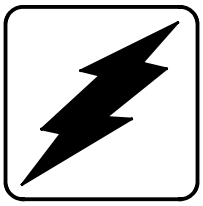
Service

Residential/Commercial Generator Sets



Models:

17RES/RESL/RESNT
18RES/RESL/RESNT/TRES

Controllers:
ADC-RES Advanced Digital Control
DC-RET Digital Control

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6519 10/09a

Table of Contents

Table of Contents, continued

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

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

⚠ DANGER

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

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

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

Accidental Starting

⚠ WARNING

Accidental starting.
Can cause severe injury or death.

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

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

Battery

⚠ WARNING

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

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

⚠ WARNING

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

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

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

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

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects.

Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

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

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

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

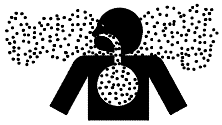
Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

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

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

Exhaust System

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building. Never operate the generator set where exhaust gas could seep inside or be drawn into a building through windows, air intake vents, or other openings.

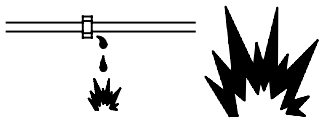
Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning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

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

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

Fuel System

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

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

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

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

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

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

Hazardous Voltage/ Moving Parts

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING

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

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

⚠ WARNING

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

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

⚠ CAUTION

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

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

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

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

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

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

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

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

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

Heavy Equipment

⚠ WARNING

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

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

Hot Parts

⚠ WARNING

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

Do not work on the generator set until it cools.

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

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

Servicing the engine heater. Hot parts can cause minor personal injury or property damage. Install the heater before connecting it to power. Operating the heater before installation can cause burns and component damage. Disconnect power to the heater and allow it to cool before servicing the heater or nearby parts.

Notice

NOTICE

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

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

This manual provides troubleshooting and repair instructions for the generator set models listed on the front cover. This manual may also be supplied for similar models not listed on the front cover.

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

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

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

For engine service procedures not covered in this manual, refer to the Engine Service Manual.

Figure 1-1 Model 17RES

Figure 1-2 Model 17RES, Door Removed

List of Related Materials

Separate manuals contain operation, installation, and parts information not provided in this manual. Separate engine operation and service manuals are also available. The following table lists the available manual part numbers.

Document Description	Part Number
Installation Manual, RES/TRES Models	TP-6514
Operation Manual, RES/TRES Models	TP-6515
Installation Manual, RESL/RESNT Models	TP-6516
Operation Manual, RESL/RESNT Models	TP-6517
Parts Catalog	TP-6518
Engine Service Manual, CH980	TP-2580

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.

Headquarters Europe, Middle East, Africa (EMEA)
Kohler Power Systems
3 rue de Brennus
93200 Saint Denis
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Phone: (33) 1 49 178300
Fax: (33) 1 49 178301

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Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 6264-6422
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China
North China Regional Office, Beijing
Phone: (86) 10 6518 7950
(86) 10 6518 7951
(86) 10 6518 7952
Fax: (86) 10 6518 7955

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

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

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

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

1.1 Introduction

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

Consult the generator set nameplate for specific generator set ratings.

1.2 Controller Specifications

The generator set is equipped with the Advanced Digital Control. For a specific description of the controller, see Section 2, Operation, in the operation manual.

Environmental Specification	All Models
Operating temperature	-20° to 70°C
Storage temperature	-60° to 70°C
Humidity	0-95% condensing
Power requirements:	
Voltage	12 VDC
Current	250 mA @ 12 VDC

1.3 Engine Service

Generator sets covered in this manual are equipped with four-cycle, twin cylinder, air-cooled Kohler engines.

For engine service information and specifications not covered in this manual, see the engine service manual. See the List of Related Materials in the Introduction section.

1.4 Engine Specifications

Engine Specification	All Models
Manufacturer	Kohler
Model	CH980
Cycle	4
Number of cylinders	2
Compression ratio	8.8:1
Displacement, cc (cu. in.)	999 (61)
Rated power, propane fuel, kw (HP)	21.7 (29.1)
Rated power, natural gas, kw (HP)	18.6 (25.0)
Rpm, 60 Hz	3600
Rpm, 50 Hz	3000
Bore x stroke, mm (in.)	90 x 78.5 (3.54 x 3.1)
Valve material	Steel/Stellite®
Cylinder block material	Aluminum w/cast iron liners
Cylinder head material	Aluminum
Piston rings	2 compression/ 1 oil
Crankshaft material	Heat-treated ductile iron
Main bearings: number, type	2, parent material
Lubrication system	Full pressure
Oil capacity (w/filter), L (qt.)	2.8 (3.0)
Oil pressure, kPa (psi)	172-241 (25-35)
Fuel system	LP gas or natural gas
LP/natural gas minimum supply pressure, in. H_2O (oz./in.^{2})	7-11 (4-6)
Battery voltage	12 VDC
Battery ground	Negative
Spark plug gap, mm (in.)	0.76 (0.030)
Ignition system	Capacitor discharge
Starter motor	Electric, solenoid shift
Cooling system	Air-cooled

1.5 Alternator Specifications

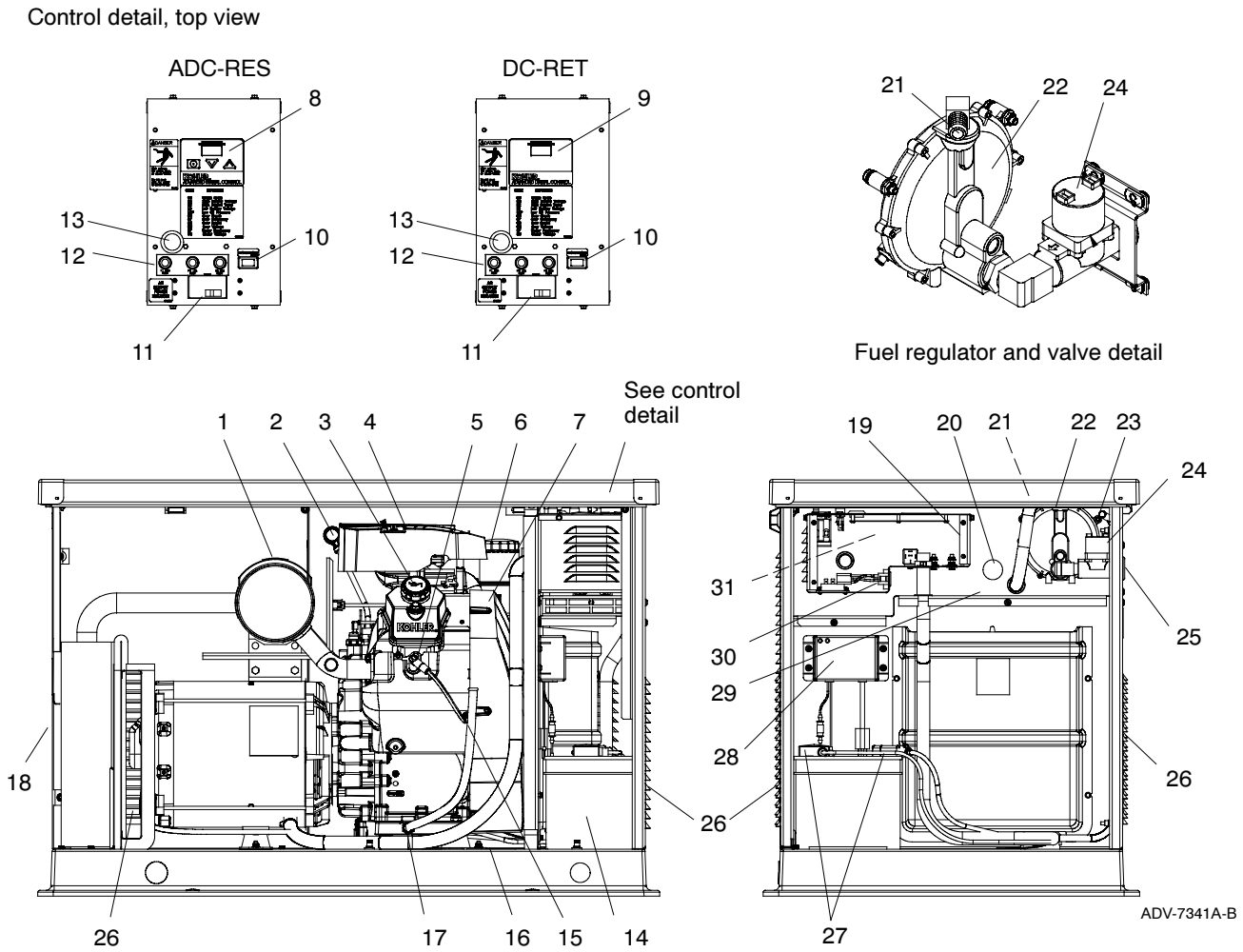
Alternator Specification	17/18RES/RESL/RESNT	18TRES
Frequency Hz	50/60	50
Phase	Single-Phase	Three-Phase
Number of leads	4	12
Excitation method	Static Excited	
Voltage regulator type	Digital	
Coupling type	Direct	
Insulation (rotor and stator)	Epoxy varnish, vacuum impregnated Class 180 (H)	
Winding material	Copper	
Bearing, number and type	1, Sealed Ball	
Circuit protection		
Controller	10 amps	
Aux. winding	20 amps	
Generator AC output	Dependent on voltage configuration	
Rotor resistance, ohms, cold	5.2	5.2
Stator resistance, ohms,* cold		
Single-Phase Leads 1-2, 3-4	0.06	N/A
Three-Phase Leads 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	N/A	0.10
11-44	0.13	N/A
55-66	0.60	0.19
Stator output voltage with separately excited rotor using 12-volt battery, minimum		
Leads: 1-2, 3-4	105 V	N/A
Leads: 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	N/A	115 V
11-44	210 V	N/A
55-66	142 V	174 V
Rotor field voltage/current readings at rated output voltage, hot		
No load	19 V/3.2 A	22 V/3.6 A
Full load	48 V/7.2 A	88 V/10.5 A
Brush length, new	19.05 mm (0.75 in.)	

* Most ohmmeters do not give accurate readings when measuring less than 1 ohm. The stator can be considered good if a low resistance reading (continuity) is obtained and there is no evidence of shorted windings (discoloration). Do not confuse a low resistance reading with a reading indicating a shorted winding.

1.6 Torque Specifications

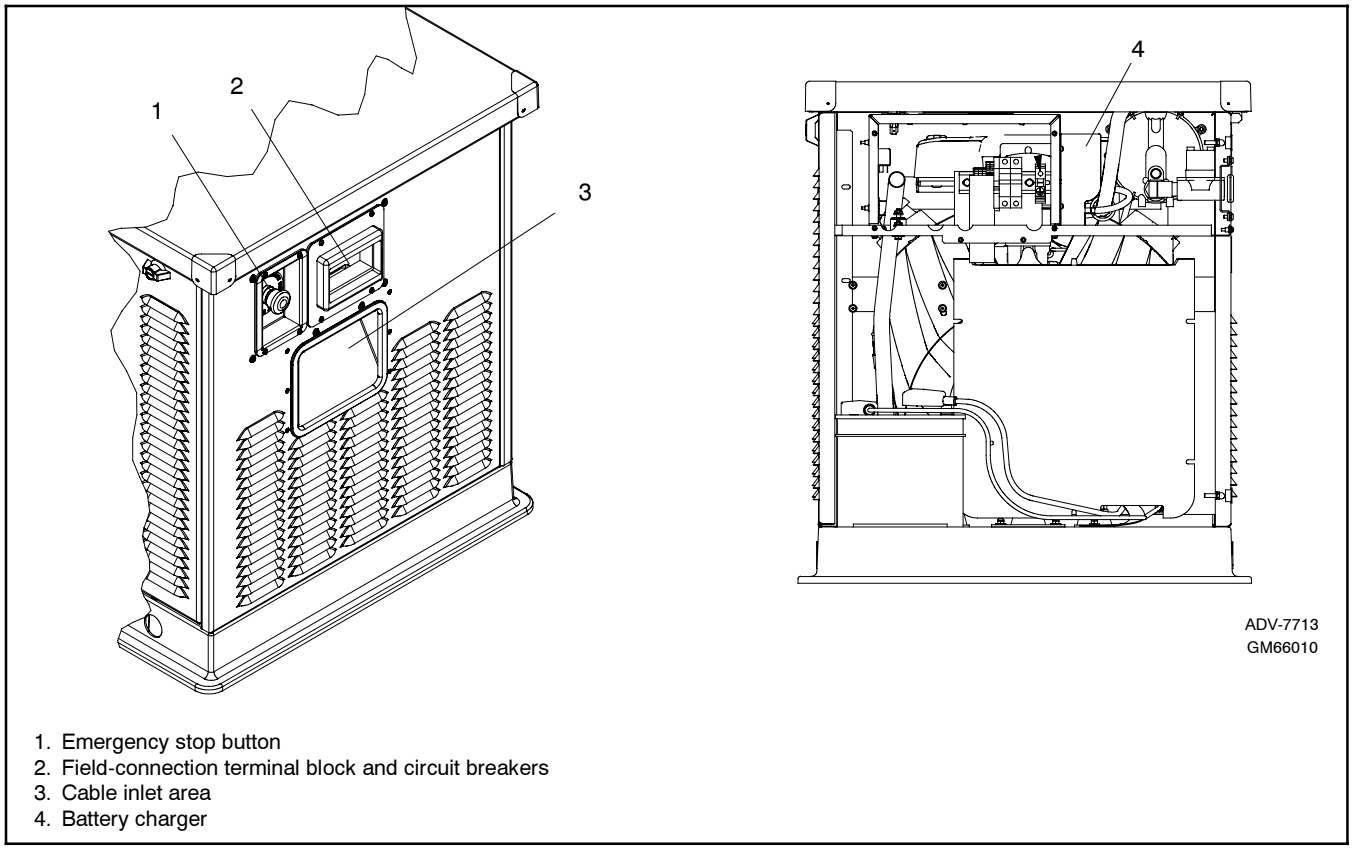
Torque Specifications	Nm (ft. lb.)
Alternator overbolts	7 (5)
Alternator thrubolt	53 (39)
Generator adapter screws	40 (28)
Muffler flange bolts	24 (17.7)
Oil filter	3/4 to 1 turn after gasket contact
Spark plug	24.4–29.8 (18–22)

1.7 Service Views



1. Muffler
2. Oil check
3. Oil fill
4. Air cleaner
5. Spark plug locations (both sides)
6. Oil filter
7. Oil cooler location
8. ADC-RES Advanced Digital Control user interface
9. DC-RET control user interface
10. Generator set master switch (RUN-OFF/RESET-AUTO)
11. Line circuit breaker
12. Fuses
13. RS-232 connector (for application program updates)
14. Engine starting battery location (battery purchased separately)
15. Oil drain hose
16. Nameplate location (on base)
17. Oil drain valve
18. Exhaust outlet
19. Relay board location (optional)
20. Carburetor heater access opening
21. LP fuel orifice location (inside hose fitting)
22. Gas regulator assembly
23. DSAI leads
24. Fuel solenoid valve
25. Fuel inlet
26. Air intake
27. Battery cables
28. Battery charger
29. Field-connection terminal block location (RES models)
30. 120 VAC receptacles for battery charger and optional carburetor heater
31. Field connections inside junction box if optional terminal block is not used

Figure 1-1 Generator Set Service View



1. Emergency stop button
2. Field-connection terminal block and circuit breakers
3. Cable inlet area
4. Battery charger

Figure 1-2 Additional Components, TRES (3-phase) Model

⚠ WARNING

Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

Do not work on the generator set until it cools.

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

⚠ WARNING

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

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

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

Alternator Service. Under normal operating conditions the generator set alternator does not require scheduled service. Refer to the service schedule for items that require maintenance.

Engine Service. Perform generator set engine service at the intervals specified by the engine service literature. Contact an authorized Kohler® service distributor/ dealer to obtain engine service literature.

All generator sets have emission-certified engines. The carburetors on emission-certified engines are not adjustable.

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

Routine Maintenance. Refer to the following generator set service schedule, the engine service schedule, and the runtime hours displayed on the generator set controller to determine when to schedule routine maintenance. Service the generator set more frequently if it is subject to extreme weather, long operating hours, or dusty or dirty conditions.

Service Schedule. Perform maintenance on each item in the service schedule at the designated interval for the life of the generator set.

Tools. Tools and instruments used to perform some maintenance items are not generally available to the generator set owner. Therefore, have service performed by an authorized distributor/dealer.

2.1 Service Schedule

Perform the items listed in the service schedule at the designated intervals for the life of the generator set. For example, an item serviced every 100 hours or 3 months must also be serviced after 200 hours or 6 months, 300 hours or 9 months, etc.

System Component or Procedure	See Section	Procedure				
		Visually Inspect	Check	Change	Clean	Test
Fuel						
Flexible lines and connections		Q		R		
Main tank supply level (LP)			W			
Fuel piping		Y				
Lubrication	2.2					
Oil level	2.2.2		8 or E			
Change oil	2.2.4			Y or 150		
Replace filter	2.2.4			Y or 150		
Crankcase breather hose		Y or 500				
Oil cooler	2.2.5	Y			Y or 100	
Cooling	2.5					
Air ducts, louvers			Y		Y	
Exhaust System	2.7					
Leakage		W	W			
Insulation, fire hazards		Y				
Obstructions or combustible materials near exhaust outlet		W				
DC Electrical System						
Battery charger operation, charge rate		M				
Remove corrosion, clean and dry battery and rack	2.8	Y			Y	
Clean and tighten battery terminals and inspect boots		Y	Y			
Tighten DC electrical connections			Y			
AC Electrical System						
Tighten control and power wiring connections			Y			
Remote control system, if equipped						M
Visible wear or damage		Q				
Wire abrasions where subject to motion		6 months	6 months			
Wire-cable insulation condition		3Y or 500				
Engine and Mounting						
Visible wear or damage		W				
Air cleaner service *	2.4		150	300		
Spark plugs	2.3		150	300		
Replace stepper motor coupling and bushing	2.6			500 (D)		
Generator						
Visible wear or damage		Q				
Exercise generator set						W
Brushes and collector ring	5.5, 5.6	Y (D)			Y (D)	
Measure and record resistance readings of windings with insulation tester (Megger®, with SCR assembly or rectifier and load leads disconnected)						3Y (D)
General Condition of Equipment						
Evidence of vibration, leakage, deterioration, unusual or excessive noise or temperature		W	W		W	
Interior of sound enclosure		Q			Q	

* Service more frequently under extremely dusty/dirty conditions.

Megger® is a registered trademark of Biddle Instruments.

E Each use
W Weekly
M Monthly
Q Quarterly
Y Yearly

Number = hours of operation
D Authorized distributor/dealer only
R Replace as necessary
S/M Service Manual

Figure 2-1 Service Schedule

2.2 Lubrication System

See Section 2.1, Service Schedule, for oil change and oil filter replacement intervals. See Section 1.7, Service View, for the oil drain, oil check, oil fill, and oil filter locations.

2.2.1 Low Oil Pressure Shutdown

The low oil pressure (LOP) shutdown feature protects the engine against internal damage if the oil pressure drops below a minimum pressure because of oil pump failure or other malfunction.

Note: The LOP shutdown feature does not protect against damage caused by operating when the oil level is low; it is not a low oil level shutdown. Check the oil level regularly, and add oil as needed.

2.2.2 Oil Check

The generator set is shipped with oil. Before operating the generator set, check the engine oil in the crankcase. See Figure 2-2 for the dipstick location.

Maintain the oil level at or near, not over, the full mark on the dipstick. Add 5W-30 synthetic oil when the oil level is low. See Section 2.2.3, Engine Oil Recommendation.

Check the oil level before each use. For extended operation, check the oil level every 8 hours. Do not check the oil level when the generator set is running. Shut down the generator set and wait several minutes before checking the oil.

