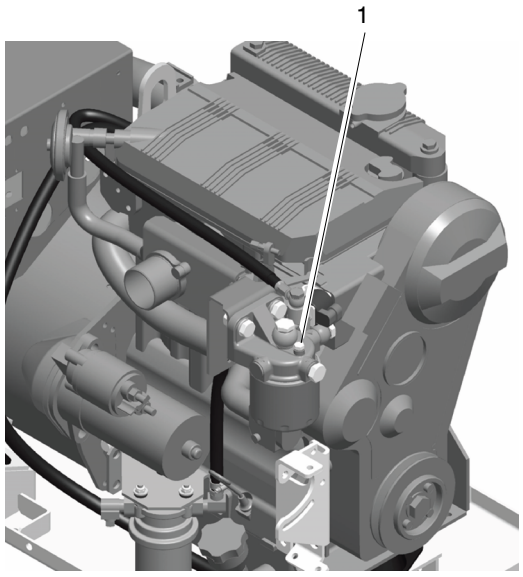
Note: Connect the battery during the priming procedure to allow engine cranking.

Note: If the ADC IId indicates an overcrank fault during this procedure, disconnect the negative wire from the fuel solenoid (allowing the fuel injection pump to fill with fuel) and repeat this procedure after allowing the starter motor to cool down.

Note: Have a rag handy during this procedure. Wipe up any spilled diesel fuel. Wash hands after any contact with fuel. Dispose of fuel in an environmentally safe manner.

Fuel System Bleed Procedure

1. Loosen the fuel filter's air vent screw. See Figure 4-4.
2. Initiate the auto/start sequence until fuel, free of air bubbles, flows from the vent screw at the fuel filter.
3. Tighten the fuel filter's air vent screw.



1. Fuel filter's air vent screw location

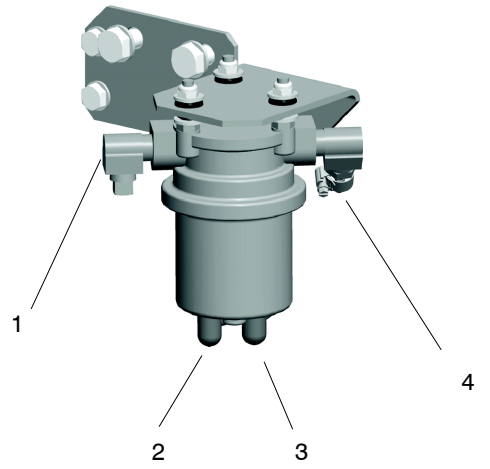
Figure 4-4 Fuel Filter's Air Vent Screw

4.3 Fuel Pump

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

Fuel Pump Test Procedure:

1. Remove the two leads at the bottom of the fuel pump. The pump terminals are labeled (–) and (+). See Figure 4-5.
2. Connect the inlet side of the pump to a fuel source. Disconnect the outlet hose from the fuel filter and place the hose end in a container to catch the fuel.
3. Connect the positive (+) terminal of a 12-volt battery to the positive terminal of the fuel pump. Connect the negative terminal of the fuel pump to the negative (–) terminal of the battery. You should hear the pump operate and see fuel discharge from the pump outlet. Replace the pump if it does not operate.
4. Connect a pressure gauge to the outlet side of the fuel pump. Repeat step 3. See Section 1 for the specified fuel pump pressure ratings.



1. Fuel inlet
2. Negative (–) terminal
3. Positive (+) terminal
4. Fuel outlet

Figure 4-5 Fuel Pump

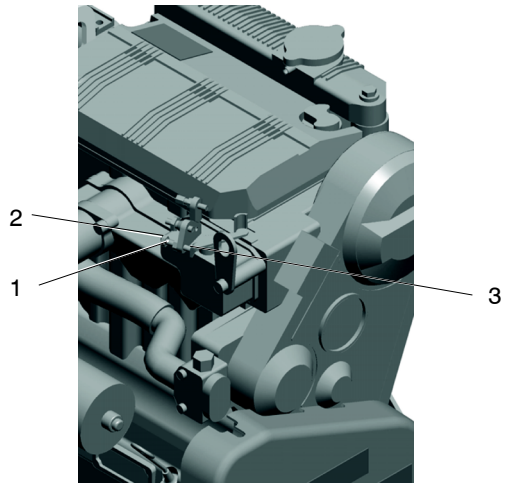
4.4 Governor

The centrifugal, mechanical governor keeps the engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load. The governor requires no regular service. The factory adjusts the governor during run-in, and further adjustment should not be needed unless greatly varying load conditions are encountered or if poor governor control develops after extended usage.

60 Hz generator sets are designed to operate in the range of 59-63 Hz (1800 rpm under full load and 1890 rpm under no load).

50 Hz generator sets are designed to operate in the range of 49-53 Hz (1500 rpm under full load and 1590 rpm under no load).

To check the engine speed, use a frequency meter connected to the load leads or use a hand tachometer. If adjustment is needed, loosen the locking nut on the speed adjusting screw. Turn the screw clockwise to increase the speed (and frequency). To decrease the speed, turn the screw counterclockwise. Tighten the locking nut when the correct setting is reached. See Figure 4-6.



1. Speed adjusting screw
2. Locking nut
3. Adjusting arm

Figure 4-6 Governor Adjustment

4.5 Fuel Solenoid

The generator set uses a 2-lead fuel solenoid. See Section 1, Service Views for location. This solenoid has lead 70A which energizes the coil during cranking, opening fuel flow to the engine. Lead N is the common ground.

Notes

5.1 General

Heat exchanger cooling consists of a heat exchanger with coolant recovery tank, thermostat, rubber impeller seawater pump, centrifugal-type engine circulating pump, water-cooled exhaust manifold, and an exhaust mixer. See Figure 5-1 for cooling system components.

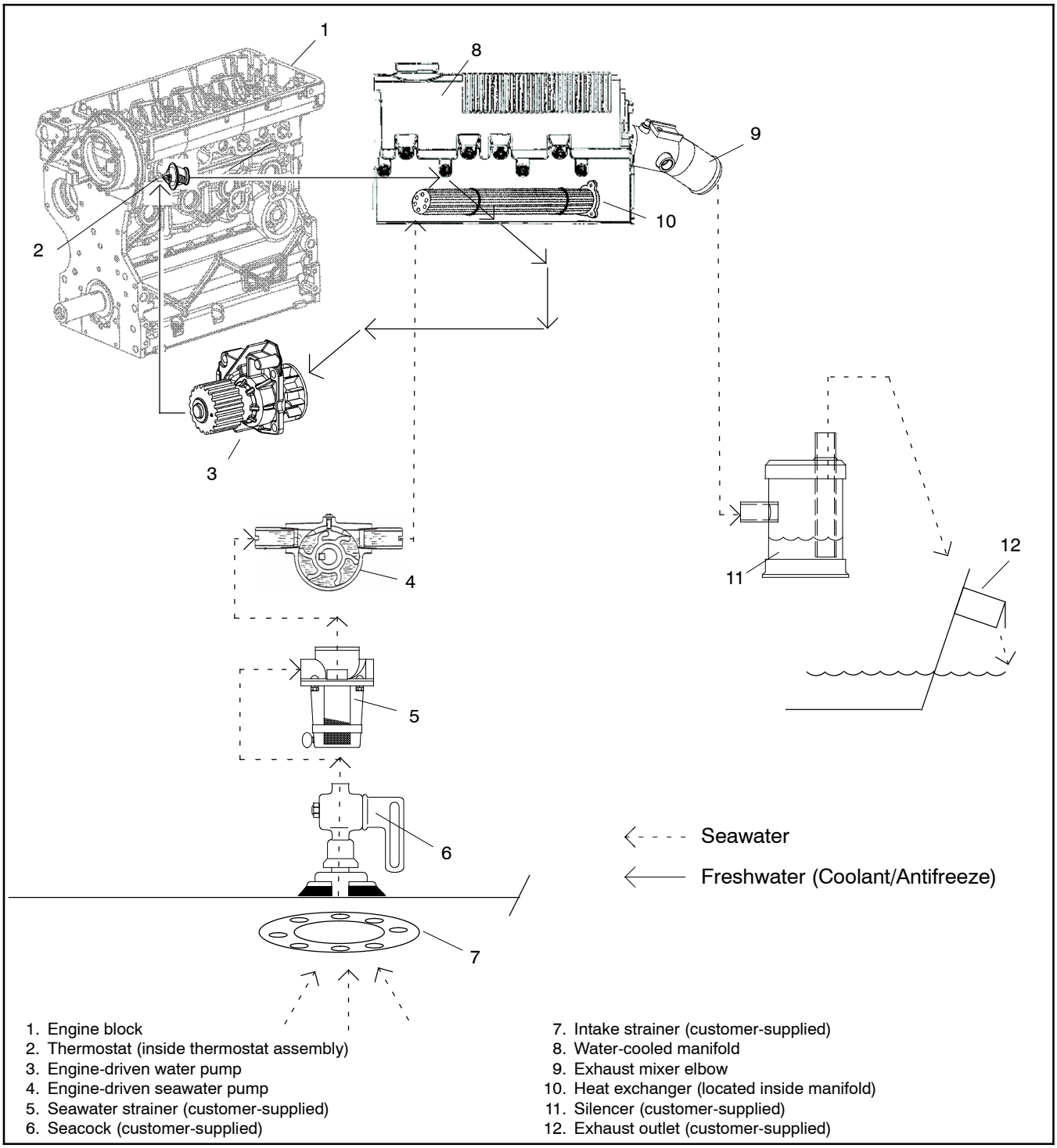


Figure 5-1 Cooling System Components

⚠ 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.

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.

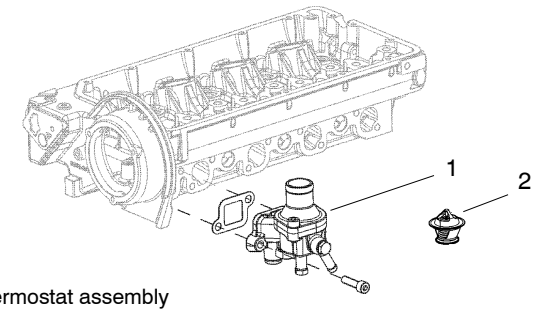
NOTICE

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

5.2 Water-Cooled Exhaust Manifold

Each marine generator set has a water-cooled exhaust manifold. The coolant solution circulates through the manifold, reducing the amount of heat radiated from the exhaust into the surrounding area.

The engine thermostat is located in the water-cooled exhaust manifold. See Figure 5-2. See Section 1 for the water-cooled exhaust manifold torque spec.



1. Thermostat assembly
2. Thermostat (located inside thermostat housing)

Figure 5-2 Thermostat Location

5.3 Coolant Replacement Including Heat Exchanger Service

At the interval specified in the Service Schedule, clean the heat exchanger tube. In a closed cooling system, seawater circulates through separate chambers within the heat exchanger to cool the engine coolant. The seawater then mixes with engine exhaust and ejects out of the exhaust mixer's outlet. See Section 1 for coolant capacity, thermostat, and pressure cap ratings.

1. Open the heat exchanger outlet to drain the coolant. See Figure 5-3.

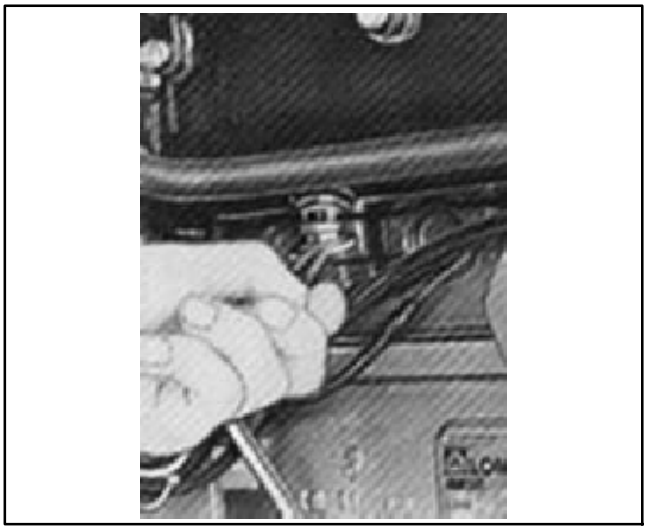


Figure 5-3 Heat Exchanger Outlet

2. Close the heat exchanger outlet.

3. Remove the engine plug to drain the engine coolant. See Figure 5-4.

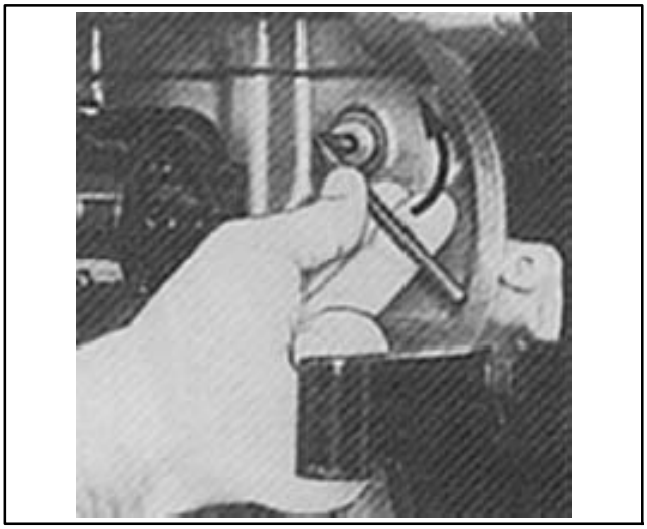


Figure 5-4 Engine Drain Plug

4. Replace the engine plug.

5. Remove the exhaust mixer's mounting nuts. See Figure 5-5.

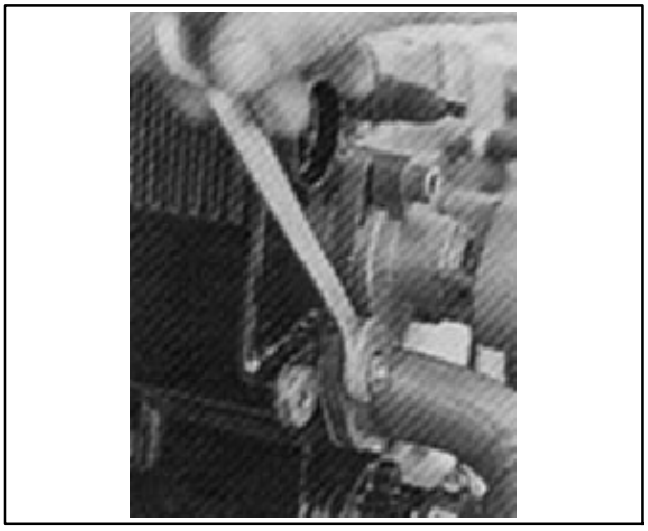


Figure 5-5 Exhaust Mixer's Mounting Nuts

6. Loosen any hose clamps.
7. Remove the exhaust mixer.
8. Loosen the front cover screws. See Figure 5-6.

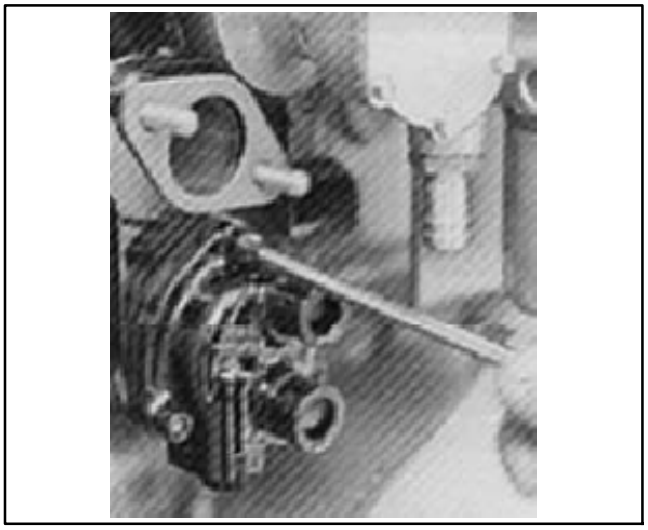


Figure 5-6 Front Cover of Heat Exchanger

9. Remove the front cover and O-ring.
10. Loosen the thermostat assembly's mounting screws and remove the thermostat assembly. See Figure 5-7.

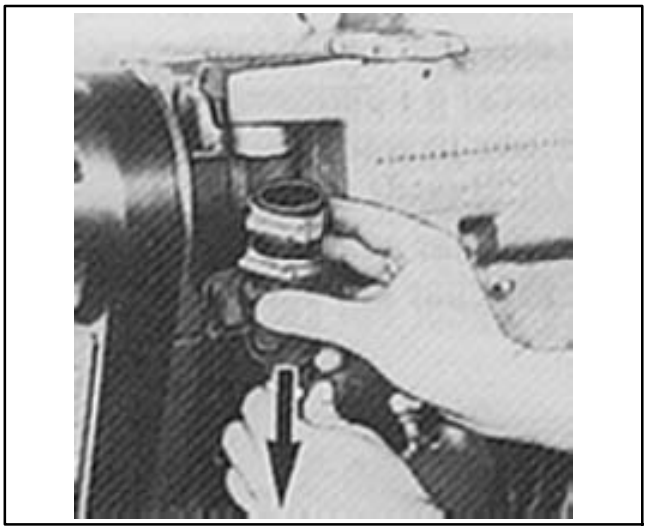


Figure 5-7 Thermostat Assembly

11. Loosen the rear cover screws. See Figure 5-8.

Figure 5-8 Rear Cover of Heat Exchanger

12. Remove the heat exchanger tube. See Figure 5-9.

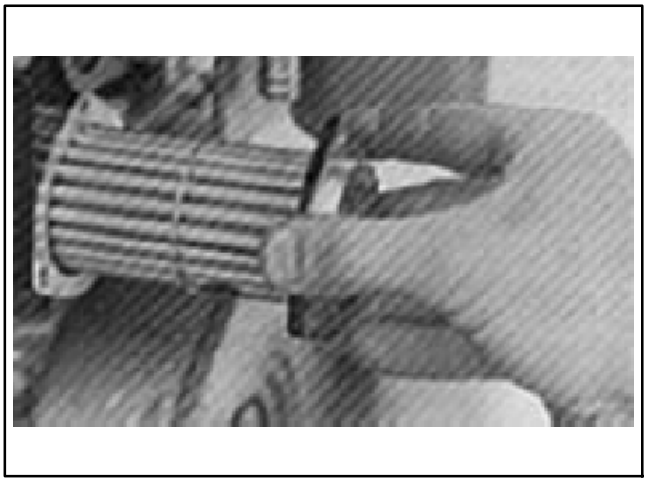


Figure 5-9 Heat Exchanger Tube

13. Dip the heat exchanger tube into a solution of 90% water and 10% hydrochloric acid. Use gloves and goggles.

14. Rinse the heat exchanger tube in clean water. See Figure 5-10.

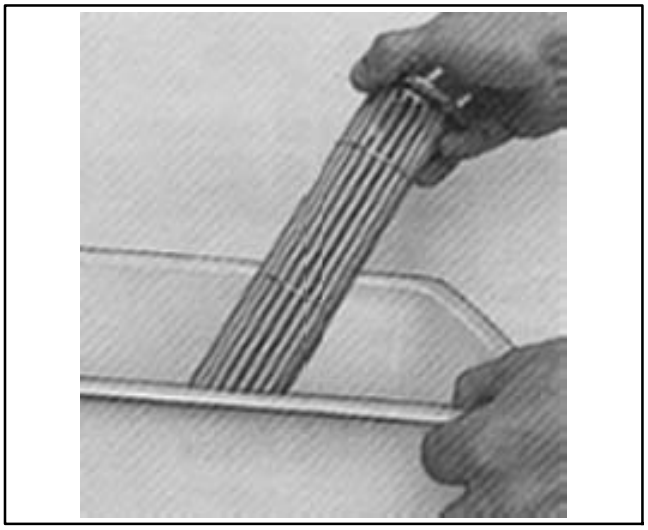


Figure 5-10 Rinse Heat Exchanger Tube

Note: Replace any damaged O-rings, seals and/or thermostat valve seals.

15. Reinstall the heat exchanger tube and O-rings. See Figure 5-11.

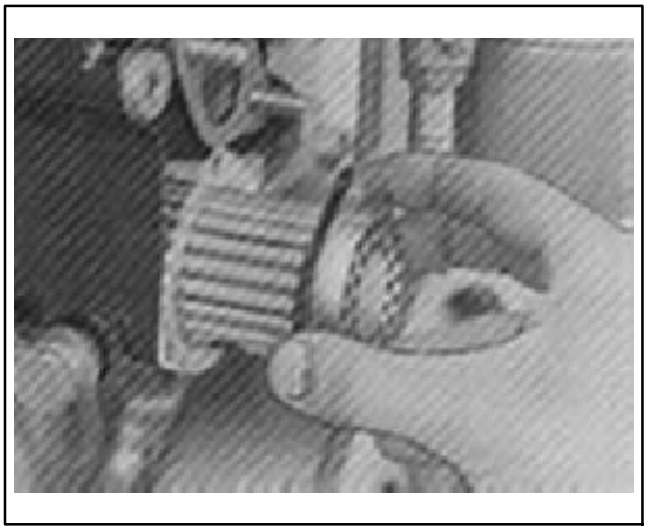


Figure 5-11 Reinstall Heat Exchanger

16. Reassemble the O-ring and front cover and tighten the screws. See Figure 5-12 and Figure 5-13.

Figure 5-12 Reinstall the O-ring and Front Cover

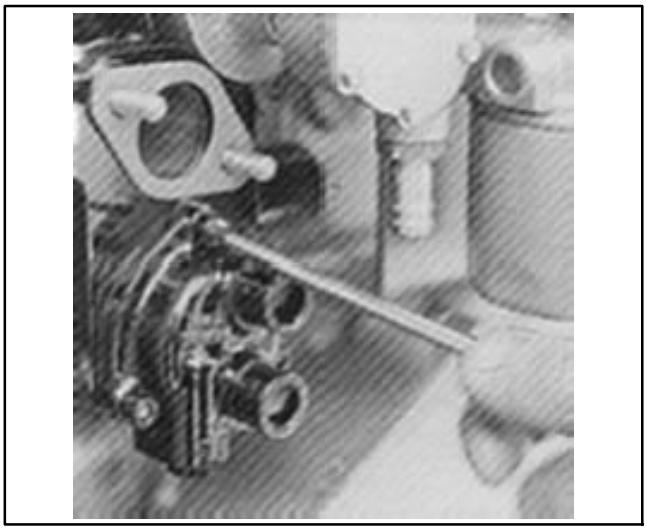


Figure 5-13 Tighten the Front Cover Screws

17. Fit the circlip and flange back into position. See Figure 5-14.

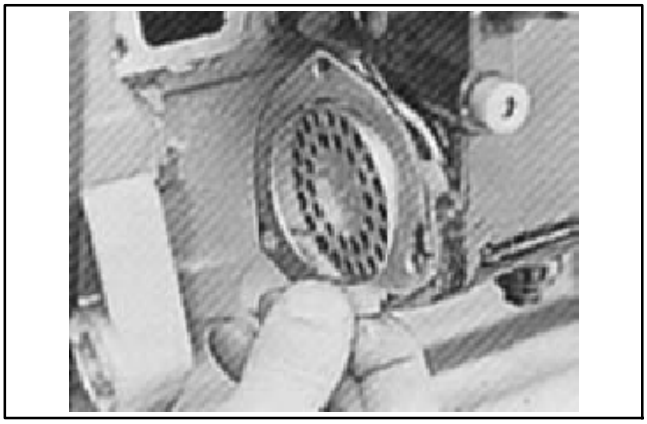


Figure 5-14 Heat Exchanger's Circlip

18. Reassemble the O-ring and rear cover and tighten the screws. See Figure 5-15.

Figure 5-15 Rear Cover of Heat Exchanger

19. Replace the thermostat assembly and tighten the screws. See Figure 5-16.

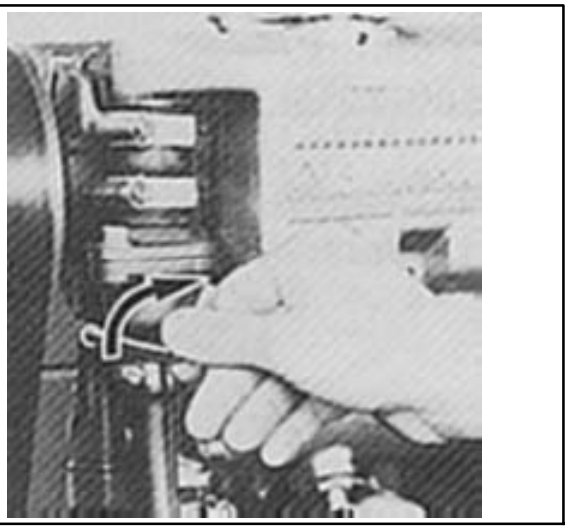


Figure 5-16 Thermostat Assembly

20. Reassemble the O-ring and exhaust mixer.

21. Tighten the exhaust mixer's mounting nuts.

22. Tighten the hose clamps for seawater inlet and outlet.

23. Remove the pressure cap and refill the coolant. See Section 5.4 for details on coolant check and fill instructions. The level should be approx. 2 cm (0.75 in.) below the filling hole.

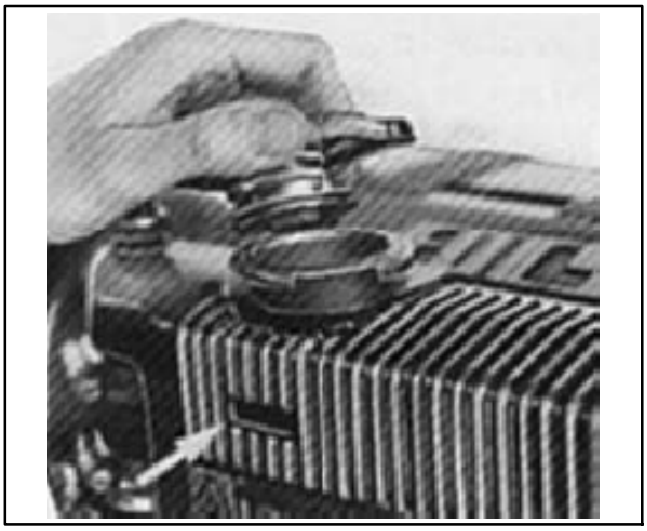


Figure 5-17 Pressure Cap

24. Replace the pressure cap.

5.4 Check and Fill Coolant

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

Maintain the coolant level in the coolant recovery tank at 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/corrosion and prevent freezing. Add coolant, 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 level is just below the overflow tube opening.

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.

5.5 Flush and Clean Cooling System

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

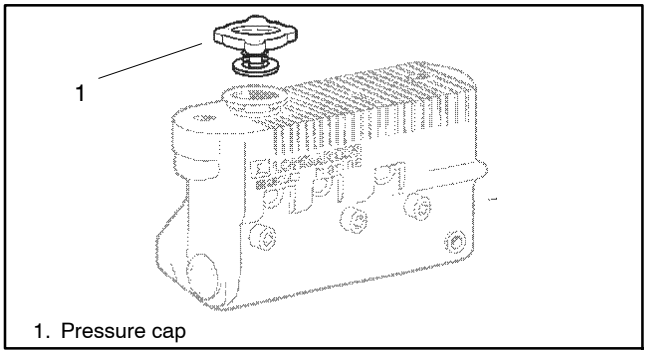
Pay special attention to the coolant level. When refilling the cooling system, allow time for complete refill of the engine water jacket. Check the coolant level as described in Section 5.4.

Flush and Clean Procedure:

1. Remove the water drain pipe plug located at the heat exchanger and completely drain the system.
2. Remove the pressure cap to make draining easier.
3. Drain, clean, and flush the cooling system and the coolant recovery tank with clean water.
4. Replace the water drain pipe plug.
5. Fill the cooling system with recommended coolant.
6. Replace the pressure cap.

5.6 Pressure Cap

Closed heat exchanger systems utilize a pressure cap to raise the boiling point of the coolant, enabling proper operating temperatures. If the cap leaks, replace it with a cap of the same rating. See Section 1, Specifications. The pressure cap typically has the pressure rating stamped on the cap body.



1. Pressure cap

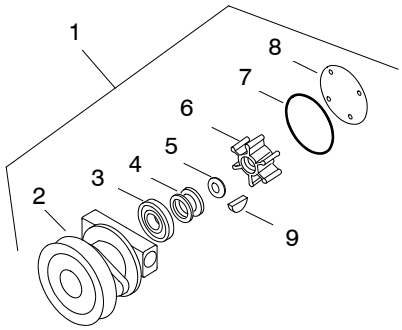
Figure 5-18 Pressure Cap Location

5.7 Impeller Inspection and Replacement

The belt-driven seawater pump is located on the service side of the generator set. 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 and Replacement Procedure:

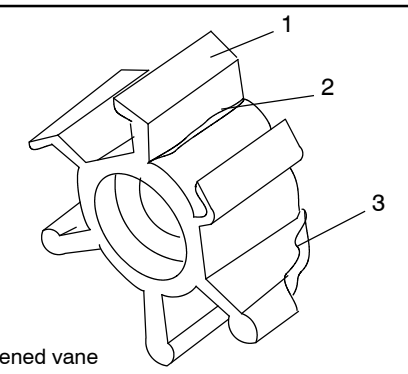
1. Close the seacock.
2. Remove the seawater pump coverplate. See Figure 5-19.



1. Seawater pump
2. Pulley
3. Ball bearing
4. Seal
5. Ceramic seat
6. Impeller
7. Gasket
8. Cover plate
9. Key

Figure 5-19 Seawater Pump, Typical

3. Remove the impeller.
4. Inspect the impeller for damage, including cracks, broken or flattened vanes. See Figure 5-20. The impeller vanes should be straight and flexible.



1. Flattened vane
2. Crack
3. Broken vane

607153

Figure 5-20 Worn Impeller

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 silicon grease and attach 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.

5.8 Belt Tension

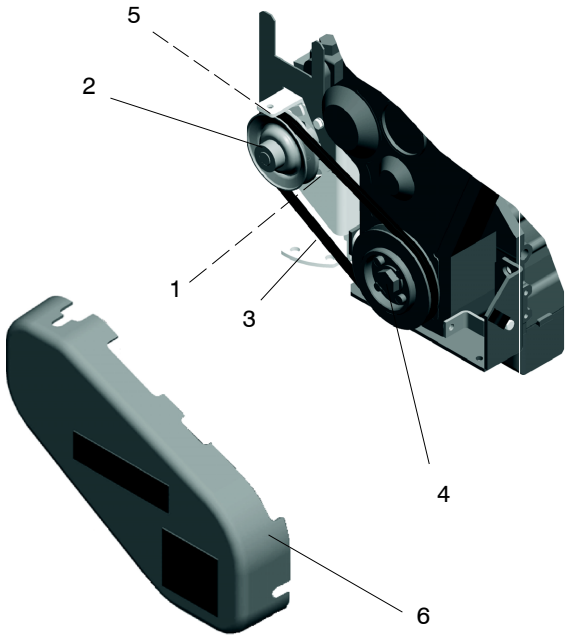
⚠ WARNING

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

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

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.

Check the belt tension at the interval specified in the service schedule. If tension is not within the specification, adjust as necessary using the following procedure.



1. Seawater pump adjusting screw
2. Seawater pump pulley
3. Check the seawater pump belt deflection (tension) here
4. Crankshaft pulley
5. Pivot screw
6. Belt guard

Figure 5-21 Belt Tension

5.8.1 Seawater Pump Belt Tensioning Procedure

1. Remove the belt guard. See Figure 5-21.

2. Check the belt tension at the midpoint of the longest span of the belt by pressing with your finger approx. 10 kg (22 lbs.) of force. See Figure 5-22 for belt deflection. Recheck a new belt tension after 10 minutes of operation.

Deflection mm (in.)
10 (0.4)

Figure 5-22 Belt Specification

Note: If the belt tension is not within specification, go to step 3. If the belt tension is within specifications, go to step 7.

3. Loosen the pivot and adjusting screws.

4. While prying the seawater pump outward, tighten the adjusting screw.

5. Tighten the pivot screw.

6. Recheck and adjust as necessary.

7. Replace the belt guard.

5.9 Anticorrosion Zinc Anode

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

Check and replace the anticorrosion zinc anode at intervals recommended in the service schedule. Depending upon operating conditions and seawater properties, the anticorrosion zinc anode may require more frequent replacement. See Figure 1-2 for the location and use the following procedure.

Anticorrosion Zinc Anode Replacement

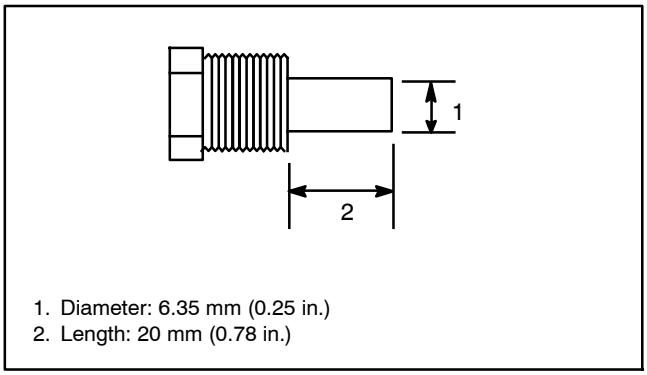
1. With the generator set cooled, close the seacock, open the petcock on the engine, and drain the coolant into a suitable container.

2. Remove the anticorrosion zinc anode (plug) from the heat exchanger.

3. Use a wire brush to remove the loose corrosion on the anticorrosion zinc anode. Replace the anode according to Figure 5-23 and Figure 5-24.

Anticorrosion Zinc Anode Replacement		
Models	**New Anode Dimensions mm (in.)**	**Replace When Percent of Zinc Remaining Is:**
6EKOD/ 5EFKOD, 9EKOZD/ 7EFKOZD, 11EKOZD/ 9EFKOZD	6.35 (0.25) x 20 (0.78)	<50% of length/diameter

Figure 5-23 Anticorrosion Zinc Anode (Plug) Measurements



1. Diameter: 6.35 mm (0.25 in.)
2. Length: 20 mm (0.78 in.)

Figure 5-24 Anticorrosion Zinc Anode (Plug)

4. Clean the threaded hole of the heat exchanger and coat the threads of the anticorrosion zinc anode (plug) with pipe sealant suitable for marine applications. Cut the anticorrosion zinc to the correct length. Install the anticorrosion zinc anode into the heat exchanger.