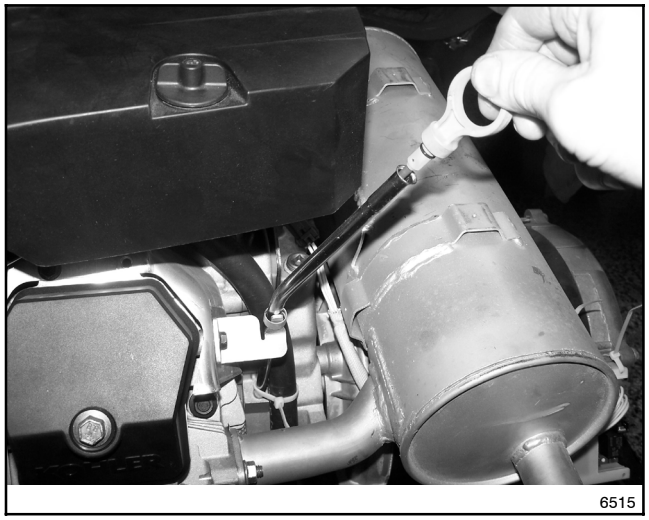


Figure 2-2 Oil Check

2.2.3 Engine Oil Recommendation

Use 5W-30 API (American Petroleum Institute) Service Class SG, SH, or SJ synthetic oil. Synthetic oil oxidizes and thickens less than other oils and leaves the engine intake valves and pistons cleaner.

2.2.4 Oil Change Procedure

Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner.

Drain the oil while it is still warm.

1. **Drain the oil.**

   a. Place the generator set master switch in the OFF position.

   b. Disconnect the power to the battery charger.

   c. Disconnect the generator set engine starting battery, negative (–) lead first.

   d. Remove the housing side panel.

   e. Clean the area around the dipstick and oil fill cap.

   f. Remove the oil drain hose from its retaining clip. Remove the cap from the oil drain hose and lower the hose into an oil collection container.

   g. Open the oil drain valve on the engine.

   h. Remove the dipstick and oil fill cap. Allow time for the engine oil to drain completely.

   i. Close the oil drain valve. Replace the cap on the oil drain hose. Replace the oil drain hose in its retaining clip.

   j. Replace the dipstick.

2. **Replace the oil filter.**

   a. Clean the area around the oil filter. Remove the oil filter by rotating it counterclockwise with an oil filter wrench.

   b. Clean the gasket sealing surface of the oil filter adapter.

   c. Apply a light coat of clean oil to the rubber seal of the new oil filter.

   d. Install the new oil filter following the instructions provided with the filter.

3. **Fill with oil.**

   a. Fill the engine to the F mark on the dipstick. The engine oil capacity is approximately 2.8 L (3.0 qt.). See Section 2.2.3, Engine Oil Recommendation, for oil selection.

   b. Reinstall the dipstick and the oil fill cap.

   c. Check that the generator set master switch is in the OFF position.

   d. Reconnect the generator set engine starting battery, negative (–) lead last.

   e. Reconnect the power to the battery charger.

   f. Start and run the generator set for a minute to allow the oil pressure to reach operating range.

   g. Stop the generator set, wait 1 minute, and then recheck the oil level. Add oil to bring the level up to the F mark on the dipstick.

4. **Check for leaks.**

   a. Check for oil leaks.

   b. Fix leaks and recheck the oil level.

   c. Reinstall the housing side panel.

2.2.5 Oil Cooler

Inspect and clean the oil cooler at the intervals indicated in the service schedule. The oil cooler must be kept free of debris.

See Figure 2-3 for the oil cooler location. The oil cooler is located under the No. 2 cylinder shroud. Remove the top mounting screw and loosen the two side screws, then lift off the cylinder shroud.

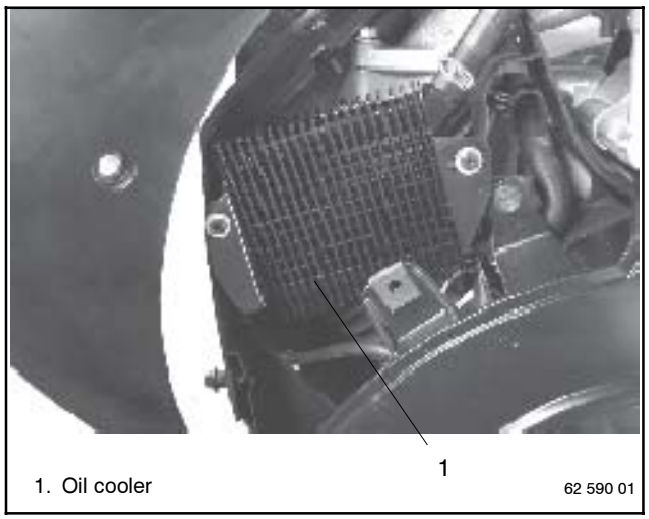


Figure 2-3 Oil Cooler Location

Clean the outside of the oil cooler fins with a brush or with compressed air.

2.3 Spark Plugs

Reset the spark plug gap or replace the plugs with new plugs as necessary.

1. Clean the area around the base of the spark plug to keep dirt and debris out of the engine.

2. Remove the spark plug and check its condition. Replace the spark plug if it is worn or if its reuse is questionable.

3. Check the spark plug gap using a wire feeler gauge. Adjust the gap to 0.76 mm (0.030 in.) by carefully bending the ground electrode. See Figure 2-4 and Figure 2-5.

4. Reinstall the spark plug into the cylinder head. Torque the spark plug to 24.4–29.8 Nm (18–22 ft. lb.)

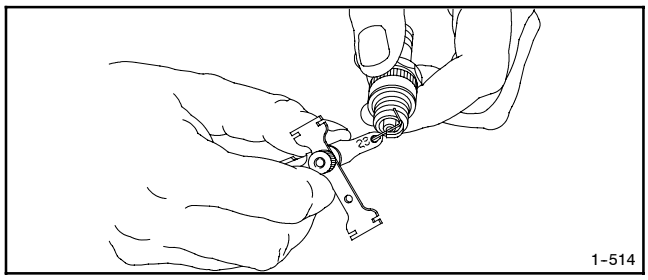


Figure 2-4 Checking the Spark Plug Gap

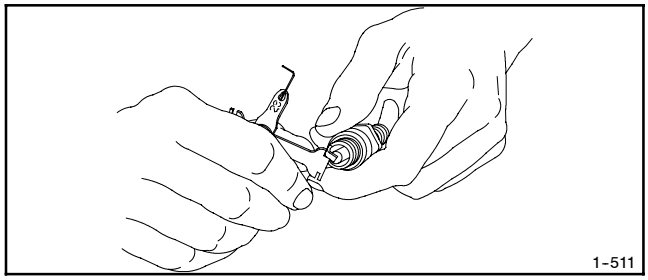
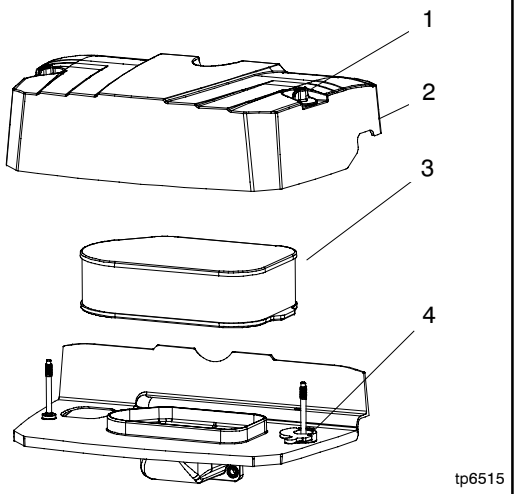


Figure 2-5 Adjusting the Spark Plug Gap

2.4 Air Cleaner Service

The engine is equipped with a replaceable, high density paper air cleaner element. See Figure 2-6.



1. Knobs (qty. 2)
2. Cover
3. Paper element
4. Air filter latch

Figure 2-6 Air Cleaner Components

Check the air cleaner daily or before starting the engine. Check for a buildup of dirt and debris around the air cleaner system. Keep this area clean. Also check for loose or damaged components. Replace all bent or damaged air cleaner components.

Note: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine causing premature wear and failure.

Paper Element Service

Replace the paper element at the intervals indicated in the service schedule. See Figure 2-1 for the service schedule. See Figure 2-6 for the air cleaner components.

1. Loosen the two cover retaining knobs and remove the cover.

2. Rotate the air filter latch counterclockwise to unlock, then remove the paper element.

3. Do not wash the paper element or use pressurized air, as this will damage the element. Replace a dirty, bent, or damaged element. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged.

4. When servicing the air cleaner, check the air cleaner base and latch. Make sure it is secured and not bent or damaged. Also, check the element cover for damage or improper fit. Replace all damaged air cleaner components.

Note: If any loose dirt or debris fell on the air cleaner base when the element was removed, carefully remove it and wipe the base clean. Be careful that none of it drops into the intake throat.

5. Reinstall the paper element onto the air cleaner base. Make sure the element is flat and properly seated. Rotate the latch clockwise, over the molded lip on the element.

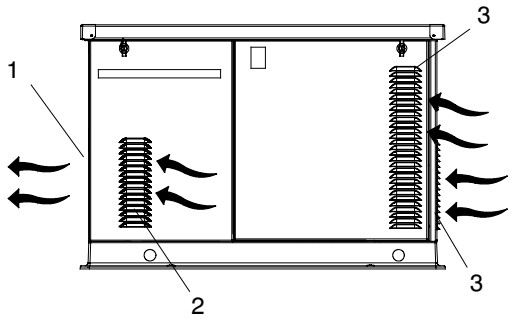
6. Install the air cleaner cover and secure with the two retaining knobs.

7. When element replacement is necessary, order genuine Kohler parts.

2.5 Cooling System

The engine fan draws cooling air through the openings in the sides and end near the battery. The alternator fan draws cooling air through openings on the side walls of the enclosure. The cooling air mixes with the engine exhaust and is discharged at the exhaust outlet. See Figure 2-7. To prevent generator set damage caused by overheating, keep the housing cooling inlets and outlets clean and unobstructed at all times.

Note: Do not block the generator set cooling air inlets or mount other equipment above them. Overheating and severe generator damage may occur.



1. Exhaust outlet
2. Alternator air intake (both sides)
3. Engine air intake

Figure 2-7 Cooling Air Intake and Exhaust

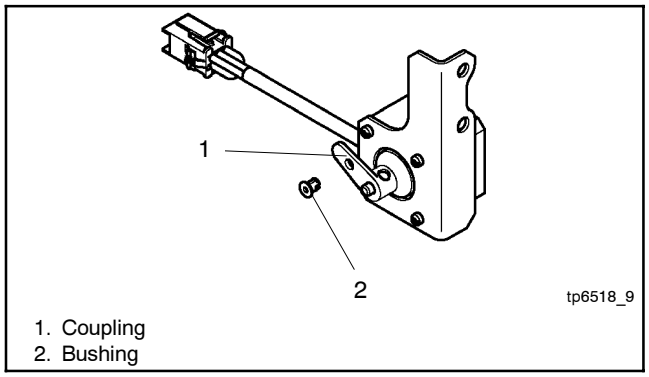
2.6 Stepper Motor Coupling

Replace the stepper motor coupling and bushings at the intervals shown in the service schedule. See the Parts Catalog for replacement part numbers.

Figure 2-8 shows the location of the coupling assembly under the air cleaner. Loosen the set screw to remove the coupling from the motor shaft.

1. Coupling and bushing

Figure 2-8 Stepper Motor Coupling



1. Coupling
2. Bushing

Figure 2-9 Stepper Motor Coupling and Bushing

2.7 Exhaust System

Remove all combustible materials from the exhaust location. Combustible materials include building materials as well as natural surroundings. Keep dry field grass, foliage, and combustible landscaping material a minimum of 1.5 m (5 ft.) from the exhaust outlet.

Periodically inspect the exhaust system components for cracks, leaks, and corrosion.

- Check for corroded or broken metal parts and replace them as needed.
- Check that the exhaust outlet is clear.

2.8 Battery

⚠ WARNING

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

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

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

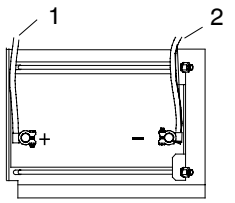
Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled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

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

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

This section contains general battery information and maintenance instructions. Also consult the battery manufacturer's instructions for battery maintenance.

All generator set models use a negative ground with a 12-volt engine electrical system. Consult the generator set nameplate for the engine electrical system voltage. Consult the generator spec sheet for battery capacity recommendations for replacement purposes. Wiring diagrams provide battery connection information. See Figure 2-10 for typical battery connections.



EZ-273000-J

1. To positive (+) terminal on starter solenoid.
2. To ground (–) terminal on or near starter motor.

Figure 2-10 12-Volt Engine Electrical System Single Starter Motor, Typical Battery Connection

Clean the battery and cables and tighten battery terminals using the service schedule recommendations. To prevent corrosion, maintain tight, dry electrical connections at the battery terminals. To remove corrosion from battery terminals, disconnect the cables from the battery and scrub the terminals with a wire brush. Clean the battery and cables with a solution of baking soda and water. After cleaning, flush the battery and cables with clean water and wipe them with a dry, lint-free cloth.

After reconnecting the battery cables, coat the battery terminals with petroleum jelly, silicone grease, or other nonconductive grease.

2.9 Battery Charger

The generator set is equipped with a battery charger to maintain the engine starting battery. See Section 1.7, Service Views, for the battery charger location.

The charger's DC leads are factory-wired. Periodically tighten all connections. See the generator set operation manual for battery charger troubleshooting instructions.

2.10 Storage Procedure

Perform the following storage procedure before removing the generator set from service for three months or longer. Follow the engine manufacturer's recommendations for storage, if available.

Note: Run the generator set monthly whenever possible.

2.10.1 Lubricating System

1. Operate the generator set until it reaches operating temperature, or about 15 minutes.
2. Stop the generator set.
3. While the engine is still warm, drain the engine lubrication oil from the engine crankcase.
4. Refill the engine crankcase with oil. See Section 2.2.3 for oil recommendations.
5. Run the generator set for a few minutes to distribute the clean oil.
6. Stop the generator set.

2.10.2 Fuel System

1. Start the generator set.
2. With the generator set running, shut off the gas supply.
3. Run the generator set until the engine stops.
4. Place the generator set master switch in the OFF/ RESET position.

2.10.3 Cylinder Lubrication

1. Remove the spark plugs.
2. Pour one tablespoon of engine oil into each spark plug hole. Install the spark plugs and *ground* the spark plug leads. *Do not connect the leads to the plugs.*
3. Toggle the generator set master switch to crank the engine two or three revolutions to lubricate the cylinders.

2.10.4 Exterior Preparation

1. Clean the exterior surface of the generator set.
2. Seal all openings in the engine with nonabsorbent adhesive tape.
3. Mask all areas to be used for electrical contact.
4. Spread a light film of oil over unpainted metallic surfaces to prevent rust and corrosion.

2.10.5 Battery

Perform battery storage last.

1. Place the generator set master switch in the OFF/ RESET position.
2. Disconnect the battery, negative (–) lead first.
3. Clean the battery.
4. Place the battery in a warm, dry location.
5. Connect the battery to a float/equalize battery charger, or charge the battery monthly using a trickle charger. Follow the battery charger manufacturer's recommendations.

3.1 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 for engine service information. See the List of Related Materials for the document part number.

If the troubleshooting procedures in this section identify a failed part, refer to the parts catalog for replacement part numbers. See the List of Related Materials in the Introduction for the parts catalog number.

3.2 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 controller display. Section 4.4 describes the warning and shutdown fault codes.
- **Blown fuses.** Fuses on the controller junction box protect the controller, SCR module, and optional relay interface board. A battery charger fuse is located in the positive battery lead. Always check for and replace any blown fuses before replacing other components. Identify and correct the cause of the blown fuse. See Figure 1-1 for fuse locations and Section 5.13.2 for fuse part numbers.
- **Incorrect controller settings.** Always check the controller configuration settings before replacing the controller. Section 4.5 contains the instructions for checking and changing the controller configuration.
- **Inadequate fuel supply.** Check for damaged primary or secondary fuel regulators, loose connections to the fuel solenoid valve, a damaged or closed fuel shutoff valve, an empty LP fuel tank, or other problems with the fuel supply. Check the fuel supply pressure to the generator set. See Section 5.12, Fuel Systems.

3.3 Troubleshooting Chart

Use the following table 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.

Problem	Possible Cause	Test	Corrective Action	Reference
Generator set engine does not crank	Battery connections	Check for reversed or poor battery connections.	Correct and tighten battery connections.	—
	Weak or dead battery	Test the battery voltage. Test battery according to battery manufacturer's recommendations.	Recharge or replace battery.	O/M
		If battery is weak or dead, check the battery charger. Check battery charger fuse and connections. Check 120VAC power supply to the charger. Test charger operation.	 Tighten connections and replace charger fuse if blown. Connect 120VAC power to charger. Replace charger if necessary.	O/M
	Open circuit in engine/controller connections	Check for loose connections. Check the wire harness continuity.	Tighten connections. Replace harness or harness leads if damaged.	Section 5.15 Section 7
	Blown controller fuse F3	Use a test lamp or meter to check fuse F3.	Replace fuse; if fuse blows again, check circuit and components.	Section 5.13.2 Section 7

* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.
W/D = Wiring Diagram(s) (Section 7) S/S = Generator Set Specification Sheet O/M = Generator Set Operation Manual
I/M = Generator Set Installation Manual Engine S/M = Engine Service Manual

Problem	Possible Cause	Test	Corrective Action	Reference
Generator set engine does not crank, continued	Blown fuse F2	Use a test lamp or meter to check fuse F2.	Replace fuse.	Section 5.13.2.
			If fuse blows again, disconnect the following leads. Reconnect one at a time and attempt to start to identify the cause of the blown fuse: Lead 70A at the fuel valve Lead IGN at the ignition module Lead 71A at the starter relay Leads FP and FN at the rotor Repair or replace the component causing the blown fuse.	Section 7
	Crank relay K3 on controller circuit board	Check connections to the controller.	Tighten connections. Replace wiring if damaged.	Section 4.6
		Check for a good ground connection.	Tighten/repair ground connection.	Section 7
		Check LED3 to verify 12VDC to relay K3.	If LED3 is not lit, check for 12VDC to the board. If LED3 is lit but relay K3 does not operate, replace the controller circuit board.	Section 7 Section 4.6
	Generator set master switch	Check connections to the master switch.	Tighten connections. Replace wiring if damaged.	Section 4.2.1 Section 5.15
		Test function of switch.	Replace switch.	Section 5.15
	Poor ground (-) connection	Test ground connection.	Clean and retighten.	—
	Starter relay	Check connections to the starter relay.	Tighten connections. Replace wiring if damaged.	Section 1.7
		Check continuity of circuit.		Section 5.15 Section 7
		Check that the starter relay picks up when 12VDC is applied at lead 71A connection.	Replace starter relay.	Section 7
	Starter	Check starter connections.	Tighten connections. Replace wiring if damaged.	Section 1.7 Section 7
		Troubleshoot the starter. See the engine service manual for instructions.	Rebuild or replace starter.	Engine S/M
	Controller	Check the controller settings.	Adjust controller settings.	Section 4.5
		Test the controller as described in Section 3.4.	See Section 3.4.	Section 3.4
Cranks but does not start	No fuel	Verify that manual fuel valve is open. Check fuel supply tank (LP).	Open (turn on) manual fuel valve. Contact fuel supplier to add fuel to fuel supply tank (LP).	—
	Insufficient fuel pressure	Check fuel pressure to the generator set. Verify adequate fuel pressure and pipe size for the generator set plus all other gas appliances.	Contact fuel supplier to replace fuel supply lines with larger pipe and replace gas meter if fuel pressure is insufficient.	Section 5.12.2
	Fuel regulator/valve	Check regulator/valve operation.	Check regulator/valve operation.	Section 5.12 Section 4

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Problem	Possible Cause	Test	Corrective Action	Reference
Cranks but does not start, continued	Spark plugs or spark plug connections	Check spark plug wires and connections. Check spark plugs.	Tighten connections. Replace spark plug wires if damaged. Replace or clean and regap spark plugs.	O/M
	Loose connection or open circuit	Check for loose or open connection at the fuel valve (lead 70A) and at the engine spark control module (leads IGN and 70A). Check controller/engine wiring continuity.	Tighten connections. Replace wiring if damaged.	Section 7
	Air cleaner clogged	Check for a dirty air cleaner element.	Replace air cleaner element. Check and replace air cleaner element at the intervals shown in the Service Schedule.	O/M
	Magnetic pickup	Check for 1.75 volts or higher from the magnetic pickup during cranking. Test magnetic pickup and check gap according to the procedure in Section 5.9.4.	Tighten loose connections or replace wiring as necessary. Adjust magnetic pickup air gap if necessary. Replace mag pickup if necessary after testing.	Section 5.9.4
	Incorrect controller configuration	Check for correct controller configuration parameters: unit configuration (UC) and engine configuration (EC).	Enter the correct controller configuration parameters.	Section 4.5
	Ignition system spark control or ignition coil	Test according to instructions in the engine service manual.	Adjust or replace components as indicated in engine service manual.	Engine S/M
	Digital spark advance (DSAI) leads incorrectly connected or disconnected	Check DSAI leads. Check for loose connections.	Connect for natural gas. Disconnect for LP. Tighten connections. Replace wiring if damaged.	Section 5.12.4
	No engine rotation sensed (check for an overcrank fault shutdown)	Check mag pickup. See Magnetic pickup, above.	See Magnetic pickup, above.	Section 5.9.4
Starts hard	Low battery voltage	Check battery voltage during cranking. Check battery charger connections, power supply, and operation.	Charge battery. Replace battery if necessary. Tighten loose connections.	O/M
	Air cleaner clogged	Check for a dirty air cleaner element.	Replace element.	O/M
	Fuel mixture adjustment incorrect	Use oxygen sensor to check fuel mixture.	Adjust fuel mixture.	Section 5.12
	DSAI leads incorrectly connected or disconnected	Check DSAI connection.	Connect for natural gas. Disconnect for LP.	Section 5.12.4
	Spark plug(s)	Check spark plug condition and gap.	Replace or regap spark plug(s).	O/M
	Spark plug wire(s)	Check spark plug wires and connections.	Tighten connections. Replace spark plug wires if damaged.	Engine S/M
	Ignition components (spark control or ignition module)	Test ignition components according to instructions in the engine service manual.	Replace ignition components if necessary.	Engine S/M

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Problem	Possible Cause	Test	Corrective Action	Reference
Starts hard, continued	Insufficient fuel pressure	Check fuel pressure to the generator set. Verify adequate fuel pressure and pipe size for the generator set plus all other gas appliances.	Contact fuel supplier to replace fuel supply lines with larger pipe and replace gas meter if fuel pressure is insufficient.	Section 5.12.2
	Worn piston rings, valves	Check compression. See the engine service manual.	See engine service manual.	Engine S/M
Starts but shuts down	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Identify the cause of the fault.	Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.4 Section 5.10
Cranks but does not start	No engine rotation sensed (check for an overcrank fault shutdown)	Check for locked rotor.	Repair or replace rotor.	Section 5.4
Stops suddenly	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Identify the cause of the fault.	Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.4 Section 5.10
	No fuel	Check fuel valves and fuel supply.	Open manual fuel valve. Contact fuel supplier to replenish fuel supply.	—
	Fuel line restriction	Inspect fuel lines.	Clear restriction.	—
	Fuel lines too long	Check fuel line length and pipe size.	Contact fuel supplier to replace fuel lines with larger pipe.	Generator set S/S, I/M
	Air cleaner clogged	Check for a dirty air cleaner element.	Replace air cleaner element.	O/M
	Blown fuse	Check fuse F1, F2, and F3.	Replace fuse. If fuse blows again, test generator components.	Section 5.13.2
	Spark plug(s)	Check spark plug(s).	Replace or regap plug(s).	O/M
	Engine overheated (hot engine only)	Check air intake and generator set enclosure air inlets and outlet. Use oxygen sensor to check fuel mixture. Check oil level.	Clear air intake and enclosure air inlets and outlets. Adjust fuel mixture. Add oil. Check and replace oil at the intervals shown in the Service Schedule.	O/M Section 5.12 O/M
	Low oil pressure (LOP) switch	Check oil pressure. Attempt startup. If unit shuts down, remove lead from LOP switch and reset controller. A successful restart attempt indicates a faulty LOP shutdown switch. **Note:** Check engine oil pressure before performing test and/or replacing LOP shutdown switch.	See engine S/M. Replace faulty LOP shutdown switch. **Note:** Check engine oil pressure before performing test and/or replacing LOP shutdown switch.	Engine S/M Section 5.10.2
	Fuel valve/fuel regulator	Check fuel valve connections. Check regulator/valve operation. Check fuel pressure.	Tighten fuel valve connections. Replace damaged wires. Replace regulator or valve .	Section 5.12
	Engine overloaded	Reduce electrical load and check operation.	Unplug some lights or appliances connected to the generator set.	—
	Magnetic pickup connections	Check for loose connections to the mag pickup.	Tighten connections to the mag pickup. Replace damaged wiring.	Section 5.9

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Problem	Possible Cause	Test	Corrective Action	Reference
Stops suddenly, continued	Ignition module	Test the ignition system according to the instructions in the engine service manual.	Service the ignition system according to the instructions in the engine service manual.	Engine S/M
	Flash relay (K3) on controller	Check fuse F2. Check flash LED 1 on controller.	Replace fuse F2. If LED1 indicates power to the relay but the relay does not operate, replace controller board.	Section 5.13.2 Section 4.6
	Loss of generator output voltage to controller	Check connections at P15 plug. Check continuity of AC sensing leads 11 and 44 (1 ph) or V7, V8, and V9 (3 ph). See Section 5 for alternator test procedures.	Tighten connections at P15 plug. Replace wiring if damaged. Repair or replace components if necessary, as indicated by tests in Section 5.	Section 7 Section 5.3 Section 5
Overheats	Inadequate cooling	Inspect engine and enclosure for air intake obstructions.	Clear any air intake obstructions.	O/M
	Fuel mixture adjustment incorrect	Use an oxygen sensor to check the fuel mixture.	Readjust fuel mixture. **Note:** Adjusting the fuel mixture may void the emission certification.	Section 5.12
Noisy operation	Exhaust system leaks	Check silencer and connections for leaks.	Replace gaskets and exhaust system components as necessary.	—
	Engine not running smoothly	See “Generator set operates erratically,” this table.	See “Generator set operates erratically,” this table.	—
	Broken or damaged vibromount(s)	Inspect vibromounts.	Replace as necessary.	Section 6
	Loose or vibrating sheet metal/housing	Check for loose screws and rivets.	Retighten screws, replace rivets.	—
	Exhaust piping or air inlets/outlets not securely installed	Inspect for loose parts.	Secure loose parts as necessary.	—
	Excessive engine/generator vibration	Check rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Check, rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Section 6 Engine S/M
Operates erratically	Air cleaner clogged	Check air filter element.	Replace element.	O/M
	Spark plug(s)	Check spark plug condition and gap.	Replace or regap plugs.	O/M
	Spark plug wire(s)	Check spark plug connections and wires.	Tighten connections. Replace damaged spark plug wires.	Engine S/M
	DSAM leads incorrectly connected or disconnected	Check DSAM/DSAI lead connection.	Connect for natural gas. Disconnect for LP.	Section 5.12.4
	Fuel line restriction	Check fuel lines. Check fuel pipe size.	Clear restricted fuel lines. Contact fuel supplier to install larger diameter pipe.	Section 5.12.2
	Fuel mixture adjustment incorrect	Use oxygen sensor to check fuel mixture.	Adjust fuel mixture.	Section 5.12
	Magnetic pickup connections	Check for loose connections to the mag pickup.	Tighten mag pickup connections. Replace damaged wiring.	Section 5.9

* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.
W/D = Wiring Diagram(s) (Section 7) S/S = Generator Set Specification Sheet O/M = Generator Set Operation Manual
I/M = Generator Set Installation Manual Engine S/M = Engine Service Manual

Problem	Possible Cause	Test	Corrective Action	Reference
Operates erratically, continued	Governor adjustment incorrect	Check governor operation. Check controller engine speed (frequency) adjustment. *	Adjust governor. Adjust controller engine speed. *	Section 5.9 Section 4.5 and Installation Man.
	Ignition system	Test ignition system according to instructions in engine service manual.	Service ignition system according to instructions in engine service manual.	Engine S/M
	Inadequate cooling (hot engine only)	Check air inlet and outlet.	Clear air inlet and outlet.	—
	Other engine service required	See engine service manual.	Service according to instructions in engine service manual.	Engine S/M
Light flicker	Voltage stability (gain) setting	Check the voltage stability (gain) setting using the ADC controller. *	Adjust the voltage stability (gain) setting using the ADC controller. *	Section 4.5.4
High output voltage	Incorrect controller configuration	Check the controller configuration parameters. *	Adjust the controller configuration parameters. *	Section 4.5.1
	Incorrect controller voltage settings	Check the controller voltage settings. *	Adjust the controller voltage settings. *	Section 4.5.4
	Engine speed too high	Check engine speed using tachometer or frequency meter.	Adjust engine speed on the controller. * Adjust governor as necessary.	Section 4.5 Section 5.9
	Loose voltage sensing connections	Check connections: stator leads 11 and 44 (1 ph) or V7, V8, and V9 (3 ph) and P15 controller connection.	Tighten connections.	Section 7 W/D
	SCR module	Check wiring and connections to the SCR module.	Tighten connections and/or replace wiring to the SCR module.	Section 4.8
		Check auxiliary winding fuse F1 (lead 55).	Replace auxiliary winding fuse F1.	Section 5.13.2
		Test the SCR module using the procedure in Section 4.8.	Replace the SCR module and recheck voltage.	Section 4.8
	Controller	Check the controller settings.	Adjust controller settings.	Section 4.5
		Test the controller as described in Section 3.4.	See Section 3.4.	Section 3.4
Lacks power	Air intake restriction, inadequate cooling	Inspect air intakes and exhaust for obstructions. Check air cleaner.	Inspect air intakes and exhaust for obstructions. Check air cleaner.	O/M O/M
	Generator overloaded	Reduce electrical load and check operation.	Unplug some lights or appliances connected to the generator set.	—
	Spark plug(s)	Check spark plugs.	Regap and/or replace plug(s).	O/M
	Spark plug wire(s)	Check tightness and condition of spark plug wires.	Tighten or replace spark plug wires.	Engine S/M
	DSAI leads incorrectly connected or disconnected	Check DSAI leads. Connect for natural gas. Disconnect for LP.	Connect for natural gas. Disconnect for LP.	Section 5.12.4
	Insufficient fuel pressure	Check fuel pressure at carburetor outlet. Check for adequate fuel pipe size and meter capacity for generator set and all gas-fired appliances.	Contact fuel supplier to replace pipe and/or meter as required to provide sufficient fuel supply pressure for the generator set and all gas-fired appliances.	Section 5.12
	Fuel line restriction	Check fuel pipe size.	Contact fuel supplier to provide larger pipe.	Section 5.12
	Fuel regulator	Check function of fuel regulator.	Repair or replace fuel regulator.	Section 5.12

* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.
W/D = Wiring Diagram(s) (Section 7) S/S = Generator Set Specification Sheet O/M = Generator Set Operation Manual
I/M = Generator Set Installation Manual Engine S/M = Engine Service Manual

Problem	Possible Cause	Test	Corrective Action	Reference
Lacks power, continued	Engine not running at rated rpm	Check controller settings for unit configuration (UC) and engine type (EC). * Check engine speed.	Reset controller settings for unit configuration (UC) and engine type (EC). * Adjust engine speed.	Section 4.5
	Engine power loss	Refer to the engine service manual for troubleshooting and repair instructions.	Refer to the engine service manual for troubleshooting and repair instructions.	Engine S/M
	Governor malfunction or misadjustment	Test governor.	Adjust governor.	Section 5.9
	Ignition system	See the engine service manual for service procedures.	See the engine service manual for service procedures.	Engine S/M
Low output or excessive drop in voltage	Generator overloaded	Reduce electrical load and check operation.	Unplug some lights or appliances connected to the generator set.	—
	Incorrect controller configuration	Check the controller configuration parameters. *	Adjust the controller configuration parameters. *	Section 4.5
	Incorrect controller voltage settings	Check the controller voltage settings. *	Adjust the controller voltage settings. *	Section 4.5.4
	Alternator or control system	Perform separate excitation procedure to isolate problem to the alternator or the control system.	Troubleshoot the alternator or control system as indicated by test results.	Section 5.2
	SCR module	Check wiring and connections to the SCR module. Check auxiliary winding fuse F1 (lead 55). Replace SCR module and recheck voltage.	Tighten connections and/or replace wiring as required. Replace auxiliary winding fuse F1 (lead 55). Replace SCR module and recheck voltage.	Section 7 Section 5.13.2 Section 4.8
	Controller	Check the controller settings.	Adjust controller settings.	Section 4.5
		Test the controller as described in Section 3.4.	See Section 3.4.	Section 3.4
	Rotor	Test rotor for open, grounded, or shorted windings.	Replace rotor if faulty windings are found.	Section 5.4
	Stator	Test stator for open, grounded, or shorted windings.	Replace stator if faulty windings are found.	Section 5.3
	Brush connection	Check for loose brush connections. Check for loose brush mounting. Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.	Tighten loose brush connections. Tighten mounting screws. Replace brushes if they show uneven wear or are worn to one-half their original length.	Section 5.6
	Low engine speed causing voltage roll-off	Check system voltage/frequency (Uu) and engine type (Ec) parameters. * Check engine speed. Engine problem.	Change system voltage/frequency (Uu) and engine type (Ec) parameters if not correct. * Adjust engine speed. Troubleshoot the engine.	Section 4.5.1 Section 4.5.4 Engine S/M
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.	—

* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.
W/D = Wiring Diagram(s) (Section 7) S/S = Generator Set Specification Sheet O/M = Generator Set Operation Manual
I/M = Generator Set Installation Manual Engine S/M = Engine Service Manual

Problem	Possible Cause	Test	Corrective Action	Reference
No output voltage, continued	Alternator or control system	Perform separate excitation procedure to isolate the problem to the alternator or the control system.	Troubleshoot the alternator or control system components as described below and elsewhere in this table.	Section 5.2
	SCR module	Check auxiliary winding fuse F1 (lead 55). Replace SCR module and test voltage.	Check auxiliary winding fuse F1 (lead 55). Replace SCR module and test voltage.	Section 5.13.2 Section 4.8
	Controller	Check the controller settings.	Adjust controller settings.	Section 4.5
		Test the controller as described in Section 3.4.	See Section 3.4.	Section 3.4
	Open wiring, terminal, or pin in buildup circuit or SCR module circuit	Check fuses and wiring.	Replace fuses or wiring as necessary.	Section 5.13.2 Section 7 W/D
	Brushes	Inspect brushes.	Replace brushes if worn.	Section 5.6
		Check for brushes sticking in brush holder or broken brush spring.	Replace brush spring or brush assembly.	Section 5.6
		Check that brush holder is securely mounted.	Tighten brush holder screws.	Section 5.6
	Rotor slip rings dirty or corroded	Check slip ring condition.	Clean slip rings as described in Section 5.5. Machine slip rings if necessary.	Section 5.5
	Rotor (open, grounded, or shorted windings)	Check voltage and continuity as described in Section 5.4.	Repair or replace rotor if indicated by the tests.	Section 5.4
	Stator (open, grounded, or shorted windings)	Check voltage and continuity as described in Section 5.3.	Repair or replace the stator if indicated by the test results.	Section 5.3
	Flash relay (K3) on controller	Check fuse F2. Check flash LED 1 on controller.	Replace fuse F2. If LED1 indicates power to the relay but the relay does not operate, replace controller board.	Section 5.13.2 Section 4.6
	Aux. winding fuse blown (lead 55)	Check fuse. If fuse blows again, check stator.	Replace blown fuse. If fuse blows again, check stator.	Section 5.13.2 Section 5.3

* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.
W/D = Wiring Diagram(s) (Section 7) S/S = Generator Set Specification Sheet O/M = Generator Set Operation Manual
I/M = Generator Set Installation Manual Engine S/M = Engine Service Manual

3.4 Controller Troubleshooting

Refer to the controller troubleshooting table in this section when troubleshooting procedures in Section 3.3 indicate a possible controller problem. Always check the ADC-RES controller configuration settings before replacing the controller. The Installation Manual contains the instructions for checking and changing the controller configuration.

Note: The DC-RET controller parameters are factory-set and cannot be changed in the field.

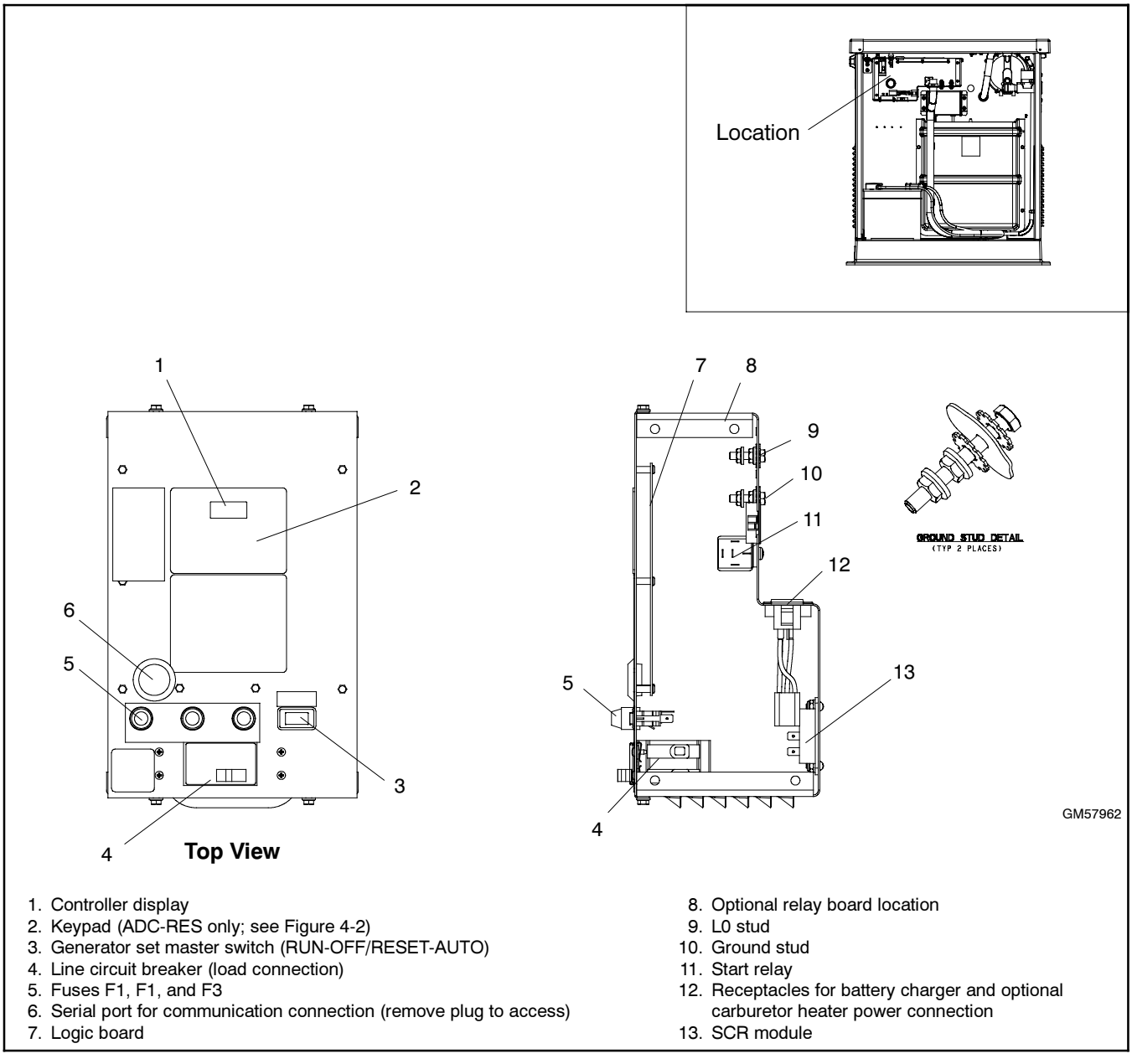
Possible Cause	Test	Corrective Action	Reference
Controller	Check controller settings. *	Adjust controller settings as required. *	Section 4.5
	Check for power to the controller at lead PF1.	Check/replace fuse F3. Check battery.	Section 7
	Check controller fuse F3.	Replace controller fuse.	Section 5.13.2
	Check controller wiring and connections.	Tighten connections and/or replace wiring.	—
	Replace SCR module and recheck voltage.	Replace the SCR module.	Section 4.8
	Perform all tests listed under high output voltage.	Replace the controller only if previous steps do not solve the problem.	Section 4.9
SCR module	Check wiring and connections to the SCR module.	Tighten connections and/or replace wiring to the SCR module.	Section 4.8
	Test the SCR module using the procedure in Section 4.8.	Replace the SCR module and recheck voltage.	Section 4.8
	Check auxiliary winding fuse F1 (lead 55).	Replace auxiliary winding fuse F1 (lead 55).	Section 5.13.2
* ADC-RES controller only. The DC-RET controller settings cannot be adjusted in the field.			