5. Close the petcock on the engine and open the seacock. Refill the cooling system.

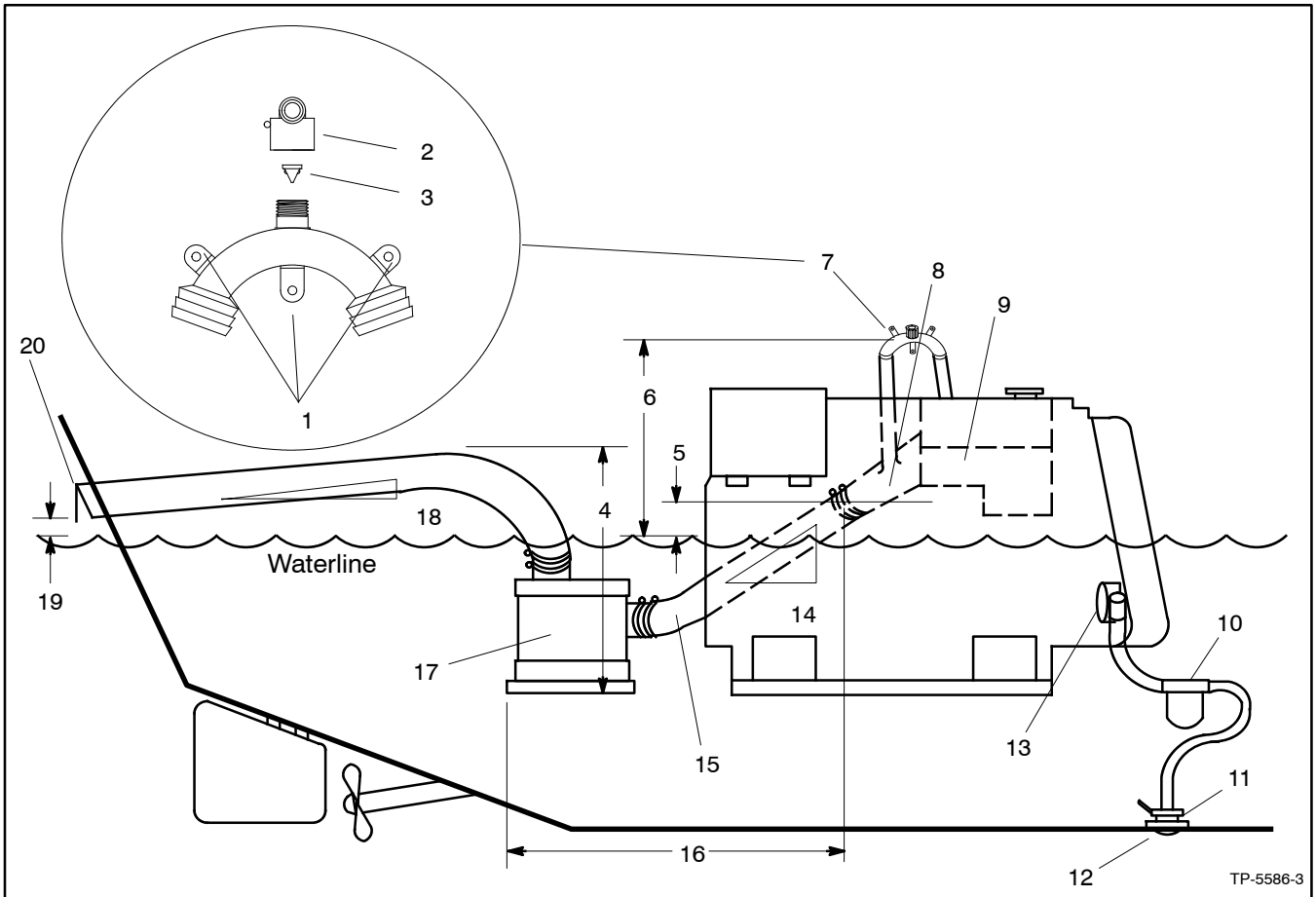
6. Start the generator set and check for leaks at the anticorrosion zinc anode location. The pump is operating if the cooling water flows from the exhaust outlet. If water is not discharging at the exhaust outlet, see Prestart Checklist—Seawater Pump Priming in the operation manual.

5.10 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 the waterline of a fully-loaded, shut-down craft. Use the following procedure to inspect the siphon break.

Siphon Break Inspection Procedure:

1. Stop the generator set.
2. Remove the retaining cap and lift out the reed valve assembly for inspection. See Figure 5-25.
3. Use a light detergent to clean the reed valve to remove residue and oxidation.
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 into the mounting base with the valve downward.
7. Install the retaining cap and finger-tighten only. Do not overtighten.



1. Mounting base
2. Retaining cap
3. Reed valve assembly
4. Silencer vertical lift 1.2 m (4 ft.) max.
5. Exhaust mixer elbow distance above waterline; if less than 23 cm (9 in.), siphon break is required
6. Siphon break distance above waterline 30.5 cm (1 ft.) min.
7. Siphon break
8. Exhaust mixer elbow
9. Heat exchanger (locations vary by model)
10. Seawater strainer
11. Seacock
12. Intake strainer
13. Engine-driven seawater pump
14. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in./ft.) min.
15. Water lock (optional)
16. Silencer distance from exhaust mixer elbow 3 m (10 ft.) max.
17. Silencer (customer-supplied)
18. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in./ft.) min.
19. Exhaust outlet distance above waterline 10 cm (4 in.) min.
20. Seawater outlet

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

Figure 5-25 Siphon Break (Plastic “U” Type)

Notes

6.1 Introduction

Corrective action and testing in many cases requires knowledge of electrical systems and electronic circuits. Have an authorized distributor/dealer or trained service technician perform testing and service.

Refer to the Engine Service Manual, TP-6776 for engine service information.

The first step in troubleshooting the generator set controls is to verify that the controller is correctly configured for the generator set. The Generator Set Operation Manual explains how to check and change the controller configuration.

If the troubleshooting procedures in this section identify a bad part, refer to the parts catalog for replacement part numbers.

6.2 Initial Checks

When troubleshooting, always check for simple problems first. Check for the following common problems before replacing parts:

- **Loose connections or damaged wiring.**
- **Dead battery.**
- **Fault shutdown.** Check for a fault code on the ADC IId display. Section 7.10.1 describes the warning and shutdown fault codes.
- **Blown fuses.** See Figure 6-1 for fuse identification. Always check and replace the fuses before replacing other components. See the operation manual or parts catalog for fuse part numbers.

Label	Amp	Fuse
F1	10	Auxiliary winding
F2	20	Controller, fuel pump, and fuel shutoff solenoid
F3	5	Customer connection

Figure 6-1 Fuse Identification

- **Incorrect controller settings.** *Always* check the controller configuration settings before replacing the controller. Section 7.13 explains how to check and change the controller settings.

Some problems may be solved by updating the controller's application program. Check Tech Tools, Software, for information on ADC IId application program updates. See Section 7.13.2 for instructions to check the version number of the controller's application program and for more information on updating the application program.

6.3 Troubleshooting Chart

Use the following table(s) as a reference in troubleshooting individual problems. Generator set faults are listed in groups and include likely causes and remedies. The simplest and most likely causes of the problem are listed first; follow the recommendations in the order shown. The reference column provides additional sources of information in this and related manuals regarding the problem and solution.

Note: In the following table(s), O/M refers to the Operation Manual, I/M refers to the Installation Manual, and S/M refers to the Service Manual.

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank	Weak or dead battery	Recharge or replace battery.	Generator O/M
	Battery connections	Check for reversed or poor battery connections.	—
	Open circuit in engine/controller connections	Check for loose connections. Check the wire harness continuity.	Section 10
	Blown F2 fuse	Replace fuse; if fuse blows again, check circuit and components. Check the controller wiring. Check the starter solenoid for a stuck solenoid. Check wiring for open grounds or loose connections. Also, check for pushed out pins.	Section 8.15 Section 10
	Crank relay	Check for 12VDC on lead 71N.	Section 10
		Check for a good ground connection (lead N).	Section 10
	Poor ground (–) connection	Clean and retighten.	—
	Starter	Check starter connections.	Section 10
		Rebuild or replace starter.	Engine S/M
	Controller	Check controller connections and operation. Check for power to the controller.	Section 7 Section 10
Cranks but does not start	No fuel	Check the fuel supply. Check the fuel filters for blockage.	—
	Loose connection or open circuit	Check for loose or open connections at the fuel pump or fuel solenoid. Check the controller/engine wiring continuity.	Section 10
	Incorrect controller configuration	Check for correct controller configuration settings.	Section 7.13
	No engine rotation sensed (check for an overcrank fault shutdown)	Check for locked rotor.	Section 8.8
Starts hard	Low battery voltage	Check battery voltage, power supply, and operation.	O/M
	Worn piston rings, valves	Check compression.	Engine S/M
	Glow plug(s)	Verify that battery voltage is present at each glow plug (control wire to ground) while cranking. To check glow plug condition, remove each glow plug and measure the resistance from the control wire connection point to the tip of the glow plug. If the resistance is approx. 1 ohm, the glow plug is good. OR Remove each glow plug, ground the threaded portion of the glow plug, and crank the unit. If the tip of the glow plug glows, the glow plug is good.	—
Starts but shuts down	Fault shutdown	Check for a fault shutdown code on the controller's display. Correct the fault and then reset the controller.	Section 7.10.1 Section 7.10.2 Section 8.14

Problem	Possible Cause	Corrective Action	Reference
Stops suddenly	Fault shutdown	Check for a fault shutdown code on the controller's display. Correct the fault and then reset the controller.	Section 7.10.1 Section 7.10.2 Section 8.14
	No fuel	Check the fuel supply.	—
	Fuel line restriction	Inspect fuel lines and fuel filter for blockage.	—
	Blown controller fuse (F2)	Replace fuse. Check wiring to the controller.	Section 8.15 Section 10
	Blown auxiliary winding fuse (F1)	Replace fuse. If fuse blows again, test generator components.	Section 8.15 Section 10
	Engine overheated (hot engine only)	Check air intake, fuel, oil level, air inlet/outlet.	O/M and I/M
	Low oil pressure (LOP) sender	Attempt startup. Shutdown should say "**Oil Pres Low Shutdwn**" if unit shuts down, remove the lead from the LOP sender and reset the controller. A successful restart attempt indicates a faulty LOP shutdown sender. **Note:** Check the engine oil pressure before performing the test and/or replacing the LOP shutdown sender.	Section 8.14.2 Engine S/M
	Engine overloaded	Reduce electrical load.	I/M
	Loss of generator output voltage to controller	Check connections at P2 plug. Check continuity of AC sensing leads 11 and 44 (for 1-phase models) or leads V7, V8, and V9 (for 3-phase models).	Section 10 Section 8.9
	Intermittent wiring connections	Inspect fuel pump wiring to ensure good connections.	—
	Blown F1 fuse	Troubleshoot rotor and stator assembly and wiring.	Section 8.8 Section 8.9 Section 10
Operates erratically	Governor adjustment incorrect	Adjust the governor stability.	Section 4.4
	Fuel line restriction	Check fuel lines, filter, and pump.	—
	Inadequate cooling (hot engine only)	Inspect air inlet and outlet.	—
	Carbon buildup in engine	Clean cylinder head.	Engine S/M
	Engine valves not seating correctly	Check cylinder pressures with leakdown test. Inspect valves and valve seats.	Engine S/M
Lacks power	Air intake restriction, inadequate cooling	Inspect air intakes and exhaust for obstructions.	—
	Generator overloaded	Reduce load.	—
	Engine not running at rated rpm	Check controller configuration setting. Adjust the governor speed.	Section 4.4
	Engine power loss	Refer to the Engine Service Manual for troubleshooting and repair instructions.	Engine S/M
	Governor malfunction or misadjustment	Test/readjust the governor.	Section 4.4
Overheats	Inadequate cooling	Inspect cooling system for air intake obstructions. Check the engine coolant system for blockage and clean as necessary.	—

Problem	Possible Cause	Corrective Action	Reference
Low output or excessive drop in voltage	Generator overloaded	Reduce load.	—
	Incorrect controller configuration	Check and adjust the controller configuration settings.	Section 7.13
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 8.10
	Alternator or control system	Perform separate excitation procedure to isolate problem to the alternator or the control system.	Section 8.2
	Intermittent wiring connection or lack of compression	Check the harness connections. Check the P2 plug and F1 fuse connections.	Section 8.15 Section 10
	Controller	Check the controller settings. Check the controller fuse, wiring and connections.	Section 7.13 Section 10
	Rotor (open, grounded, or shorted windings)	Test and/or replace.	Section 8.8
	Stator (open, grounded, or shorted windings)	Test and/or replace.	Section 8.9
	Brush connection (6EKOD/5EFKOD models)	Check for loose brush connections. Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.	Section 8.6
	Low engine speed causing voltage roll-off	Check the system voltage/frequency settings. Adjust the engine governor speed. Troubleshoot the engine.	Section 8.10 Section 4.4 Engine S/M
Light flicker	Voltage stability (gain) setting	Check and adjust the voltage stability (gain) setting using the ADC IId.	Section 8.10
High output voltage	Incorrect controller configuration	Check and adjust the controller configuration settings.	Section 7.13
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 8.10
	Engine speed too high	Check the engine speed using tachometer or frequency meter. Adjust the governor as necessary.	Section 4.4
	Loose voltage sensing connections	Check connections: stator leads 11 and 44 (for 1-phase models) or leads V7, V8, and V9 (for 3-phase models) and P2 controller connection.	Section 8.9 Section 10
	Controller	Check fuses, wiring and connections.	Section 7 Section 10

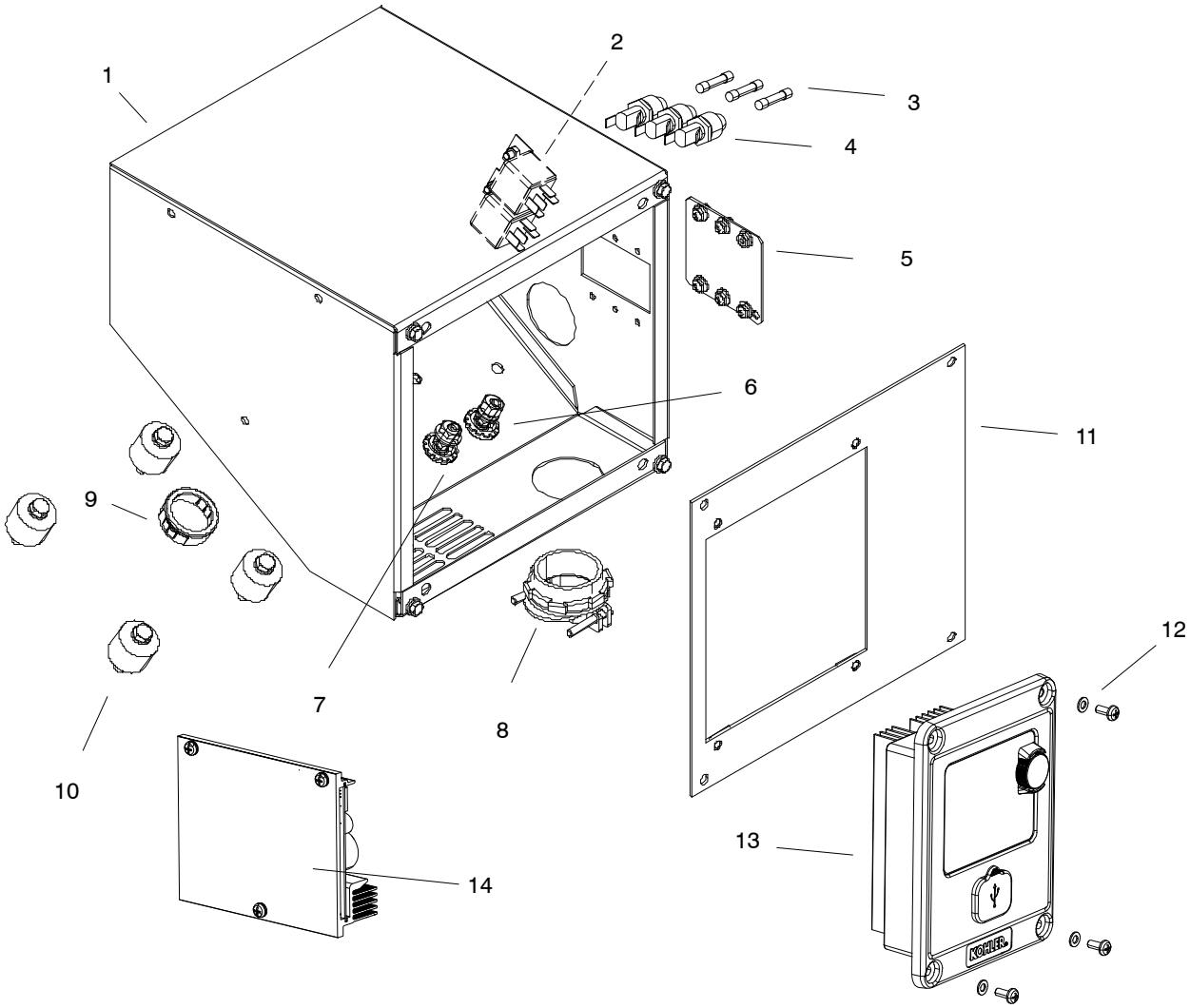
Problem	Possible Cause	Corrective Action	Reference
No output voltage	AC output circuit breaker open	Check for AC voltage on the generator side of circuit breaker. If there is AC voltage on the generator side of the breaker, then a problem in the load circuits is causing the line circuit breaker to trip. Check for and correct short circuits or overloading on the load side before resetting the circuit breaker.	—
	Alternator or control system	Perform separate excitation procedure to isolate the problem to the alternator or the control system. Then troubleshoot the alternator or control system components as follows.	Section 8.2
	Aux. winding F1 fuse blown	Replace blown fuse. If fuse blows again, check stator.	Section 8.15 Section 8.9
	Controller	Check controller settings. Check wiring and connections.	Section 7.13 Section 10
	Open wiring, terminal, or pin in buildup circuit	Check continuity.	Section 8.16 Section 10
	Brushes (6EKOD/5EFKOD models)	Inspect brushes and replace if worn.	Section 8.6
		Check for brushes sticking in brush holder or broken brush spring.	Section 8.6
	Rotor connections	Check for open circuit in rotor connection circuit (leads FN and FP).	Section 8.8 Section 10
	Rotor slip rings dirty or corroded (6EKOD/5EFKOD models)	Check slip ring condition.	Section 8.5
	Rotor (open, grounded, or shorted windings)	Check voltage and continuity.	Section 8.8
	Stator (open, grounded, or shorted windings)	Check voltage and continuity.	Section 8.9
Noisy operation	Exhaust system leaks	Check and replace as necessary.	O/M
	Engine not running smoothly	See “Operates erratically,” this table.	—
	Broken or damaged vibromount(s)	Check and replace as necessary.	—
	Loose or vibrating sheet metal/housing	Retighten screws, replace rivets.	—
	Exhaust piping or air inlets/outlets not securely installed	Inspect for loose parts and secure if necessary.	—
	Excessive engine/generator vibration	Check the rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Engine S/M
Emits black or gray smoke	Oil level high	Check the oil level.	Generator set O/M
	Worn piston rings, valves, etc.	Check compression.	Engine S/M
High oil use	External leakage/defective gaskets	Replace gaskets.	Engine S/M
	Worn piston rings, valves, etc.	Check compression.	Engine S/M
Engine knocks	Excessive load	Reduce load.	Generator set I/M
	Low oil level	Check the oil level and add oil if low.	Generator set O/M

Notes

7.1 Introduction

This section covers operation, configuration, adjustment, and replacement of the ADC IId controller. See Section 6 for troubleshooting procedures.

See Figure 7-1 for the locations of the controller and related components.



1. Junction box
2. Preheat relays (qty. 2) located inside junction box
3. F1, F2, and F3 fuses (qty. 3)
4. Fuse holders (qty. 3)
5. Line circuit breaker cover plate
6. GRD lead connection
7. LO lead connection
8. Cable connector
9. Bushing
10. Vibromounts (qty. 4)
11. Junction box controller panel
12. Screws and washers (qty. 4)
13. Advanced Digital Control IId
14. Battery charging module (shown removed from inside of the junction box)

GM76137

Figure 7-1 Advanced Digital Control IId (ADC IId) and Junction Box Detail

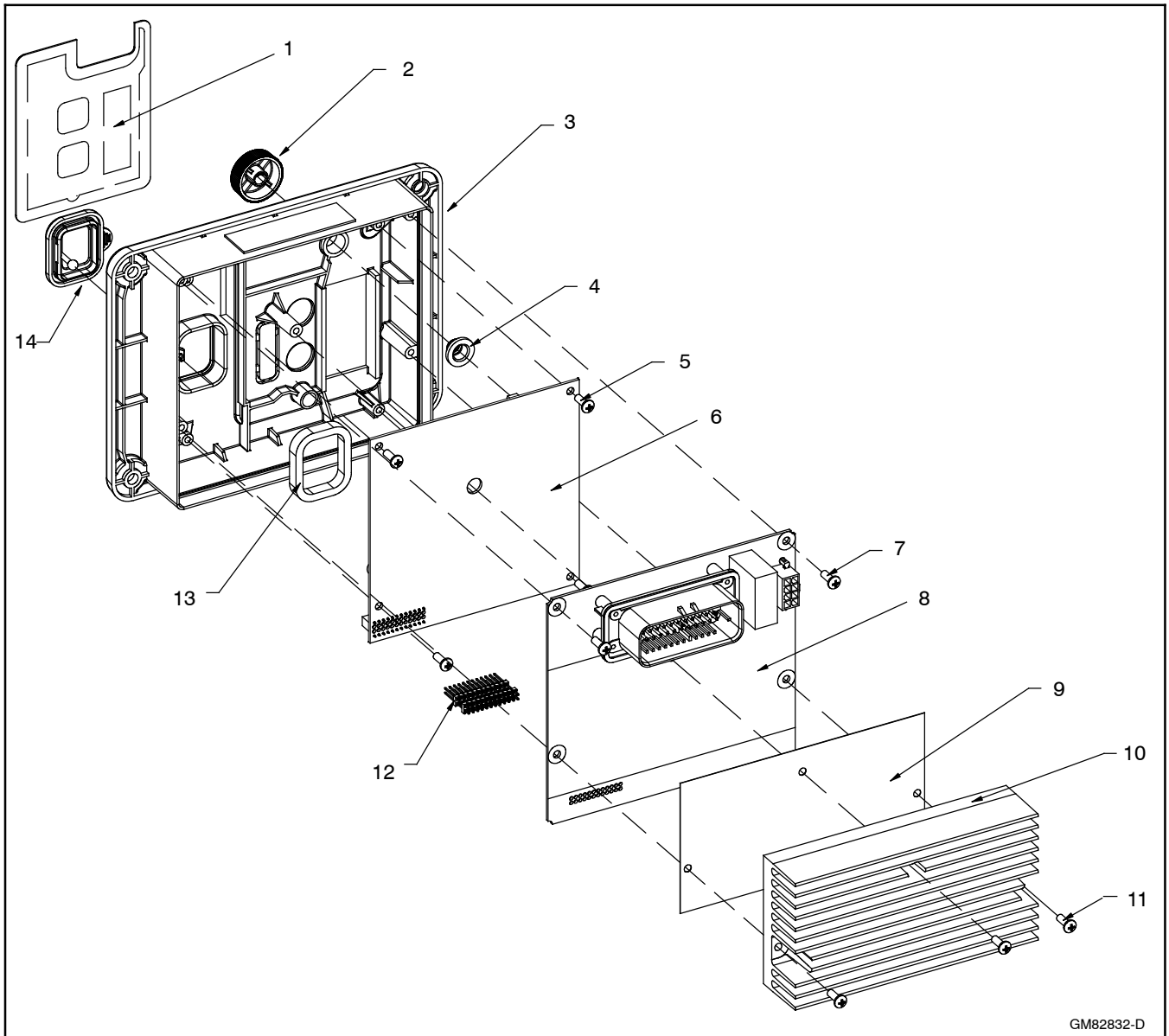
7.2 General Repair Information

This section contains ADC IId controller repair information. Service replacement of the controller is limited to the items shown in Figure 7-2. Refer to the respective parts catalog for service part numbers. No other replacement service parts are available.

Before replacing the controller, remove all external accessories and other electrical connections to verify that these items are not the cause of the controller problems. Verify that the accessories and connections are functioning correctly before reconnecting them to the new controller.

Go to the Overview Menu and verify that the Software (SW) Version is correct for the generator set model and alternator voltage. See Section 7.13.2 or the respective operation manual for details regarding accessing the Overview Menu.

Use SiteTech™ software for updating the controller application code.



1. Decal
2. Adjustment knob
3. Controller bezel
4. Protective boot
5. Plastic tapping screw (qty. 6)
6. Circuit board, control
7. Plastic tapping screw (qty. 6)
8. Circuit board, power
9. Insulator
10. Controller heatsink
11. Plastic tapping screw (qty. 3)
12. Pin header connector
13. USB gasket
14. USB plug

Figure 7-2 Advanced Digital Control IId (ADC IId)

7.3 SiteTech™ Software

The following items are necessary PC requirements for using the SiteTech™ software.

- **SiteTech™ Software Version 3.0 or higher** by accessing TechTools to download on your PC hard drive or disk if not already installed on your PC.
- **TP-6701 SiteTech™ Software Operation Manual** available by accessing TechTools.
- **USB Cable** with a male USB-A connector on the PC side and a male standard B connector on the controller side.

7.4 Controller Service Replacement Kit GM83745

If the troubleshooting procedures in Section 6 identify a faulty controller, use the procedure in this section for controller replacement. Always check the controller configuration, fuse, wiring, and connections before replacing the controller.

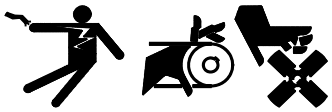
After replacing the controller, verify that the new controller's configuration settings match the generator set system voltage and frequency, battery voltage, and communications settings. Refer to Section 7.13 for instructions to check the controller configuration and to change the settings, if necessary.

After the controller configuration has been checked and set to match the generator set, use a voltmeter to check the generator set output voltage. If the output voltage or frequency needs adjustment, use the voltage adjustment procedure in Section 7.10.4 and 7.13.8 and the governor adjustment instructions in Section 4.4.

ADC IId Controller Replacement Procedure

1. Push the generator set power button OFF.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (–) lead first.

⚠ WARNING

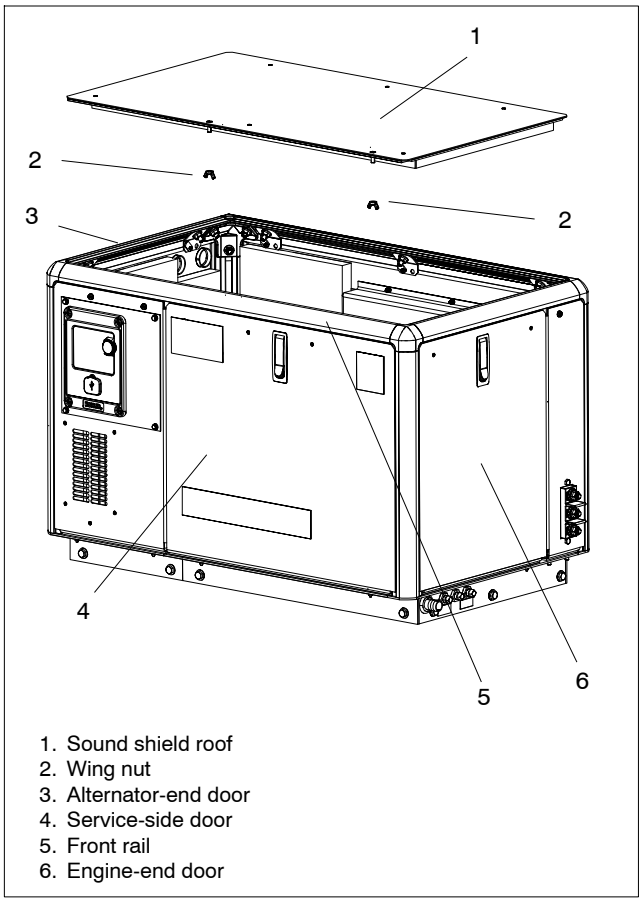


Accidental starting.
Can cause severe injury or death.

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.

Sound Shield Equipped Models: For access to the generator set to perform regular maintenance, remove the sound shield doors and roof.

4. **Sound-Shielded Models:** Open the service-side door.
5. **Sound-Shielded Models:** Release the two wing nuts located underneath the roof. See Figure 7-3.
6. **Sound-Shielded Models:** Lift up the roof.
7. **Sound-Shielded Models:** Slide the roof towards the service side of the unit for removal.
8. **Sound-Shielded Models:** Open the front, rear, and non-service side doors as needed.

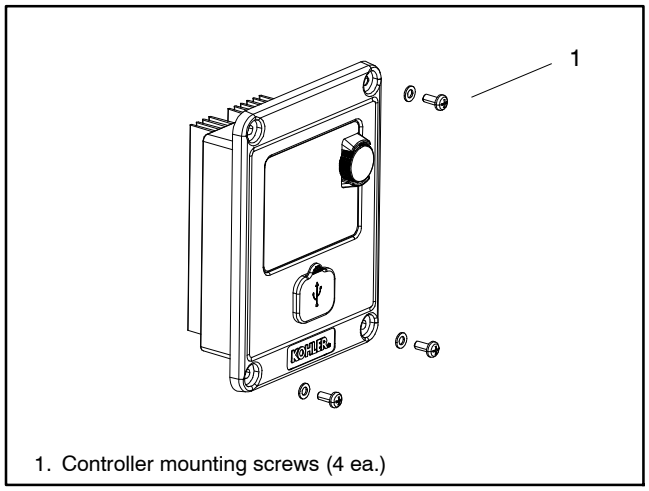


1. Sound shield roof
2. Wing nut
3. Alternator-end door
4. Service-side door
5. Front rail
6. Engine-end door

Figure 7-3 Sound Shield Roof Removal

9. Loosen and remove the four controller mounting screws securing the controller and *carefully* lift the controller.

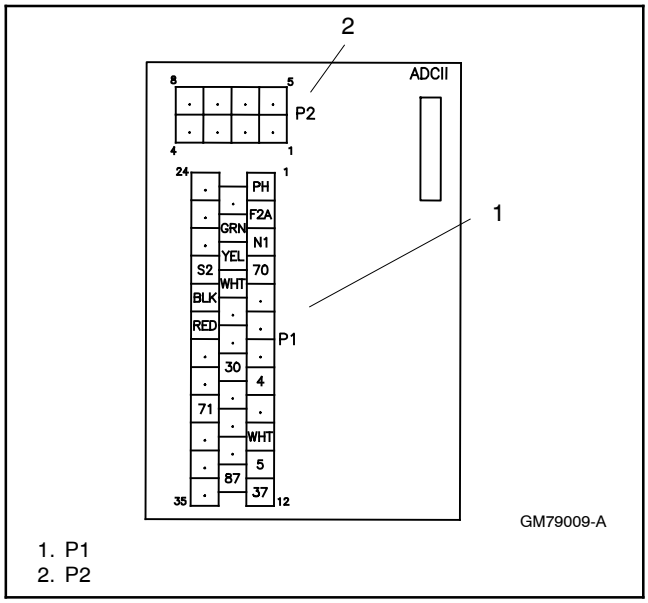
   Note: Be careful of the leads and harness connected to the controller.



1. Controller mounting screws (4 ea.)

Figure 7-4 Controller Mounting Screws

10. Note the connections on the back of the controller and then disconnect wiring harness plugs P1 (35-pin plug) and P2 (8-pin plug) from the ADC IId. See Figure 7-5.



1. P1
2. P2

Figure 7-5 Controller Connections

11. Remove the old controller.

12. Reconnect P1 (35-pin plug) and P2 (8-pin plug) to the new controller assembly.

13. Mount the new controller assembly onto the junction box using the four (4) screws removed in step 9.

14. Reconnect the engine starting battery, negative (–) lead last.

15. Reconnect power to the battery charger, if equipped.

16. Follow the instructions in Section 7.13 to change the new controller's configuration settings to match the generator set system voltage and frequency, battery voltage, and communications settings.

17. Use a voltmeter to check the output voltage. Follow the instructions in Sections 7.10.4 and 7.13.8 to adjust the output voltage and stability.

18. Check the output frequency. Follow the instructions in Section 4.4, Governor, to adjust the output frequency.

19. Place the generator set master switch in the AUTO position if an ATS or remote start/stop switch is used.

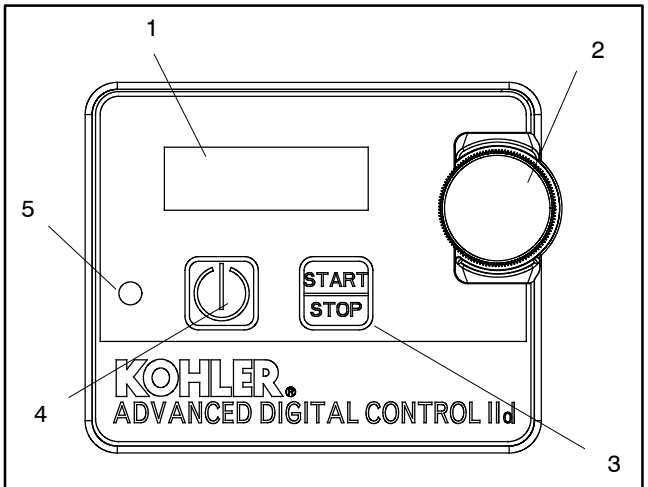
20. Replace the sound shield roof and door(s), if equipped.

7.5 Advanced Digital Control IId Operation

Figure 7-6 illustrates the user interface on the Advanced Digital Control.

The controller is factory-set and should not require configuration or adjustment under normal operating conditions. If the generator set is reconnected to a different voltage and/or frequency, refer to an authorized Kohler distributor/dealer for system configuration and adjustment instructions.

Note: Have setup and adjustments of the Advanced Digital Control performed only by an authorized Kohler distributor/dealer.



1. LCD digital display
2. Pushbutton/rotary selector dial
3. Engine start/stop button
4. Power button
5. LED status indicator

Figure 7-6 Advanced Digital Control IId

7.5.1 Controls and Indicators

LCD Digital Display. The LCD digital display is backlit any time the generator set is running or for at least 5 minutes after a user manipulates a button or the pushbutton/rotary selector dial. The LCD displays generator status, run time hours, fault shutdowns, and fault warnings.

Pushbutton/Rotary Selector Dial. This control provides access to the menus for monitoring. Press the selector dial to activate the digital display and to select choices shown on the display. Rotate the dial to navigate through the menus.

The pushbutton/rotary selector dial has several features and functions:

- Momentarily press the dial to activate the digital display if dark.
- Rotate the dial to navigate through the main menus—turn clockwise to go forward (down) and counterclockwise to go back (up). The menus do not wrap to the beginning.
- Press the dial at a given main menu to access the submenus within the selected main menu.
- When in the submenu, rotate the dial to navigate through the submenu—clockwise to go forward (down) and counterclockwise to go back (up). The menus do not wrap to the beginning.
- Momentarily press the dial when in the submenu to make a user selection choice (if available) or to go back to the respective main menu.
- After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu resets to the top of the main menus and auto-paging activates for the Overview submenus.

Engine Start/Stop Button. The engine start/stop button toggles the running state of the engine. When the controller is off, it has no effect. When the controller is in a low-power mode, the engine start/stop button starts the engine. When the controller is in a low-power mode, the button may need to be pressed twice to start the engine.

Power Button. The power button toggles the controller between on and off. When the controller is off, it does not respond to any input except the power button.

Note: After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu is reset to the top of the main menus and auto-paging activates for the Overview submenus.

Note: Measurements display in metric or English units. Use the Generator Set System menu to change the measurement display.

LED Status Indicator. The LED provides a summary of the generator state. Figure 7-7 shows the possible LED displays. When two or more colors are shown, the LED blinks between the two colors in 2-second intervals. The 2nd and 3rd (if any) colors are shown for 100 ms each and the 1st color appears for the remainder of the time.

Controller Power	Fault	Warning	Engine	LED Color(s)	Display		Mode
					Operational	Backlight Functional	
Off	N/A	N/A	Stopped	Black	No	No	Off
	No	None		Black/Green			Low Power Auto
	None	Yes		Black/Green/Red			Low Power Auto
	Yes	N/A		Black/Red			Low Power Auto
On	No	None	Stopped	Black/Green	Yes	No	USB Powered Auto
						Yes	Battery Powered Auto
			Running	Green	Yes	Yes	Battery Powered Auto
	None	Yes	Running	Green/Red	Yes	Yes	Battery Powered Auto
			Stopped	Black/Green/Red		No	USB Powered Auto
						Yes	Battery Powered Auto
	Yes	N/A	Stopped	Black/Red	Yes	No	USB Powered Auto
						Yes	Battery Powered Auto

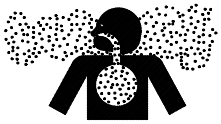
NOTE: Under unique conditions, the controller may not operate normally. If this happens, the controller uses the red LED to represent the status code. To show the status code, the controller holds the red LED for 5 seconds followed by a sequence of flashes that represents the status code:

1 flash = forced into bootloader
2 flashes = no application software
3 flashes = application code is invalid
4 flashes = RAM check failure
5 flashes = reformatting flash

See an authorized Kohler distributor/dealer.

Figure 7-7 Possible LED Status Indicator Displays

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. 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.

7.5.2 Starting the Generator Set

The following procedures describe the actions required to start the generator set.

Note: Opening seacock. Before starting the generator set, open the seacock to allow cooling water passage. Failure to do so could damage the seawater pump impeller and cause serious engine overheating damage.

Note: Transfer switch. Check that the marine ship-to-shore transfer switch, if equipped, is in the ship position.

Note: If the generator set does not start after 3 crank attempts (an overcrank fault occurs):
1) Close the seacock.
2) Completely drain the water from the exhaust system at the silencer's drain plug.
3) Do not attempt generator set restart.
4) Contact an authorized Kohler® distributor/dealer.
A water-filled exhaust piping and silencer may further hinder generator starting and cause seawater entry into the engine cylinders through the exhaust valves. Water ingested into the engine may cause major engine damage that the Kohler Co. warranty does not cover.

The controller attempts to start the generator set three times. If the generator set does not start in three attempts, the system shuts down on an overcrank fault.

Local Starting.

1. Press the power button to turn the controller on. The LED status indicator appears green and begins flashing.

2. Press the start/stop button to start the generator set. The Advanced Digital Control IId attempts to start the generator set in three crank cycles (crank cycle time is pre-programmed).

Remote Starting.

A remote start/stop switch (connected to P9 connector, leads 3 and 4) or a remote digital gauge (connected to P9 connector, pins 1, 2, and 5 via CAN) can be connected to the customer interface connection. See the wiring diagram in Section 10.

Note: A remote start/stop switch (connected to P9 connector, leads 3 and 4) is not available when configured for SmartCraft™ 1.

Press the power button to turn the controller on. Consult the instruction sheet supplied with the remote start/stop switch or remote digital gauge for starting instructions.

Note: The ADC IId allows three 7-second crank cycle attempts before the overcrank shutdown occurs.

Remote communications require an active (powered-up) controller. Be advised that the Advanced Digital Control IId enters a low-power state with an average current drain of approximately 100 uA.

The ADC IId will power down (0 mA draw) after 48 hours of inactivity. Press the start switch/button (once for the remote start/stop switch or twice for the remote digital gauge) to “wake up” the ADC IId and start the generator set.

7.5.3 Stopping the Generator Set

The following procedures describe the actions required to stop the generator set.

Local Stopping.

1. Run the generator set at no load for at least 2 minutes to ensure adequate engine cooldown.

2. Press the start/stop button to stop the generator set. The engine stops.

3. Press the power button to turn the controller off.

Remote Stopping.

1. Run the generator set at no load for at least 2 minutes to ensure adequate engine cooldown.

2. The generator set stops when the remote start/stop switch contacts close momentarily or when the remote digital gauge sends a stop command.

Consult the instruction sheet supplied with the remote start/stop switch or remote digital gauge for stopping instructions.

Note: ADC IId powers down after 48 hours of inactivity. If the generator has been started, the controller will power down 48 hours after the generator stops.

7.5.4 Fault Shutdowns and Warnings

The generator set shuts down automatically under the fault conditions listed in Figure 7-14 and the controller displays a fault code. The generator set cannot be restarted until the fault condition is corrected and the controller is reset. See Section 7.10.2 to reset the controller after a fault shutdown. The controller resets automatically after a battery voltage fault condition is corrected.

Shutdown conditions on the generator set automatically reset when the problem is corrected. The high engine temperature condition automatically resets when the generator set cools. However, the fault shutdowns do not clear until the controller is reset.

The controller displays warning text but the generator set does not shut down under the conditions shown in Figure 7-15.

System Warning Fault Lamp. Green/Red lamp identifies an existing fault condition that does not shut down the generator set. A continuing system warning fault condition may cause a system shutdown. Correct all system warnings as soon as practical.

See Section 7.10.5, System Fault Warning Lamp with Digital Displays, for definitions of the items listed. The following conditions cause a system warning:

- AC sensing loss
- High battery voltage
- High coolant temperature
- Low battery voltage
- Low cranking voltage
- Low oil pressure

System Shutdown Fault Lamp. Red lamp indicates that the generator set has shut down because of a fault condition. The unit will not start without resetting the controller, see Section 7.10.2, Controller Resetting procedure.

See Section 7.10.6, System Fault Shutdown Lamp with Digital Displays, for definitions of the items listed. The following conditions cause a system shutdown:

- AC sensing loss
- Auxiliary input (analog or digital)
- Engine over speed
- Engine under speed
- High coolant temperature
- High exhaust temperature
- Locked rotor (failed to crank)
- Low seawater pressure
- Low oil pressure
- Overcrank
- Overfrequency
- Overvoltage (each phase)
- Underfrequency
- Undervoltage (each phase)

7.5.5 Digital Display

The generator set must be running for some displays to indicate values. If the generator set is not running some values will display zero or N/A (not available).

The 12-character, 2-line backlit alpha-numeric display provides generator set and engine data, system status, and fault information. See Figure 7-6. The digital display shows abbreviations in some instances, refer to Section 7.10.1 Status Event and Fault Specifications for the abbreviations and their full descriptions.

Note: US/Metric Unit Display is selectable in Generator Set System.

Note: After about 5 minutes of no user input (pushbutton/rotary selector dial or buttons), the menu resets to the top of the main menus and auto-paging activates for the Overview submenus.

The main menus are listed below. Within each main menu are multiple submenus with descriptions following.

- Overview
- Engine Metering
- Generator Metering
- GenSet Information
- GenSet Run Time
- GenSet System
- Voltage Regulation
- Digital Inputs *(not applicable for units with ADC IId)*
- Digital Outputs *(not applicable for units with ADC IId)*
- Analog Inputs *(not applicable for units with ADC IId)*
- Event Log
- Prime
- Volt Select

Overview Menu

When a new shutdown or warning fault occurs, the auto-paging display feature activates.

Active **Shutdowns** display if any are present. This alerts the user to single or multiple shutdown fault conditions. See Section 7.10.6, System Shutdown Fault Lamp with Digital Displays for a list of possible shutdown faults.

Active **Warnings** display if any are present. This alerts the user to single or multiple warning fault conditions. See Section 7.10.5, System Warning Fault Lamp with Digital Displays for a list of possible warning faults.

Generator Set State displays the generator set status:

- Off
- Standby
- Running
- Cooldown
- Stopping

When the unit is cranking, the attempt number is displayed. When the unit is priming, the time remaining is displayed.

Average Volts Line-to-Line value displays. For three-phase configurations the average line-to-line voltage of L1, L2, and L3 is displayed. Single-phase configurations show the L1–L2 voltage.

Frequency (Hz) value displays for the output AC voltage.

Coolant Temperature diplays for the engine coolant temperature.

Oil Pressure displays the engine oil pressure.

Battery displays the DC voltage of the engine starting battery(ies).

Engine Run Time displays the total run time hours.

Next Maintenance displays the next maintenance timer in hours.

Software Version displays in the Overview menu. Use the version number to determine if an upgrade is needed and/or when troubleshooting the controller.

Engine Metering Menu

Engine Speed (Tachometer) displays the engine speed in RPM.

Oil Pressure displays the engine oil pressure. This value also shows in the Overview Menu.

Coolant Temperature displays the engine coolant temperature. This value also shows in the Overview Menu.

Battery displays the DC voltage of the engine starting battery(ies). This value also shows in the Overview Menu.

Generator Metering Menu

Volts displays the alternator output AC voltages. The display shows all line-to-line and line-to-neutral voltage combinations for three-phase or single-phase configurations.

Frequency (Hz) value displays for the output AC voltage. This value also shows in the Overview Menu.

Reset Calibration provides the means to reset the configuration values.

The calibration values are reviewable at all times and provide the calibration of the voltage sensing logic. Changing the system voltage or replacing the circuit board requires a calibration adjustment.

To enable calibration, start the generator set and select the *Volts L1-L2* display. Then push and hold the pushbutton/rotary selector dial until the *Calibration Enabled* popup appears. Calibration of each display is now available. The display will show the following values for three-phase generator sets. Single-phase generator sets will only display items marked (*).

- Volts L1-L2 *
- Volts L2-L3
- Volts L3-L1
- Volts L1-N
- Volts L2-N
- Volts L3-N

The user can change individual values or can select *Reset Calib?-Yes* to reset all values. The *Reset Calib?* display will only show if calibration is enabled. Refer to the requirements shown with Generator Set Calibration in 7.10.7 Status and Notice Digital Displays.

To disable calibration, Rotate the pushbutton/rotary selector dial until the *<-Return* popup appears. Momentarily press the pushbutton/rotary selector dial. Stop the generator set if not already done.

Generator Set Information Menu

GenSet M/N displays the generator set model number.

GenSet S/N displays the generator set serial number.

Controller S/N displays the controller serial number.

Generator Set Run Time Menu

Engine Run Time displays the total run time hours. This value also shows in the Overview Menu.

Engine Starts displays the total number of generator set startup events.

Next Maintenance displays the next maintenance timer. The maintenance interval for the ADC IId is 250 hours.

Generator Set System Menu

The values in this menus are user-entered for the generator set configuration and are NOT measured values of the generator set.

System Frequency displays the programmer-entered L1/L2/L3 output voltage frequency for three-phase or the L1/L2 output voltage frequency for single-phase.

Battery Voltage displays the engine electrical system 12 or 24 volts.

CAN A displays the remote communication's protocol in use (J1939, SmartCraft, or NMEA 2000).

Note: After changing the CAN A communication setting, power off and then power on the controller.

Measure Units displays the user selected unit of measure as Metric or English.

Contrast displays user selected resolution values to improve digital display clarity.

Voltage Regulator Menu

The voltage regulator value is reviewable at all times and provides the ability to fine adjust voltage. Changing the system voltage or replacing the circuit board typically requires a voltage adjustment.

To enable calibration, start the generator set and select the *VR Volt Adj, Volt/Hz, Gain, or Stabil* display. Then push and hold the pushbutton/rotary selector dial until the *Editing Enabled* popup appears. Editing of the Voltage Adjustment, Volts/Hz, Gain, and Stability is now available.

The user can change the individual value or can select *Reset VR?-Yes* to reset to the default value. The *Reset VR Settings* display will only show if editing is enabled.

To disable calibration, Rotate the pushbutton/rotary selector dial until the *<-Return* popup appears. Momentarily press the pushbutton/rotary selector dial. Stop the generator set if not already done.

Event Log Menu

This menu allows the user to review up to 1000 entries of system events including shutdown faults, warning faults, and status events. See 7.5.6 Controller Fault Diagnostics for a list of the items that appear on the Event Log.

Prime Menu

This menu, if confirmed, allows the user to initiate the electric fuel pump to prime the fuel system.

Volt Select Menu

Note: The generator set must be stopped before changing the voltage selection.

This menu allows the user to readily change controller voltage settings.

Note: The generator set output leads require voltage reconnection. See Section 8.11 for voltage reconnection information.

With the generator set stopped, go to the Volt Select menu. Then push and hold the pushbutton/rotary selector dial until the voltage selection starts to flash. Volt selection is now available. Scroll to the desired voltage and momentarily press the pushbutton/rotary selector dial to confirm the voltage selection.

The displays for *Volt Select* appear as shown in the following list.

- 120/240 V 1 Ph (3 wire)
- 120/208 V 3 Ph (4 wire Wye)
- 139/240 V 3 Ph (Wye)
- 277/480 V 3 Ph (Wye)
- 120/240 V 3 Ph (Delta)
- 115/230 V 1 Ph (3 wire)
- 120 V 1 Ph (2 wire)
- 230 V 1 Ph (2 wire)
- 240 V 1 Ph (2 wire)
- 110/190 V 3 Ph (Wye)
- 127/220 V 3 Ph (Wye)
- 115/230 V 3 Ph (Delta)
- 230/400 V 3 Ph (Wye)
- 240/416 V 3 Ph (Wye)

7.5.6 Controller Fault Diagnostics

This table provides descriptions of the system events and their types—warning, shutdown, status, and notice.

Warnings show green/red fault lamp and signal an impending problem. **Shutdowns** show red fault lamp and stop the generator set. **Status** is an event that is not an alert but is part of the event history. **Notice** is an alert that is NOT part of the event history. System events are available as a **Relay Output** as shown.

Throughout this manual there are examples of the display text. In some cases, the message words and phrases are abbreviated or shortened to accommodate the number of characters in the 12 x 2 digital display. See the following table for a full description of the system event display messages.

System Events Display Message List

Description	Display Message	Warning Function	Shutdown Function	Status/ Notice	Relay Output
Engine Functions					
Engine over speed	Eng Speed High Shutdwn		X		X
Engine start aid active	Preheat			N	X
Engine under speed	Eng Speed Low Shutdwn		X		X
High battery voltage	Battery High Warning	X			X
High coolant temperature	Coolnt Temp High Warning	X			X
High coolant temperature	Coolnt Temp High Shutdwn		X		X
High exhaust temperature	Exh Temp High Shutdwn		X		X
Low battery voltage	Battery Low Warning	X			X
Low seawater pressure	Sea Pressure Low Shutdwn		X		X
Low cranking voltage	Lo Crank Vlt Warning	X			X
Low oil pressure	Oil Pres Low Warning	X			X
Low oil pressure	Oil Pres Low Shutdwn		X		X
Overcrank	Over Crank Shutdwn		X		X
General Functions					
Aux. inputs 0–5 VDC, 1 analog	Aux Input Shutdwn		X		X
Backup parameters loaded	Backup Pars Status			S	No
Engine start delay active	Start Delay Notice			N	X
Engine started	Engine Start Status			S	X
Engine stopped	Engine Stop Status			S	X
Generator running	Gen Running Notice			N	X
Remote start	Remote Start Status			S	X
System ready	System Ready Status			S	X
System timer failed	Timer Error Notice			N	X
Generator Functions					
AC sensing loss	AC Sens Loss Warning	X			X
AC sensing loss	AC Sens Loss Low Shutdwn		X		X
Locked rotor (failed to crank)	Locked Rotor Shutdwn		X		X
Overfrequency	Frequency High Shutdwn		X		X
Overvoltage (each phase)	Volts xx-xx High Shutdwn		X		X
Underfrequency	Frequency Low Shutdwn		X		X
Undervoltage (each phase)	Volts xx-xx Low Shutdwn		X		X

***** Some functions require optional input sensors or are engine ECM dependent on some generator set models.

7.6 Communication Port

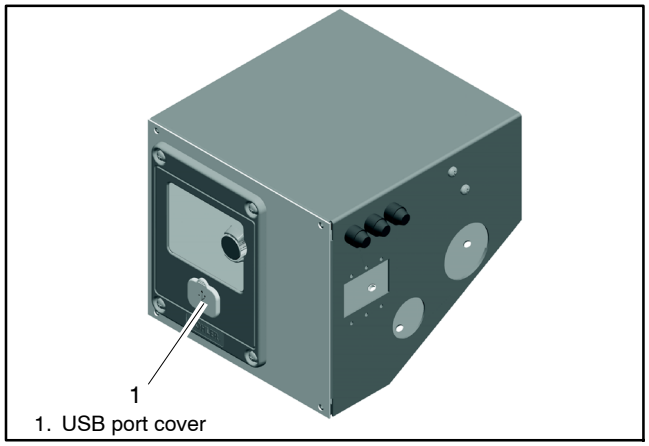
The main logic circuit board contains a standard type B USB communication port for PC connections and a USB host connector for a mass-storage device connection. See Figure 7-9 and Figure 7-10. See Section 7.13.12 for USB flowchart information. Refer to the List of Related Materials in the Introduction for corresponding SiteTech™ software and/or communication installation information.

Note: Before inserting a mass-storage device (USB host connector), power off and then power on the controller.

See Figure 7-8 for tested/approved manufacturer's USB flash drive types that work with the ADC IId controller.

CustomUSB® (Kohler® Power Systems Part Number KW-A202)	2-GB "spin" full size
Imation®	4-GB full size
Lexar®	4-GB full size
PNY®	4-GB full size and micro
Verbatim®	4-GB full size and micro

Figure 7-8 USB Types Tested/Approved for ADC IId



1. USB port cover

Figure 7-9 Communication Port

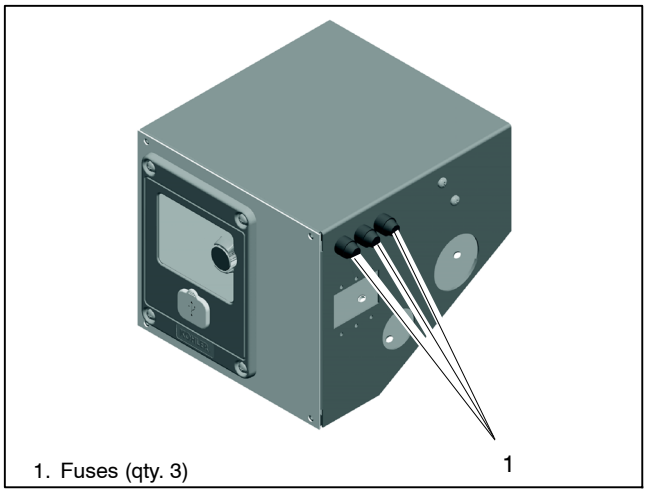
1. USB device connector (connects to SiteTech)
2. USB host connector (connects to mass-storage device)

Figure 7-10 ADC IId USB Identification

7.7 Fuses

Fuses are located on the side of the junction box. See Figure 7-11.

- **10-Amp (F1)** fuse protects the auxiliary winding.
- **20-Amp (F2)** fuse protects the controller circuits, fuel pump, and fuel shutoff solenoid.
- **5-Amp (F3)** fuse protects the customer connections.



1. Fuses (qty. 3)

Figure 7-11 Fuses on the Side of the Junction Box

7.8 Preheat Relay

The junction box contains two preheat relays that power the engine glow plugs. See Figure 7-1 for location. The programmed glow plug circuit is for cold starting. See Figure 7-12.

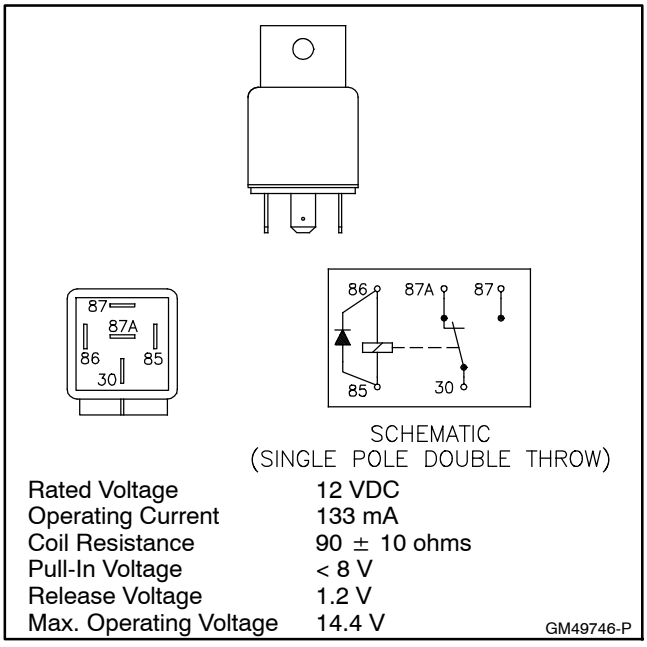


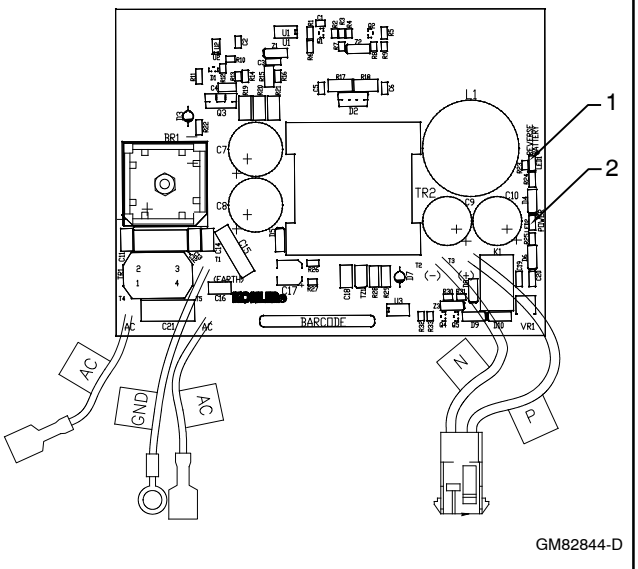
Figure 7-12 Preheat Relay Specs

7.9 Battery Charging Module

The junction box contains a battery charging module to maintain the engine starting battery. The battery charging module monitors the battery voltage and provides 10 amps to charge the battery and up to 14.2 ± 2%VDC when the generator set is running.

Note: The battery charging module is reverse-polarity protected.

Before testing the battery charging module, ensure that no other DC loads are on the generator set. At startup, after approx. 1 min., check for a change in voltage. If voltage increases, the battery charging module is functioning. If voltage decreases, the battery charging module is inoperative.



1. LED1 (red), reverse battery
2. LED2 (green), power

Figure 7-13 Battery Charging Module

7.10 Controller Logic Specifications

Refer to Figure 7-14 for inhibit and time delays on fault shutdowns. Refer to Figure 7-15 for inhibit and time delays on warnings.

Inhibit Time Delay. The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect a fault or status event. The inhibit time delay is not adjustable.

Time Delay (Shutdown or Warning). The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects a fault or status event and the controller warning or shutdown lamp illuminates. The time delay is not adjustable.

7.10.1 Fault Shutdown and Warning Specifications

The following list contains fault shutdown and warning specifications with time delays.

Fault Shutdowns							
Code	**Description**	**Sensing Mechanism**	**State(s) Detected**	**Inhibit Time**	**Delay Time**	**Trip Point**	**Check**
AC Sens Loss Low Shutdwn	The loss of AC voltage shutdown occurs when the controller does not detect the nominal generator AC output voltage for more than 3 seconds after crank disconnect.	Frequency over AC voltage	Post starting aid, running, cooldown	10 sec	3 sec	AC voltage reached AC system voltage and then drops below 5% of the trip point for low AC voltage fault/ shutdown	Check for loose connections. Check all AC leads connected to the controller for continuity. Alternator excitation failure: Inspect the brushes (6EKOD/5EFKOD) and check the FN and FP connections. Contact an authorized distributor/dealer for service.
Aux Input Shutdwn	Auxiliary fault input shutdown. **Note:** Input from a customer-supplied switch that closes when the fault is active.	Digital input	Auto, fault, start delay, ECM start, starting aid, cranking, crank pause, post starting aid, running, cooldown	0 sec	2 sec	Switch closes (shorted-to-ground)	Check the cause of the auxiliary fault. Check the condition and operation of the customer-supplied equipment connected to the auxiliary fault input.
Coolant Temp High Shutdwn	High coolant temperature shutdown occurs if the engine coolant temperature exceeds the default setting. **Note:** The high engine temp. shutdown functions only when the coolant level is in the operating range.	Analog input	Post starting aid, running, cooldown	15 sec	5 sec	Coolant temperature at or above 110° C (230° F)	Check for a low engine coolant level. Check seawater pump impeller, strainers, and seacock.
Eng Speed High Shutdwn	High engine speed shutdown occurs if the engine speed exceeds the default setting.	Frequency over AC voltage	Post starting aid, running, cooldown	0 sec	300 ms	Engine speed exceeds 115% of the rated speed	Check the engine governing system. Contact an authorized distributor/dealer for service if problem continues.
Eng Speed Low Shutdwn	Low engine speed shutdown occurs if the engine speed falls below the default setting.	Frequency over AC voltage	Post starting aid, running, cooldown	0 sec	3 sec	Engine speed falls below 85% of the rated speed	Reduce the load. Contact an authorized distributor/dealer for service.
Exh Temp High Shutdown	High exhaust temperature shutdown occurs if the engine exhaust temperature exceeds the default setting.	Digital input	Auto, fault, start, ECM start, starting aid, cranking, crank pause, post starting aid, running, cooldown	0 sec	2 sec	Switch closes (shorted-to-ground)	Check the wiring to the sensor. Check for a clogged seawater intake or sea strainer. Check for a damaged seawater pump impeller. Check the exhaust system, see the operation manual.
Frequency High Shutdwn	Overfrequency shutdown occurs when the governed frequency exceeds the default setting of the system's frequency setpoint.	Alternator output	Post starting aid, running, cooldown	10 sec	5 sec	AC frequency exceeds 110% of the systems frequency	Check the engine governing system. Contact an authorized distributor/dealer for service if problem continues.

Fault Shutdowns							
Code	**Description**	**Sensing Mechanism**	**State(s) Detected**	**Inhibit Time**	**Delay Time**	**Trip Point**	**Check**
Frequency Low Shutdown	Underfrequency shutdown occurs when the governed frequency falls below the default setting of the system's frequency setpoint.	Alternator output	Post starting aid, running, cooldown	10 sec	10 sec	AC frequency below 90% of the systems frequency	Reduce the load and restart the generator set. Check P2 AC sensing connection at the controller. Contact an authorized distributor/dealer for service if problem continues.
Locked Rotor Shutdwn	Overcrank (locked rotor) shutdown. A locked rotor condition indicates that there is no engine rotation when the starter is engaged.	Frequency over AC voltage	Cranking	0 sec	3 sec	3 sec. Engine speed is below 10 rpm and the oil pressure is below crank oil pressure (69 kPa)	Check for a locked rotor. Contact an authorized distributor/dealer for service if problem continues.
Oil Pres Low Shutdwn	Low oil pressure shutdown occurs if a low oil pressure condition exists. **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.	Analog or digital input	Post starting aid, running, cooldown	1 sec	10 sec	At or below 117 kPa	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low. Check the oil pressure sender connections and operation.
Over Crank Shutdwn	Overcrank shutdown occurs after 3 unsuccessful starting attempts.	Fail to start	ECM start, starting aid, cranking, crank pause	0 sec	7 sec on/ 15 sec off	3 crank cycles. Controller goes into the cranking state 3 consecutive times without going into post starting aid	Check the fuel supply and battery. If there is no output voltage, check the line circuit breaker. Also check for loose connections. Contact an authorized distributor/dealer for service if problem continues.
Sea Pressur Low Shutdwn	Low seawater pressure shutdown occurs after a loss of seawater pressure is detected.	Digital input	Post starting aid, running, cooldown	10 sec	5 sec	Switch closes (shorted-to-ground)	Check for a clogged seawater intake or sea strainer. Check for a damaged seawater pump impeller.
Volts xx-xx High Shutdwn	Overvoltage shutdown occurs if the voltage exceeds the default setting of the voltage regulator setpoint.	Alternator output	Post starting aid, running, cooldown	0 sec	2 sec	xx-xx AC voltage exceeds 120% of the AC system voltage	Check AC voltage. Check wiring and connections. Contact an authorized distributor/dealer for service if problem continues.
Volts xx-xx Low Shutdwn	Undervoltage shutdown occurs if the voltage falls below the default setting of the voltage regulator setpoint.	Alternator output	Post starting aid, running cooldown	0 sec	10 sec	xx-xx AC voltage below 80% of the AC system voltage	Reduce the load and restart the generator set. Check wiring and connections. Check AC voltage and adjust if necessary. Separately excite unit. Check stator continuity. Check the F1 fuse. Contact an authorized distributor/dealer for service if problem continues.

Figure 7-14 Advanced Digital Control IId Fault Shutdown

Warnings							
Code	**Description**	**Sensing Mechanism**	**State(s) Detected**	**Inhibit Time**	**Delay Time**	**Trip Point**	**Check**
AC Sens Loss Warning	Loss of AC voltage warning occurs when the controller does not detect the nominal generator set AC output voltage after crank disconnect.	Frequency over AC voltage	Post starting aid, running, cooldown	10 sec	1 sec	AC voltage is below 5% of the trip point for low AC voltage fault/ shutdown	Check for loose connections. Check all AC leads connected to the controller for continuity. Alternator excitation failure: Inspect the brushes (6EKOD/5EFKOD) and check the FN and FP connections. Contact an authorized distributor/dealer for service.
Battery High Warning	High battery voltage warning. The fault condition clears when the battery voltage returns to a voltage within the limits.	Analog input	Auto, fault, start delay, ECM start, starting aid, cranking, crank pause, post starting aid, running, cooldown	0 sec	10 sec	Battery voltage exceeds 125% of the nominal system voltage (12 V)	Check the battery rating and condition. Check the battery charger operation.
Battery Low Warning	Low battery voltage warning. The fault condition clears when the battery voltage returns to a voltage within the limits.	Analog input	Auto, fault, start delay, ECM start, starting aid, cranking, crank pause, post starting aid, running, cooldown	0 sec	90 sec	Battery voltage is at or below 100% of the nominal system voltage (12 V)	Check the battery rating and condition. Charge or replace the battery. Check the battery charger operation.
CoolInt Temp High Warning	High coolant temperature warning.	Analog	Post starting aid, running, cooldown	15 sec	5 sec	Coolant temperature at or above 105° C (221° F)	Check for a low engine coolant level. Check seawater system for reduced flow. NOTE: Allow the generator set to cool down before checking.
Low Crank Vlt Warning	Low cranking voltage warning.	Analog input	Cranking	0 sec	6 sec	Battery voltage drops below 60% of the nominal system voltage (12 V)	Check the battery rating and condition. Charge or replace the battery.
Oil Pres Low Warning	Low engine oil pressure warning.	Analog	Post starting aid, running, cooldown	1 sec	10 sec	At or below 138 kPa	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low.

Figure 7-15 Advanced Digital Control IId Warnings

7.10.2 Controller Resetting (Following System Fault Shutdown)

Always identify and correct the cause of a fault shutdown before resetting the controller. Use the following procedure to reset the generator set controller after a fault shutdown.

1. Disconnect the generator set from the load. See the safety precautions at the beginning of this manual before proceeding.
2. Identify and correct the cause of the fault shutdown. See the safety precautions at the beginning of this manual before proceeding. Refer to Section 6, Troubleshooting.
3. Use the Advanced Digital Control's pushbutton/rotary selector dial to select the Overview Page.
4. When the Overview page appears, press the pushbutton/rotary selector dial to view the active fault. Press the pushbutton/rotary selector dial again and then use the pushbutton/rotary selector dial to CONFIRM CLR FAULT: YES to clear the fault.
5. Push the pushbutton/rotary selector dial.
6. Start the generator set by pressing the generator set start/stop button to START. Test operate the generator set to verify that the cause of the shutdown has been corrected.
7. Shut the generator off by pressing the generator set start/stop to the STOP position.
8. Reconnect the generator set to the load.

7.10.3 Voltage Regulator and Calibration Specifications

The controller has a voltage regulation function that is internal to the processor. This means that no external voltage regulator is necessary. The voltage regulation of the controller uses root mean square (rms) sensing for fast response to changes in indicated and regulated voltages resulting in excellent regulation accuracy.

7.10.4 Voltage Regulator Adjustments

The descriptions of the voltage regulator adjustments and features follow.