Notes

4.1 Introduction

This section covers operation, configuration, adjustment, and replacement of the ADC-RES and DC-RET controllers. See Section 3 for troubleshooting procedures.

See Figure 4-1 for the controller location.

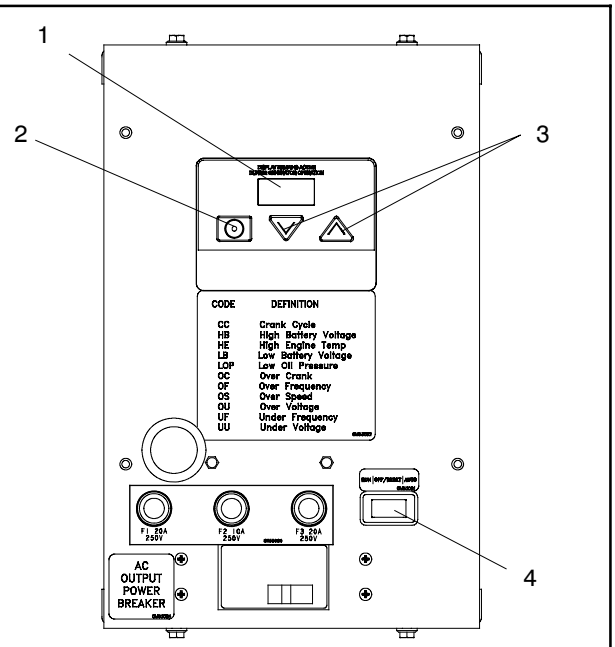


1. Controller display
2. Keypad (ADC-RES only; see Figure 4-2)
3. Generator set master switch (RUN-OFF/RESET-AUTO)
4. Line circuit breaker (load connection)
5. Fuses F1, F1, and F3
6. Serial port for communication connection (remove plug to access)
7. Logic board
8. Optional relay board location
9. L0 stud
10. Ground stud
11. Start relay
12. Receptacles for battery charger and optional carburetor heater power connection
13. SCR module

Figure 4-1 Controller Components

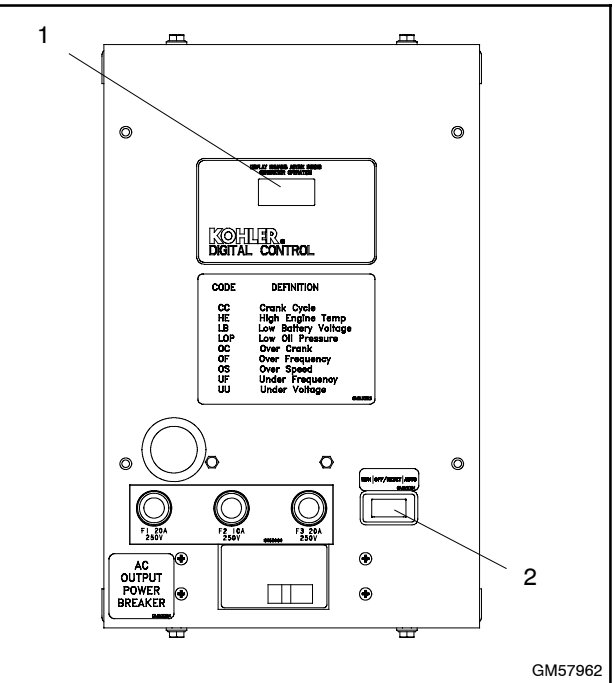
4.2 Controls and Display

The ADC-RES controller has an LED display and a three-button keypad. See Figure 4-2. The DC-RET controller has an LED display. See Figure 4-3.



1. LED display
2. Select button (use for setup and adjustment only)
3. Up and down arrow buttons (use for setup and adjustment only)
4. Generator set master switch (RUN-OFF/RESET-AUTO)

Figure 4-2 ADC-RES Controller



1. LED display
2. Generator set master switch (RUN-OFF/RESET-AUTO)

Figure 4-3 DC-RET Controller

A three-position generator set master switch is mounted on the controller junction box.

4.2.1 Master Switch

The generator set master switch is a three-position (RUN\OFF/RESET\AUTO) rocker switch. See Figure 4-2 or Figure 4-3 for the master switch location. See Section 5.11 for master switch connections.

4.2.2 LED Display

The LED display shows runtime hours, fault codes, application program version number, or controller parameters during configuration and adjustment. See Figure 4-4.

The LED display is activated by a start or RUN command as follows:

- Move the master switch to RUN.
- With the master switch in AUTO, send a remote start command (close the remote start contact across leads 3 and 4).

The LED display indicates generator set status as shown in Figure 4-5. When the generator set is running, engine runtime hours are shown.

When the generator set is running, the arrow keys on the ADC-RES can be used to step through the other displays as described in Section 4.2.3.

When the master switch is in AUTO, the display turns off 48 hours after generator set shutdown.

Control or Indicator	Item	Description
LED display	Runtime hours	Displays total generator set runtime hours while the generator set is running and when no other codes are displayed.
	Metering display (ADC-RES only)	Displays AC voltage (output), frequency, and battery voltage. Press the up or down arrow when runtime hours are displayed to step through these displays.
	Crank indication	Displays CC_1, CC_2, or CC_3 to indicate the first, second, or third attempt to start the engine. The last digit flashes during the crank cycle rest periods.
	Software version number	ADC-RES: The software version number (v#.##) is displayed when entering configuration mode. See the installation manual. DC-RET: The software version number (v#.##) is displayed during the first 2 seconds of the crank cycle.
	Fault codes	Flashes a 2- or 3-letter fault code to indicate various fault conditions. See Section 4.4.
Keypad (ADC-RES only)	Select and arrow buttons	Use the arrow buttons to step through the data displays. See Section 4.2.3. The keypad is also used for controller setup and adjustment. The setup and adjustment functions are password-protected. Have setup and adjustments performed only by an authorized distributor/dealer.
Generator set master switch	Three-position switch	Switch functions as the generator set operation and controller reset switch.

Figure 4-4 Controls and Indicators

4.2.3 Keypad

The three-button keypad is a feature of the ADC-RES controller. The keypad is used to check system status, change controller settings, and adjust the generator set output voltage and frequency.

When the generator set is running, press the up and down arrow buttons to step through system status displays as shown in Figure 4-5. After 10 seconds, the display returns to engine runtime hours.

Use the configuration and adjustment menus to change controller settings and adjust the generator set output. A password key sequence is required to enter the configuration and adjustment menus. Section 4.5 contains the instructions to enter the configuration and adjustment menus and change the settings using the controller keypad.

The DC-RET controller is not equipped with a keypad. DC-RET controllers are factory-set and not adjustable.

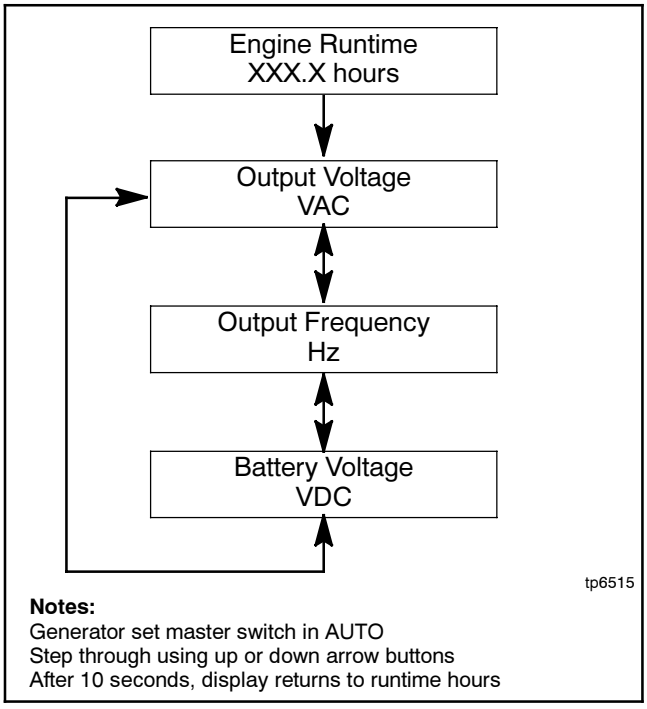


Figure 4-5 Generator Set Status Displays (ADC-RES only)

4.3 Sequence of Operation

The following sections describe the controller sequence of operation during generator start, run, stop, and fault shutdown modes. Use this as a starting point for controller and relay board fault identification. Refer to the wiring diagrams in Section 7 to assist in the troubleshooting procedure.

4.3.1 Starting Sequence, Master Switch Moved to RUN

When the master switch is moved to the RUN position, there is a delay of about 2 seconds before the controller attempts to start the engine. The electronic governor moves to its start position. The fuel (run) relay energizes and the corresponding LED on the control board turns on. (See Section 4.6 for relay information.) Then the crank and flash relays energize and the corresponding LEDs turn on. The controller display indicates the crank cycle 1 code, CC 1.

The controller attempts to start the generator set three times (three crank cycles, 15 seconds crank and 15 seconds off). If the generator set does not start in three attempts, the system shuts down on an overcrank fault.

When the engine comes up to speed, the low oil pressure switch contacts open.

Note: The controller circuit board prevents fault shutdowns during startup until the crank disconnect relay energizes.

The cyclic cranking cycle is programmed into the controller's application code and is not adjustable in the field.

The factory sets the cranking cycle for three cycles of 15 seconds on time and 15 seconds off time. If the cranking cycle seems shorter than the factory setting, check the engine starting battery.

4.3.2 Starting Sequence, Remote Start

The generator set master switch must be in the AUTO position for remote start/stop by a remote switch or automatic transfer switch.

The remote start contact closes across engine start leads 3 and 4 to start the generator set. The start sequence proceeds as described in Section 4.3.1, Starting Sequence, Master Switch Moved to RUN.

4.3.3 Running Sequence

When the engine speed reaches 750 rpm, the crank relay deenergizes and the crank LED turns off. When the output voltage reaches about 30 VAC, the flash relay deenergizes and the flash LED turns off.

4.3.4 Stopping Sequence, Master Switch Moved to OFF/RESET

Place the generator master switch in the OFF/RESET position. The run relay deenergizes and the run LED (1) turns off. The generator set stops.

4.3.5 Stopping Sequence, Remote Stop

The generator set master switch must be in the AUTO position for remote start/stop by a remote switch or automatic transfer switch.

When the remote start contact across leads 3 and 4 opens, the run relay deenergizes and the run LED (1) turns off. The generator set stops.

4.3.6 Standby Mode

When the generator set master switch is in the AUTO position, the controller is in standby mode. Engine runtime hours are shown on the display. A remote start signal (contact closure) will start and run the generator set.

If there is no start signal for 48 hours, the controller goes into sleep mode.

4.3.7 Sleep Mode

When the generator set master switch is in the AUTO position, the controller powers down automatically if there is no start signal for 48 hours after shutdown. The controller display is dark and battery draw is minimized. A remote start signal (from a transfer switch or a remote start/stop switch connected to controller leads 3 and 4) reactivates the controller. Moving the generator set master switch to the RUN position also activates the controller.

4.4 Faults

4.4.1 Warnings

The fault conditions listed in Figure 4-6 will cause the controller to display a fault code but will not shut down the generator set.

Code	Fault	Description	Check
HB *	High battery voltage warning	Fault code is displayed if the engine starting battery voltage rises above 16 VDC for a 12 VDC system or above 30 VDC for a 24 VDC system for more than one minute when the engine is not running. This fault condition does not inhibit engine starting. The fault condition clears when the battery voltage returns to a voltage within the limits for more than 10 seconds.	Check the battery rating and condition. Check the battery charger operation.
LB	Low battery voltage warning	Fault code is displayed if the engine starting battery voltage falls below 8 VDC for a 12 VDC system or below 16 VDC for a 24 VDC system for more than one minute when the engine is not running. This fault condition does not inhibit engine starting. The fault condition clears when the battery voltage returns to a voltage within the limits for more than 10 seconds.	Check the battery rating and condition. Check the battery charger operation. Charge or replace the battery.
* ADC-RES only			

Figure 4-6 Fault Warning Codes

4.4.2 Shutdowns

Under the fault conditions listed in Figure 4-7, the controller displays a fault code and the generator set shuts down.

Always identify and correct the cause of a fault shutdown before restarting the generator set. Refer to Section 3, Troubleshooting, for instructions to identify and correct the cause of the fault.

Move the generator set master switch to the OFF/ RESET position to reset the controller after a fault shutdown. Then move the switch to the AUTO or RUN position.

Code	Fault	Description	Check	See Section
AF	Auxiliary fault	Indicates a shutdown initiated by pushing the emergency stop switch or by tripping the circuit breaker. (TRES models only) Not used on single-phase models.	Reset the emergency stop button. Identify and correct the cause of the tripped circuit breaker before resetting the circuit breaker. (TRES models only)	O/M
HE	High engine temperature	Shutdown occurs if the engine coolant temperature exceeds the maximum temperature for more than 5 seconds. This protective becomes active after the engine reaches the crank disconnect speed.	Check for blocked air inlets and exhaust outlets.	1.7
LOP	Low oil pressure	Shutdown occurs if a low oil pressure condition exists for more than 5 seconds. This protective becomes active 30 seconds after the engine has reached crank disconnect speed (30 second inhibit). **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low. Check low oil pressure switch connections and operation. Check the oil pump and lubrication system.	— O/M 5.10 Engine S/M
OC	Overcrank	Shutdown occurs after 3 unsuccessful starting attempts. The crank cycle is set for three starting attempts of 15 seconds cranking and 15 seconds rest.	Check the fuel supply valves and pressure. Check spark plug and battery. See Troubleshooting Chart, generator set cranks but does not start.	5.12 O/M 3.3
	Locked rotor	The generator set shuts down on an overcrank fault if no engine rotation is sensed. Shuts down 3 seconds after the fault is detected.	Check mag pickup connections and operation. Check for a locked rotor.	5.9.4 5.4
OF	Over frequency	Shutdown occurs when the governed frequency exceeds 110% of the system's frequency setpoint for more than 5 seconds. This protective becomes active 10 seconds after engine start (10 second inhibit).	Check system frequency setting (parameter UU) on controller.	4.5
			Measure output frequency and adjust, if necessary.	5.9.5
			Check governor system condition and operation.	5.9
OS	Overspeed	Shutdown occurs if the engine speed exceeds 110% of the normal running speed for more than 0.3 seconds.	Check governor settings and operation.	5.9
OU *	Over voltage	Shutdown occurs if the voltage exceeds 120% of the system nominal voltage for more than 2 seconds.	Check AC voltage. Check wiring and connections.	5.7 7
UF	Under frequency	Shutdown occurs when the governed frequency falls below 54 Hz for more than 5 seconds. This protective becomes active 10 seconds after engine start. (10 second inhibit).	Reduce the load and restart the generator set.	—
UU	Under voltage	Shutdown occurs if the voltage falls below 80% of the nominal system voltage for more than 10 seconds.	Reduce the load and restart the generator set.	—
			Check wiring and connections.	7
			Check controller configuration, system voltage and frequency (parameter UU).	4.5
			Check AC voltage and adjust, if necessary.	5.7
			Check the SCR module. Replace if necessary and test voltage again.	4.8
			Separately excite unit.	5.2
			Check stator continuity.	5.3
SCF0	Software Comm. Fault 0	Indicates a software or communication problem within the ADC-RES.	Replace the controller.	4.9
* ADC-RES only			Engine S/M = Engine Service Manual O/M = Generator Set Operation Manual	

Figure 4-7 Fault Codes

4.5 Controller Configuration and Adjustment, ADC-RES

The first step in troubleshooting the controller is to verify that the controller is correctly configured for the generator set. The ADC-RES controller's configuration modes allow selection of the system voltage and frequency, generator set configuration (marine, mobile, or standby), and the communication parameter. Follow the instructions in the generator set installation manual to check the controller settings and change them, if necessary.

4.5.1 Controller Configuration

The controller configuration for each generator model is set at the factory. If the controller is replaced, check the configuration of the new controller and change the settings, if necessary. Follow the instructions in the generator set installation manual to check controller settings and change them if necessary.

4.5.2 Controller Time Out

The controller will automatically exit the configuration mode without saving any changes after about 1 minute if no buttons are pressed. Start the configuration procedure again from the beginning if the controller exits the configuration mode before the settings have been saved.

Changes in voltage and speed adjustments are also lost if they are not saved before the generator set shuts down. The generator set continues to run with the new settings until it shuts down but then reverts to the previous settings at the next startup. Be sure to save your changes immediately after making adjustments.

4.5.3 Controller Application Program Version Number

The ADC-RES application program version number is displayed on the LED screen during the key sequence to enter the configuration mode. Hold the Select button and move the generator set master switch to the RUN position. After about 5 seconds, the application program version number will be displayed on the controller display. For example, 01.10 will be displayed for program version 1.10.

The DC-RET application program version number is displayed during the first 2 seconds of the crank cycle.

4.5.4 Voltage and Frequency Adjustments

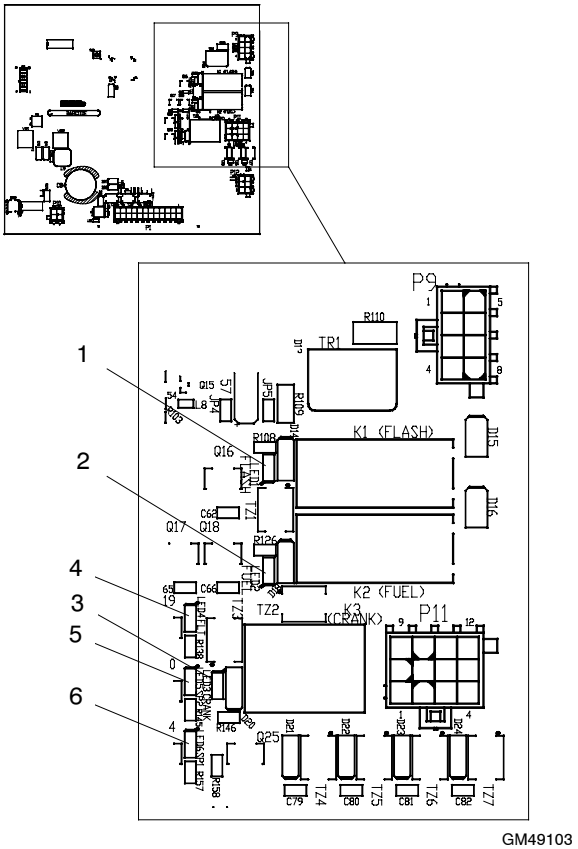
Voltage and/or frequency adjustments may be required after controller replacement or other service procedures. See Section 5.8 for instructions to adjust the generator set output voltage and frequency using the ADC-RES.

The generator set must be running during these adjustments. Use a multimeter to measure generator set output voltage and frequency during adjustments. Refer to Sections 5.8, Voltage Adjustment, and 5.9.5, Frequency Adjustment, for instructions to measure and adjust the output voltage and frequency.