Voltage Adjustment. The voltage adjustment allows the user to enter the desired generator set output level. This regulated level setting is the average of the three line-to-line voltages in three-phase configurations or L1-to-L2 in single phase configurations.

Submenus display the individual line-to-line voltages. These voltages are for reference only and are relevant in unbalanced load conditions. The voltage adjust setpoint can be changed to accommodate an important phase in an unbalanced system.

Underfrequency Unload Frequency Setpoint. This adjustment affects the voltage droop (volts per Hz) when load is applied and underfrequency occurs. The underfrequency unload setting defines the setpoint where underfrequency starts. Any frequency below the setpoint causes the voltage to drop thus reducing the load allowing the engine speed to recover according to the underfrequency unload slope setting.

Engine speed recovery depends upon characteristics such as engine make, fuel type, load types, and operating conditions. The underfrequency unload setting should match the engine speed recovery characteristics for the application.

Underfrequency Unload Slope. This setting determines how much the voltage drops during an underfrequency condition. Typically, applying a large electrical load causes a dip in engine speed and frequency. The voltage regulator reduces voltage, allowing engine speed recovery. The volts-per-Hz setting determines the amount of voltage drop.

Regulator Gain. Regulator gain refers to the gain of the control system. Generally, the higher the gain the faster the system responds to changes and the lower the gain, the more stable the system.

If the voltage is slow to recover when loads are applied or removed, increase the regulator gain. If the voltage is unstable, decrease the regulator gain.

7.10.5 System Fault Warning Lamp with Digital Displays

The system FAULT lamp blinks green then red indicating a warning fault but does not shut down the generator set.

When the system warning lamp is on and no message displays, rotate the selector dial to view messages. When the system warning continues, it may lead to a fault and cause a system shutdown.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

AC Sensing Loss. The fault lamp illuminates green then red when the controller does not detect the nominal generator set AC output voltage after crank disconnect. The controller displays *AC Sens Loss Warning.*

High Battery Voltage. The fault lamp illuminates green, then red, maybe black when the battery voltage rises above the preset level for more than 10 seconds. The local display shows *Battery High Warning*. Figure 7-16 shows high battery voltage specifications. The high battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes.

Engine Electrical System Voltage	High Battery Voltage Range	High Battery Voltage Default Setting
12	13.2–16.2	15

Figure 7-16 High Battery Voltage Specs

High Coolant Temperature. The fault lamp illuminates green, then red, maybe black when the engine coolant temperature approaches the shutdown range. The high coolant temperature warning does not function during the preset inhibit time delay period after startup. The local display shows *CoolInt Temp High Warning.*

Low Battery Voltage. The fault lamp illuminates green, then red, maybe black when the battery voltage drops below a preset level for more than 90 seconds. The local display shows *Battery Low Warning*. See Figure 7-17 for low battery voltage specifications.

Engine Electrical System Voltage	Low Battery Voltage Range	Low Battery Voltage Default Setting
12	9.6–12.6	12

Figure 7-17 Low Battery Voltage Specs

The low battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes. The controller logic inhibits the low battery voltage warning during the crank cycle.

Low Cranking Voltage. The fault lamp illuminates green, then red when the battery voltage drops below 60% of the nominal voltage (12 VDC) for more than 6 seconds during the crank cycle. The local display shows *Lo Crank Vlt Warning.*

Low Oil Pressure. The fault lamp illuminates green then red when the engine oil pressure approaches the shutdown range. The low oil pressure warning does not function during the first 11 seconds after startup. The local display shows *Oil Press Low Warning*.

7.10.6 System Fault Shutdown Lamp With Digital Displays

The system FAULT lamp flashes red and the unit shuts down to indicate a fault shutdown under the following conditions. See Section 7.10.2, Controller Resetting procedure, for information on resetting a system shutdown.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

AC Sensing Loss. The fault lamp flashes red and the unit shuts down when the controller does not detect the nominal generator set AC output voltage for more than 3 seconds after crank disconnect. The controller displays *AC Sens Loss Low Shutdwn.*

Auxiliary Input (Shutdown). The fault lamp flashes red and the unit shuts down when an auxiliary inputs signals the controller. Use SiteTech™ software to define inputs as shutdowns. The local display shows *Aux Input Shutdwn.*

Engine Over Speed. The fault lamp flashes red and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models exceeds the over speed setting. The local display shows *Eng Speed High Shutdwn*.

Engine Under Speed. The fault lamp flashes red, the alarm horn sounds, and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models drop below the underspeed setting. The local display shows *Eng Speed Low Shutdwn*.

High Coolant Temperature. The fault lamp flashes red and the unit shuts down because of high engine coolant temperature. The high coolant temperature shutdown does not function during the preset inhibit time delay period after startup. The local display shows *Coolnt Temp High Shutdwn*.

Note: The high engine temperature shutdown function and the low seawater pressure shutdown function are independent. A low seawater pressure condition may not activate the high engine temperature switch.

High Exhaust Temperature. The fault lamp flashes red and the unit shuts down because of high exhaust temperature. The local display shows *Exh Temp High Shutdwn*.

Locked Rotor (failed to crank). If none of the speed sensing inputs show engine rotation within the preset time delay of initiating engine cranking, the ignition and crank circuits turn off for the preset period and the cycle repeats. The fault lamp flashes red and the unit shuts down after the second cycle of the preset period of cranking. The local display shows *Locked Rotor Shutdown.*

Low Seawater Pressure. The fault lamp flashes red and the unit shuts down because of low seawater pressure. Shutdown occurs 5 seconds after low seawater pressure is detected. Local display shows *Sea Pressure Low Shutdwn.*

Low Oil Pressure. The fault lamp flashes red and the unit shuts down because of low oil pressure. The shutdown occurs 10 seconds after the low pressure condition is detected. The low oil pressure shutdown does not function during the first 15 seconds after startup. The local display shows *Oil Press Low Shutdwn*.

Overcrank. The fault lamp flashes red and cranking stops when the unit does not start within the defined cranking period. The local display shows *Over Crank Shutdwn*. See Section 7.5.2, Starting the Generator Set and Section 7.10.1, Status Event and Fault Specifications for cyclic crank specifications.

Note: The controller is equipped with an automatic restart function. When speed drops below 25 Hz (750 rpm) while the engine is running, the unit attempts to recrank. The unit then follows the cyclic cranking cycle and, when the engine fails to start, will shut down on an overcrank fault condition.

Overfrequency. The fault lamp flashes red and the unit shuts down when the frequency is above the overfrequency setting. The local display shows *Freq High Shutdwn*. See Figure 7-18.

Overfrequency Setting Range	Time Delay	Overfrequency Default Setting
102%–140% of nominal	10 sec.	110% of nominal

Figure 7-18 Overfrequency Specs

Overvoltage (Each Phase). The fault lamp flashes red and the unit shuts down when the voltage exceeds the overvoltage setting for the preset time delay period. The local display shows *Volts (L1-L2, L2-L3, or L3-L1) High Shutdwn*. See Figure 7-19 for overvoltage specifications.

Note: Overvoltage can damage sensitive equipment in less than one second. Install separate overvoltage protection on online equipment requiring faster than 2-second shutdown.

Inhibit Time	Delay Time	Overvoltage Default Setting
10 sec.	2 sec.	120% of nominal

Figure 7-19 Overvoltage Specs

Underfrequency. The fault lamp flashes red and the unit shuts down when the frequency drops below the underfrequency setting. The local display shows *Frequency Low Shutdwn*. See Figure 7-20 for underfrequency specifications.

Inhibit Time	Delay Time	Underfrequency Default Setting
10 sec.	5 sec.	90% of nominal

Figure 7-20 Underfrequency Specs

Undervoltage. The fault lamp flashes red and the unit shuts down when the voltage drops below the undervoltage setting for the time delay period. The local display shows *Volts (L1-L2, L2-L3, or L3-L1) Low Shutdwn*. See Figure 7-21 for undervoltage specifications

Inhibit Time	Delay Time	Undervoltage Default Setting
10 sec.	10 sec.	80% of nominal at 10 sec.

Figure 7-21 Undervoltage Specs

7.10.7 Status and Notice Digital Displays

Warnings and shutdown faults appear on the digital display and become part of the event history. Beyond the warnings and shutdowns there are several events which also appear on the digital display. Status is an event that is not an alert but is part of the event history. Notice is an alert that is not part of the event history.

The controller allows a selected number of changes by the user for setting up the controller application which are covered in this section.

Note: Text shown in *italics* in this section of the manual represents digital display messages.

Backup Parameters Loaded. This status message indicates that backup parameter firmware is now loaded on the controller. The local display shows *Backup Pars Status.*

Engine Start Aid Active. This notice message indicates that the start aid is active and will energize an engine equipped preheat or ether system during the crank cycle. The local display shows *Preheat.*

Engine Start Delay Active. This notice message indicates that the delay for engine start is active where the generator set will not start right after the RUN button is pressed. The unit will start cranking after the time delay times out. The local display shows *Preheat.*

Engine Started. This status indicates that the generator set start circuit is closed allowing the engine to crank and run. The local display shows *Engine Start Status.*

Engine Stopped. This status indicates that the generator set start circuit is open causing the engine to shut down. The local display shows *Engine Stop Status.*

Generator Running. This notice indicates that the generator set has started and is running. The local display shows *Gen Running Notice.*

Generator Set Calibration (User Defined). This selectable display is in the GenSet Metering Menu allowing the user to calibrate the controller and generator set. Use the pushbutton/rotary selector dial to navigate and select this feature.

Changes to this display must be done with the generator set running. The local display shows *Enter calib? No or Yes.* Select No to make no change. Select Yes to calibrate the following values:

- Volts L1–L2: x.x V
- Volts L2–L3: x.x V
- Volts L3–L1: x.x V
- Volts L1–N: x.x V
- Volts L2–N: x.x V
- Volts L3–N: x.x V

The user can individually calibrate the values above or reset all of them. The local display *Reset all calib? No or Yes*. Select No to make no changes and exit GenSet Calibration. Select Yes to reset all of the values.

When calibrating voltage, the metered value and the number being entered as the calibrated value must be within 10% of the system operating voltage.

Measurement Units (User Defined). This selectable display is in the GenSet System Menu allowing the user to choose between Metric and English displays. Use the pushbutton/rotary selector dial to navigate and select this feature. Changes to this display can be done with the generator set running or stopped. The local display shows *Meas Units: Metric* or *Meas Units: English.*

Remote Start. This status indicates that the generator set start circuit was closed from a remote location allowing the engine to crank and run. The remote location is typically a set of contacts on a transfer switch or remote start switch. The local display shows *Remote Start Status.*

System Ready. This status indicates that the generator set is in the AUTO mode and available to start if the start circuit is closed. The local display shows *System Ready.*

System Timer Failed. This notice indicates that the controller timer logic has failed to time out a designated function. The local display shows *Timer Error Notice.*

Voltage Regulator Adjustment (User Defined). This feature is in the Voltage Regulator Menu allowing the user to fine adjust the output voltage. Use the pushbutton/rotary selector dial to navigate and select this feature. Changes to this display must be done with the generator set running. The local display shows *Enter volt reg? No or Yes.* Select No to exit the voltage regulator menu. Select Yes to change the local display *VR Volt Adj: xxx.x V.*

7.11 Menu Displays

Use the Menu Summary List section after reading and understanding the features of the pushbutton/rotary selector dial. See Section 7.5.5, Digital Display.

The Menu Summary List provides a quick reference to the digital display data. Some digital display data may not be identical to your display due to generator set application differences. The closed bullet items represent main level data and the open bullet items are sub-level data. The Menu Summary List indicates items that are user selectable. Use SiteTech™ software for changing programmable information.

Section 7.13, Reviewing the Menu Displays, provides a digital display menu overview and explains the navigation using the pushbutton/rotary selector dial.

Menu Summary List (Legend: ● First level submenu, ○ second level submenu)

Overview Menu

Available as scrolling or fixed display text

- Active Shutdowns (if present)
- Active Warnings (if present)
- Genset State
- Average Volts Line-to-Line
- Frequency
- Coolant Temperature
- Oil Pressure
- Battery DC Voltage
- Engine Run Time
- Next Maintenance
- Software Version

Engine Metering Menu

- Engine Speed (Tachometer)
- Oil Pressure
- Coolant Temperature
- Battery DC Voltage

Generator Metering Menu

- Volts, L1-L2 *
- Volts, L2-L3 *
- Volts, L3-L1 *
- Volts, L1-N *
- Volts, L2-N *
- Volts, L3-N *
- Frequency
- Reset Calibration (User can reset individual volt values or reset all values)

GenSet Information Menu

- Generator Set Model No.
- Generator Set Serial No.
- Controller Serial No.

GenSet Run Time Menu

- Engine Run Time
- Engine Starts
- Next Maintenance

GenSet System Menu

- System Frequency
- Battery DC Voltage
- CAN A (J1939, SmartCraft, NMEA 2000) *
- Measurement System (Metric or English) *
- Contrast (display) *

Voltage Regulator Menu

- Voltage Regulator Voltage Adjust *
- Volt/Hz Adjust *
- Gain Adjust *
- Stability Adjust *
- Reset Voltage Regulator Settings *
  - ○ Reset Voltage Regulator?

Event Log Menu

- See Section 7.5.6 for a list of items that can appear in Event Log

Prime Menu

- See Section 7.13.10

Volt Select Menu

- Volt Select: *
  - ○ 120/240 V 1 Ph
  - ○ 120/208 V 3 Ph
  - ○ 139/240 V 3 Ph
  - ○ 277/480 V 3 Ph
  - ○ 120/240 V 3 Ph
  - ○ 115/230 V 1 Ph
  - ○ 120 V 1 Ph
  - ○ 230 V 1 Ph
  - ○ 240 V 1 Ph
  - ○ 110/190 V 3 Ph
  - ○ 127/220 V 3 Ph
  - ○ 115/230 V 3 Ph
  - ○ 230/400 V 3 Ph
  - ○ 240/416 V 3 Ph

USB Menu

- See Section 7.13.12 for USB flowchart information

***** User-Defined (Changeable) Menu Displays. **NOTE:** Some changes require activating the calibration or adjustment mode. Some displays may only appear when in the calibration or adjustment mode. Refer to Section 7.13 Reviewing Menu Displays to activate the calibration or adjustment mode.

7.12 Monitoring and Programming Setup

The user programmer can access the controller data with the controller digital display or a personal computer (PC) with optional SiteTech™ software to monitor and/or program. Access the controller system with a PC using a USB cable with a standard type A and a standard type B USB plug. Refer to the Introduction, List of Related Materials for related software literature.

While this manual focuses on data access through the controller pushbutton/rotary selector dial and display, some data entries require input using a PC for initial setup. The PC entries typically include alpha characters such as digital input descriptions.

7.12.1 PC Communications

Communicate between a PC and the generator set controller logic using USB communication protocol. The PC connections require optional SiteTech™ software. Contact your authorized distributor/dealer for assistance.

Local Single Connection

A PC connects to the USB port of the generator set controller using a standard type-B USB connector. See Figure 7-22, Figure 7-10, and Section 7.13.12.

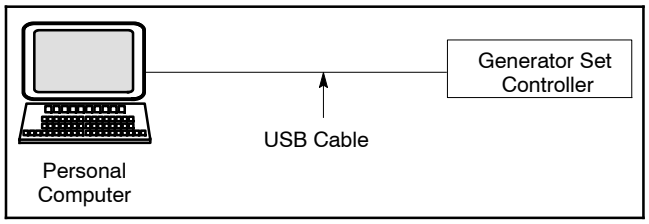


Figure 7-22 Local Single Connection

7.13 Reviewing Menu Displays

Use this section to review a summary of the generator set controller data. See Figure 7-23 for which menus provide data monitoring, data adjustments, or SiteTech™ software to make data adjustments.

Use the pushbutton/rotary selector dial to navigate to the respective menus.

Menus displaying the # symbol represent one of the following data types:

- System-calculated data
- System-measured data
- User-entered data

Note: The examples given on the following pages represent digital displays with the Measurement Units set to English.

7.13.1 Error Messages

Certain entries or attempted entries may cause the controller to display an error message.

Cannot Calibrate appears when attempting to calibrate the voltage values in the Generator Metering menu with the unit stopped. The unit must be running in order to make adjustments.

Cannot Edit When Stopped appears in the Voltage Regulator menu when attempting to change the VR Volt Adj value when the unit is not running.

Menu Name	Controller Viewable	Controller Adjustable	SiteTech Adjustable
Overview	X		
Engine Metering	X		
Generator Metering	X	X	
GenSet Information	X		
GenSet Run Time	X		
GenSet System	X	X	X
Voltage Regulation	X	X	X
Event Log	X		
Prime	X	X	
Volt Select	X	X	X*

* In SiteTech™, the voltage and phase get set individually.

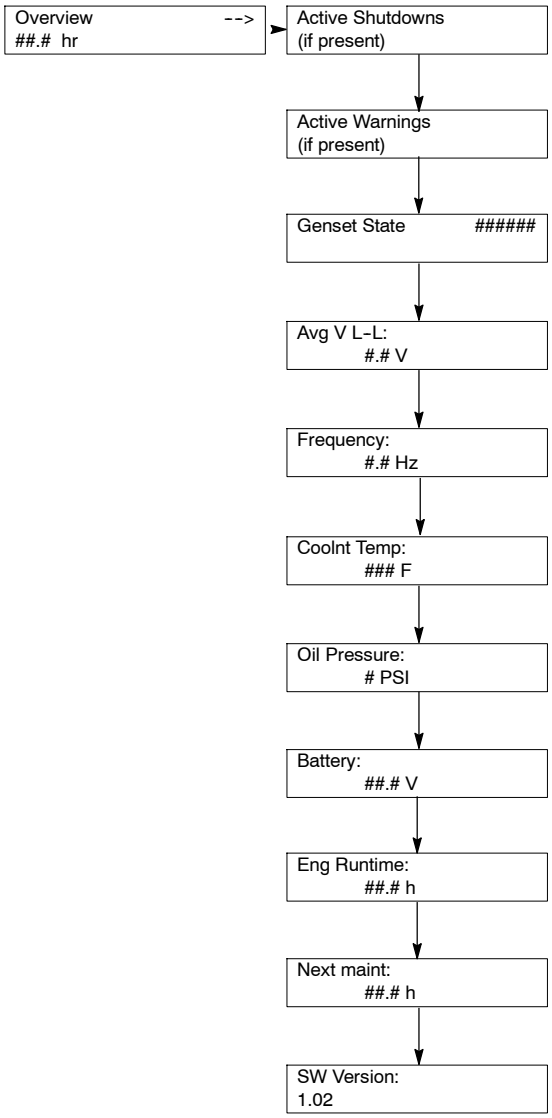
Figure 7-23 Menu Displays for Viewing and Adjusting

7.13.2 Overview

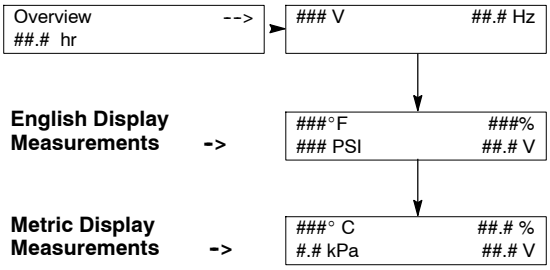
Displays basic and commonly sought after information about the generator set. This information scrolls automatically after about 5 minutes of no user input (pushbutton/rotary selector dial or button activity).

To change from auto scrolling to fixed display, press the rotary dial and the main menu will appear. Press the rotary dial again to select the first menu item Overview. Turn the rotary dial to select the desired fixed view.

Overview (Auto Scrolling Display)



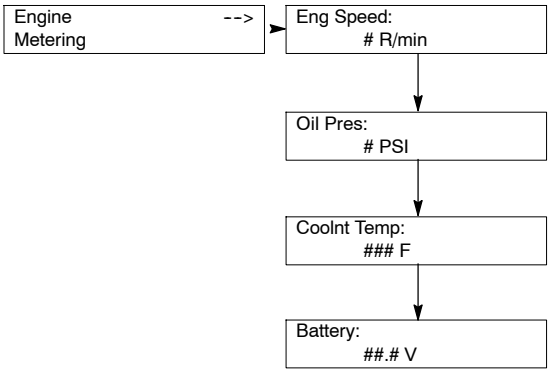
Overview (Fixed Display)



7.13.3 Engine Metering

Displays engine operating data as measured by the engine and other sensors.

Engine Metering



7.13.4 Generator Metering (and Calibration)

Displays generator output data including line-to-line and line-to-neutral voltages and frequency. The menu displays three-phase voltage readings when applicable.

All menu displays apply to both single-phase or three-phase voltages on the menu overview. The phase designation does not appear in the controller menu displays. Some displays will show 0 values when single-phase connections are shown.

Display also provides access to the calibration factors for metering (volts). Changing the system voltage or replacing the main logic control circuit board requires calibration adjustment. Connect a meter with a minimum accuracy of 1% to the generator set output leads to calibrate the voltage-sensing logic.

To enable calibration, start the generator set and select the *Volts L1-L2* display. Then push and hold the pushbutton/rotary selector dial until the *Calibration Enabled* popup appears. Calibration of each display is now available. The display will show the following values for three-phase generator sets. Single-phase generator sets will only display items marked (*).

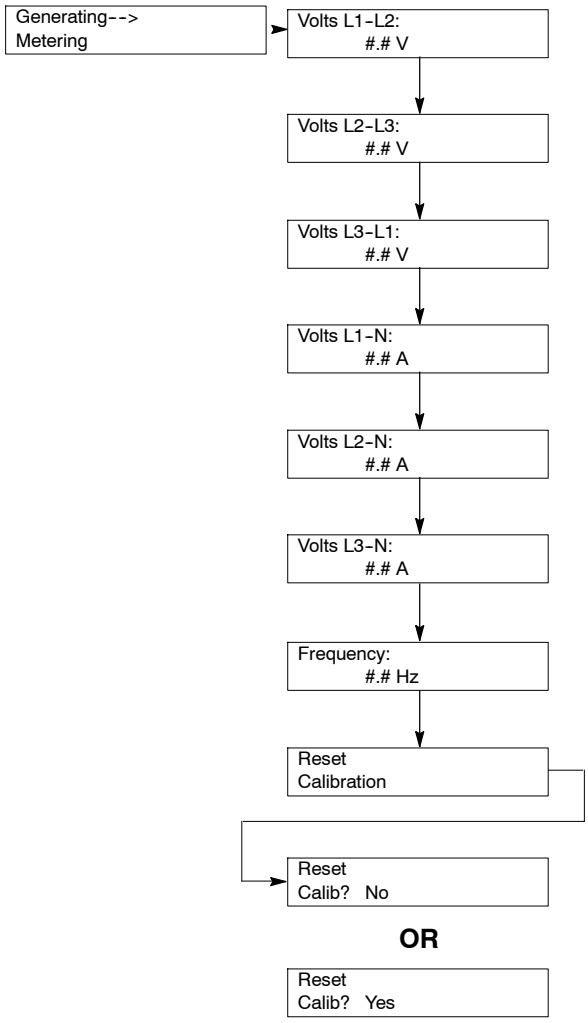
- Volts L1-L2 *
- Volts L2-L3
- Volts L3-L1
- Volts L1-N
- Volts L2-N
- Volts L3-N

The user can change individual values or can select *Reset Calib?-Yes* to reset all voltage values. The *Reset Calib?* display will only show if calibration is enabled.

When calibrating voltage, the metered value and the number being entered as the calibrated value must be within 10% of the system operating voltage.

To disable calibration, Rotate the pushbutton/rotary selector dial until the *<-Return* popup appears. Momentarily press the pushbutton/rotary selector dial. Stop the generator set if not already done.

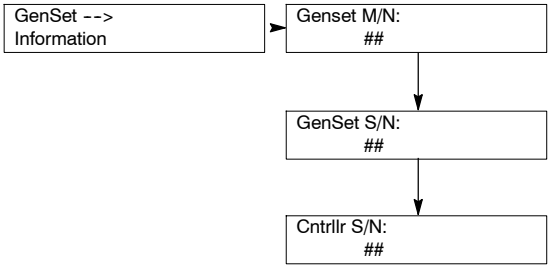
Generator Metering



7.13.5 GenSet Information

Displays generator set and controller information. Displayed data is factory entered.

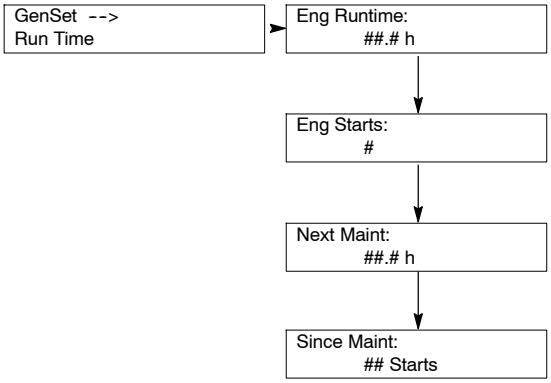
GenSet Information



7.13.6 GenSet Run Time

Displays the generator set's operating record including total run time loaded and unloaded, number of starts, and total energy kW hours.

GenSet Run Time



7.13.7 GenSet System

Display shows the generator set system data. Use the values entered in this menu to help determine shutdown values and time delays.

The programming user defines the data shown in the GenSet System menu. It is NOT data measured by the controller and associated sensing devices. The programming user defines these values for purposes of calibrating the control.

Some alternators are designed to operate at limited voltage, frequency, or phase connections and as a result some settings may have limited parameters.

Display for Measurement System is user selectable as English or Metric.

Contrast display is user adjustable to help improve digital display visibility in dimly lit rooms or in direct sunlight.

Note: The contrast feature is a controller hardware change and may not be available on older units even if the firmware is updated.

To **enable editing** of "*GenSet System*" parameters:

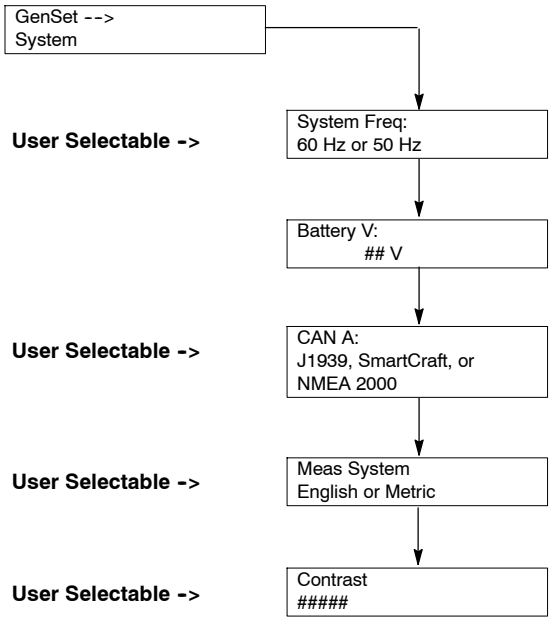
1. At the "*GenSet System*" menu, press the selector dial and rotate until "*System Freq*" appears.
2. Press and hold the selector dial until "*Editing Enabled*" appears.
3. Scroll through the parameters and press the selector dial at the parameter that requires changing. The parameter blinks to indicate that it is editable.
4. Press the selector dial to change the parameter.

Note: Parameters automatically scroll and keep blinking until the desired selection is made by pressing the selector dial.

5. Select "*Return*" to return to the *"GenSet System"* menu.

Note: After changing the CAN A communication setting, power off and then power on the controller.

GenSet System



7.13.8 Voltage Regulator

Displays the voltage regulator adjustment, volt/Hz, gain, and stability adjustment values.

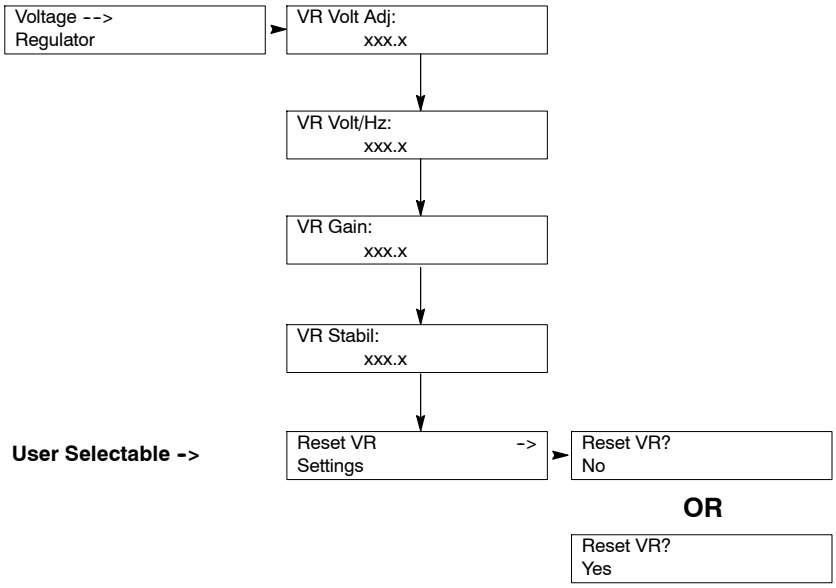
The voltage regulator value is reviewable at all times and provides the ability to fine adjust voltage. Changing the system voltage or replacing the circuit board typically requires a voltage adjustment.

To enable calibration, start the generator set and select the *VR Volt Adj, Volt/Hz, Gain, or Stability* display. Then push and hold the pushbutton/rotary selector dial until the *Editing Enabled* popup appears. Editing of the voltage adjustment is now available.

The user can change the individual value or can select *Reset VR?–Yes* to reset to the default value. The *Reset VR Settings* display will only show if editing is enabled.

To disable calibration, Rotate the pushbutton/rotary selector dial until the *<–Return* popup appears. Momentarily press the pushbutton/rotary selector dial. Stop the generator set if not already done.

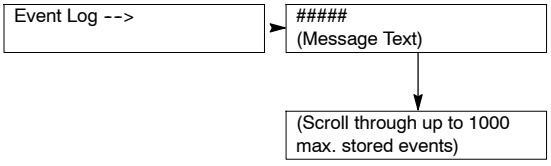
Voltage Regulator



7.13.9 Event Log

Displays up to 1000 stored status, warning, and shutdown events. After the first 1000 events, each additional new event replaces the oldest event. See 7.5.6 Controller Fault Diagnostics for a list of possible events.

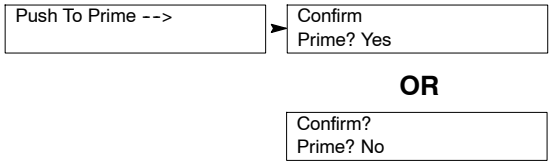
Event Log



7.13.10 Prime Menu

This menu, if confirmed, allows the user to initiate the electric fuel pump to prime the fuel system.

Prime the Fuel System



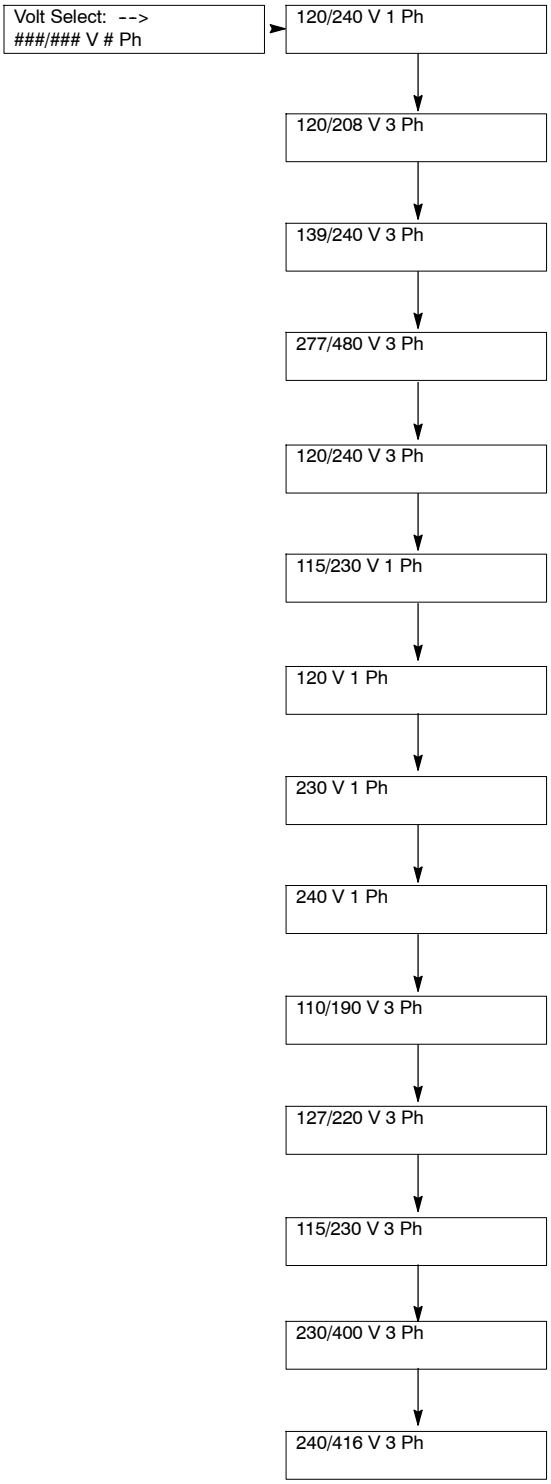
7.13.11 Volt Select

This menu allows the user to readily change controller voltage settings.

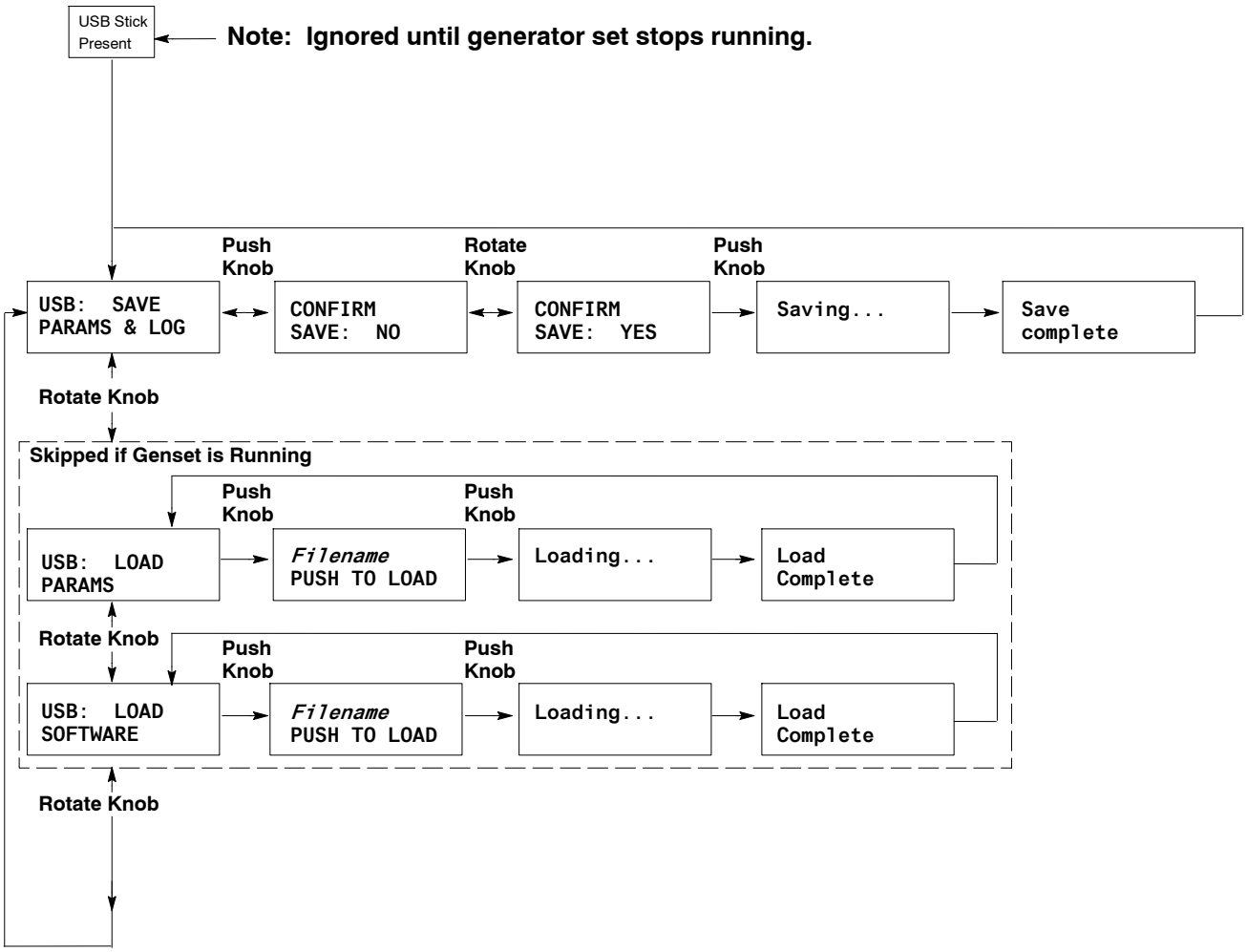
Note: The generator set output leads require voltage reconnection. See Section 8.11 for voltage reconnection.

With the generator set stopped, go to the Volt Select menu. Then push and hold the pushbutton/rotary selector dial until the voltage selection starts to flash. Volt selection is now available. Scroll to the desired voltage and momentarily press the pushbutton/rotary selector dial to confirm the voltage selection.

Volt Select



7.13.12 USB Flowchart



Note: Before inserting a mass-storage device (USB host connector), power off and then power on the controller.

See Figure 7-24 for tested/approved manufacturer's USB flash drive types that work with the ADC IId controller.

CustomUSB® (Kohler® Power Systems Part Number KW-A202)	2-GB "spin" full size
Imation®	4-GB full size
Lexar®	4-GB full size
PNY®	4-GB full size and micro
Verbatim®	4-GB full size and micro

Figure 7-24 ADC IId USB Identification

8.1 Theory of Operation

These generator sets utilize a rotating-field alternator to produce AC voltage. Upon activation of the generator start button, DC current from the battery magnetizes the rotor (field). When the magnetized rotor rotates within the stator windings, an electrical voltage develops within the stator. As engine speed and generator output increase, the ADC IId feeds rectified stator output current to the rotor through the exciter (or brushes/slip rings for model 6EKOD/5EFKOD) to increase the strength of the rotor field. As the rotor field increases in strength, generator output also increases. The ADC IId monitors the generator output voltage through leads 11 and 44 (for 1-phase models) or leads V7, V8, and V9 (for 3-phase models) and adjusts the DC current to the rotor to meet load requirements. See Figure 8-1.

8.2 Separate Excitation

To determine the cause of no- or low-AC output, refer to the troubleshooting flowchart in Figure 8-2. Before beginning the test procedures, read all of the safety precautions at the beginning of this manual. Many of the test procedures include additional safety precautions.

Check the condition of the alternator fuse (F1) before performing the separate excitation procedure. See Figure 8-1. See Figure 1-2 for the fuse location. If the fuse is not blown, use the following procedure to separately excite the generator using an external voltage source (a 12-volt automotive battery).

Separately exciting the generator can identify faulty voltage regulation by the ADC IId controller or reveal a running fault in the rotor and/or stator. An external power source duplicates the role of the voltage regulator and excites the generator field (rotor). A generator component that appears to be in good condition while stationary may exhibit a running open or short circuit while moving. Short circuits can be caused by centrifugal forces acting on the windings during rotation or insulation breakdown as temperatures increase.

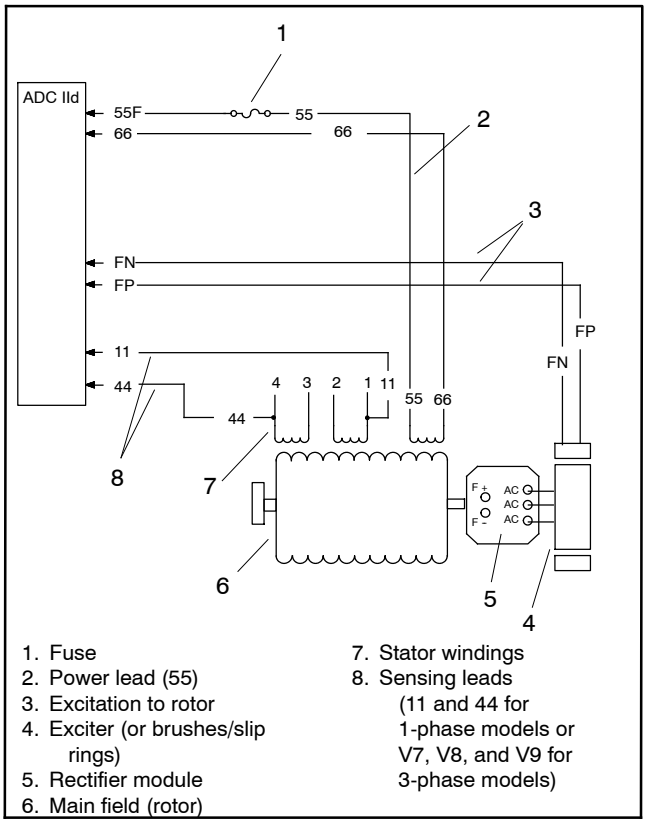


Figure 8-1 Generator Schematic (Single-Phase Model Shown)

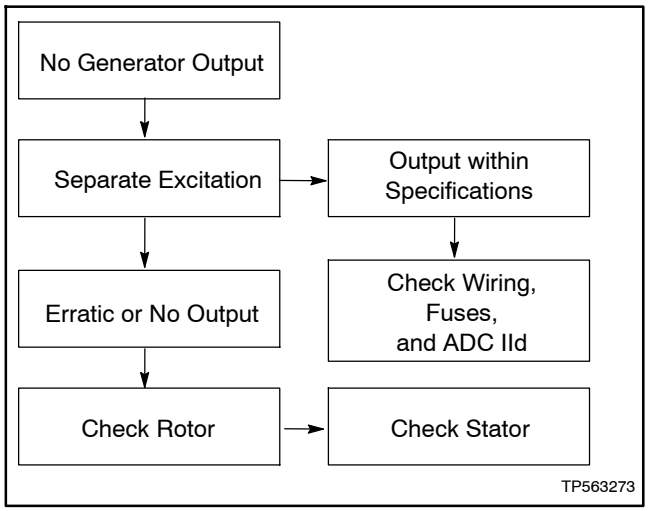


Figure 8-2 General Troubleshooting

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

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.

Separate Excitation Procedure:

Perform the following procedure to use an external voltage source to excite the main field (rotor).

1. Remove the junction box cover and disconnect the black FN and FP leads from the alternator at the ADC IId (+) and (–) terminals.

2. Connect a DC ammeter, 10-amp fuse, and a 12-volt automotive battery to the positive (FP) and negative (FN) exciter leads (or brush leads) as shown in Figure 8-3. Note and record the ammeter reading.

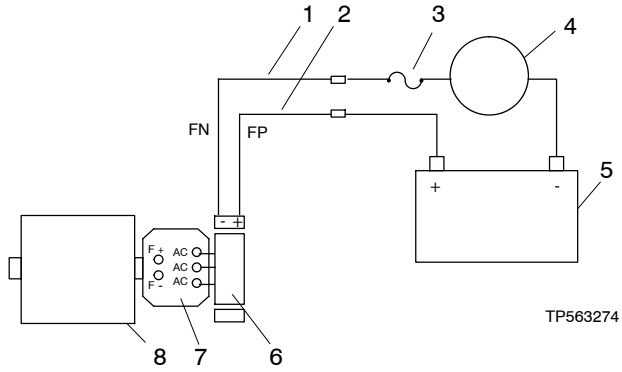
Note: The approximate ammeter reading should be the battery voltage divided by the specified rotor resistance. See Section 1, Specifications, for the specified rotor resistance values.

$$\text{Example}: \frac{\text{12 volts (battery voltage)}}{\text{3.5 ohms (rotor resistance)}} = \text{3.4 amps (rotor current)}$$

3. Start the engine and check that the ammeter reading remains stable. An increasing meter reading indicates a shorted rotor. A decreasing meter reading to zero or an unstable reading suggests a running open. Refer to Section 8.8, Rotor, to test the rotor. If the ammeter reading is stable, proceed to step 4.

4. Check for AC output across the stator leads; see Section 8.9, Stator. Compare the readings to the AC output values shown in Section 1, Specifications. If the readings vary considerably, a faulty stator is likely. Refer to Section 8.9, Stator, for further information.

5. If this test shows that the rotor and stator are in good condition, check the wiring and fuses. Check the controller settings and connections. See Section 7, Controller.



1. FN lead (disconnected in step 1)
2. FP lead (disconnected in step 1)
3. 10-amp fuse
4. DC ammeter
5. 12V battery
6. Exciter (or brushes/slip rings)
7. Rectifier module
8. Main field (rotor)

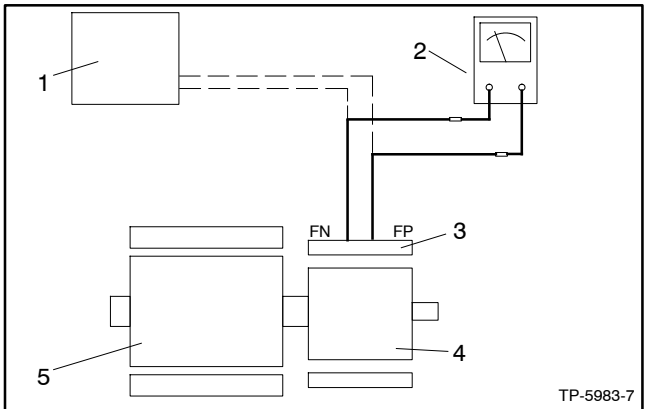
Figure 8-3 Separate Excitation Connections

8.3 Exciter Field (9-11EKOZD/7-9EFKOZD Models)

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

Exciter Field Test Procedure:

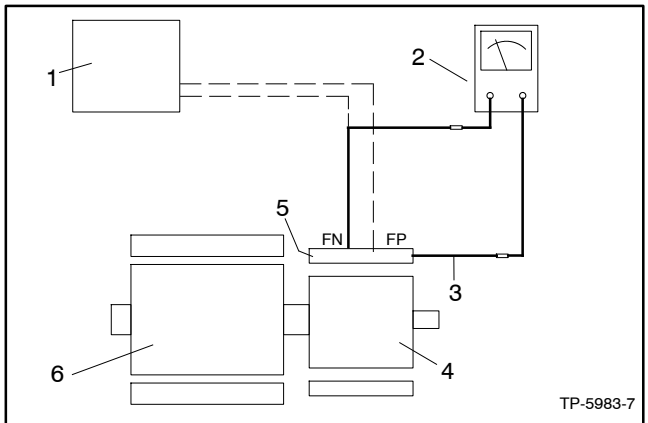
1. Press the start/stop button to stop the generator set.
2. Press the power button to turn the controller off.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Disconnect the FN/FP leads.
5. Check the exciter field resistance by connecting an ohmmeter across exciter field FN and FP leads. See Figure 8-4. See Section 1, Specifications for the resistance reading of a cold exciter field. A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the exciter field if the ohmmeter readings indicate an inoperative exciter field (refer to Section 9 for removal). If the resistance test is inconclusive, perform a megohmmeter test on the exciter field as described in the next step.



1. ADC IId
2. Ohmmeter
3. Exciter field
4. Exciter armature
5. Main field (rotor)

Figure 8-4 Exciter Field Resistance Test

6. Check the exciter field for a short-to-ground condition. Use a megohmmeter to apply 500 volts DC to the FN or FP lead and the exciter field frame. See Figure 8-5. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. A reading of approximately 1.5 MOhms and higher indicates the field winding is functional. A reading of less than approximately 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter field.



1. ADC IId
2. Megohmmeter
3. Frame connection
4. Exciter armature
5. Exciter field
6. Main field (rotor)

Figure 8-5 Megohmmeter Connections on the Exciter Field

8.4 Exciter Armature (9–11EKOZD and 7–9EFKOZD Models)

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

Exciter Armature Test Procedure:

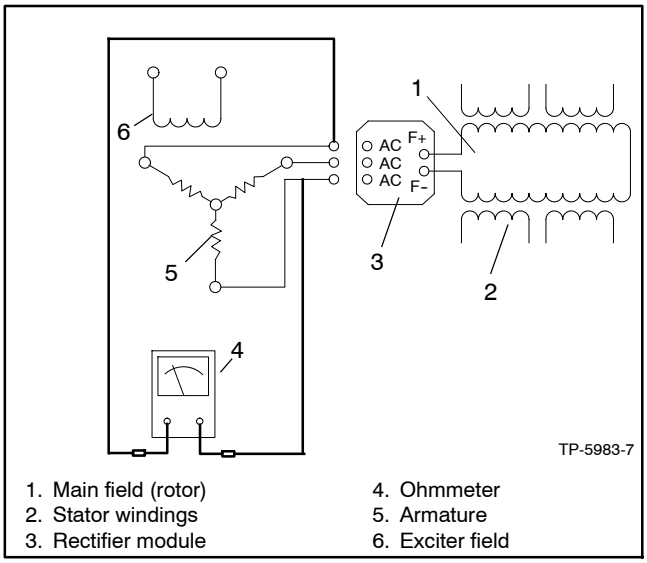
1. Disassemble the alternator. Refer to Section 9.

2. With the alternator disassembled, disconnect the armature leads from the rectifier module AC terminals. Refer to Section 10.

3. With an ohmmeter on the R x 1 scale, check the resistance across the exciter armature leads. See Figure 8-6. See Section 1, Specifications for the armature resistance. No continuity indicates an open armature winding. If the resistance test is inconclusive, perform a megohmmeter test on the exciter armature as described in the next step.

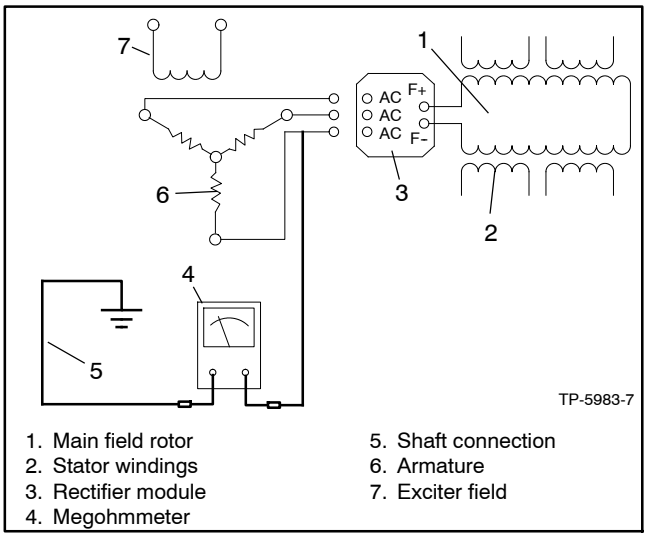
   Note: Most ohmmeters will not accurately measure less than one ohm. Consider the exciter armature functional if the resistance reading (continuity) is low and there is no evidence of a shorted winding (heat discoloration).

4. Check the exciter armature winding for a short-to-ground condition. Use a megohmmeter to apply 500 volts DC to either armature lead and the armature frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. See Figure 8-7. A reading of approximately 1.5 MOhms and higher indicates the exciter armature is functional. A reading of less than approximately 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter armature.



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

Figure 8-6 Exciter Armature Ohmmeter Test



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

Figure 8-7 Megohmmeter Connections on Exciter Armature

8.5 Slip Rings (6EKOD/5EFKOD Models)

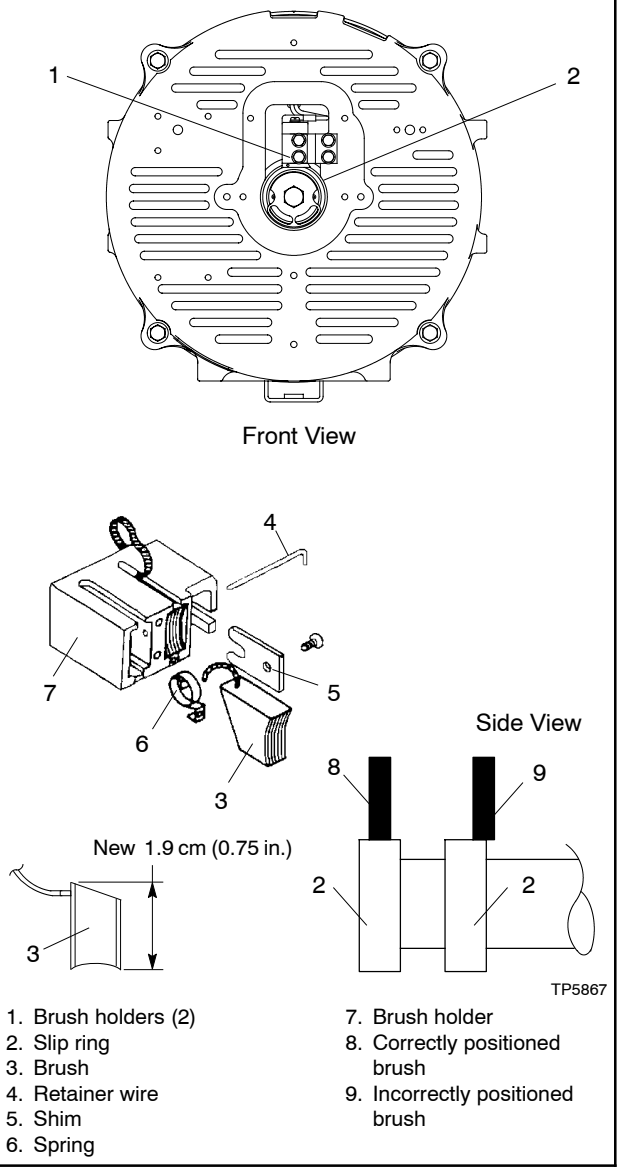
Slip rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly-machined appearance on the slip rings. Cleaning with a dry, lint-free cloth is usually sufficient. Use very fine sandpaper (#00) and apply light pressure to remove roughness. Do not use emery or carborundum paper or cloth. Clean all carbon dust from the generator after sanding the slip rings. If the rings are black or pitted, remove the rotor and use a lathe to remove some of the slip ring surface material.

8.6 Brushes (6EKOD/5EFKOD Models)

The brushes transfer current from the ADC IId to the slip rings. The brushes should last the life of the generator. Abrasive dust on the slip rings, however, shortens the life of the brushes. Excessive arcing at the brushes could damage the ADC IId controller. Weak springs, damaged slip rings, sticking brushes, a loose brush holder, or poor brush contact causes arcing.

The brushes must be free to move within the holder and be held in contact with the slip rings by the springs. When correctly positioned, spring pressure on the brush surface causes the brush to wear evenly. The entire brush must ride on the ring or arcing occurs and causes burned rings or voltage regulator failure. Figure 8-8 shows the correct positioning of the brushes. Add or remove shims as necessary to center the brushes on the slip rings. Replace the brushes if they show uneven wear or are worn to one half their original length.

Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.



1. Brush holders (2)
2. Slip ring
3. Brush
4. Retainer wire
5. Shim
6. Spring
7. Brush holder
8. Correctly positioned brush
9. Incorrectly positioned brush

Figure 8-8 Brush Assembly

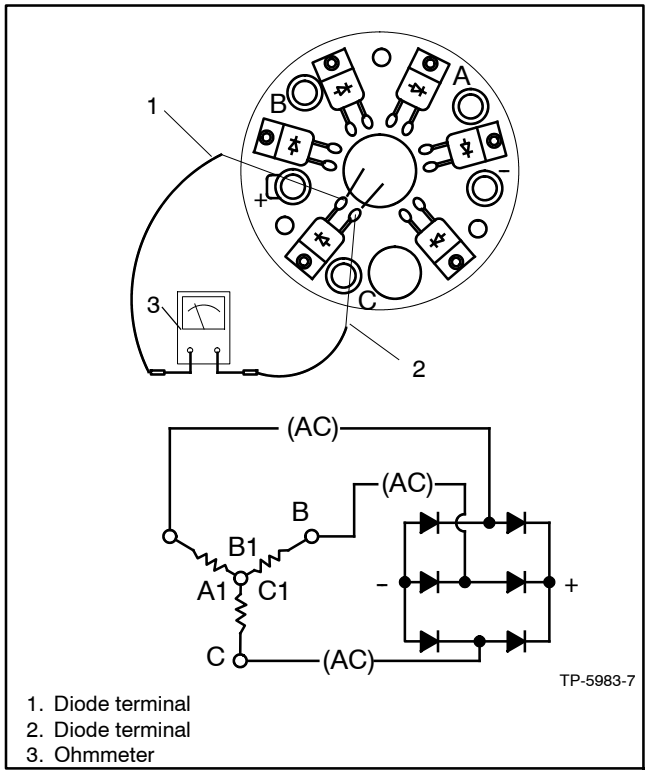
8.7 Rectifier Module (9-11EKOZD and 7-9EFKOZD Models)

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

Rectifier Module Test Procedure:

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

2. Use an ohmmeter on the R x 100 scale to check the resistance between all the rectifier diodes as shown in Figure 8-9. The ohmmeter should show a low resistance in one direction and, upon reversing the ohmmeter leads, a high resistance in the other direction. Replace the rectifier module if any of the diodes tests differently than described.



1. Diode terminal
2. Diode terminal
3. Ohmmeter

Figure 8-9 Rectifier Module Test

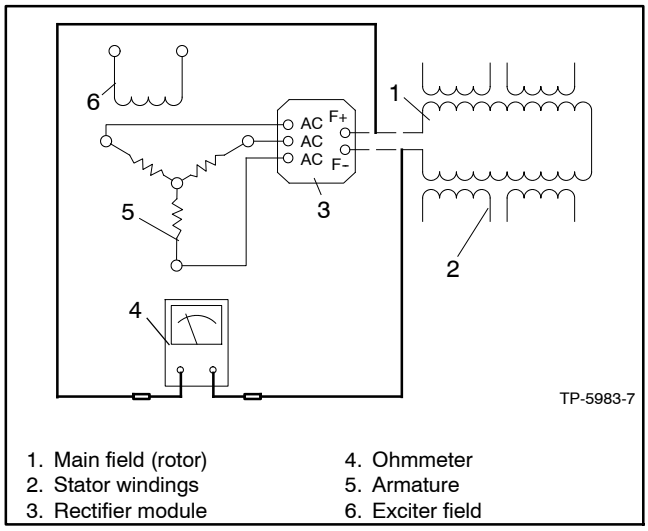
8.8 Rotor

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

Generator Main Field (Rotor) Test Procedure:

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

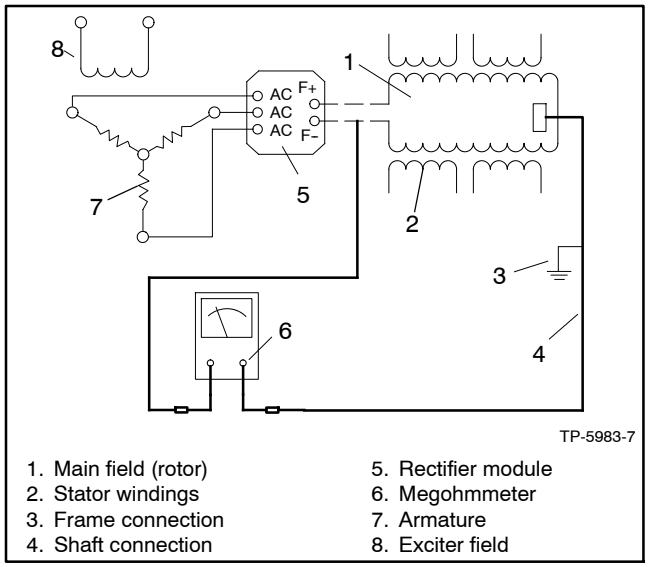
2. Check the main field resistance by connecting an ohmmeter across the main field F+ and F– leads. See Figure 8-10. See Section 1, Specifications for the resistance reading. A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the main field if the ohmmeter readings indicate the main field is inoperative. If the resistance test is inconclusive, perform a megohmmeter test on the main field as described in the next step.



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

Figure 8-10 Ohmmeter Connections on Main Field

3. Check the main field for a short-to-ground condition by using a megohmmeter. Apply 500 volts DC to either field lead and the main field frame. Follow the megohmmeter manufacturers instructions for using the megohmmeter. See Figure 8-11. A reading of 1.5 MOhms and higher indicates the main field is functional. A reading of less than 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the main field.



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

Figure 8-11 Megohmmeter Connections on Main Field

8.9 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.

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

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 55 and 66 are the voltage regulator supply and sensing leads. Refer to the schematic in Figure 8-12 when performing the following tests.

Stator Test Procedure:

1. Place the generator master switch in the OFF position.
2. Disconnect the generator set engine starting battery, negative (–) lead first.
3. Check the generator output lead connections. See Section 10, Wiring Diagrams.

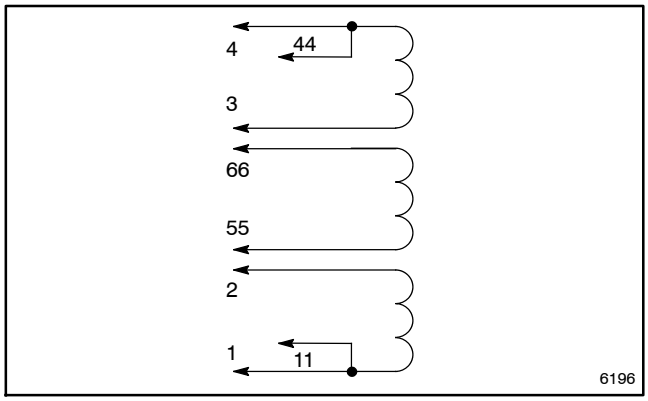


Figure 8-12 Alternator Stator Leads

4. Disconnect all the stator leads to isolate the windings. To check the stator continuity, set the ohmmeter on the R x 1 scale. Check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 8-12. See Figure 8-13 for single-phase and Figure 8-14 for three-phase values. Perform the stator tests on all the stator windings.

Leads	Continuity
1 and 2	Yes
1 and 11	
2 and 11	
3 and 4	
3 and 44	
4 and 44	
55 and 66	
1 and 3, 4, 44, 55, or 66	No
2 and 3, 4, 44, 55, or 66	
3 and 1, 2, 11, 55, or 66	
4 and 1, 2, 11, 55, or 66	
Any stator lead and ground on stator housing or frame laminations	

Figure 8-13 Stator Continuity Test Results on a Good Stator (1-Phase)

Leads	Continuity
1 and 4	Yes
2 and 5	
3 and 6	
7 and 10	
8 and 11	
9 and 12	
55 and 66	
1 and 2, 3, 7, 8, or 9	No
1 and 55	
Any stator lead and ground	

Figure 8-14 Stator Continuity Test Results on a Good Stator (3-Phase)

5. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads as shown in Figure 8-13 or Figure 8-14. See Section 1, Specifications for the stator resistance values. If the stator resistance test is inconclusive, perform a megohmmeter test on the stator as described in the next step.

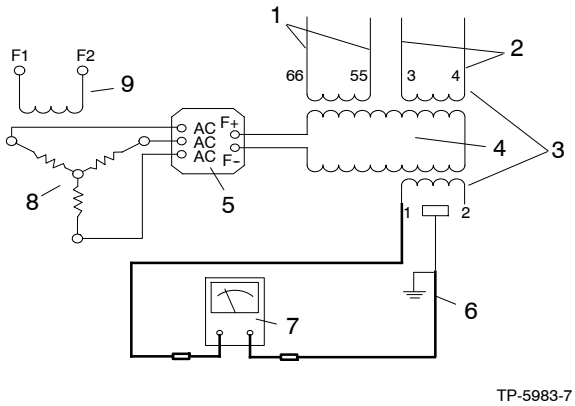
   Note: Consider the stator functional if the resistance reading (continuity) is low and there is no evidence of shorted windings (heat discoloration).

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

   Note: The stator resistance can vary directly with increased temperature.

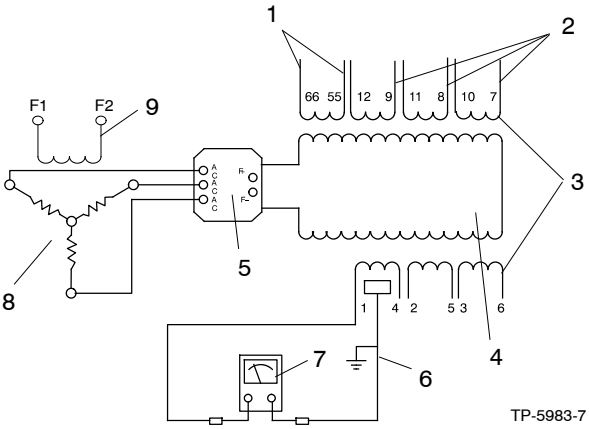
If any of the stator readings vary during the previous checks, replace the stator.

6. Check the stator for a short-to-ground condition using a megohmmeter. See Figure 8-15 for a single-phase megohmmeter connections and Figure 8-16 for three-phase megohmmeter connections. Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. Repeat the test on the other leads until all of the stator windings have been tested. A reading of 1.5 MOhms and higher indicates the stator is functional. A reading of less than 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, repair or replace the stator.



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

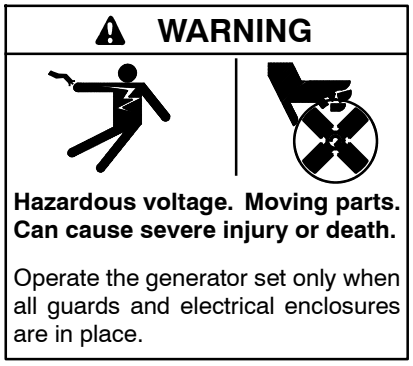
Figure 8-15 Megohmmeter Connections on 1-Phase Stator



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

Figure 8-16 Megohmmeter Connections on 3-Phase Stator

8.10 Voltage Regulator



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.

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

8.10.1 Voltage Regulator and Calibration Specifications

The Advanced Digital Control IId (ADC IId) has a voltage regulation function that is internal to the processor. This means that no external voltage regulator is necessary. The voltage regulation of the controller uses root mean square (rms) sensing for fast response to changes in indicated and regulated voltages resulting in excellent regulation accuracy.

8.10.2 Voltage Regulator Adjustments

The descriptions of the voltage regulator adjustments and features follow.

Voltage Adjustment. The voltage adjustment allows the user to enter the desired generator set output level. This regulated level setting is the average of the three line-to-line voltages in three-phase configurations or L1-to-L2 in single phase configurations.

Submenus display the individual line-to-line voltages. These voltages are for reference only and are relevant in unbalanced load conditions. The voltage adjust setpoint can be changed to accommodate an important phase in an unbalanced system.

Underfrequency Unload Frequency Setpoint. This adjustment affects the voltage droop (volts per Hz) when load is applied and underfrequency occurs. The underfrequency unload setting defines the setpoint where underfrequency starts. Any frequency below the setpoint causes the voltage to drop thus reducing the load allowing the engine speed to recover according to the underfrequency unload slope setting.

Engine speed recovery depends upon characteristics such as engine make, fuel type, load types, and operating conditions. The underfrequency unload setting should match the engine speed recovery characteristics for the application.

Underfrequency Unload Slope. This setting determines how much the voltage drops during an underfrequency condition. Typically, applying a large electrical load causes a dip in engine speed and frequency. The voltage regulator reduces voltage, allowing engine speed recovery. The volts-per-Hz setting determines the amount of voltage drop.

Regulator Gain. Regulator gain refers to the gain of the control system. Generally, the higher the gain the faster the system responds to changes and the lower the gain, the more stable the system.

If the voltage is slow to recover when loads are applied or removed, increase the regulator gain. If the voltage is unstable, decrease the regulator gain.

8.10.3 Voltage Regulator

Displays the voltage regulator adjustment, volt/Hz, gain, and stability adjustment values.