Note: Be sure to save your settings before exiting the configuration mode. The controller reverts to the last saved settings when the master switch is moved to the OFF/RESET position.

4.6 Controller Relays

The K1 flash, K2 fuel (run), and K3 crank relays are located on the controller's logic board. An LED is associated with each relay. See Figure 4-8.



1. LED1 Flash (K1)
2. LED2 Fuel (K2)
3. LED3 Crank (K3)
4. LED4 Fault
5. LED5 SP2
6. LED6 SP1

Figure 4-8 Relays and LEDs on Controller Logic Board

The LED indicates power to the corresponding relay. If the LED is illuminated but the relay is not activated, the relay is faulty.

The individual relays are not replaceable. If one or more relays are faulty, replace logic board.

LED 4 lights to indicate a fault condition. See Section 4.4, Faults.

The controller board is protected by a 10-amp fuse (F2) located on the controller. If the fuse blows repeatedly, disconnect the board loads one at a time to identify the cause of the blown fuse:

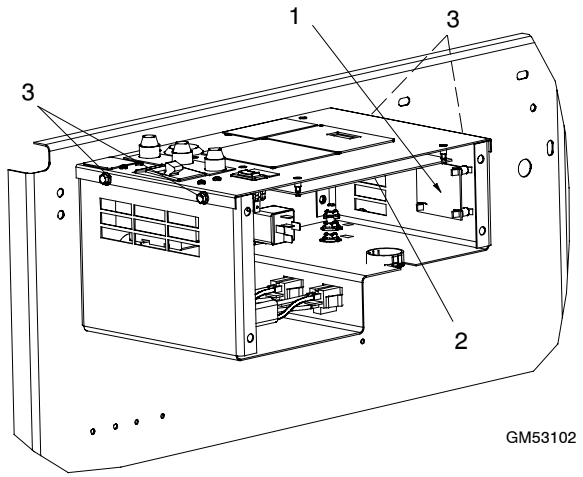
- Lead 70C at the fuel valve
- Lead IGN at the ignition module
- Lead 71A at the starter relay
- Leads FP and FN at the rotor

Repair or replace the component causing the blown fuse.

If fuse continues to blow and disconnecting components did not identify the cause, remove the leads from the P14 connector using a pin pusher. If replacing the leads does not solve the problem, replace the controller logic board.

4.7 Optional Relay Board

The generator set may be equipped with an optional relay board, which contains the K1 common fault relay and K4 auxiliary run relay. See Figure 4-9 for the relay board location inside the controller junction box.

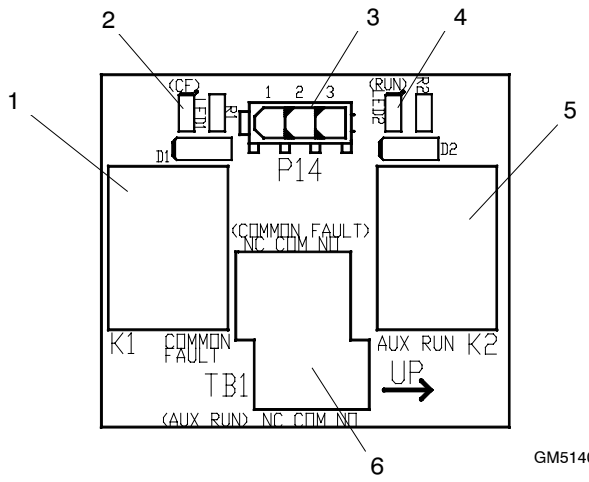


1. Relay board GM51403
2. Controller circuit board location
3. Cover screws (qty. 4)

Figure 4-9 Relay Board Location (inside controller junction box)

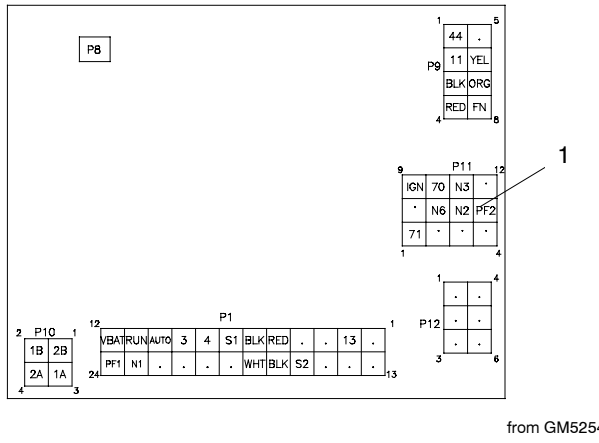
Troubleshooting

First check for loose connections. Check the relay board harness connections to the relay board, control board, and engine harness. See Figure 4-10, Figure 4-11, and Figure 4-12.



1. K1 common fault (CF) relay
2. LED1 (for K1 CF relay)
3. Connect P14 from RIB harness GM52639 to P14 on the relay board
4. LED2 (for K2 aux. run relay)
5. K2 auxiliary run relay
6. Connect customer equipment to TB1, 14 AWG max.

Figure 4-10 Optional Relay Board



1. Disconnect engine harness from controller circuit board at P11. Connect relay board harness GM52639 to P11.

Figure 4-11 Connection to Controller Circuit Board

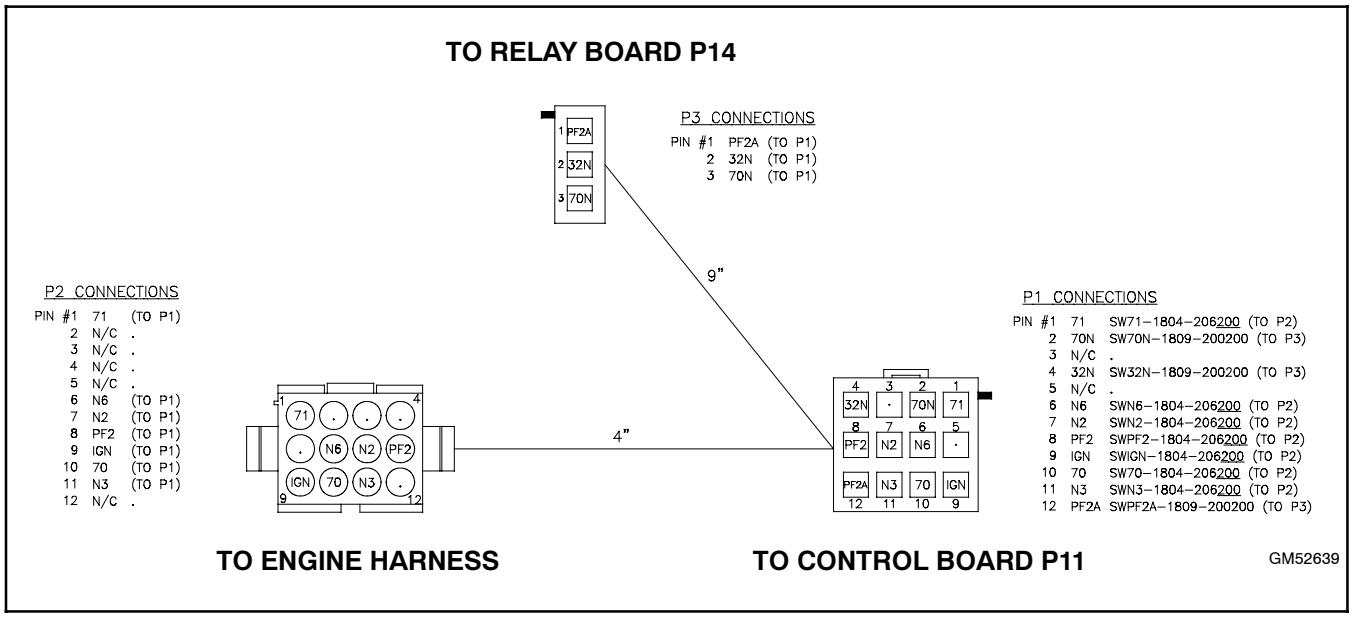


Figure 4-12 Relay Board Connection Harness

Check for loose customer connections to terminal strip TB1 on the relay board. See Figure 4-10 and Figure 4-13.

TB1 Terminal Label	Description
COMMON FAULT NC	Common fault relay normally closed contact. Opens on a fault.
COMMON FAULT COM	Common fault relay common
COMMON FAULT NO	Common fault relay normally open contact. Closes on a fault.
AUX RUN NC	Auxiliary run relay normally closed contact. Open when generator set is running.
AUX RUN COM	Auxiliary run relay common
AUX RUN NO	Auxiliary run relay normally open contact. Closed when generator set is running.
Note: Use maximum 14 AWG wire for TB1 connections.	

Figure 4-13 TB1 Customer Connections

Check the harness and wiring for open circuits or shorts. Replace the harness or customer wiring as necessary.

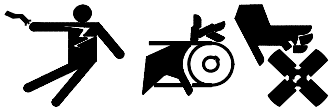
Check that the ratings of the customer's connected equipment do not exceed the relay contact specifications shown in Figure 4-14.

Contact Ratings	10 A @ 120 VAC 10 A @ 28 VDC
Maximum Operating Voltage	250 VAC/60 VDC
Maximum Switching Capacity	440 VA/75 W

Figure 4-14 Relay Contact Ratings

An LED is associated with each relay. See Figure 4-10. The LED indicates power to the corresponding relay. If the LED is illuminated but the relay is not activated, the relay is faulty. The individual relays are not replaceable. If one or more relays are faulty, replace the entire RIB.

⚠ 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.

Relay Board Replacement Procedure

1. Access the controller junction box to locate the relay board. See Figure 4-9.
2. Disconnect relay board harness connector P3 from connector P14 on the relay board.
3. Pull the faulty relay board off the four mounting standoffs inside the junction box.
4. Press the new relay board onto the four standoffs.
5. Connect three-pin connector of harness GM52639 to P14 on relay board GM51403. See Figure 4-10 and Figure 4-12.
6. Verify that harness GM52639 is securely connected to P11 on the control board. See Figure 4-11 and Figure 4-12.
7. Verify that harness GM52639 is securely connected to the engine harness. See Figure 4-12.

4.8 Silicon Controlled Rectifier Module

The silicon controlled rectifier (SCR) module works with the ADC-RES to regulate the output voltage. The ADC-RES monitors generator output voltage and adjusts the excitation current to the rotor through the SCR module. The SCR module location is shown in Figure 4-1.

The SCR module is powered through stator leads 55 and 66 connected to SCR terminals AC1 and AC2. Leads G connected to terminals G1 and G2 provide the controller signal. Leads FP and FN connected to the positive (+) and negative (-) SCR terminals provide excitation current to the rotor. See Figure 4-15 and the wiring diagrams in Section 7.

The SCR module is protected by a 20-amp fuse (F1) on the controller. Check the fuse and replace it, if blown.

In the case of output voltage problems, check the controller configuration and settings. Then test the SCR module using the following procedure.

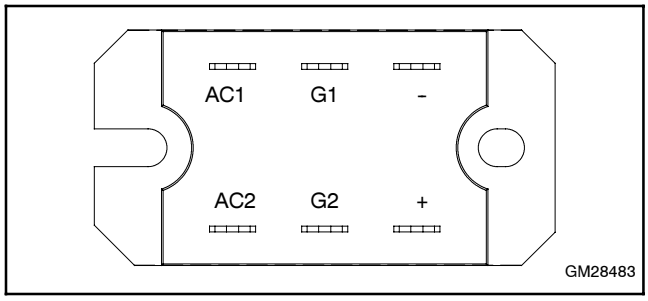


Figure 4-15 Silicon Controlled Rectifier (SCR) Module

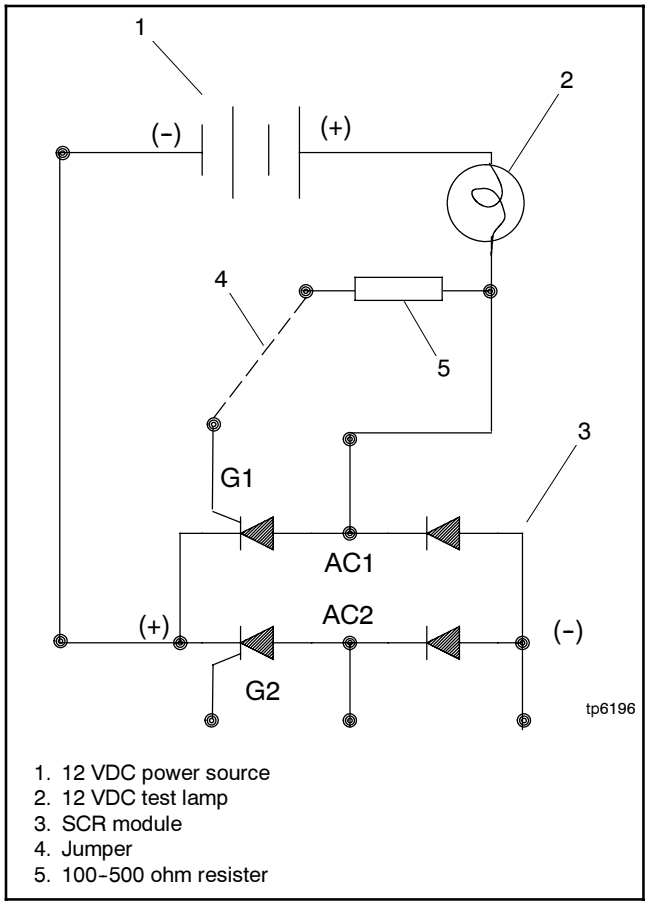
SCR Module Test Procedure

Required equipment:

- Ohmmeter
- 12-volt test lamp (or voltmeter)
- 12-volt DC power source
- 100–500 ohm resistor
- Jumper

1. Set the ohmmeter to the R x 1 scale.
2. Connect the ohmmeter from (+) to (-) on the SCR module. You should read high resistance in one direction and low resistance in the other (reverse the leads).
3. Connect the ohmmeter from AC1 to (+) on the SCR module. You should read high resistance in both directions.
4. Connect the ohmmeter from AC1 to (-) on the SCR module. You should read high resistance in one direction and low resistance in the other.
5. Repeat steps 3 and 4 for AC2.
6. Connect the ohmmeter from G1 to (+) on the SCR module. You should read low resistance in both directions.
7. Repeat step 6 for G2. You should read low resistance in both directions.
8. See Figure 4-16. Connect the *negative* (-) lead from the DC power source to the *positive* (+) terminal on the SCR module.

   Note: The SCR module may be damaged if the power supply is connected incorrectly. Be sure to connect the *negative* lead from the battery to the *positive* terminal on the SCR module.



1. 12 VDC power source
2. 12 VDC test lamp
3. SCR module
4. Jumper
5. 100–500 ohm resister

Figure 4-16 SCR Test

9. Connect the positive (+) lead from the DC power source, with the lamp in series, to terminal AC1 on the SCR module. The lamp should not glow.

10. Connect the jumper, with the resistor in series, from the positive lead of the DC power source to terminal G1 on the SCR module. The lamp should glow.

11. Repeat steps 9 and 10, with the positive (+) lead and lamp connected to terminal AC2 on the SCR module, and connecting the jumper with resister to terminal G2.

12. If any of the above checks indicates a failed SCR module, replace the module.

Note: When replacing the SCR module, be sure to apply thermal compound to the back of the module to prevent overheating. Thermal compound is provided with the SCR module replacement kit.

4.9 Controller Replacement

If the troubleshooting procedures in Section 3 identify a failed controller, use the procedure in this section for controller replacement. Always check the controller configuration, fuse, wiring, and connections before replacing the controller. For output voltage problems, replace the SCR module and check the operation again before replacing the controller.

After replacing the controller, verify that the new controller's configuration settings match the generator set system voltage/frequency and unit configuration. Refer to the generator set installation manual 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 and frequency. If the output voltage or frequency needs adjustment, use the voltage and frequency adjustment procedure in Section 5.8. Also see the frequency adjustment procedure in Section 5.9.5.

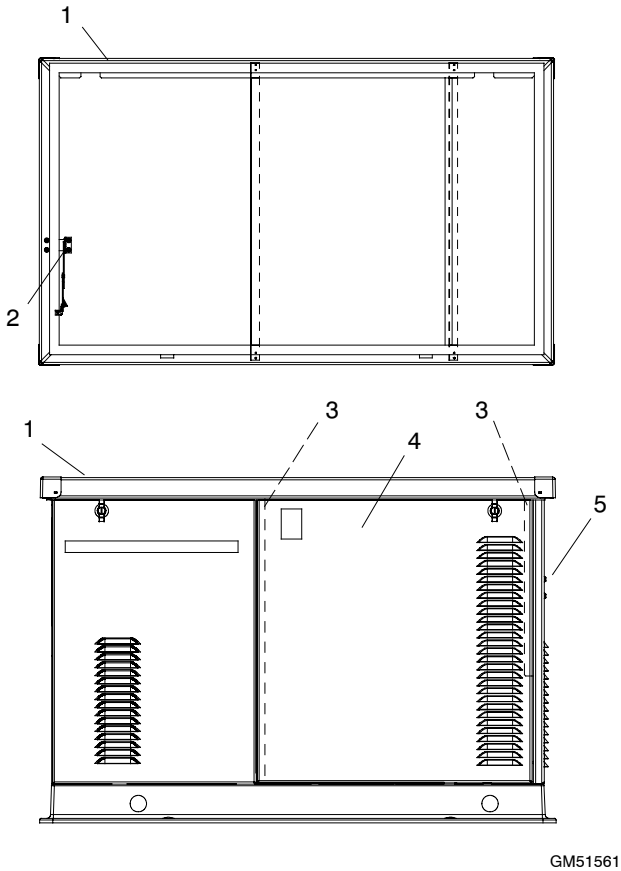
⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

Controller Replacement Procedure

1. Open the enclosure roof. Prop the roof open using the roof stay or remove the roof if desired. See Figure 4-17.



1. Roof
2. Roof stay
3. Door screws (2 ea.)
4. Service-side door
5. Front panel

Figure 4-17 Enclosure Roof and Door

2. Place the generator set master switch in the OFF position.

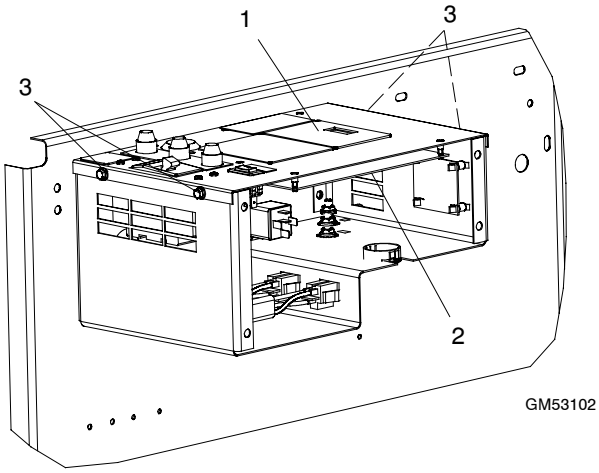
3. Remove 2 door screws. Lift the door up and off. See Figure 4-17.

4. Disconnect power to the battery charger.

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

6. Remove the four screws securing the top panel of the controller junction box and *carefully* lift the panel. Note connections to the panel and disconnect as necessary to access the inside of the junction box. See Figure 4-18.

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



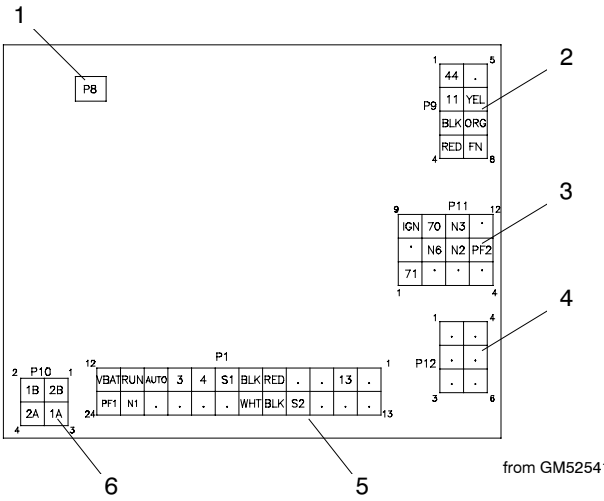
1. User interface membrane
2. Controller logic board location
3. Cover screws (qty. 4)

Figure 4-18 Controller in Junction Box

Logic Board Replacement Procedure

7. Note the connections on the logic board, and then disconnect. See Figure 4-19.

8. Pull the old board straight off the mounting standoffs.



1. P8 switch membrane connection
2. P9
3. P11 to engine harness and optional relay board, if equipped
4. P12 not used at this time
5. P1
6. P10

Figure 4-19 Controller Logic Board Connections

9. Check that the replacement board is positioned so that the display shows through the opening in the cover plate and then press the board onto the standoffs. Check that all corners are securely mounted.