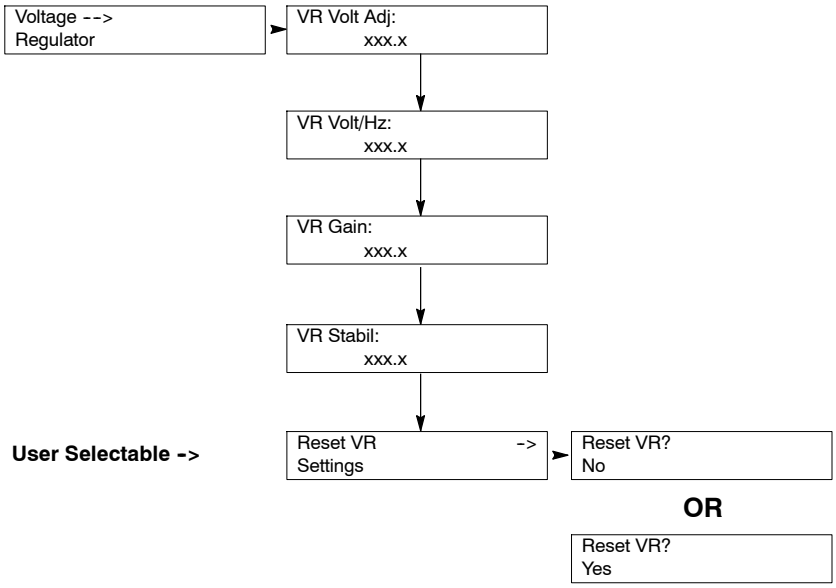
The voltage regulator value is reviewable at all times and provides the ability to fine adjust voltage. Changing the system voltage or replacing the circuit board typically requires a voltage adjustment.

To enable calibration, start the generator set and select the *VR Volt Adj, Volt/Hz, Gain, or Stability* display. Then push and hold the pushbutton/rotary selector dial until the *Editing Enabled* popup appears. Editing of the voltage adjustment is now available.

The user can change the individual value or can select *Reset VR?-Yes* to reset to the default value. The *Reset VR Settings* display will only show if editing is enabled.

To disable calibration, Rotate the pushbutton/rotary selector dial until the *<-Return* popup appears. Momentarily press the pushbutton/rotary selector dial. Stop the generator set if not already done.

Voltage Regulator



8.11 Voltage Reconnection

Use the following voltage reconnection procedure to change the voltage of 4- and 12-lead generator sets. Frequency changes require voltage regulator *and* governor adjustments.

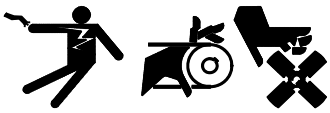
Refer to the following procedure and the connection schematics. Follow the safety precautions at the front of this manual and in the procedure text and observe National Electrical Code (NEC) guidelines.

NOTICE

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

Note: Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the selected line voltage.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

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

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

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.

Voltage Reconnection Procedure

1. Stop the generator set.

2. Turn the controller pushbutton/rotary selector dial until it stops at the Volt Select menu. See Figure 8-17.

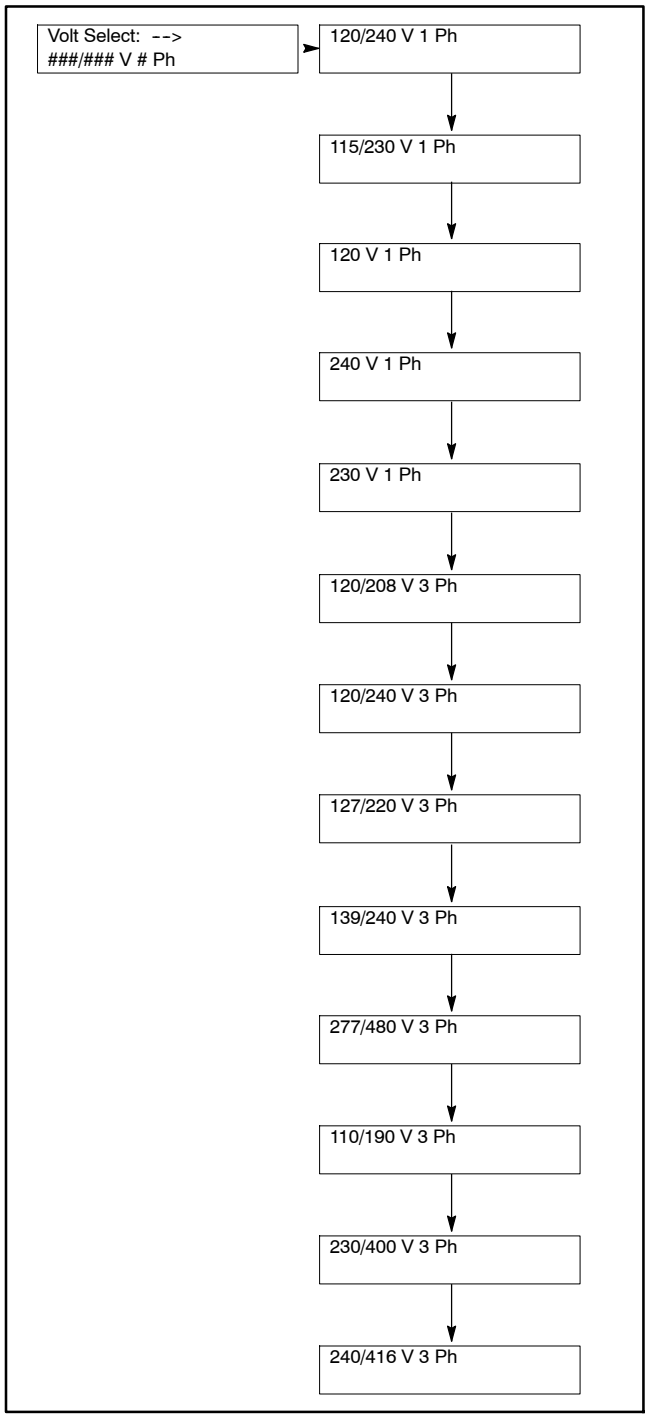


Figure 8-17 Volt Select Menu

3. Press the selector dial and the voltage selection option (second line on the display) will start to flash.

4. Turn the selector dial clockwise or counterclockwise until the desired voltage selection option appears.

5. Press the selector dial. The second line on the display will stop flashing and the new voltage will appear.

6. Disconnect the generator set engine starting battery, negative (–) lead first. Disconnect power to the battery charger (if equipped).

7. Use Figure 8-18, Figure 8-19, Figure 8-20, Figure 8-21, or Figure 8-22 to determine the generator set voltage configuration. Note the original voltage and reconnect as needed.

8. Reconnect the battery, negative lead last.

9. Start the generator set. Check the digital display for correct voltages using Section 7.13.4, Generator Metering.

10. Stop the generator set after completing the voltage adjustments.

8.12 Four-Lead Reconnection

The following information illustrates the reconnection of four-lead generator sets. In all cases, conform to the National Electrical Code (NEC).

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.

8.12.1 100–120-Volt Configurations

If the installation requires a factory two-pole circuit breaker, do not connect the load-side terminals of the circuit breaker together; see Figure 8-18. If the installation requires a 100–120-volt, 2-wire system, use a single-pole circuit breaker. See Figure 8-19. When connecting stator phase leads together, size the output lead (L1) to handle the amperage. Use a jumper lead on the *line* side of the circuit breaker to balance the load of the generator set.

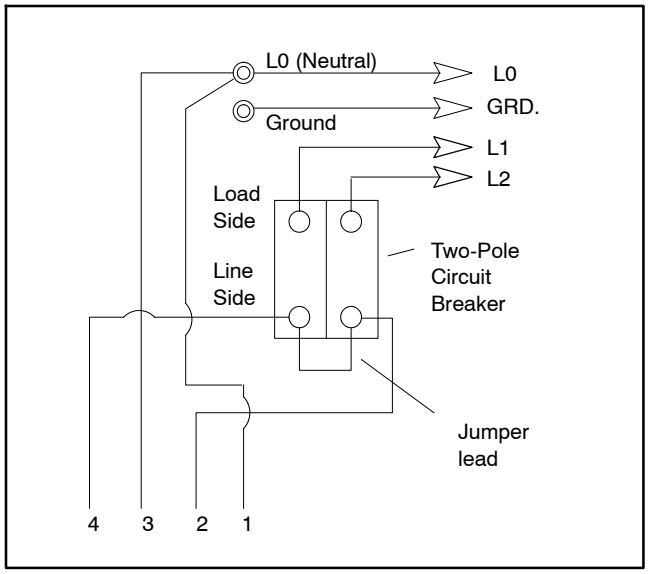
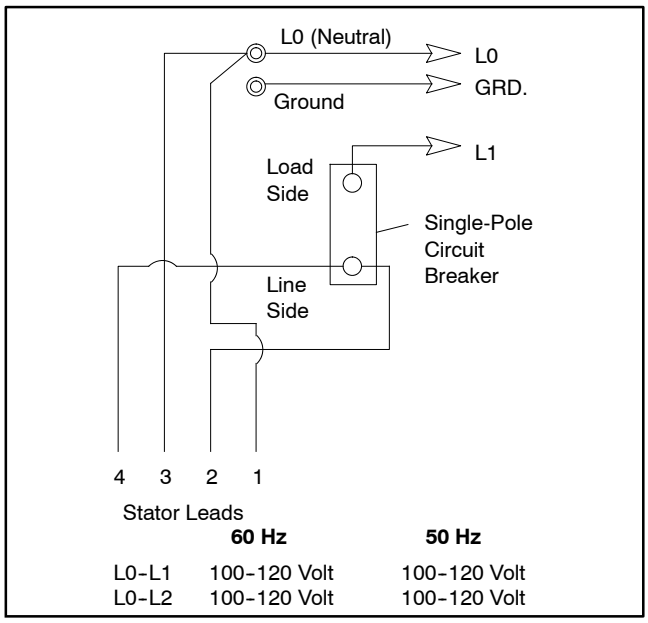


Figure 8-18 100–120-Volt, 3-Wire Configuration

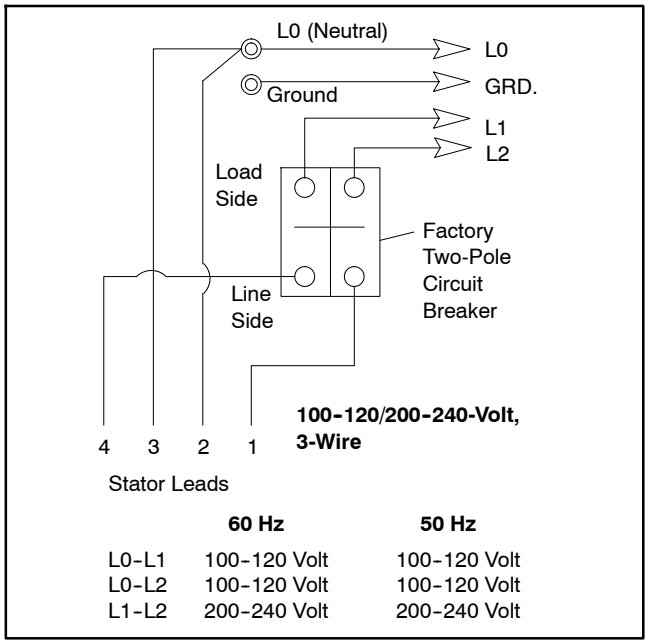
8.12.2 100–120/200–240-Volt Configurations

The 100–120/200–240-volt configuration does not use a jumper lead. If the unit was originally wired for straight 100–120 volt, 3-wire, remove the jumper lead (see Figure 8-18 for location). Select a two-pole circuit breaker. Application of two single-pole circuit breakers does not conform to NEC requirements for supplying a 200–240-volt load, even if the breakers are mechanically attached together. Leads L1 and L2 are for different phases; *never* connect them together.



	60 Hz	50 Hz
L0–L1	100–120 Volt	100–120 Volt
L0–L2	100–120 Volt	100–120 Volt

Figure 8-19 100–120-Volt, 2-Wire Configuration



	60 Hz	50 Hz
L0–L1	100–120 Volt	100–120 Volt
L0–L2	100–120 Volt	100–120 Volt
L1–L2	200–240 Volt	200–240 Volt

Figure 8-20 100–120/200–240-Volt, 3-Wire Configuration

8.12.3 200-240-Volt Configurations

The 200-240-volt configuration does not use a jumper lead. If the unit was originally wired for straight 100-120 volt, 3-wire, remove the jumper lead (see Figure 8-18 for location). See Figure 8-21.

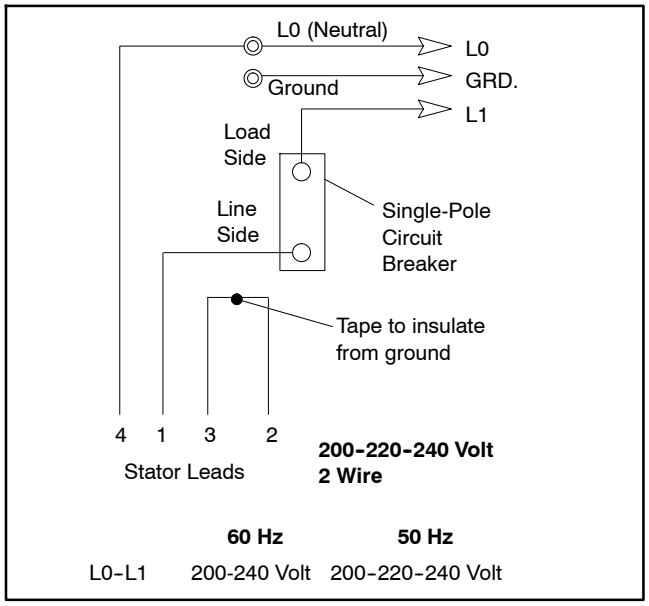


Figure 8-21 200-220-240-Volt, 2-Wire Configuration for ***Models with ADC IId***

8.13 Twelve-Lead Reconnection

The reconnection procedure following details voltage reconnections only. If the generator set requires frequency changes, adjust the governor.

The following information illustrates the reconnection of 12-lead generator sets. In all cases, follow the National Electrical Code (NEC) guidelines.

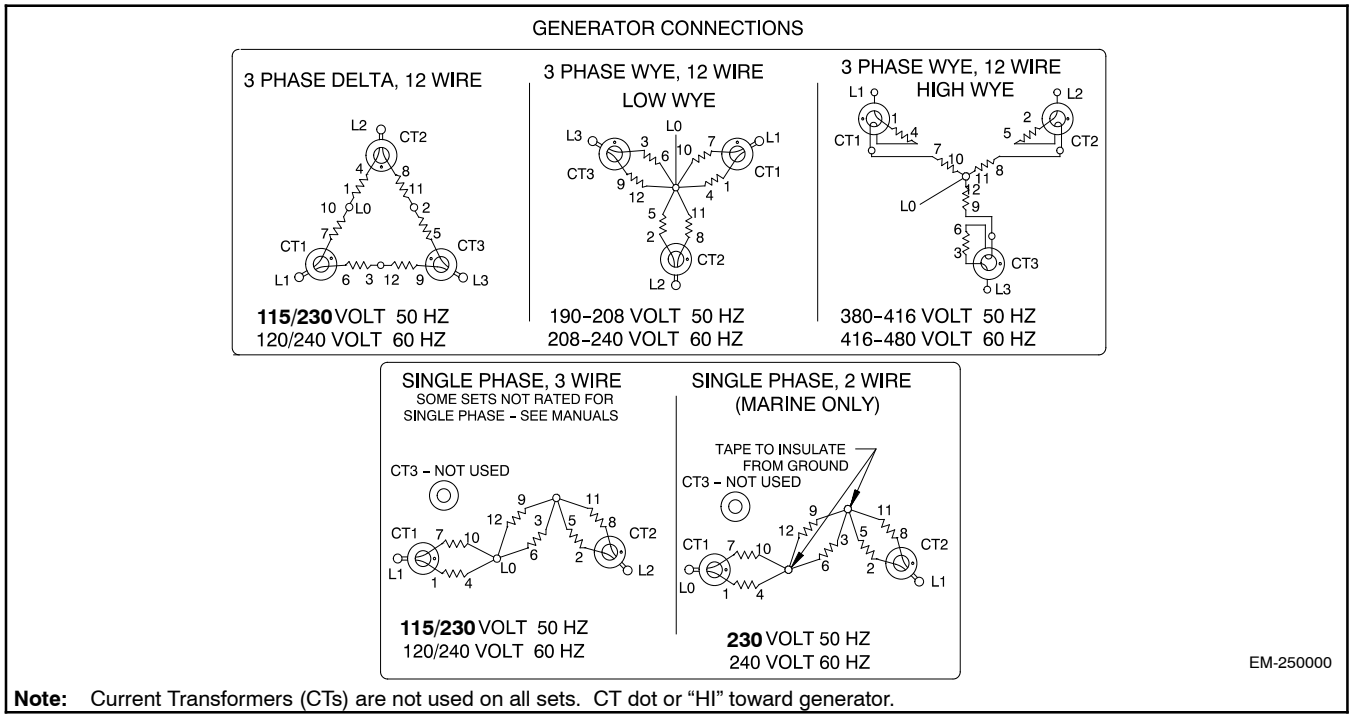
Reconnect the stator leads of the generator set to change output phase or voltage. Refer to the following procedure and connection schematics. Follow all safety precautions at the front of this manual and in the text during reconnection procedure.

NOTICE

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

Twelve-Lead Reconnection Procedure

1. Move generator set master switch to OFF position.
2. Disconnect engine starting battery, negative (-) lead first. Disconnect power to battery charger, if equipped.
3. Use Figure 8-22 to determine generator set voltage configuration. Note the original voltage and reconnect the generator set as needed.



Note: Current Transformers (CTs) are not used on all sets. CT dot or "HI" toward generator.

Figure 8-22 Generator Reconnection

8.14 Fault Shutdown Tests

Verify the operation of the generator set overspeed, overcrank, high engine temperature, and low oil pressure shutdowns by performing the following tests. If these tests are inconclusive, test individual shutdown circuit components (wiring harness, switch, etc.) as described elsewhere in this section.

⚠ WARNING

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

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

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.

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.

⚠ WARNING

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

Do not work on the generator set until it cools.

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

8.14.1 Controller Fault Shutdown Functions

Check the operation of the fault functions programmed in the ADC IId by performing the following tests. If the ADC IId does not operate as described, check the ADC IId configuration settings; see Section 7.13. Also check the ADC IId wiring and connections; see Section 10.

Overspeed Shutdown

The overspeed setting is programmed into the ADC IId controller and is not adjustable. Verify that the following controller configuration is set correctly for your unit.

Open the generator set output circuit breaker before beginning the test. (See 1, Service Views for the circuit breaker location.)

Connect a DVM to measure the output frequency. Start the generator set and manually adjust the engine speed. See Section 4.4.

Increase the engine speed to at least 115% of the rated engine speed, 69 Hz on 60 Hz models or 58 Hz on 50 Hz models. Verify that the generator set shuts down on an overspeed fault (*Eng Speed High Shutdwn*). If the overspeed shutdown does not operate, the generator set should shut down on an overfrequency fault (*Frequency High Shutdwn*) after approximately 5 seconds.

Low Oil Pressure (LOP) Shutdown

Connect a jumper wire from the LOP sender (lead 7) to the generator set ground. Start the generator set. Verify that the generator set shuts down after approximately 25–35 seconds of operation. Remove the jumper wire from the LOP sender and ground. Start the generator set and run it for at least 25–35 seconds to verify that the generator set does not shut down.

Overcrank Shutdown

Disconnect the fuel supply line. Press the power button to turn the controller on. Press the start/stop button to start the generator set. Observe that the generator set simulates cranking for 15 seconds and then rests for 15 seconds. Check that the generator set shuts down after the third crank/rest cycle.

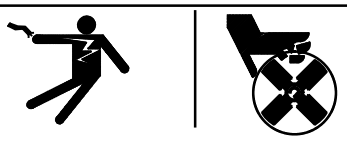
High Engine Temperature Shutdown

Connect a jumper wire across coolant temperature sensor (CTS) connections P8-1 and P8-2. Start the generator set. Verify that the generator set shuts down approximately 5 seconds after the generator set comes up to speed. Remove the jumper wire. Start the generator set and run it for at least 30 seconds to verify that the generator set does not shut down.

8.14.2 Fault Shutdown Senders/Switches

Check the senders/switches on the engine by performing the following tests. If the sensor does not function as described, replace it.

⚠ WARNING



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

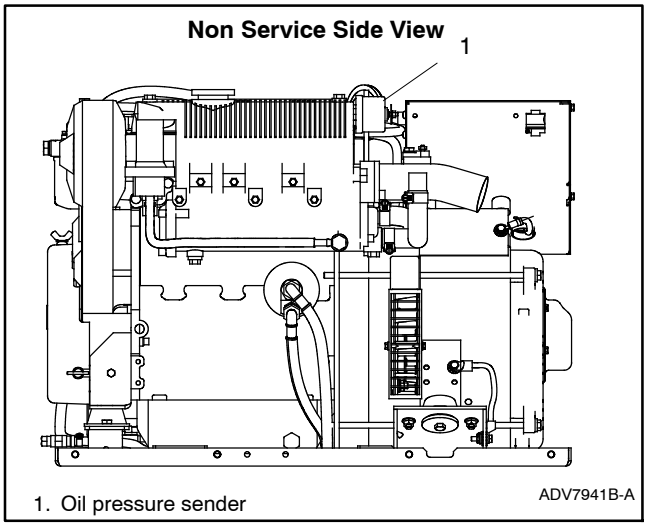
Operate the generator set only when all guards and electrical enclosures are in place.

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.

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.

Low Oil Pressure (LOP) Sender

Disconnect the low oil pressure sender and use an ohmmeter to measure the resistance of the sender. The sender resistances varies with pressures and should be within the values shown in Figure 8-24. If the resistance is very low or very high, replace the low oil pressure sender.



1. Oil pressure sender

Figure 8-23 Oil Pressure Sender Location

Pressure, psi	Resistance, Ohms
0	240 +2.5/-10.5
100	33.5 +10.5/-7.5

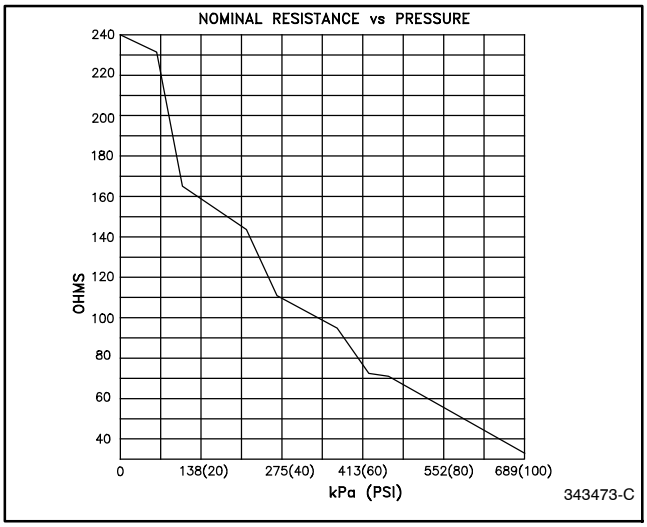
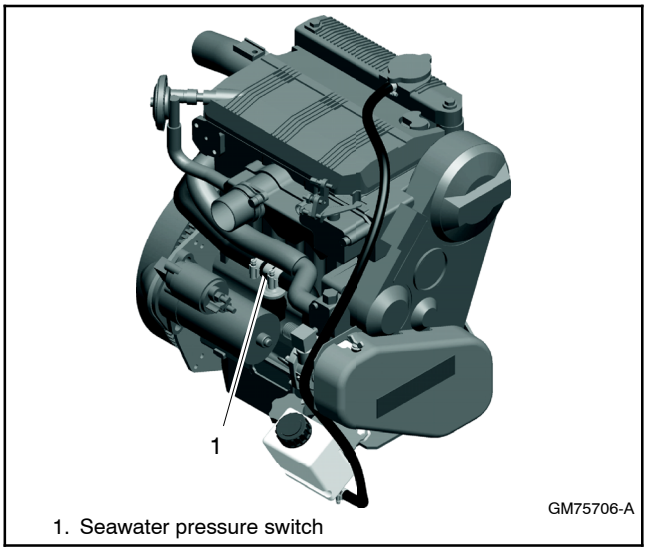


Figure 8-24 Oil Pressure Sensor Resistance Readings

Seawater Pressure Switch

See Figure 8-25 for the seawater pressure switch location. Remove the seawater pressure switch and install a pressure gauge to verify that the seawater pressure is within the range specified before testing or replacing the seawater pressure switch.

To test the seawater pressure switch, reinstall the switch and start the generator set. If the unit shuts down, disconnect lead 87 from the seawater pressure switch and reset the controller. Restart the generator set and verify that it does not shut down. A successful restart indicates a bad seawater pressure switch. Replace the seawater pressure switch if the calibration pressure (or opening adjustment range) is not 0.5 ±0.2 psi.

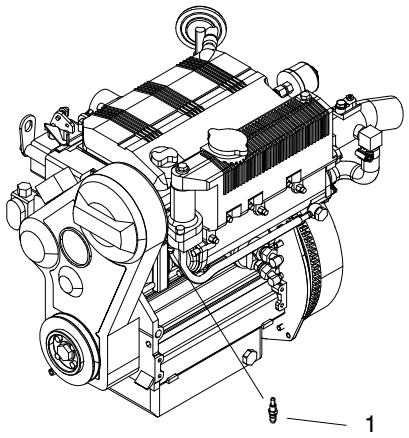


1. Seawater pressure switch

Figure 8-25 Seawater Pressure Switch Location

Coolant Temperature Sensor (CTS)

The coolant temperature sensor (CTS) is used to monitor engine temperature for the high engine temperature fault shutdown. See Figure 8-26 for the coolant temperature sensor location. Power down the generator set and allow the generator set to cool. Disconnect the CTS and use an ohmmeter to measure the resistance across the sensor. The sensor resistance varies with temperature and should be within the values shown in Figure 8-27. If the resistance is very low (indicated a short circuit) or very high (indicating an open circuit) replace the CTS.



1. Coolant temperature sensor

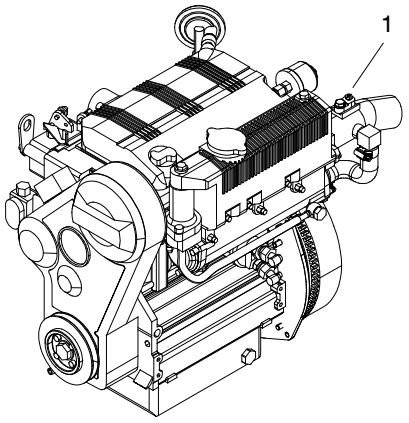
Figure 8-26 Coolant Temperature Sensor Location

Temperature, °C (°F)	Resistance, Ohms
30 (86)	2106-2392
100 (212)	182-198

Figure 8-27 Coolant Temperature Sensor Resistance Readings (All Models)

High Exhaust Temperature (HET) Switch

In the event of a shutdown because of high exhaust temperature, the ADC IId controller will display fault code *Exh. Temp High Shutdown*. See Figure 8-28 for the high exhaust temperature switch location. High exhaust temperature of 215° ±5° F (102° ±2.8° C) will cause the unit to shut down.



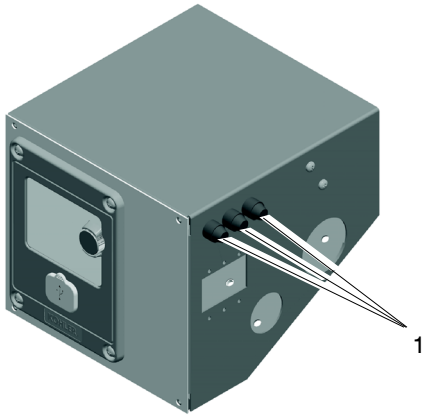
1. High exhaust temperature switch

Figure 8-28 High Exhaust Temperature Switch Location

8.15 Fuses

Fuses are located on the side of the junction box. See Figure 8-29. Always identify and correct the cause of a blown fuse before restarting the generator set. Refer to Section 6, Troubleshooting, for conditions that may indicate a blown fuse. Replace blown fuses with identical replacement parts.

- **10-Amp (F1)** fuse protects the auxiliary winding.
- **20-Amp (F2)** fuse protects the controller circuits, fuel pump, and fuel shutoff solenoid.
- **5-Amp (F3)** fuse protects the customer connections.



1. Fuses (qty. 3)

Figure 8-29 Fuses on the Side of the Control Box

Fuse	Amps	Label	Part No.
Auxiliary Winding	10	F1	358337
Controller, Fuel Pump, and Fuel Shutoff Solenoid	20	F2	GM39266
Customer Connection	5	F3	239298

Figure 8-30 Fuses

8.16 Continuity Checks

⚠ WARNING

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

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

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.

To further check generator set components, disconnect the battery and remove wiring harness plugs from the ADC IId circuit board. Use an ohmmeter to check the continuity of the components listed in Figure 8-31. Also see Section 10, Wiring Diagrams.

Figure 8-31 gives resistance readings for functional components. A zero reading on the ohmmeter indicates continuity. No ohmmeter reading indicates very high resistance or an open circuit. A measurement that varies significantly from the value shown in the table indicates a faulty component; replace faulty components.

Note: Disconnect the generator set battery before performing continuity checks to prevent damage to the ohmmeter.

Component	Ohmmeter Connections	Ohmmeter Scale	Generator Set Master Switch Position	Ohmmeter Readings for Operative Components*
P1 wiring harness	P1-3 and ground	R x 1	OFF	Zero ohms (continuity) Any other reading indicates a poor ground connection.
	P2-6 and P2-7 (stator leads 11 and 44 for 1-phase models) or P2-6, P2-7, and P2-8 (stator leads 7, 8, and 9 for 3-phase models)	R x 1	OFF	Zero ohms (continuity). If no continuity, check wiring.
	P2-3 and P2-4 (stator leads 55 and 66)	R x 1	OFF	Zero ohms (continuity). If no continuity, check fuse F1 and wiring.
Controller fuse and wiring	P1-2 and battery positive (+)	R x 100	OFF	Zero ohms (continuity). If no continuity is found, check fuse F2 and wiring.
Auxiliary winding fuse 10 amp fuse	P2-3 and stator lead 55	R x 100	OFF	Zero ohms (continuity). If no continuity is found, check for an open circuit and/or a blown fuse.
Low oil pressure (LOP) sender *	Lead 7 and ground (engine block)	R x 100	OFF	Zero ohms (continuity). No continuity indicates a bad switch and/or wiring.
Temperature sensor (CTS) *	P8-1 and P8-2	R x 1000	OFF	180–2500 ohms, depending on engine temperature. Zero ohms or an open circuit indicates bad wiring or a bad switch.
Preheat relay (PH1 and PH2)	Terminals 85 and 86	R x 1	OFF	12-volt relay: 90 ±10 ohms coil resistance Lower resistance indicates a shorted relay coil and/or wiring. High resistance indicates an open relay coil and/or wiring.

* See Section 8.14.2, Fault Shutdown Senders

Figure 8-31 Continuity Checks

9.1 Disassembly

Disconnect all of the external connections—battery cables at the battery (negative (–) lead first), AC-output leads, remote interface connector, water line at the seawater pump, fuel line at the fuel pump filter inlet, and exhaust line at the mixing elbow. Remove the sound shield enclosure, if equipped. Observe all of the safety precautions listed at the beginning of this manual during the disassembly/reassembly procedures.

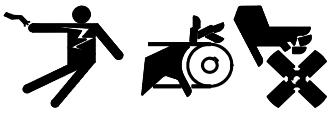
Note: Because this manual covers several models, the procedure for disassembly may vary because of product updates and the assembly variations.

Note: Mark leads that are disconnected. Refer to the wiring diagrams in Section 10 during reassembly.

Disassembly Procedure:

1. Press the start/stop button to stop the generator set.
2. Press the power button to turn the controller off.
3. Disconnect power to the battery charger, if equipped.
4. Disconnect the generator set engine starting battery, negative (–) lead first.

⚠ WARNING

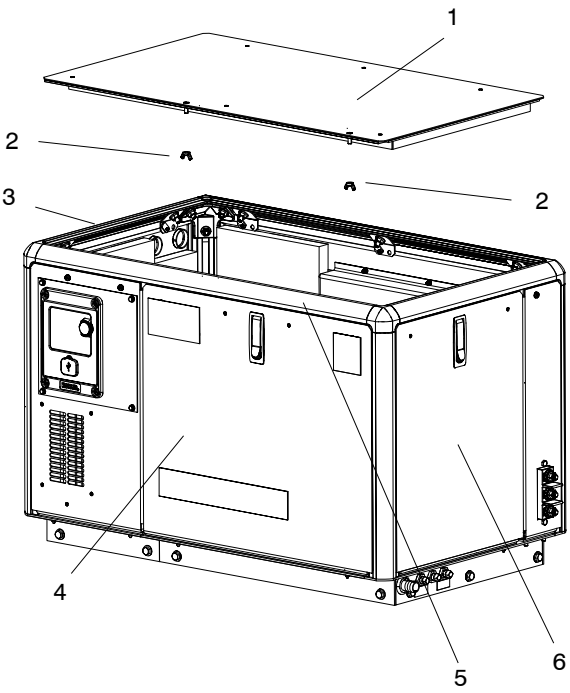


Accidental starting.
Can cause severe injury or death.

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.

Sound Shield Equipped Models: For access to the generator set to perform regular maintenance, remove the sound shield doors and roof.

5. **Sound-Shielded Models:** Open the service-side door.
6. **Sound-Shielded Models:** Release the two wing nuts located underneath the roof. See Figure 9-1.
7. **Sound-Shielded Models:** Lift up the roof.
8. **Sound-Shielded Models:** Slide the roof towards the service side of the unit for removal.
9. **Sound-Shielded Models:** Open the front, rear, and non-service side doors as needed.

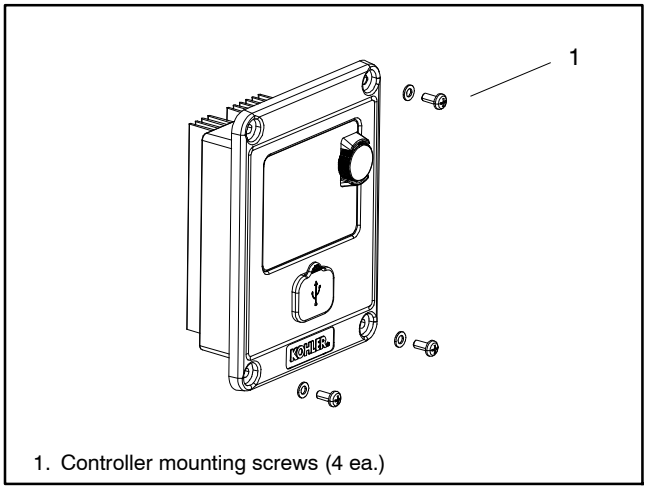


1. Sound shield roof
2. Wing nut
3. Alternator-end door
4. Service-side door
5. Front rail
6. Engine-end door

Figure 9-1 Sound Shield Roof Removal

10. Loosen and remove the four controller mounting screws securing the controller and *carefully* lift the controller. See Figure 9-2.

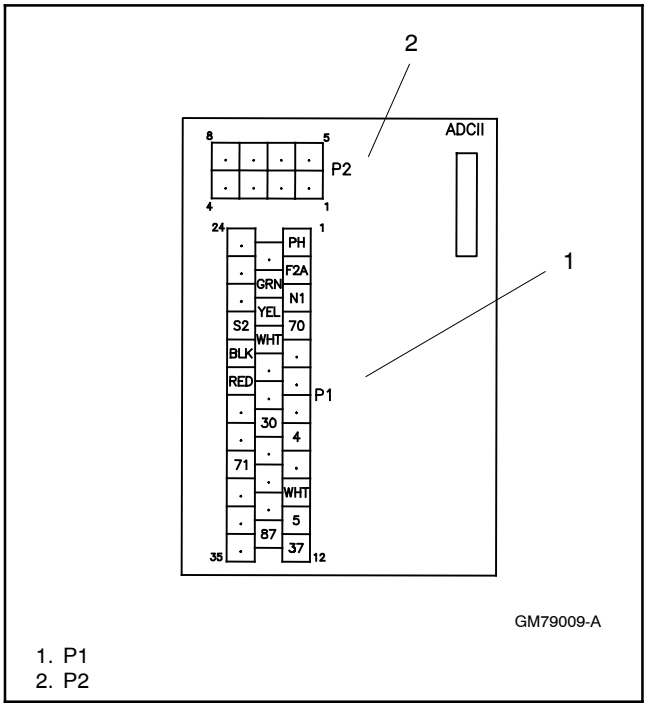
    Note: Be careful of the leads and harness connected to the controller.



1. Controller mounting screws (4 ea.)

Figure 9-2 ADC IId Mounting Screws

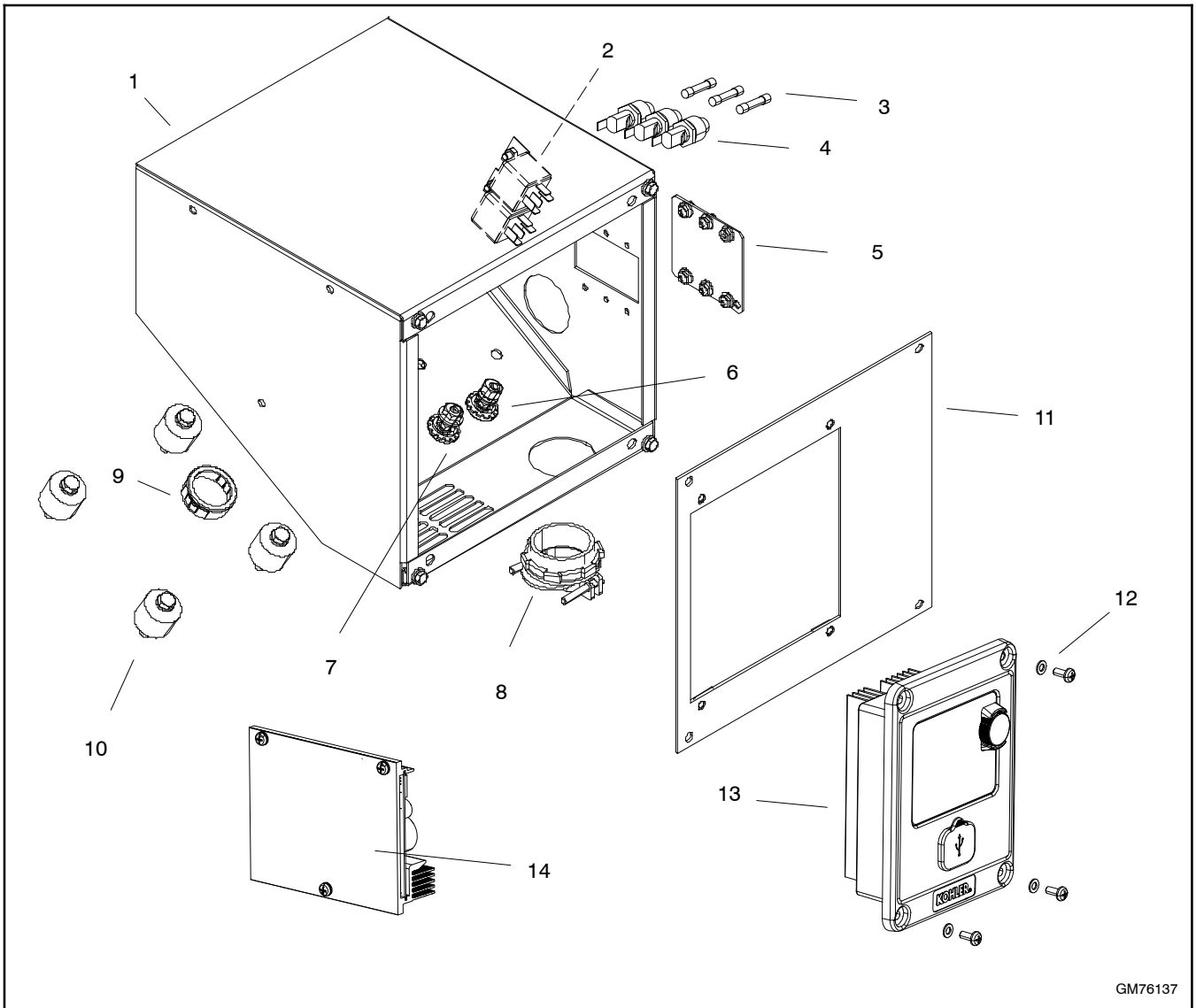
11. Note the connections on the back of the controller and then disconnect wiring harness plugs P1 (35-pin plug) and P2 (8-pin plug) from the ADC IId. See Figure 9-3.



1. P1
2. P2

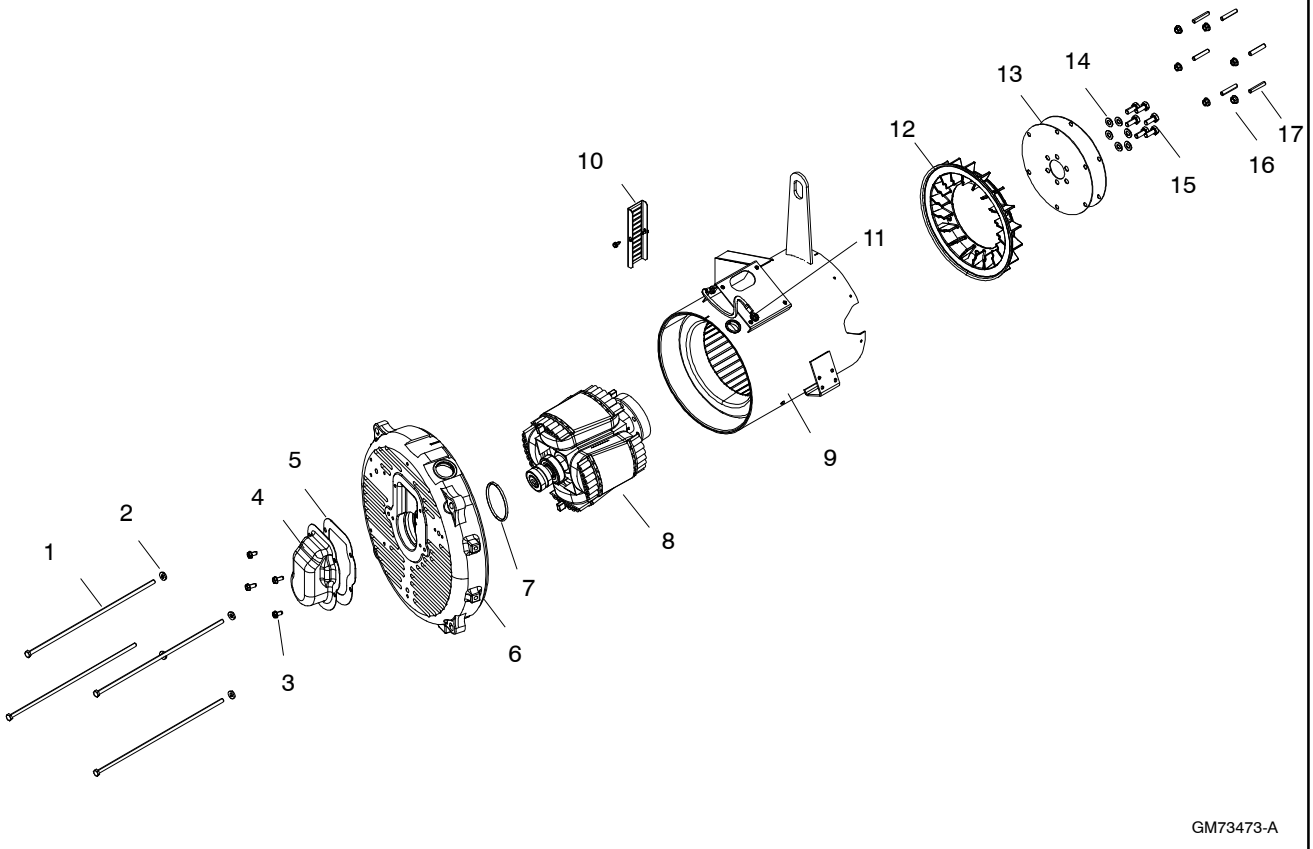
Figure 9-3 Controller Connections

12. Refer to Figure 9-4 while performing steps 13 to 20.
13. Remove the controller.
14. Remove the junction box controller panel.
15. Disconnect the generator output leads from the circuit breakers.
16. Disconnect the LO and GRD lead connections.
17. Disconnect the leads to the fuses.
18. Disconnect the connectors to the preheat relays.
19. Disconnect the AC lead connections and the P4 connector to the battery charging module.
20. Remove the junction box from the four vibromounts.



1. Junction box
2. Preheat relays (qty. 2) located inside junction box
3. F1, F2, and F3 fuses (qty. 3)
4. Fuse holders (qty. 3)
5. Line circuit breaker cover plate
6. GRD lead connection
7. LO lead connection
8. Cable connector
9. Bushing
10. Vibromounts (qty. 4)
11. Junction box controller panel
12. Screws and washers (qty. 4)
13. Advanced Digital Control IId
14. Battery charging module (shown removed from inside of the junction box)

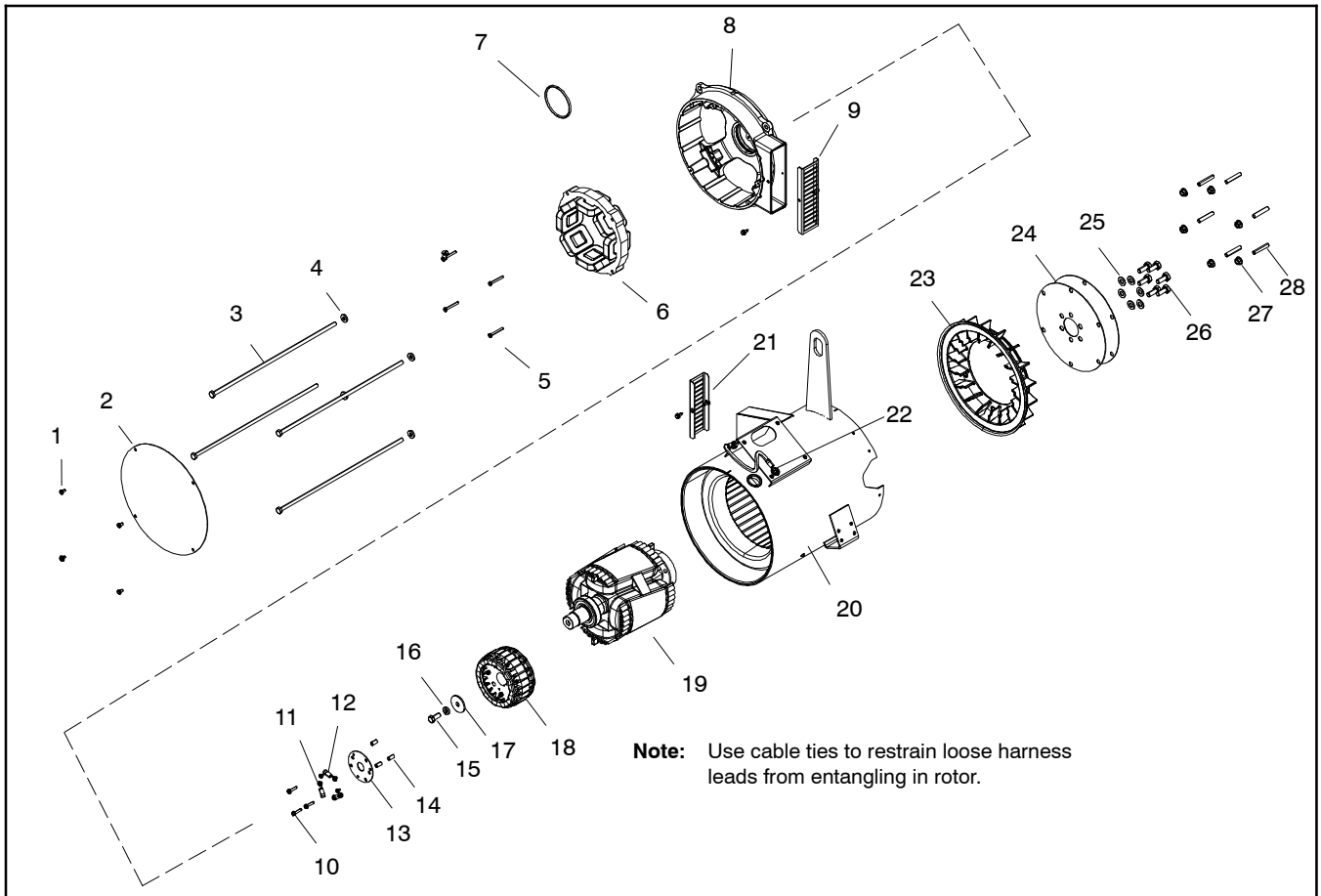
Figure 9-4 Advanced Digital Control IId (ADC IId) and Junction Box Detail



1. Overbolts. Torque to 23 Nm (17 ft. lbs.)
2. Washers
3. Screws
4. Brush holder cover.
   During disassembly, push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holder. Remove the brush holder and carefully pull the leads out of the stator housing.
   During reassembly, feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws. Remove the brush retainer and check alignment. See Section 8.6.
5. Gasket
6. End bracket
7. O-ring
8. Rotor assembly
9. Stator assembly
10. Alternator air outlet guard and screw
11. Lead, screw, lock washer, and plain washer
12. Alternator fan
13. Drive disk
14. Washers
15. Screws. Torque to 45 Nm (34 ft. lbs.)
16. Nuts
17. Studs. Torque to 23 Nm (17 ft. lbs.)

Figure 9-5 6EKOD/5EFKOD Alternator Assembly (Disassembly/Reassembly)

Follow the general torque specification found in Appendix C of this manual unless noted above or in Section 1.6, Torque Specifications.

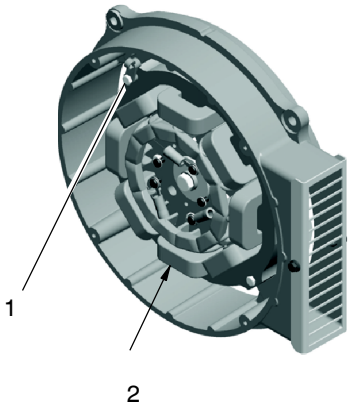


1. Screws and washers
2. End bracket panel
3. Overbolts. Torque to 23 Nm (17 ft. lbs.)
4. Washers
5. Screws
6. Exciter field assembly
7. O-ring. Assemble O-ring into groove in bearing insert.
8. End bracket
9. End bracket air inlet guard and screw
10. Screws
11. Screws and lock washers
12. Terminals
13. Rotating diode board
14. Spacers
15. Bolt. Torque to 38 Nm (28 ft. lbs.)
16. Lock washer
17. Washer
18. Exciter armature. Note: Apply a thin coat of anti-seize compound to shaft surface before attaching exciter armature.
19. Rotor assembly
20. Stator assembly
21. Alternator air outlet guard and screw
22. Lead, screw, lock washer, and plain washer
23. Alternator fan
24. Drive disk
25. Washers
26. Screws. Torque to 45 Nm (34 ft. lbs.)
27. Nuts
28. Studs. Torque to 23 Nm (17 ft. lbs.)

Figure 9-6 9-11EKOZD/7-9EFKOZD Alternator Assembly (Disassembly/Reassembly)

Follow the general torque specification found in Appendix C of this manual unless noted above or in Section 1.6, Torque Specifications.

21. **9-11EKOZD and 7-9EFKOZD Models:** Remove the four screws to remove the exciter field. See Figure 9-7.



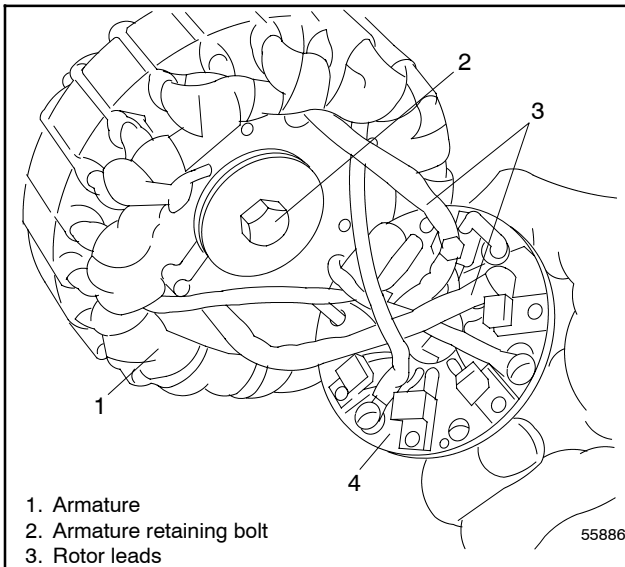
1. Screws (4)
2. Exciter field

Figure 9-7 Exciter Field Removal

22. **9-11EKOZD and 7-9EFKOZD Models:** Remove the three screws and spacers from the rectifier board.

23. **9-11EKOZD and 7-9EFKOZD Models:** Disconnect the main field rotor leads from the rectifier board positive/negative terminals. Remove the armature retaining bolt and washer. See Figure 9-8.

24. **9-11EKOZD and 7-9EFKOZD Models:** Remove the armature from the shaft, guiding the rotor leads through the armature bores. See Figure 9-8.



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

Figure 9-8 Armature Removal

25. **6EKOD/5EFKOD Model:** Remove the four screws to remove the brush holder cover and brush cover gasket.

26. **6EKOD/5EFKOD Model:** Push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holder. See Section 8.6.

27. **6EKOD/5EFKOD Model:** Remove the brush holder and carefully pull the leads out of the stator housing.

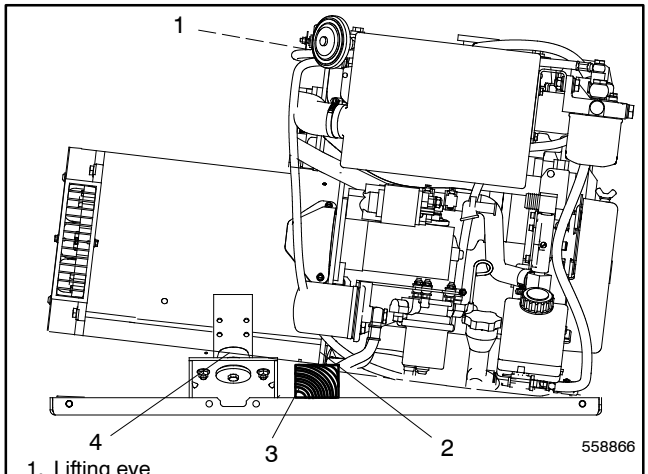
28. Attach a hoist hook to the generator lifting eye. See Figure 9-9.

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

29. Remove the two vibromount bolts. See Figure 9-9.

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

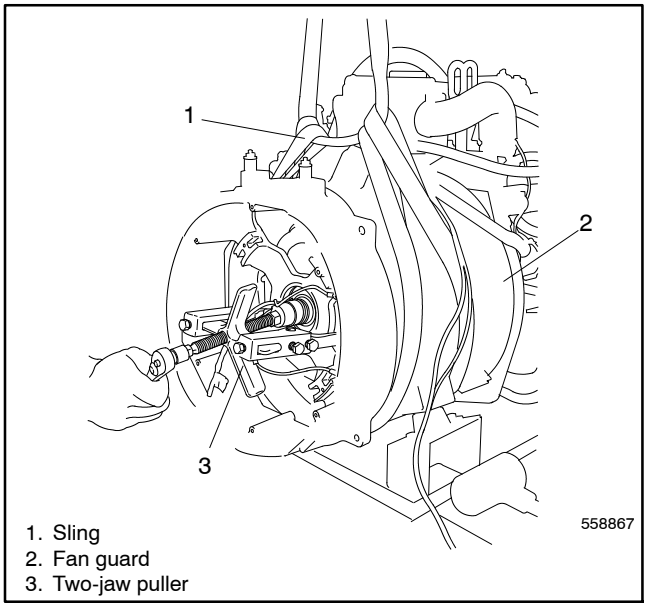
31. Remove the four overbolts from the end bracket.



1. Lifting eye
2. Backplate
3. Wood block
4. Vibromounts

Figure 9-9 Supporting the Generator, Typical

32. Install a sling capable of handling the weight of the stator housing on the stator housing. See Figure 9-10.



1. Sling
2. Fan guard
3. Two-jaw puller

Figure 9-10 Stator Assembly Removal

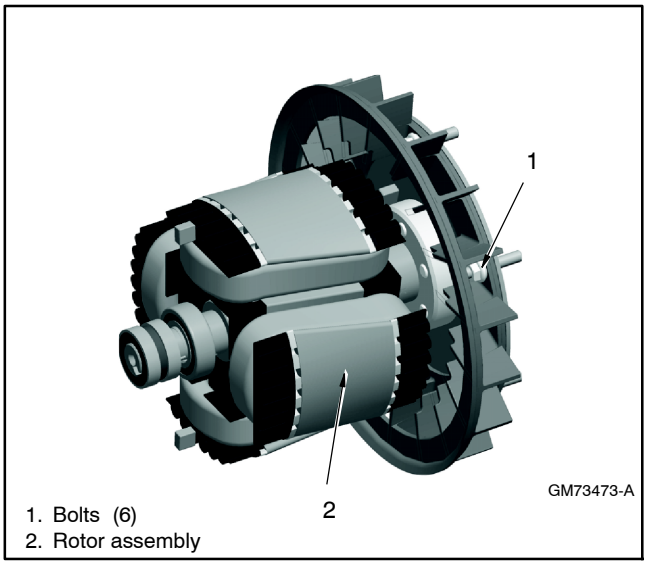
33. Use a two-jaw puller to pull the end bracket/stator assembly from the bearing on the rotor shaft. See Figure 9-10.

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

35. Mark the fan's position on the rotor/drive disc assembly with a permanent marker.

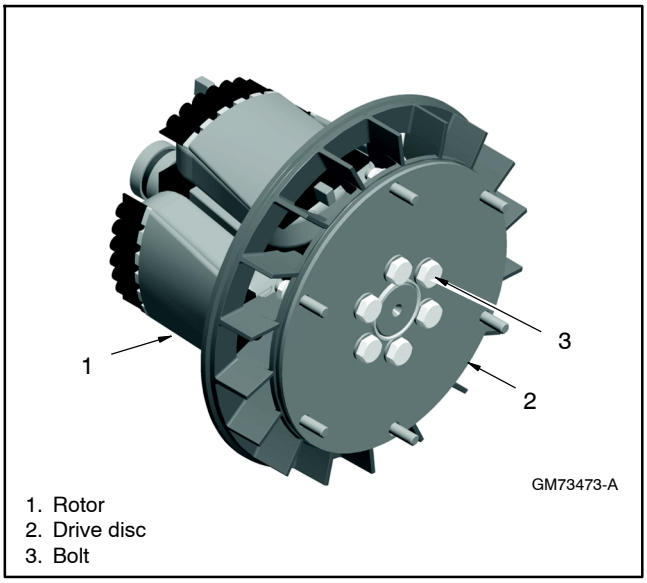
36. Remove the rotor/fan assembly from the engine flywheel by removing the six nuts and stud. See Figure 9-11.

37. Clamp the rotor in a soft-jaw vise. Remove the six bolts and remove the drive disc assembly from the rotor. See Figure 9-12.



1. Bolts (6)
2. Rotor assembly

Figure 9-11 Rotor/Fan Assembly



1. Rotor
2. Drive disc
3. Bolt

Figure 9-12 Drive Disc

9.2 Collector Ring and Bearing Replacement (6EKOD/5EFKOD Model)

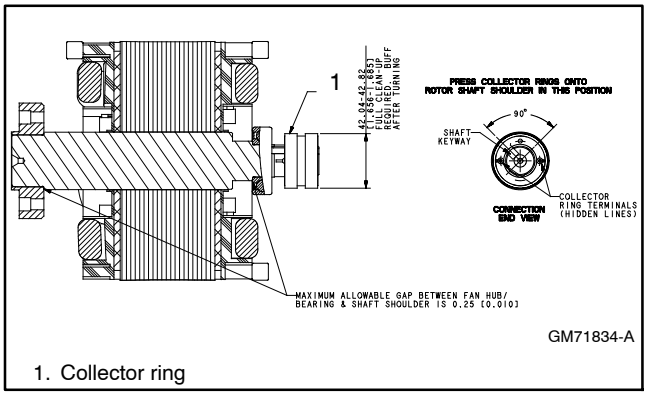
1. Unsolder the collector ring leads from the collector ring terminals.
2. Remove the collector rings with a three-jaw puller.
3. Remove the bearing with a three-jaw puller.
4. Press the new bearing onto the rotor shaft.
5. Align the collector ring keyway with the keyway on the rotor shaft. See Figure 9-14.
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. Bend over terminal and insulate with heat shrink tubing. Terminal and insulator not to extend more than 6.4 mm (0.25 in.) beyond collector ring. See Figure 9-14.
8. Test to ensure continuity at the collector rings.

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

Figure 9-13 Collector Ring Dimensions

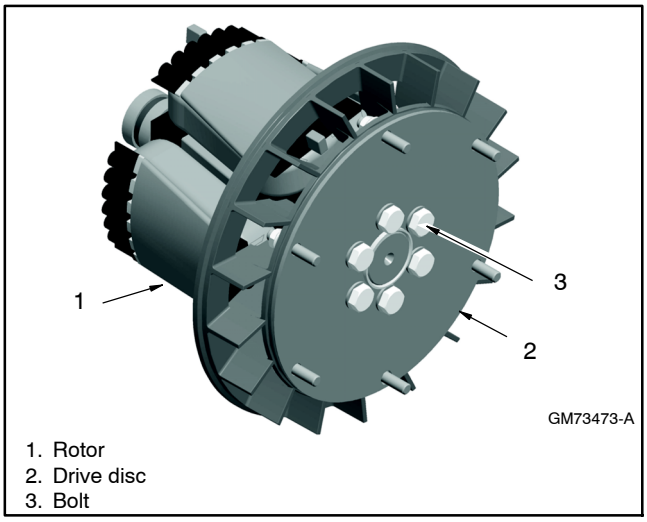


1. Collector ring

Figure 9-14 Rotor Assembly

9.3 Reassembly

1. Clamp the rotor in a soft-jaw vise. Install a new drive disc and fan on the rotor. Tighten the six bolts to 45 Nm (34 ft. lbs.) See Figure 9-15.



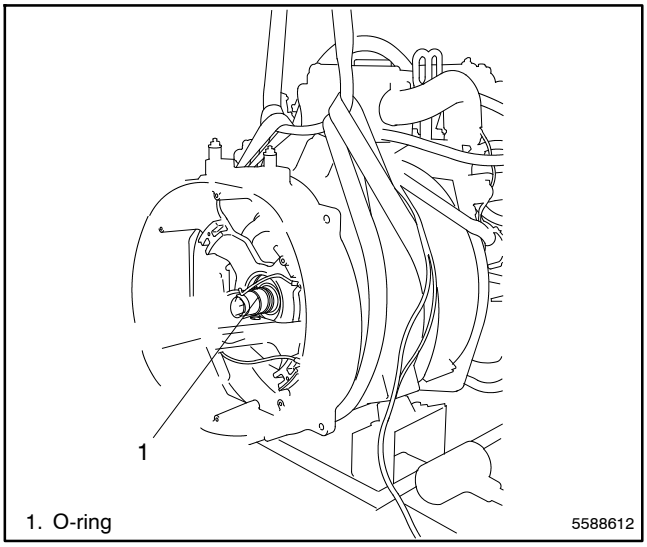
1. Rotor
2. Drive disc
3. Bolt

Figure 9-15 Drive Disc Installation

2. Install the rotor/drive disc assembly on the engine flywheel using six studs and nuts torqued to 23 Nm (17 ft. lbs.).
3. Align the fan to the rotor/drive disc assembly using the mark created in the disassembly procedure.

   Note: Install the fan with the flange side facing away from the flywheel.

4. Replace the O-ring in the end bracket bearing bore. Use a sling to support the stator assembly while installing the stator over the rotor. Do not damage the rotor. See Figure 9-16.



1. O-ring

Figure 9-16 Stator Installation

5. Install the four overbolts. Check that the indent marks on the top of the stator housing match the locator plate and the end bracket. Tighten the overbolts to 23 Nm (17 ft. lbs.).

6. Use the hoist to raise the alternator end. Remove the wood block from under the locator plate. Lower the generator set and install a bolt and washer on each vibromount.

7. Apply anti-seize compound to the keyed end of the rotor shaft. Bring the rotor leads through the bores in the armature while installing the armature on the shaft. Check the keyway of the shaft and key of the armature for damage. Install the armature retaining bolt and washer.

8. **6EKOD/5EFKOD Model:** Feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws.

9. **6EKOD/5EFKOD Model:** Remove the brush retainer and check alignment. See Section 8.6.

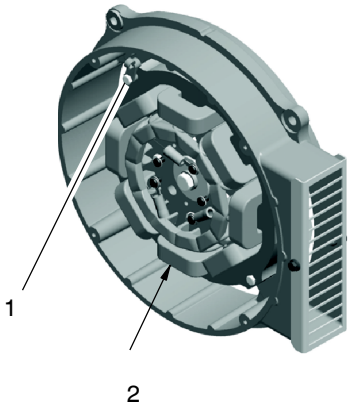
10. **6EKOD/5EFKOD Model:** Replace the brush cover gasket and install the brush holder cover.

11. **9-11EKOZD and 7-9EFKOZD Models:** Use screws and lock washers to install the rotor leads to the rectifier board at the positive (+) and negative (-) terminals.

    Note: Position the lock washers against the rectifier board.

12. **9-11EKOZD and 7-9EFKOZD Models:** Position the field leads at the top. Install the exciter field using four bolts and washers. See Figure 9-17.

Note: Use cable tie(s) to restrain loose harness leads from entangling in rotor.



1. Screws (4)
2. Exciter field

Figure 9-17 Installing Exciter Field

13. Remount the junction box on the four vibromounts.

14. Reconnect the AC lead connections and the P4 connector to the battery charging module.

15. Reconnect the connectors to the preheat relays.

16. Reconnect the leads to the fuses.

17. Reconnect the LO and GRD lead connections.

18. Reconnect the generator output leads to the circuit breakers.

    Note: Check the generator set nameplate to verify the original voltage configuration.

19. Replace the junction box controller panel.

20. Reconnect the P1 (35 pin) and P2 (8 pin) connectors to the ADC IId controller.

21. Reinstall the ADC IId controller.

22. Reconnect all of the external connections—the exhaust line to the mixing elbow, the fuel line to the fuel pump filter inlet, the water line to the seawater pump, the remote interface connector, the AC output leads, and the battery cables to the battery (negative (-) lead last).

23. Verify that the generator set is stopped and the power button is off.

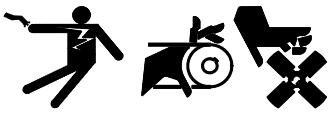
24. Reconnect the engine starting battery, negative (-) lead last.