10. Reconnect all cables and harnesses to the board. See the wiring diagram in Section 7 for connections.

    Note: Connector P12 on the logic board is not used at this time.

Replacing the user interface membrane

11. Disconnect the membrane ribbon cable from connector P8 on the logic board.

12. Carefully remove the membrane from the junction box cover.

13. Remove the protective backing to expose the adhesive on the new membrane.

14. Thread the new membrane's ribbon cable through the small rectangular opening in the cover. Line up the membrane window with the larger rectangular opening.

15. Press the membrane firmly into place.

16. Connect the ribbon cable to the P8 connector on the logic board.

17. Replace the junction box cover and tighten the four cover screws.

18. Verify that the generator set master switch is in the OFF position.

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

20. Reconnect power to the battery charger.

21. Replace the door and tighten the two door screws.

22. Replace the enclosure roof if it was removed.

23. Check settings and adjustments for the ADC-RES controller only:

    a. Follow the instructions in the generator set installation manual to change the new controller's configuration settings to match the generator set system voltage/frequency and unit configuration.

    b. Use a voltmeter to check the output voltage. Follow the instructions in Sections 4.5.4, Voltage and Frequency Adjustments, and 5.8, Voltage Adjustment, to adjust the output voltage and stability.

    c. Check the output frequency. Follow the instructions in Sections 4.5.4, Voltage and Frequency Adjustments, and 5.9.5, Frequency Adjustment, to adjust the output frequency and stability.

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

25. Close and latch the enclosure roof.

Notes

5.1 Theory of Operation

The generator set utilizes a rotating-field alternator to produce AC voltage. Upon activation of the generator master switch, 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 SCR module feeds rectified stator output current to the rotor through the brushes/slip rings to increase the strength of the rotor field. As the rotor field increases in strength, generator output also increases. The ADC-RES controller monitors the generator output voltage through leads 11 and 44 (single-phase) or leads V7, V8, and V9 (three-phase) and adjusts the DC current from the SCR module to the rotor to meet load requirements. See Figure 5-1.

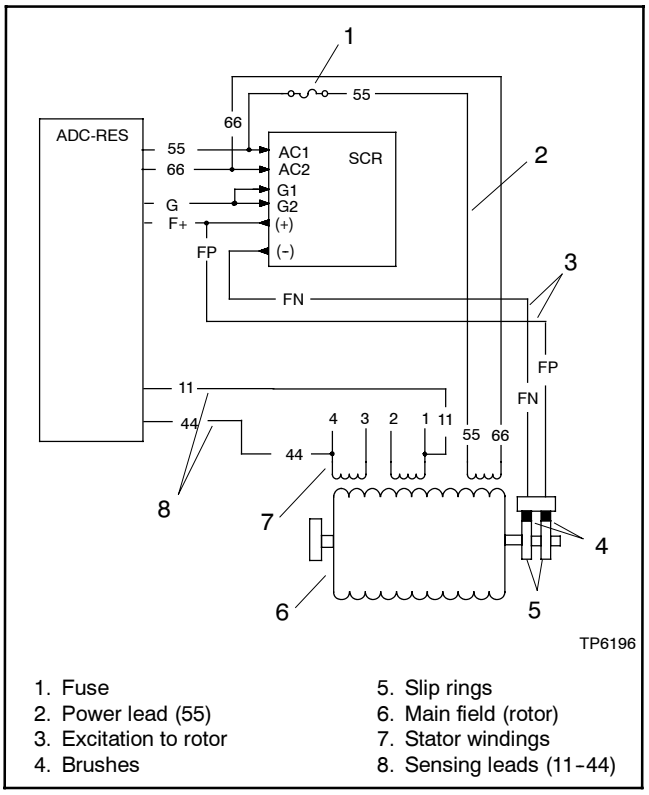


Figure 5-1 Single-Phase Generator Schematic

5.2 Separate Excitation

To determine the cause of no or low AC output, refer to the troubleshooting flowchart in Figure 5-2. Before beginning the test procedures, read all safety precautions at the beginning of this manual. Many of the test procedures include additional safety precautions.

Check the condition of the alternator fuse before performing the separate excitation procedure. The inline fuse is located in lead 55 on the controller. See Figure 5-1. 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 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. Centrifugal forces acting on the windings during rotation cause a broken circuit to open, or increasing temperatures cause the insulation to break down, resulting in a running fault. If this test shows that the rotor and stator are in good condition, test the voltage regulation using the tests in Section 5.7.

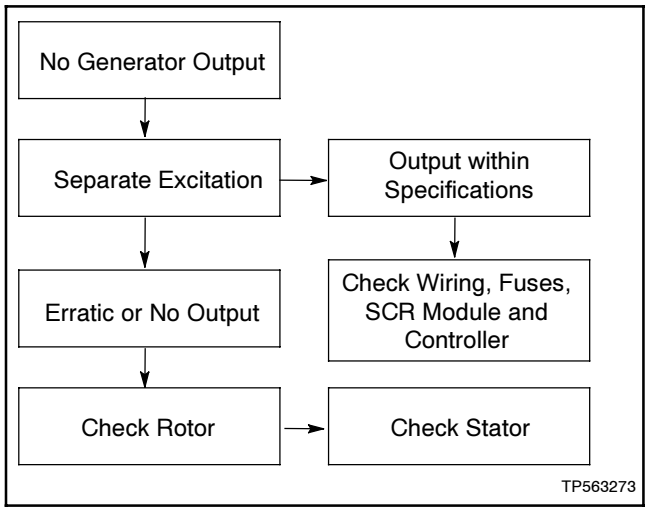


Figure 5-2 Generator Troubleshooting

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. Disconnect the black FN and FP leads from the alternator at the SCR module (+) and (–) terminals.

2. Connect a DC ammeter, 20-amp fuse, and a 12-volt automotive battery to the positive (FP) and negative (FN) brush leads as shown in Figure 5-3. 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 specified rotor resistance values.

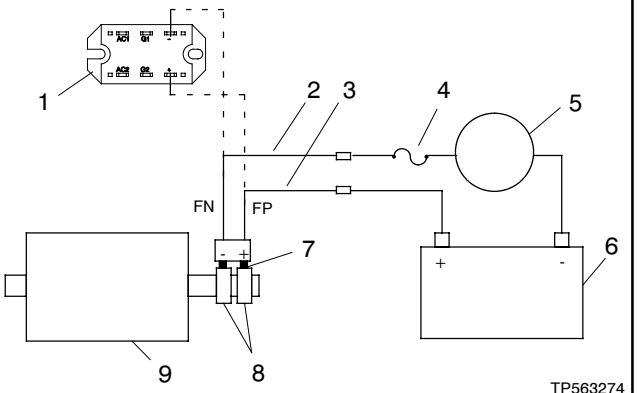
   Example:

   $$\frac{\text{12 volts (battery voltage)}}{\text{4 ohms (rotor resistance)}} = \text{3 amps (rotor current)}$$

3. Start the engine and check that the ammeter reading remains stable. An increasing meter reading indicates a shorted rotor. A meter reading decreasing to zero or an unstable reading suggests a running open. Refer to Section 5.4, Main Field (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 5.3, 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 5.3, 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 SCR module. See Section 4.8, Silicon Controlled Rectifier (SCR) Module. Check the controller settings and connections. See Section 4, Controller.



1. SCR module
2. FN lead disconnected from SCR
3. FP lead disconnected from SCR
4. 10-amp fuse
5. DC ammeter
6. 12V battery
7. Brushes
8. Slip rings
9. Main field (rotor)

Figure 5-3 Separate Excitation Connections

5.3 Stator

The stator contains a series of coils of wire laid in a laminated steel frame. The stator leads supply AC voltage to the load and voltage regulator. Before testing the stator, inspect it for heat discoloration and visible damage to housing lead wires, exposed coil windings, and exposed areas of frame laminations. Be sure the stator is securely fastened to the stator housing.

Note: Disconnect all stator leads before performing all stator tests.

⚠ 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.

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

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.

Stator Continuity and Resistance Tests

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Disconnect all stator leads before performing all stator tests.
5. To check for stator continuity, set the ohmmeter on R x 1 scale. First set the ohmmeter zero by holding the red and black meter leads together and setting the ohmmeter reading to zero. Then check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 5-4.

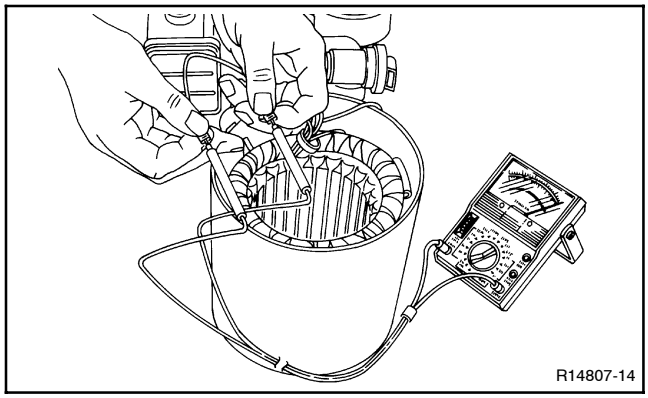


Figure 5-4 Testing Stator Windings

Note: For single-phase models. leads 1, 2, 3, and 4 are the generator output leads. Leads 11, 44, 55, and 66 are the controller and SCR module sensing and supply leads. Refer to the schematic in Figure 5-5 when performing the following steps.

Note: For three-phase models, leads 1-12 are the generator output leads. Leads V7, V8, V9, 55, and 66 are the controller and SCR module sensing and supply leads. Refer to the schematic in Figure 5-6 when performing the following steps.

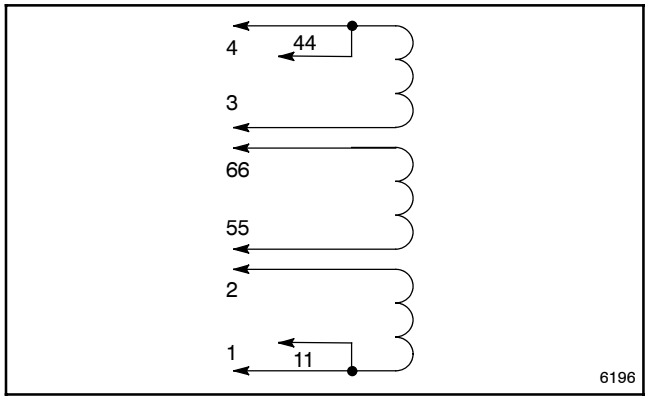


Figure 5-5 Single-Phase Alternator Stator Leads

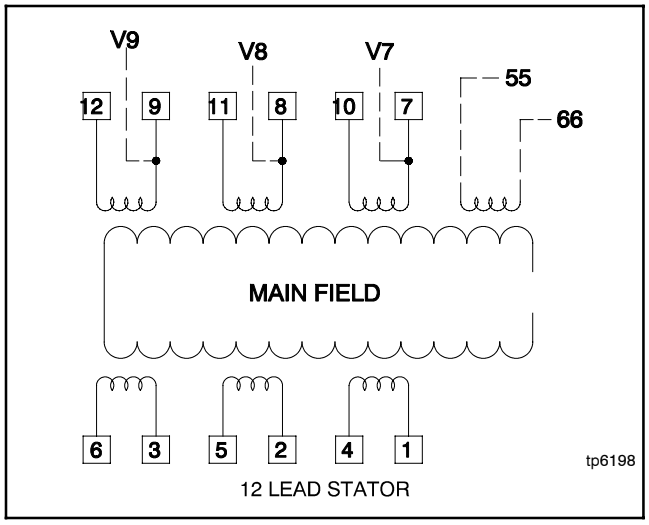


Figure 5-6 Three-Phase Alternator Stator Leads

6. Contact the ohmmeter leads and readjust the ohmmeter to read zero ohms.

7. Check the cold resistance of the stator windings by connecting the meter leads to stator leads 1-2, 3-4, and 55-66. See Section 1.5, Alternator Specifications, for stator winding resistances. Most ohmmeters do not provide accurate readings below 1 ohm. Low resistance readings (continuity) and no evidence of shorted windings (heat discoloration) indicate a stator in good condition. See Figure 5-7.

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 5-7 Continuity Test Results on a Good Stator (single-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 5-8 Continuity Test Results on a Good Stator (three-phase)

8. If the resistance test proves inconclusive, use a megohmmeter to test the stator as described in the next step.

   Note: Because ohmmeter accuracy varies, resistance readings are approximate readings. Take readings of the rotor and stator at room temperature.

   Note: Make sure that all stator leads are disconnected before running the megohmmeter test.

9. Use a megohmmeter to determine whether the stator is shorted to ground.

   a. Apply 500 volts DC to any stator lead and the stator frame. Perform the megohmmeter test following the instructions of the megohmmeter manufacturer.

   b. Repeat the test on the other stator leads until each coil is tested.

      Note: A reading of approximately 500 kOhms (1/2 megohm) and higher indicates a good stator.

   c. Repair or replace the stator if any reading is less than approximately 500 kOhms. A reading of less than 500 kOhms indicates deterioration of the winding insulation and possible current flow to ground.

5.4 Main Field (Rotor)

The two-pole rotor creates the magnetic field needed to produce alternating current in the stator windings. Before testing, inspect the rotor for visible damage to pole shoes, insulation, exposed coil windings, and slip ring surfaces. Rotate the bearing to check for wear, heat discoloration, or noise.

5.4.1 Rotor Continuity and Resistance Tests

⚠ 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.

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

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.

Rotor Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the brush cover from the alternator end bracket.
5. Check the rotor for continuity and resistance. Raise the brushes from the slip rings while performing ohmmeter tests. Measure the rotor resistance (ohms) between the two slip rings; see Figure 5-9. See Section 1.5 for rotor resistance readings. If the resistance readings are low, perform a megohmmeter test on rotor as described in the next step.

   Note: Because ohmmeter accuracy varies, resistance readings are approximate. Take readings at room temperature.

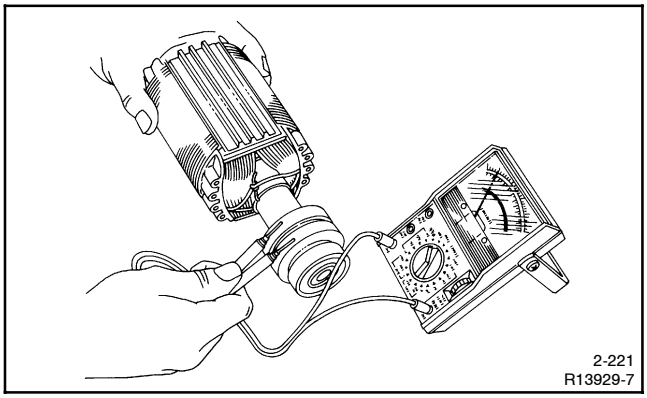


Figure 5-9 Rotor Resistance Check

6. Perform a megohmmeter test to determine whether the rotor is shorted to ground.

   a. Raise and secure the brushes away from the slip rings by inserting a retaining wire in the brush holder hole.

   b. Using a megohmmeter, apply 500 volts DC to one rotor slip ring and the rotor poles or shaft. Follow the instructions of the megohmmeter manufacturer when performing this test.

      Note: A reading of approximately 500 kOhms (1/2 megohm) or higher indicates a good rotor.

   c. Repair or replace the rotor if the reading is less than approximately 500 kOhms. A reading of less than 500 kOhms indicates deterioration of the winding insulation and possible current flow to ground.

   d. Following the test, remove the retainer wire from the brush holder and check the brush positions on the slip rings. See Section 5.6, Brushes.

   e. Reinstall the brush cover on the end bracket.

5.5 Slip Rings

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.

5.6 Brushes

The brushes transfer current from the SCR module to the slip rings. The brushes should last the life of the generator. However, abrasive dust on the slip rings shortens the life of the brushes.

Excessive arcing at the brushes could damage the SCR module and the 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 5-10 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.

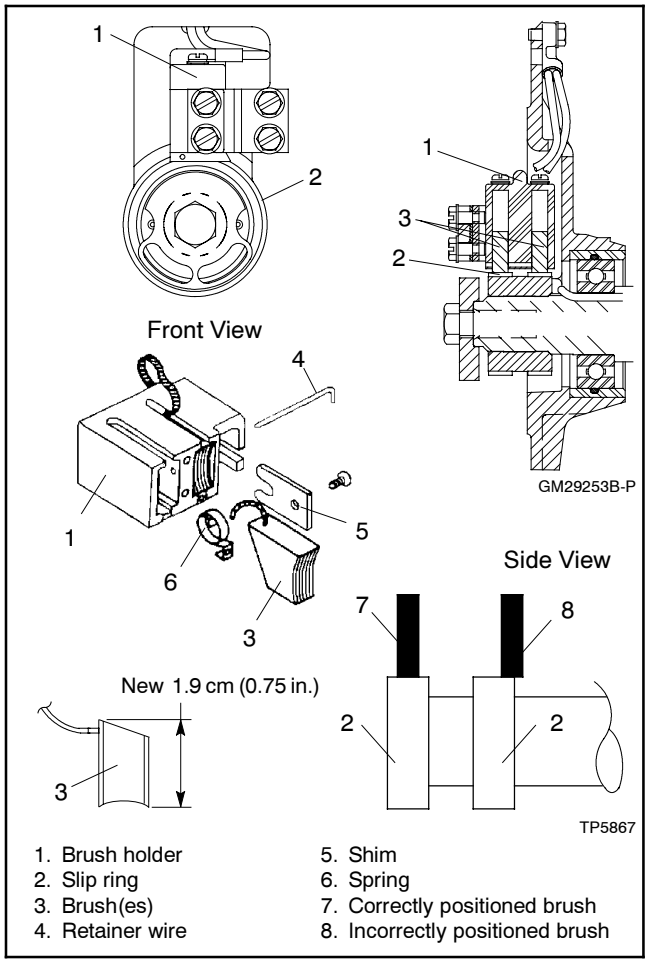
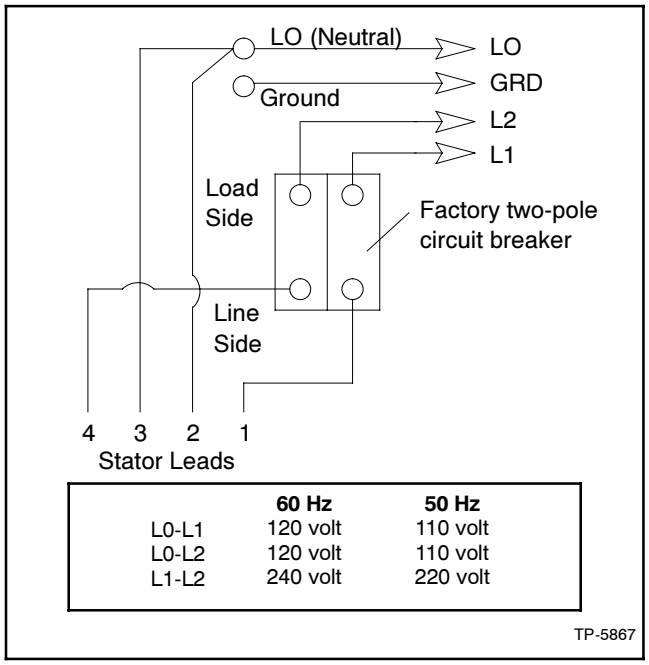


Figure 5-10 Brush Assembly

5.7 Voltage Connections

5.7.1 Voltage Connections, Single-Phase Models

Single-phase generator sets are available from the factory connected for 110/220 volt 50 Hz or 120/240 volt 60 Hz. See Figure 5-11 for the factory connections. Generator sets are not reconnectable.



	60 Hz	50 Hz
L0-L1	120 volt	110 volt
L0-L2	120 volt	110 volt
L1-L2	240 volt	220 volt

Figure 5-11 110/220 and 120/240 Volt, 3-Wire Configurations

5.7.2 Voltage Connections, 3-Phase Models

Three-phase model TRES generator sets are connected for 230/400 Volts, 50 Hz. See Figure 5-12 for the factory connections. The generator sets are not reconnectable.

Note: Current transformers (CTs) shown in Figure 5-12 are not used on these models.

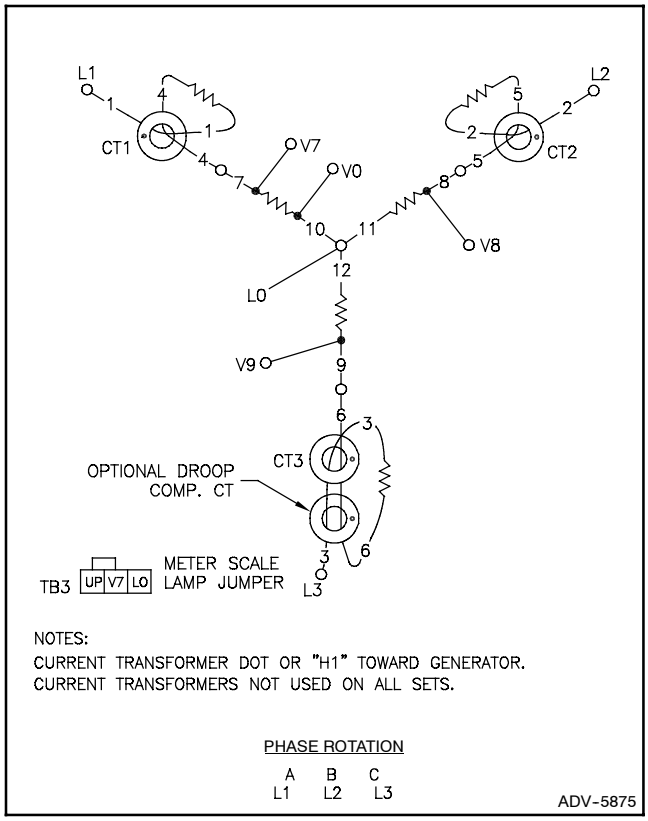


Figure 5-12 3-Phase Configuration

5.7.3 Voltage Regulation

Voltage regulation is performed by the controller and the SCR module. The controller monitors generator output voltage and adjusts the excitation current to the rotor through the SCR module. See Section 4.8, Silicon Controlled Rectifier module.

5.8 Voltage Adjustment (ADC-RES only)

The factory sets the voltage for correct generator operation under a variety of load conditions. Usually, the voltage needs no further adjustment.

Adjust the voltage when necessary according to the following procedure. The adjustment procedure requires a meter that can measure voltage and frequency.

Use the ADC-RES controller keypad to adjust the voltage, gain, and volts/Hz. This section contains instructions to adjust each setting and save the changes using the controller keypad.

Note: The controller will time out and exit the adjustment mode after approximately 1 minute if no buttons are pressed. Any unsaved changes are discarded if the controller times out before the settings are saved. Refer to Section 4.5 for instructions to save your settings.

Voltage Adjustment. Adjusts generator output between 100 and 130 volts.

Gain (Stability) Adjustment. Fine tunes regulator circuitry to reduce light flicker.

Volts/Hz Adjustment (voltage droop). Determines frequency (Hz) at which generator output voltage begins to drop. The controller maintains generator output at the specified voltage under load until the generator engine speed drops to a preset level (see Figure 5-16 for cut-in frequencies). Then the controller allows the generator voltage and current to drop. The voltage/current drop enables the engine to pick up the load. When the generator speed returns to normal (60 Hz or 50 Hz) as load is accepted, the generator output also returns to normal. See Section 5.8.2 for instructions to adjust the voltage droop.

⚠ 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.

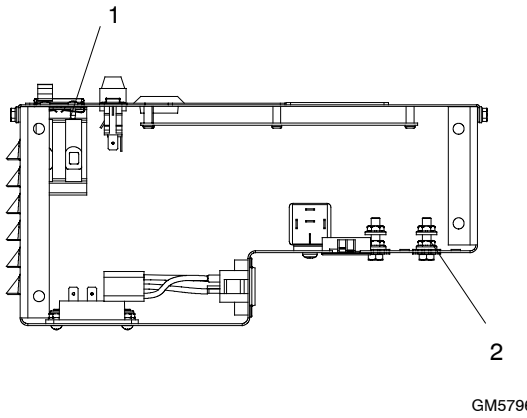
Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

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.

5.8.1 Voltage Adjustment Procedure

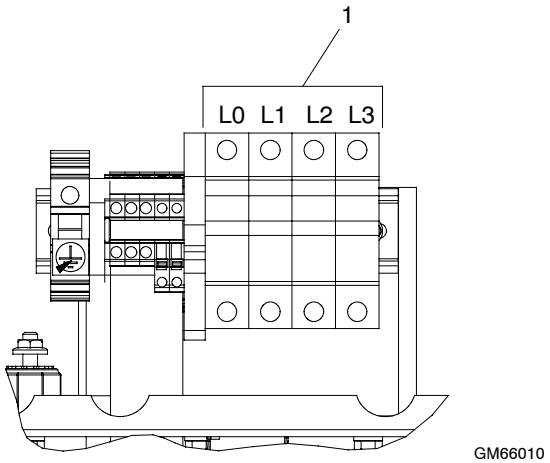
Refer to Figure 5-19 through Figure 5-21 during the adjustment procedure.

1. Connect a digital voltmeter from one side of the circuit breaker (L) to the L0 terminal inside the controller assembly. See Figure 5-13. For 3-phase models. connect the voltmeter from L0 to L1, L2, or L3 on the circuit breaker. See Figure 5-14. Set the meter to measure AC volts.



1. Line circuit breaker (L)
2. Terminal L0

Figure 5-13 Circuit Breaker and L0 Terminal Location, Single-Phase Models



1. Measure voltage across circuit breaker terminals L0 and L1, L2, or L3

Figure 5-14 Voltage Measurement, Three-Phase Models

2. Start the generator set.

3. Follow the controller instructions in Figure 5-19 to enter the adjustment mode. Increase or decrease voltage (parameter 1P) until the output reaches the desired voltage. See Figure 5-15.

Models	Voltage Measurement	Approximate Voltage, VAC
1 phase, 60 Hz	L – L0	120
	L - L	240
1 phase, 50 Hz	L – L0	115
	L - L	230
3 phase, 50 Hz	L – L0	230
	L - L	400

Figure 5-15 Voltage Measurement

4. Follow the controller instructions to step to the voltage gain (parameter 2P) adjustment menu. Adjust the voltage gain (2P) until the light flicker minimizes. Save the settings. See Figure 5-21.

5. Check and readjust the voltage if necessary.

6. Set the voltmeter to measure frequency. Adjust the engine speed to the cut-in frequency shown in Figure 5-16 by adjusting the engine governor speed (parameter 4P) through the ADC controller. See Figure 5-20.

Frequency	Cut-In Frequency
60 Hz	57.5 Hz
50 Hz	47.5 Hz

Figure 5-16 Cut-In Frequencies

7. Set the voltmeter to measure voltage. Adjust the volts/Hz (parameter 3P) until the voltage level measured by the voltmeter begins to drop. When set, the generator (as load is applied) attempts to maintain normal output until the engine speed drops below the cut-in frequency set in step 6.

   Note: See Section 5.8.2 for more information about the volts/Hz (droop) adjustment.

8. Set the voltmeter to measure frequency. Adjust the engine speed to the operating frequency (50 or 60 Hz) by adjusting the engine governor speed (parameter 4P) through the ADC controller.

9. Readjust the voltage gain (parameter 2P) until the light flicker minimizes, if necessary.

10. Check the voltage. Readjust the voltage (parameter 1P), if necessary.

11. Save the settings. Refer to Figure 5-21 for instructions.

    Note: The controller will revert to the previous settings at the next startup if the changes are not saved.

12. Stop the generator set.

5.8.2 Volts per Hertz (Hz) Adjustments (Droop)

Refer to Section 5.8 and the instructions in the generator set installation manual to adjust the volts/Hz using controller parameter 3P.

When the frequency falls below the cut-in frequency (see Figure 5-17), output voltage is reduced to relieve the engine. The magnitude of the voltage reduction is set by the 3P parameter. Monitor engine speed and output voltage as loads are applied.

- If there is excessive droop in engine speed and little droop in voltage, increase the 3P value.
- If there is little engine speed droop but excessive voltage droop, decrease the 3P value.
- Readjust the voltage stability (2P) and voltage (1P) parameters after adjusting the 3P setting, if necessary.
- Remember to save your settings.

Frequency	Cut-In Frequency
60 Hz	57.5 Hz
50 Hz	47.5 Hz

Figure 5-17 Cut-In Frequencies

Each step of 3P changes the amount of voltage droop approximately 0.5% of system voltage for each cycle (Hz) below the cut-in frequency. See Figure 5-18.

3P	Voltage Droop, % of System Voltage per 1 Hz Cycle Below Cut-In Frequency
0	0
1	0.5%
2	1.0%
3	1.5%
4	2.0%
5	2.5%
6	3.0%
7	3.5%
8	4.0%
9	4.5%

Figure 5-18 Voltage Droop Adjustments

Output Voltage and Frequency Adjustment Mode:

Display :*

Move the generator set master switch to the RUN position. The generator set engine starts and the controller display shows the engine runtime hours.

Display: X X X X

Hold:

Wait about 5 seconds until the display changes from runtime hours to the program version number.

Display: X. X X

Press the down arrow key and then the up arrow key 3 times to enter the adjustment mode. (This is the controller "password.")

Display: 1 P X X

The controller is now in the voltage coarse adjustment mode.

Press:

or — To raise or lower the voltage in large increments (approximately 5–7 volts per step). (Parameter 1P)

Display: 1 P X X

To enter fine voltage adjustment mode.

or — To raise or lower the voltage in smaller increments (approximately 0.5–0.7 volts per step). (Parameter 1P)

Display: 1 P X X

To enter coarse voltage stability (gain) adjustment mode.

Display: 2 P X X

or — To raise or lower the voltage stability (gain) in large increments. (Parameter 2P)

To enter fine voltage stability (gain) adjustment mode.

Display: 2 P X X

or — To raise or lower the voltage stability (gain) in smaller increments. (Parameter 2P)

To enter volts/Hz adjustment mode. (Parameter 3P)

Display: 3 P X X

or — To raise or lower the volts/Hz: 00=low; 09= high

Continued on Figure 5-20.

* Shaded boxes show which character in the controller display changes for each adjustment. *X* in the examples above denotes any number from 0 to 9. The actual values may vary from model-to-model.

TP6196

Figure 5-19 Output Voltage and Frequency Adjustments

Continued from Figure 5-19:

Press:			Display : *
		To enter engine governor speed coarse adjustment mode. (Parameter 4P)	4 P x x
	or 	To raise or lower the engine speed in large increments.	
		To enter engine governor speed fine adjustment mode. (Parameter 4P)	4 P x x
	or 	To raise or lower the engine speed in smaller increments.	
		To enter engine governor stability (gain) coarse adjustment mode. (Parameter 5P)	5 P x x
	or 	To raise or lower the engine governor stability (gain) in large increments.	
		To enter engine governor stability (gain) fine adjustment mode. (Parameter 5P)	5 P x x
	or 	To raise or lower the engine governor stability (gain) in smaller increments.	
		To enter SAVE mode. Go to Figure 5-21.	S A V E

Note: Be sure to save your settings before exiting the configuration mode. The controller reverts to the last *saved* settings when the master switch is moved to the OFF/RESET position.

* Shaded boxes show which character in the controller display changes for each adjustment. *X* in the examples above denotes any number from 0 to 9. The actual values may vary from model-to-model.

Figure 5-20 Output Voltage and Frequency Adjustments, Continued

There are 3 options when the display says SAVE:
Press:

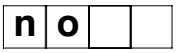
To return to the first parameter, coarse voltage adjustment, to check or change settings before saving. See Figure 5-19.

or

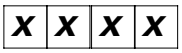
To save changes.

or

To discard changes without saving.



"Yes"or "no" flashes when the up or down arrow is pressed and then the controller exits the configuration mode. The display returns to the runtime hours.



Now move the master switch to OFF/RESET.

Figure 5-21 Save Mode

5.9 Governor System

The governor system consists of an electromechanical stepper motor (actuator) and a magnetic pickup. The ADC-RES controls the governor system operation. See Section 7, Wiring Diagrams, for the governor connections.

5.9.1 Operation

The frequency of the alternator output is determined by the speed of the engine. A two-pole alternator must be driven at 3600 rpm to provide 60 Hertz. (A 50 Hz model must be driven at 3000 rpm.) The engine speed is maintained by an electronic governor system that consists of a magnetic pickup and electric actuator (stepper motor). The governor system is controller by the generator set controller.

The magnetic pick-up, which monitors the speed of the flywheel ring gear, provides the speed reference signal to the controller. The controller provides regulated power to the bidirectional stepper motor actuator, which is linked to the carburetor throttle arm.

At cranking speed a properly adjusted pick-up should produce a minimum of 1.75 VAC. The magnetic pick-up air gap is factory-set to 0.5 mm (0.020 in.). Failure or loss of the input speed signal from the magnetic pick-up will result in erratic speed.

A setting on the ADC-RES allows adjustment of the engine speed. See Section 5.9.3.

A gain adjustment may be required if an unstable (hunting/surging) condition occurs. Adjusting the gain may require readjustment of the engine speed. See Section 5.9.3.

5.9.2 Initial Checks and Operation Test

The factory sets the electronic governor. Under normal circumstances the electronic governor requires no further adjustment. Verify that the governor stepper motor moves smoothly and steadily during operation. If the engine operates erratically check the following connections and conditions *before* adjusting the governor.

- Verify that the electrical connections are clean and tight.
- Check the magnetic pickup connections. Poor connections may cause an erratic signal or an overspeed condition. An erratic signal causes the generator set to govern poorly but not shut down.
- Verify that the battery connections are clean and tight.
- Check for dirt buildup on the magnetic pickup. Metal filings or caked-on dirt or grease decreases the output signal of the magnetic pickup.
- Check for a loose or worn stepper motor/throttle shaft coupling. Replace the shaft and bushing every 500 hours of engine operation.
- Check the carburetor for dirt, grime, or misadjustment. Check for a loose mixer assembly.
- Check the idle-adjustment screw. The screw should not prevent the throttle plate from closing completely.
- Check the throttle linkage for any binding, dirt, damage, or other visible problems.
- Check for electronic governor faults. The fuel shutoff solenoid deenergizes and the generator set shuts down under the following conditions:
  - Closed throttle
  - Engine overspeed
  - Broken fuel shutoff solenoid lead
  - Broken stepper motor leads (erratic performance)
  - Failed actuator linkage (erratic performance)

5.9.3 Hunting/Surging

Often hunting/surging problems thought to be caused by the governor are actually caused by engine or carburetor problems. Check engine speed stability using the following procedure before testing the governor.

⚠ WARNING

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

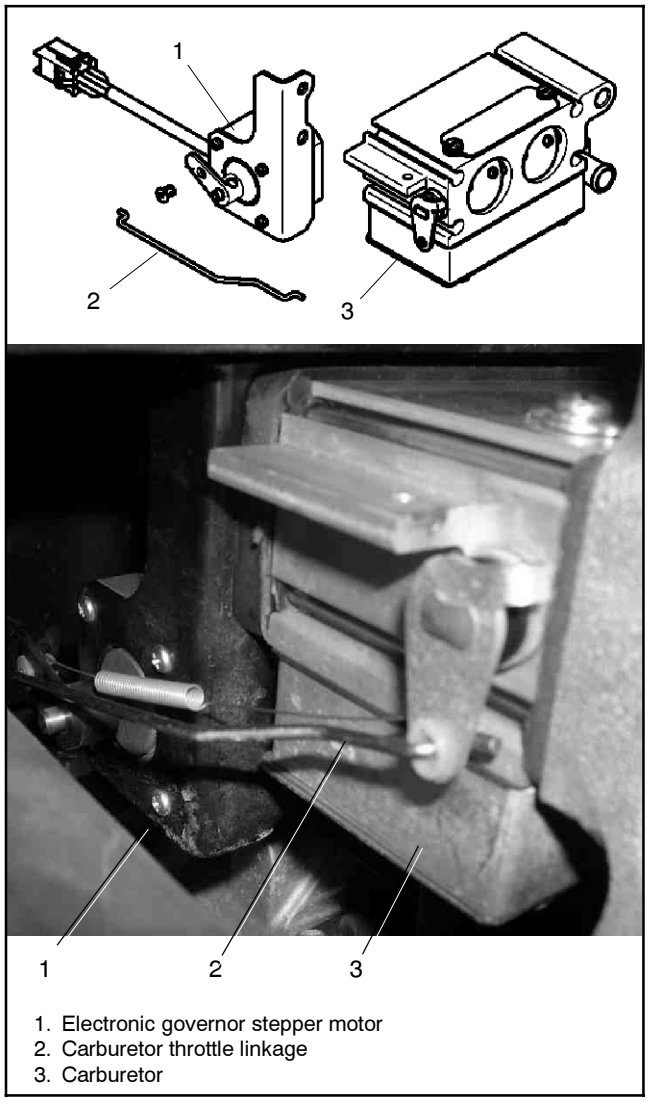
Do not work on the generator set until it cools.

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.

1. Open the generator set line circuit breaker.
2. Start the generator set.
3. Hold the throttle linkage steady while the engine is running. See Figure 5-22. If the engine runs at a steady speed with no hunting or surging when the throttle is held steady, then the hunting/surging

problems during operation are probably caused by the governor. Proceed to Section 5.9.4.

4. If the engine speed hunts or surges while the throttle is held steady, check the carburetor and engine operation. Refer to the engine service manual for engine diagnostic and service information.



1. Electronic governor stepper motor
2. Carburetor throttle linkage
3. Carburetor

Figure 5-22 Stepper Motor and Carburetor

5.9.4 Governor System/Magnetic Pickup Operation Test

If the engine continues to operate erratically after the previous checks, test the governor system operation using the following procedure. The procedure is summarized in the flowchart in Figure 5-23.

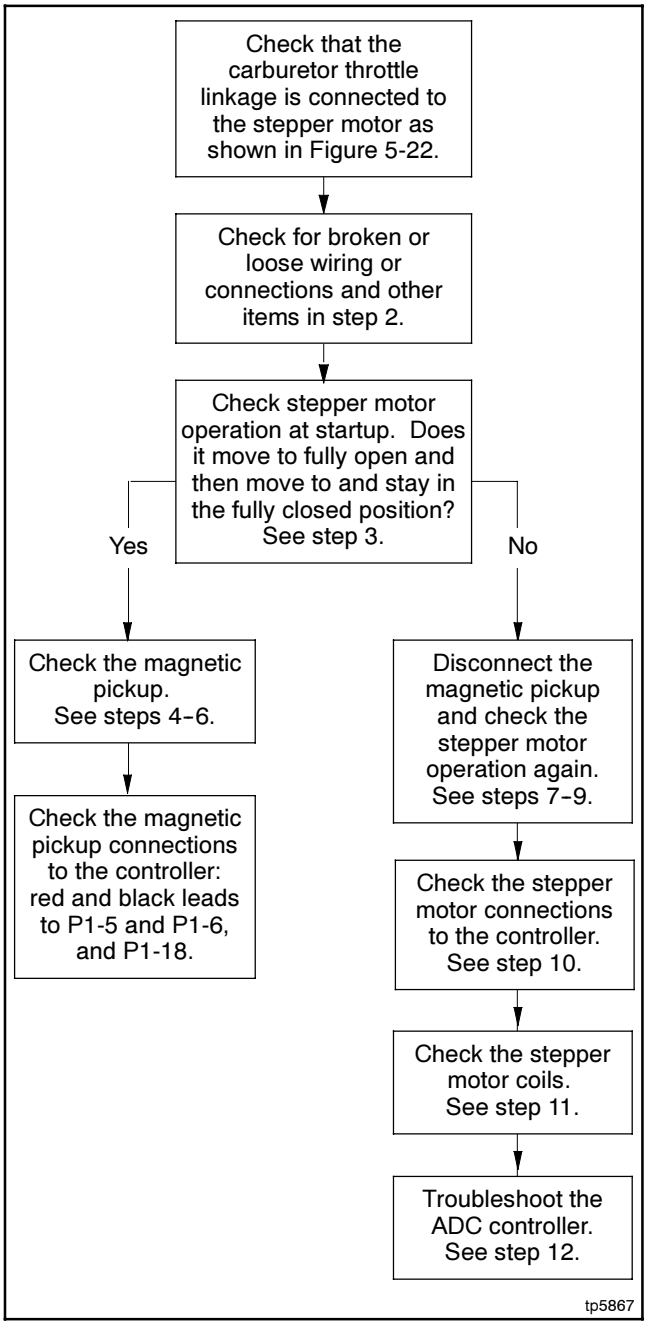


Figure 5-23 Governor System Operation Test Procedure Summary (Section 5.9.4)

Governor System Operation Test Procedure

1. Verify that the carburetor throttle linkage is connected to the stepper motor as shown in Figure 5-22.

2. Look for broken or loose wiring or plug connections if the stepper motor moves erratically. Check the condition of the throttle linkage, and verify that the throttle plate closes completely.