25. Reconnect power to the battery charger, if equipped.

26. Replace the sound shield roof and door(s), if equipped.

Notes

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

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

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

10.1 Wiring Diagram Reference

Model	Point-to-Point	Figure	Schematic	Figure	Accessory	Figure
6EKOD/5EFKOD 9EKOZD/7EFKOZD 11EKOZD/9EFKOZD	GM79008-C	Figure 10-3	ADV-7995-C	Figure 10-4	GM33846-D	Figure 10-7

Figure 10-1 Wiring Diagrams for Units without Isolated Ground

Model	Point-to-Point	Figure	Schematic	Figure	Accessory	Figure
6EKOD/5EFKOD 9EKOZD/7EFKOZD 11EKOZD/9EFKOZD	GM79009-E	Figure 10-5	ADV-7996-D	Figure 10-6	GM33846-D	Figure 10-7

Figure 10-2 Wiring Diagrams for Units with Isolated Ground

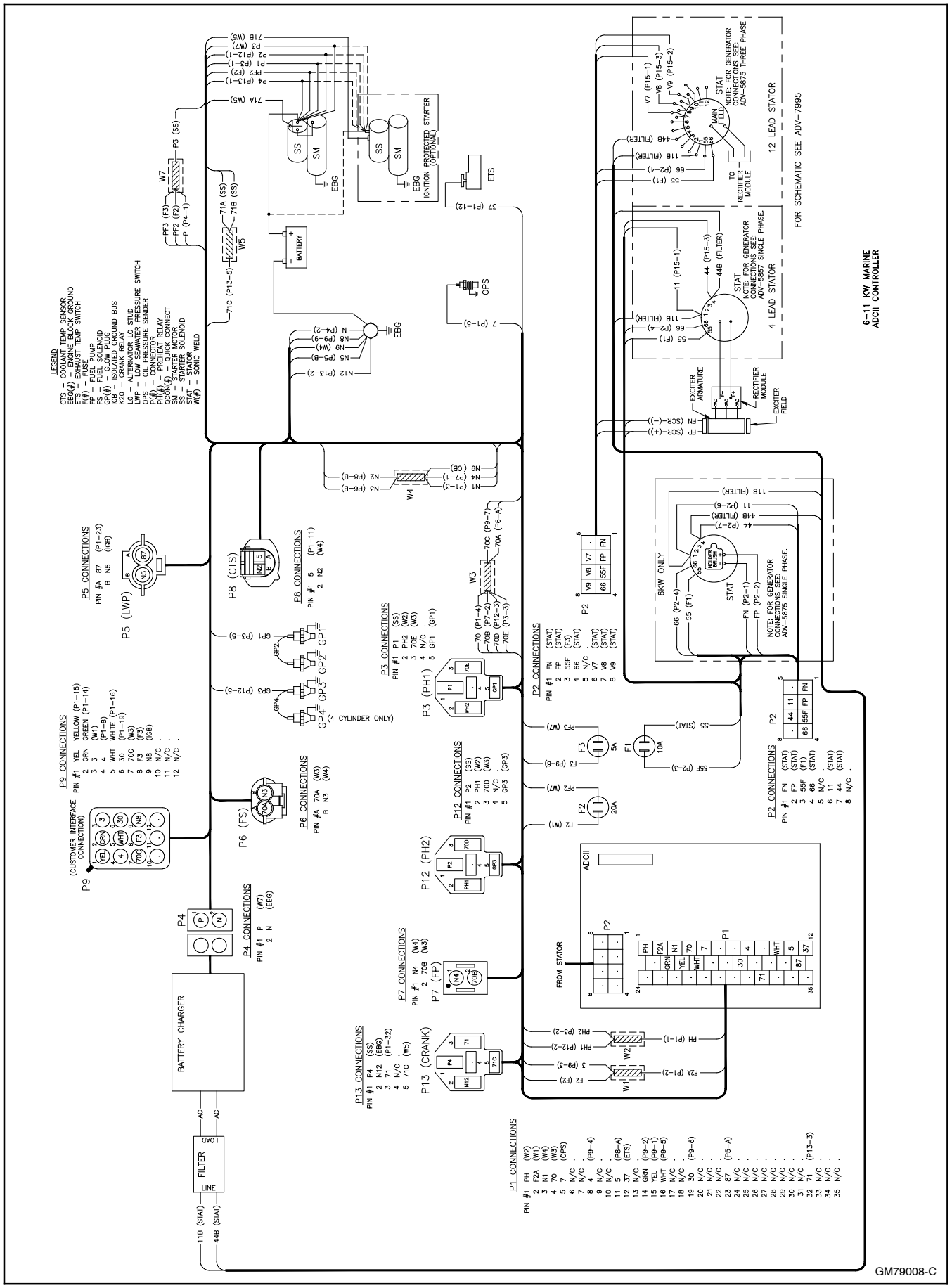


Figure 10-3 Wiring Diagram, Point-to-Point

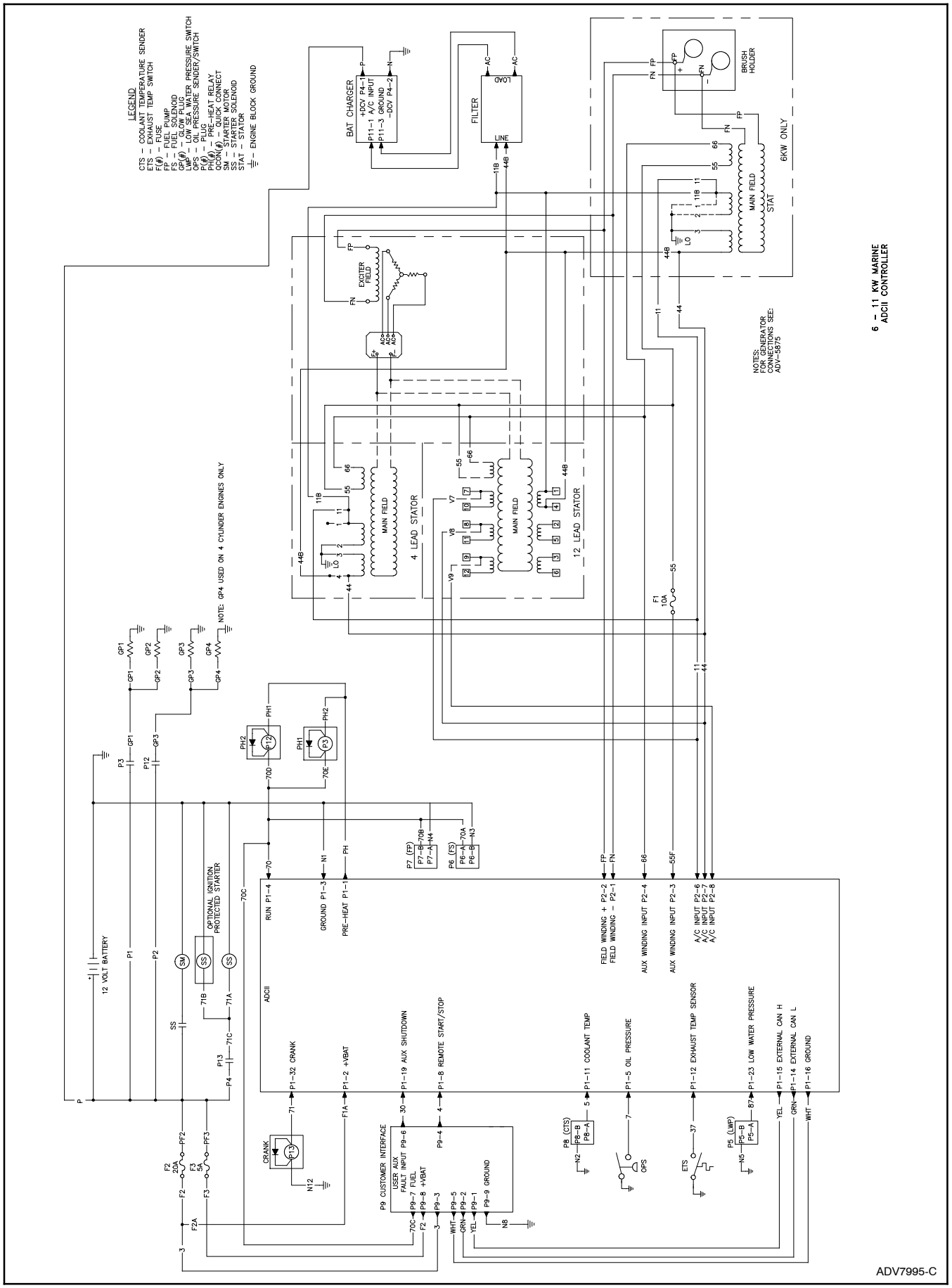


Figure 10-4 Wiring Diagram, Schematic

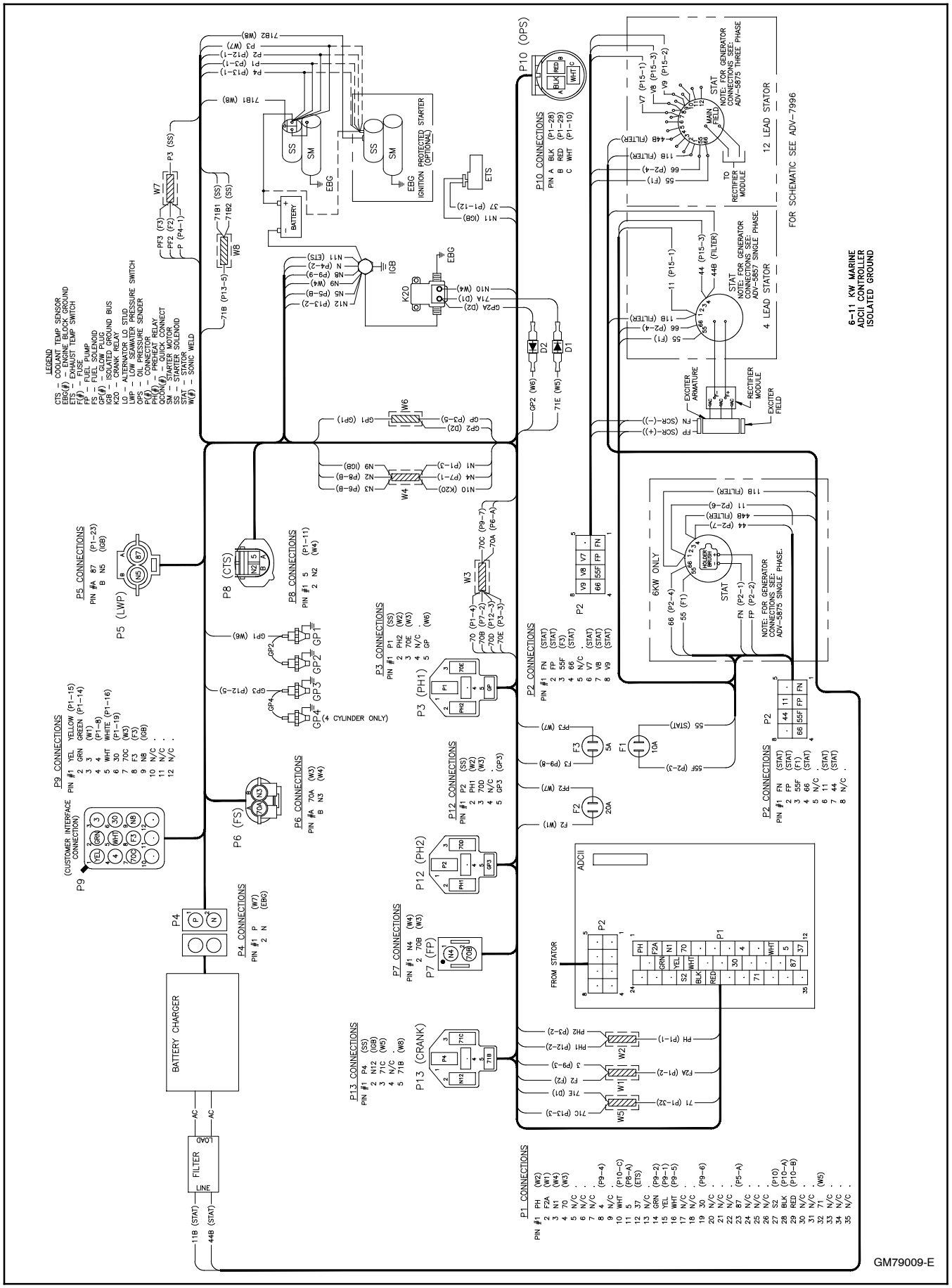


Figure 10-5 Isolated Ground Wiring Diagram, Point-to-Point

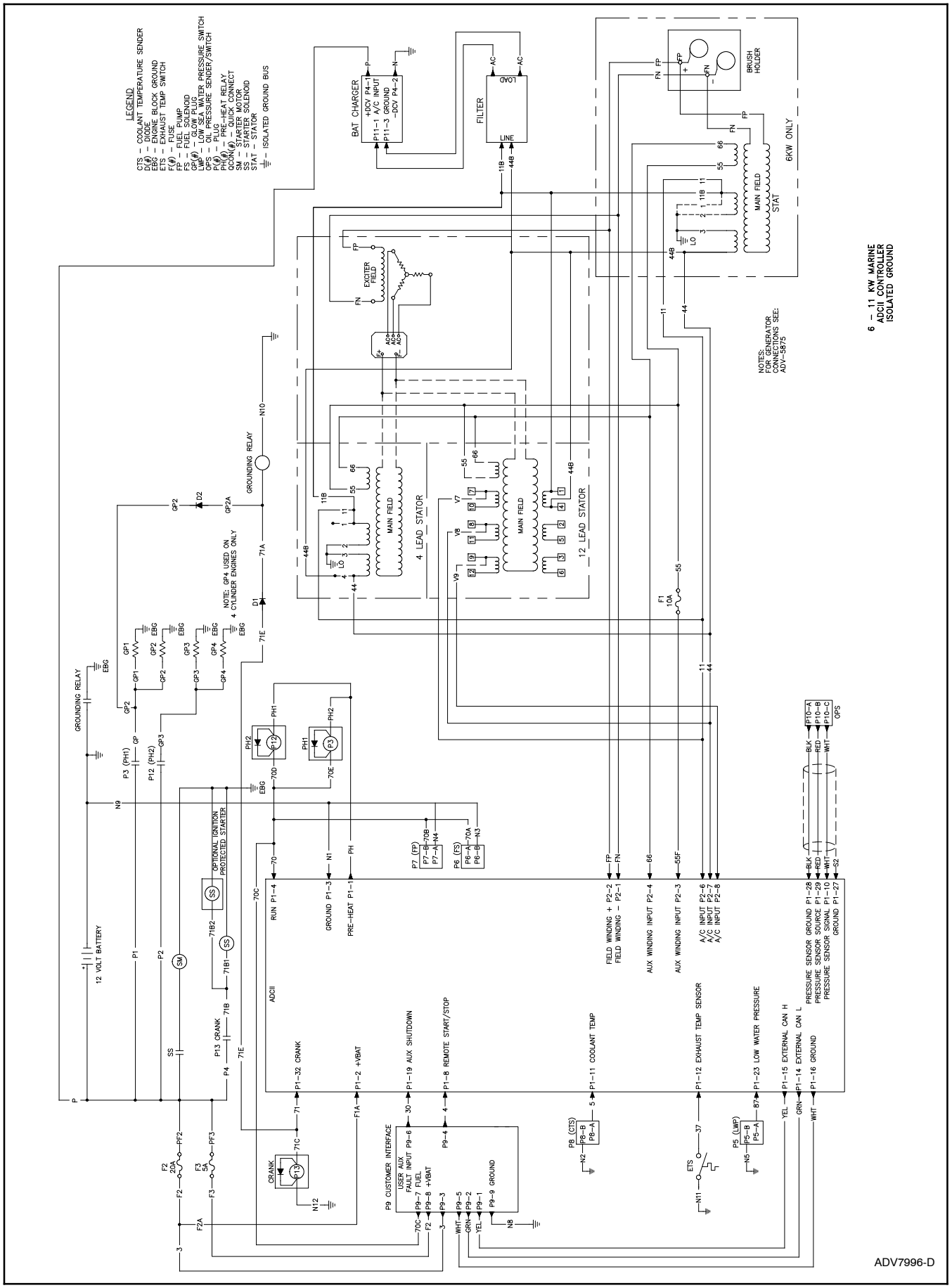


Figure 10-6 Isolated Ground Wiring Diagram, Schematic

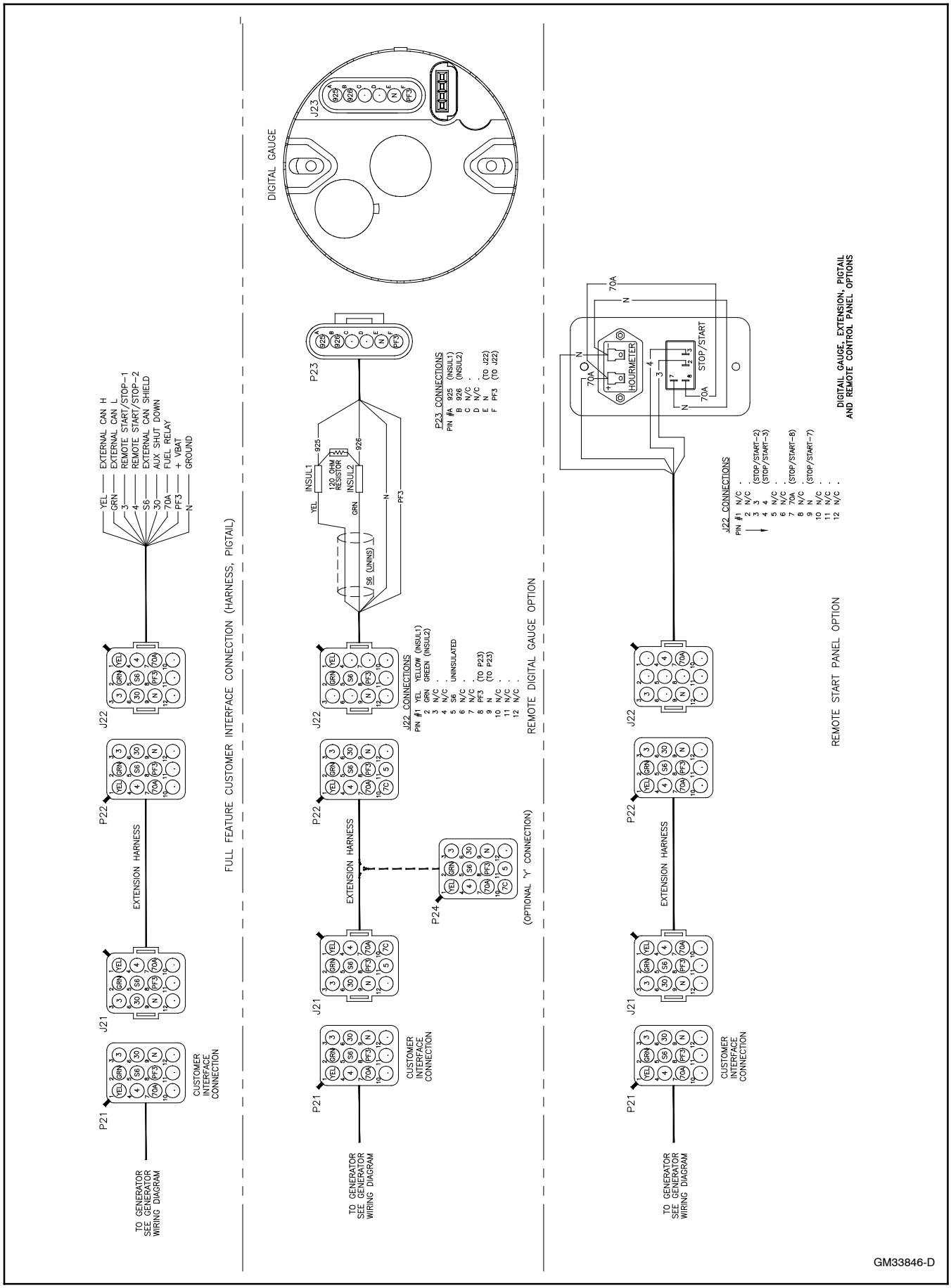
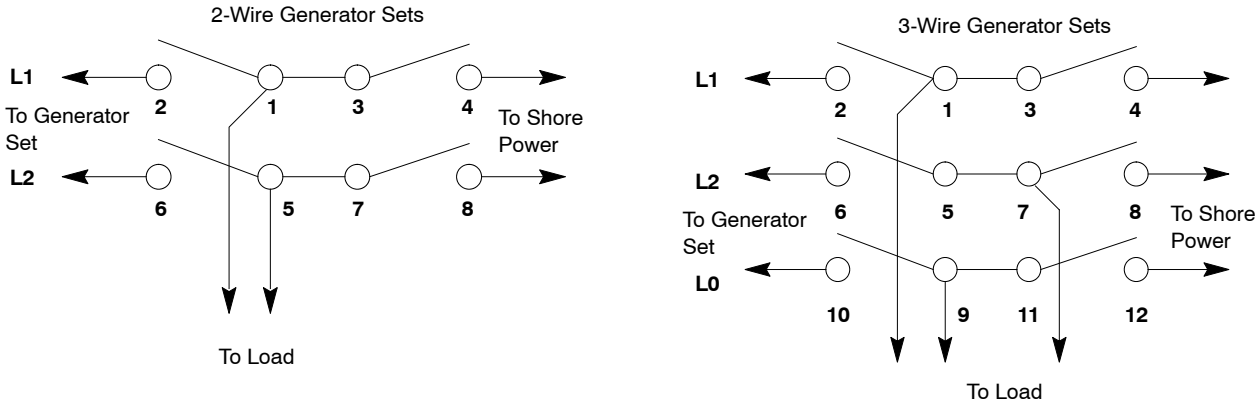


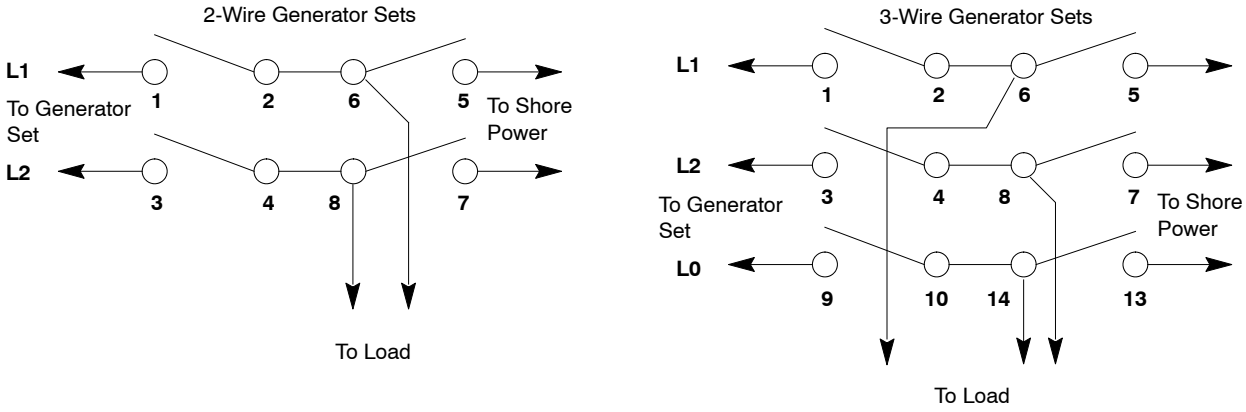
Figure 10-7 Accessory Interconnection Drawing

10.2 Manual Marine (Ship-to-Shore) 2 Wire and 3 Wire Transfer Switches

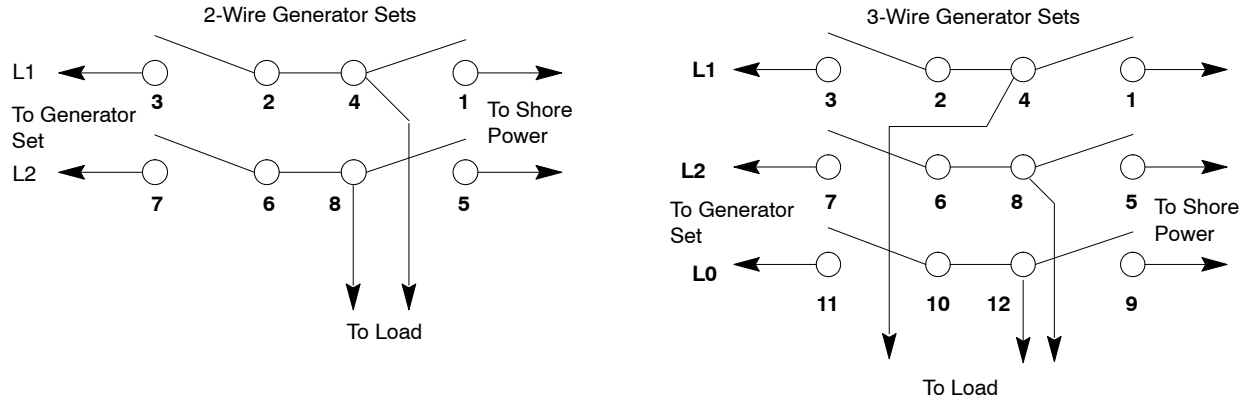
Electro Switch



Kraus Naimler/American Solenoid (Early Rectangular Design)

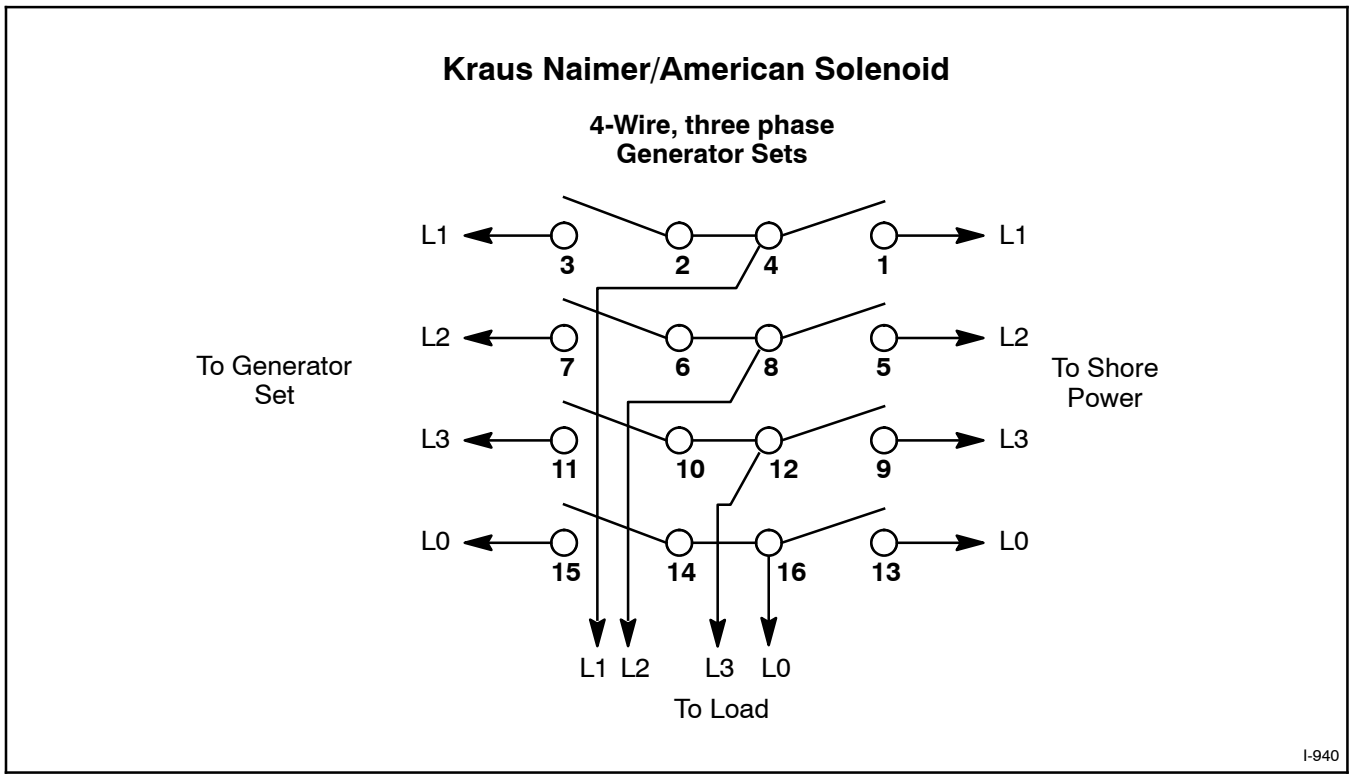


Kraus Naimler/American Solenoid (Newer Round Design)



TP-5399-5

10.3 Manual Marine (Ship-to-Shore) 4 Wire Transfer Switch



Appendix A Abbreviations

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

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

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

Appendix B Common Hardware Application Guidelines

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

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

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

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

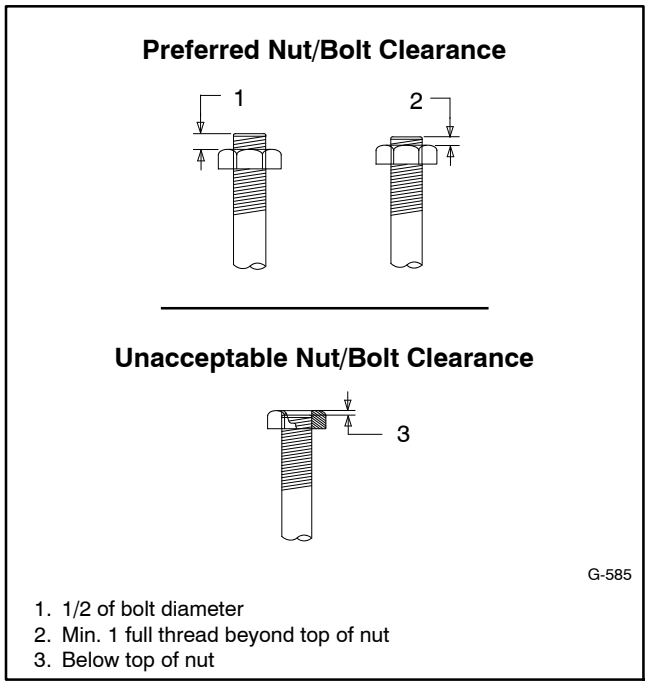


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

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

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

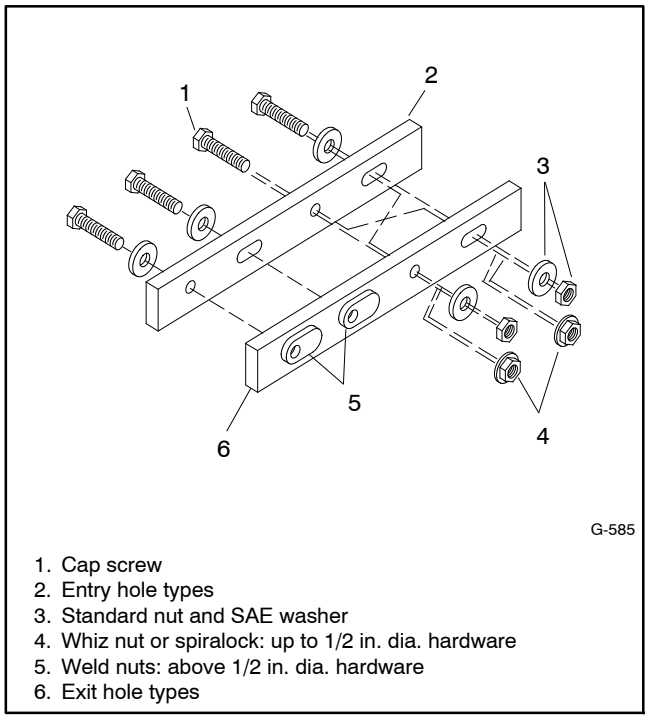


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

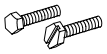
American Standard Fasteners Torque Specifications								
Size	Torque Measurement	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 2 or 5
		Grade 2		Grade 5		Grade 8		
8-32	Nm (in. lb.)	1.8	(16)	2.3	(20)	—		See Note 3
10-24	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
10-32	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
1/4-20	Nm (in. lb.)	6.8	(60)	10.8	(96)	14.9	(132)	
1/4-28	Nm (in. lb.)	8.1	(72)	12.2	(108)	16.3	(144)	
5/16-18	Nm (in. lb.)	13.6	(120)	21.7	(192)	29.8	(264)	
5/16-24	Nm (in. lb.)	14.9	(132)	23.1	(204)	32.5	(288)	
3/8-16	Nm (ft. lb.)	24.0	(18)	38.0	(28)	53.0	(39)	
3/8-24	Nm (ft. lb.)	27.0	(20)	42.0	(31)	60.0	(44)	
7/16-14	Nm (ft. lb.)	39.0	(29)	60.0	(44)	85.0	(63)	
7/16-20	Nm (ft. lb.)	43.0	(32)	68.0	(50)	95.0	(70)	
1/2-13	Nm (ft. lb.)	60.0	(44)	92.0	(68)	130.0	(96)	
1/2-20	Nm (ft. lb.)	66.0	(49)	103.0	(76)	146.0	(108)	
9/16-12	Nm (ft. lb.)	81.0	(60)	133.0	(98)	187.0	(138)	
9/16-18	Nm (ft. lb.)	91.0	(67)	148.0	(109)	209.0	(154)	
5/8-11	Nm (ft. lb.)	113.0	(83)	183.0	(135)	259.0	(191)	
5/8-18	Nm (ft. lb.)	128.0	(94)	208.0	(153)	293.0	(216)	
3/4-10	Nm (ft. lb.)	199.0	(147)	325.0	(240)	458.0	(338)	
3/4-16	Nm (ft. lb.)	222.0	(164)	363.0	(268)	513.0	(378)	
1-8	Nm (ft. lb.)	259.0	(191)	721.0	(532)	1109.0	(818)	
1-12	Nm (ft. lb.)	283.0	(209)	789.0	(582)	1214.0	(895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)								
Size (mm)	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 5.8 or 8.8
	Grade 5.8		Grade 8.8		Grade 10.9		
M6 x 1.00	6.2	(4.6)	9.5	(7)	13.6	(10)	See Note 3
M8 x 1.25	15.0	(11)	23.0	(17)	33.0	(24)	
M8 x 1.00	16.0	(11)	24.0	(18)	34.0	(25)	
M10 x 1.50	30.0	(22)	45.0	(34)	65.0	(48)	
M10 x 1.25	31.0	(23)	47.0	(35)	68.0	(50)	
M12 x 1.75	53.0	(39)	80.0	(59)	115.0	(85)	
M12 x 1.50	56.0	(41)	85.0	(63)	122.0	(90)	
M14 x 2.00	83.0	(61)	126.0	(93)	180.0	(133)	
M14 x 1.50	87.0	(64)	133.0	(98)	190.0	(140)	
M16 x 2.00	127.0	(94)	194.0	(143)	278.0	(205)	
M16 x 1.50	132.0	(97)	201.0	(148)	287.0	(212)	
M18 x 2.50	179.0	(132)	273.0	(201)	390.0	(288)	
M18 x 1.50	189.0	(140)	289.0	(213)	413.0	(305)	

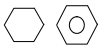
Notes:

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

Appendix D Common Hardware Identification

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

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

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

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

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

Sample Dimensions

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

1/4-20 x 1

- 1 — Length In Inches (Screws and Bolts)
- 20 — Threads Per Inch
- 1/4 — Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- 20 — Length In Millimeters (Screws and Bolts)
- 1.25 — Distance Between Threads In Millimeters
- M8 — Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- 1/16 — Thickness
- 5/8 — External Dimension
- 9/32 — Internal Dimension

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

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

American Standard

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

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

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

Washers

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

Metric

Hex head bolts are hardness grade 8.8 unless noted.

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
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60*
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

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
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200
Hex Head Bolts (Full Thread)	
M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Part No.	Dimensions
Hex Head Bolts (Full Thread), continued	
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70
Pan Head Machine Screws	
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100
Flat Head Machine Screws	
M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

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

Metric, continued

Hex Nuts

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

Washers

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

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

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