3. Check the operation of the stepper motor at startup.

   a. If the throttle moves to the fully open throttle position and then steps to and remains in the fully closed position, the engine speed input is probably missing. The engine starts and then shuts down on an overspeed fault. Proceed to step 4 to check the magnetic pickup.

   b. If the throttle linkage moves erratically or not at all at during startup, proceed to step 7 to check the stepper motor.

4. Verify the operation of the magnetic pickup by connecting a voltmeter to the magnetic pickup leads. See Figure 5-24.

   If the air gap is correct, the voltage should be 1.75 volts AC minimum during engine cranking.

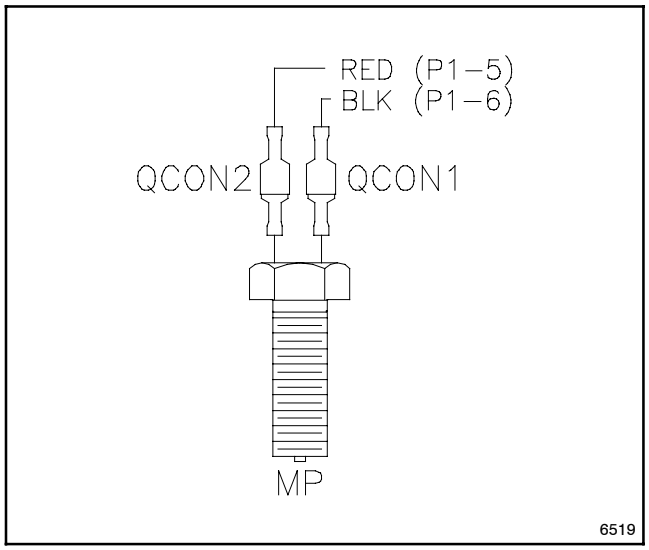
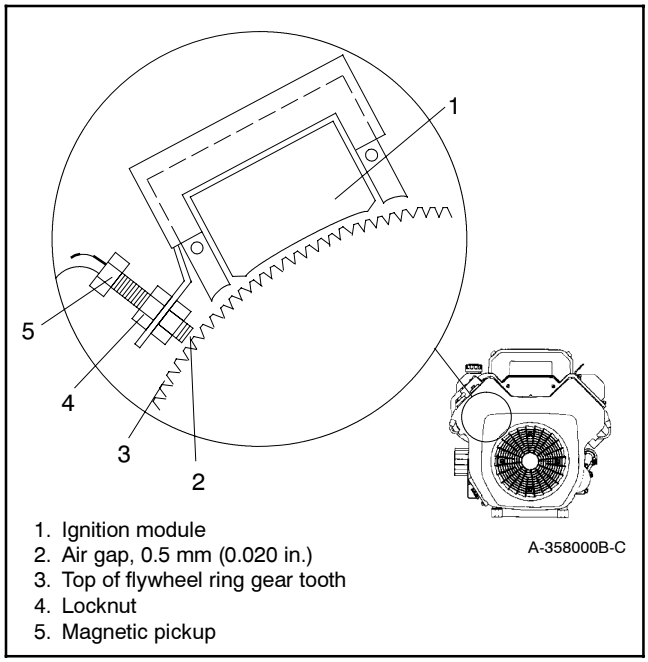


Figure 5-24 Magnetic Pickup Leads

5. If the voltmeter displays less than 1.75 volts AC, check the air gap as described in the following steps before replacing the sensor. Verify that the magnetic pickup air gap is 0.5 mm (0.020 in.). Measure the air gap at 3 or 4 places to get an accurate reading. See Figure 5-25.



1. Ignition module
2. Air gap, 0.5 mm (0.020 in.)
3. Top of flywheel ring gear tooth
4. Locknut
5. Magnetic pickup

Figure 5-25 Magnetic Pickup Air Gap

   a. Stop the generator set. Remove housing panels as required to gain access to the front of the engine.

   b. Remove the engine blower housing.

   c. Use a feeler gauge to check the gap. The gap should be 0.5 mm (0.020 in.).

   d. Adjust the air gap, if necessary, by loosening the locknut and turning the pickup. See Figure 5-25.

   e. Hold the pickup in position and retighten the locknut.

   f. Verify the magnetic pickup air gap after tightening the locknut.

   g. Reinstall the engine blower housing.

   h. Reinstall the junction box and housing panels removed to gain access to the front of the engine.

6. After adjusting the air gap, check the voltage again as described in step 4. If the voltage does not measure 1.75 VAC minimum, replace the magnetic pickup.

7. To test controller's governing function, disconnect the magnetic pickup leads and open the generator set circuit breaker.

8. Manually move the throttle shaft/governor stepper motor fully counterclockwise (closed throttle).

9. Start the generator set. The stepper motor should step clockwise to the wide open throttle position. The stepper motor should remain in the clockwise (throttle fully open) position. If the stepper motor does not operate as described here, proceed to the next steps to check the governor and stepper motor.

10. Place the generator set master switch in the OFF position. Check the stepper motor connections to the controller. See the wiring diagrams in Section 7.

11. Check the stepper motor coil resistance across pins 2 and 3 and across pins 1 and 4. Only two stepper motor leads of each coil group are used (BLK-YEL and RED-WHT). See Figure 5-26. The resistance per half coil is 38.5 ohms. If one of the coils has a significantly higher resistance or is shorted, replace the stepper motor.

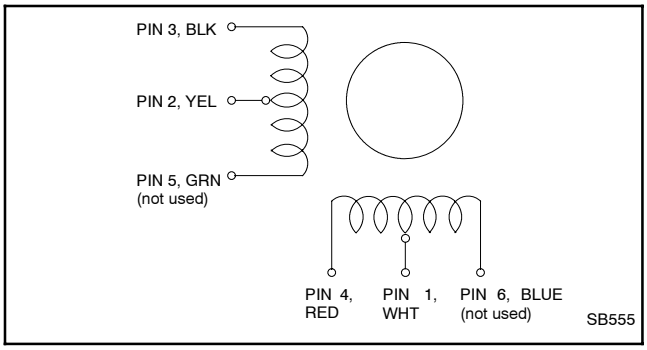


Figure 5-26 Actuator Coil Group

12. If there is power and a good ground connection to the controller and the stepper motor coil resistances are good, but the stepper motor does not operate as described in step 9, the problem is with the ADC controller. Check controller connections, fuses, wiring, and settings. Refer to the troubleshooting procedures in Section 3.

5.9.5 Frequency Adjustment

The engine speed determines the generator output frequency; 60 Hz units operate at 3600 rpm and 50 Hz units run at 3000 rpm. Adjust the engine governor to change the output frequency using the following procedure.

Note: Engine governor speed (frequency) and gain adjustments are made using the ADC controller. See Section 5.8 for instructions.

Frequency Adjustment Procedure

1. Open the generator set line circuit breaker.
2. Attach a frequency meter to the AC output leads.
3. Start and run the generator set until it reaches normal operating temperature (at least 10 minutes).
4. Use the ADC-RES controller to adjust the electronic governor speed (parameter 4P) to obtain a frequency reading of 60 Hz (or 50 Hz on 50 Hz models).

   Note: Often hunting/surging problems thought to be caused by the governor are actually caused by engine or carburetor problems. If the generator set speed is unstable, hunts, or surges, check for the cause using the procedure in Section 5.9.3 before proceeding.

5. Check stability with the generator set running and with no load applied. If the generator set speed is unstable, hunts, or surges, use the ADC controller to decrease the gain (parameter 5P) until the generator set becomes stable with no hunting or surging. Observe the frequency reading.
6. Repeat steps 4 and 5 to obtain the rated frequency and stable operation.
7. Save the settings. Refer to Section 5.8 for instructions.

   Note: The controller will revert to the previous settings at the next startup if the changes are not saved within one minute after the last change.

8. Apply rated load to the generator set and observe the frequency reading. The no load and full load frequencies should be within 0.4 Hz of the rated generator frequency; if not, check that the carburetor throttle plate opens completely without sticking and check the carburetor adjustment. If these procedures do not correct the problem, replace the controller.
9. Check for hunting and surging at full load. Use the controller to increase the gain (parameter 5P) until the engine hunts and surges. Then decrease the gain in small steps using the governor gain fine adjust parameter until the engine operation stabilizes. Save the controller changes.
10. Remove the load and observe the frequency. The frequency should return to the value stated in step 4. Gain adjustment may affect the generator set speed/frequency. If the frequency has changed, repeat step 4.

    Note: Speed adjustments have no effect on gain adjustments. It is not necessary to repeat the gain adjustments (steps 5 and 8) after adjusting the engine speed.

Check the overspeed shutdown operation when investigating a shutdown problem. See Section 5.10.1 for the overspeed shutdown test procedure.

5.10 Fault Shutdown Tests

Verify the operation of the generator set overspeed, overcrank, 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.

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.

5.10.1 Controller Fault Shutdown Functions

Check the operation of the fault functions programmed in the ADC-RES by performing the following tests. If the ADC-RES does not operate as described, check the controller configuration settings; see Section 4.5.1. Also check the controller wiring and connections.

Overspeed Shutdown

The overspeed setting is factory-set and is not adjustable. Verify that the following controller configuration parameters are set correctly for your unit. See the generator set installation manual for the settings.

- System voltage/frequency parameter (UU)
- Unit configuration parameter (UC)

⚠ 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.

Open the generator set output circuit breaker before beginning the test. (See Figure 4-1 for the circuit breaker location.)

Connect a DVM to measure the output frequency. Start the generator set and manually adjust the engine speed by moving the throttle linkage.

Note: Be careful not to touch the hot silencer when reaching in to adjust the throttle linkage.

Increase the engine speed (parameter 4P) 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 (OS). If the overspeed shutdown does not operate, the generator set should shut down on an overfrequency fault (OF) after approximately 5 seconds.

If the controller does not indicate an overspeed fault (OS), check the wiring to the magnetic pickup (red and black leads, P1-5 and P1-6). Check the magnetic pickup air gap and voltage output; see Section 5.9.4.

Low Oil Pressure (LOP) Shutdown

Connect a jumper wire from the LOP switch (lead 13) 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 switch 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 starter motor lead at the starter solenoid (K20) terminal. Move the controller master switch to the RUN position. 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 P1-18 and P1-19. 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.

5.10.2 Fault Shutdown Switches

Check the low oil pressure and high engine temperature shutdown 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.

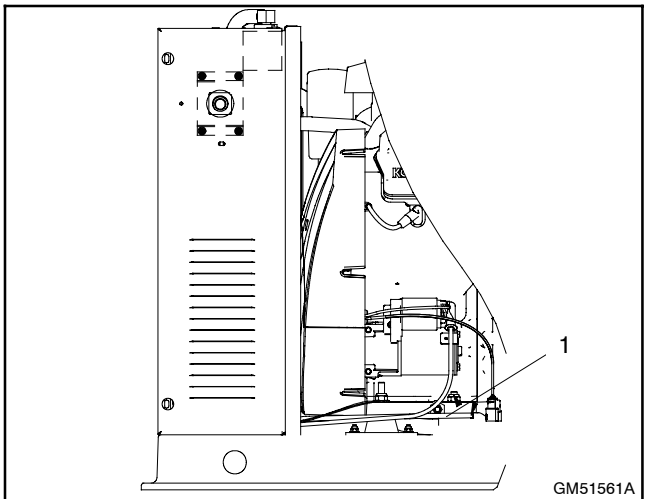
Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

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.

Temperature Sensor (CTS)

The coolant temperature sensor (CTS) is used to monitor engine temperature for the high engine temperature fault shutdown (HE). See Figure 5-27 for the coolant temperature sensor location. Set the generator set master switch to the OFF position 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 5-28. If the resistance is very low (indicated a short circuit) or very high (indicating an open circuit) replace the CTS.

Note: The CTS switch is located in the engine oil pan. Drain the engine oil before removing the switch.



1. CTS location

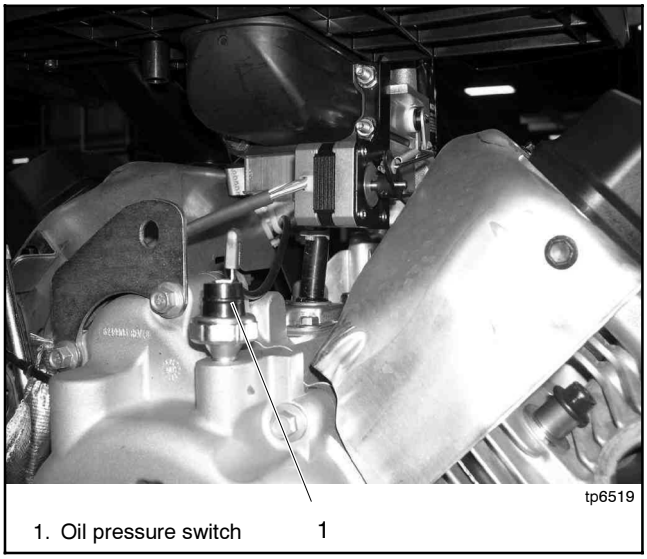
Figure 5-27 CTS Location

Temperature, °C (°F)	Resistance, Ohms
30 (86)	2100–2400
100 (212)	180–200

Figure 5-28 Coolant Temperature Sensor Resistance Readings

Low Oil Pressure (LOP) Switch

The low oil pressure (LOP) switch is located under the engine air cleaner. See Figure 5-29.



1. Oil pressure switch

Figure 5-29 Oil Pressure Switch Location (under the air cleaner)

Remove the LOP switch and install an oil pressure gauge to verify that the engine oil pressure is within the range specified in Section 1, Specifications, before testing or replacing the LOP switch. To test the LOP switch, reinstall the switch and start the generator set. If the unit shuts down, disconnect lead 13 from the LOP switch and reset the controller. Restart the generator set and verify that it does not shut down. A successful restart indicates a faulty LOP switch. Replace switch.

5.11 Generator Set Master Switch

The generator set master switch is a three-position (RUN\OFF/RESET\AUTO) rocker switch. The leads connecting to the master switch are labeled RUN, VBAT, and AUTO. Check that the three connectors are connected to the terminals on the back of the switch as shown in Figure 5-30. Be careful not to reverse the RUN and AUTO leads.

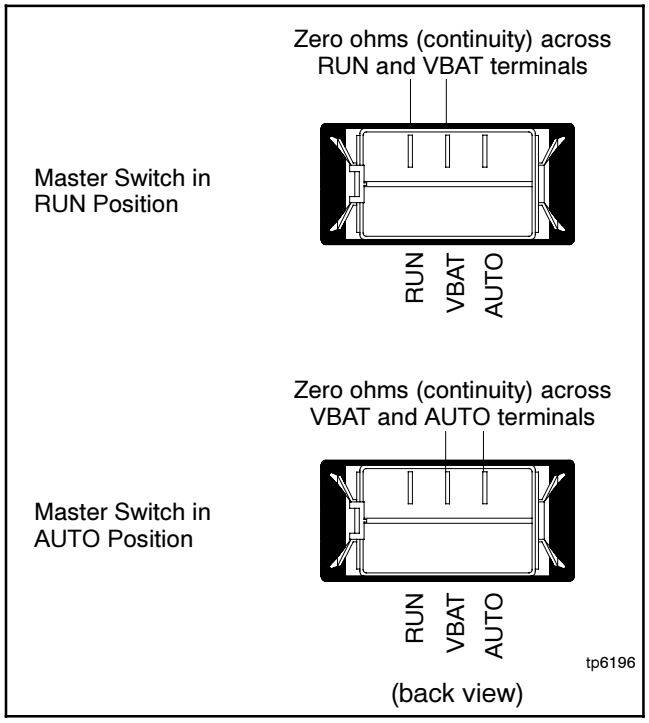
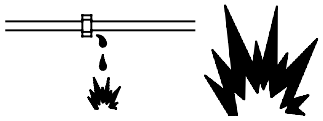


Figure 5-30 Generator Set Master Switch Continuity Checks

5.12 Fuel Systems

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

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

The fuel supplier provides and maintains manual shut-off valves and the primary regulator. See the generator set installation manual for fuel pipe size recommendations. Verify that the fuel system capacity is adequate to supply the generator set plus all other gas appliances.

A factory-installed secondary regulator and 12 VDC solenoid valve are located in the front inlet air compartment. The controller energizes the fuel solenoid valve to open at startup and deenergizes the valve to close at shutdown. The secondary fuel regulator reduces fuel pressure for delivery to the fuel block. The fuel flows from the fuel block to the carburetor in a gaseous state. The carburetor mixes the fuel with intake air for consumption by the engine.

Refer to the troubleshooting instructions in Section 3, Troubleshooting, to identify generator set operation problems that may be caused by an inadequate fuel supply, incorrect adjustments, or damaged fuel system components. Then use the instructions in this section to check fuel system components.

5.12.1 Fuel Solenoid Valve

A solenoid valve upstream of the regulator and the flexible fuel connector provides automatic fuel on/off control. The engine starting battery powers the solenoid valve and the engine starting controls open the valve when the engine cranks or runs.

Gas Valve Operation Test Procedure

1. Disconnect the positive (+) battery lead from the gas valve terminal.
2. Apply 12 VDC to the gas valve terminal and listen for an audible click, indicating that the valve actuates.
3. Replace the gas valve if it does not actuate in step 2.

5.12.2 Fuel Regulators

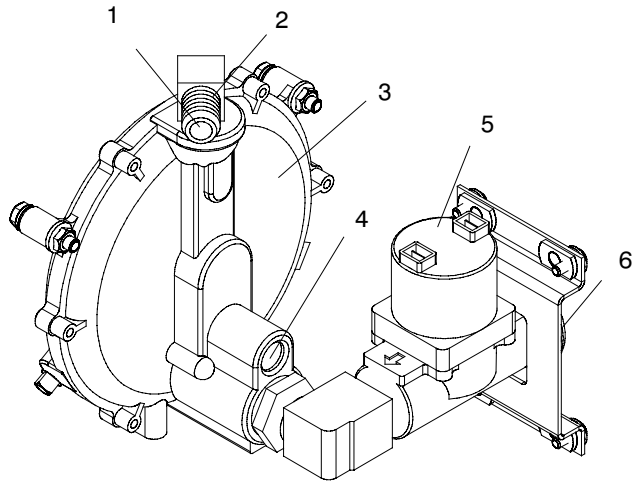
The typical gaseous fuel system uses two regulators. The primary regulator reduces the line pressure to an allowable inlet pressure for the secondary regulator. The fuel supplier provides and maintains the primary regulator. The secondary regulator is factory-installed on the generator set and is designed for a maximum inlet pressure of 2.7 kPa (6 oz./in.^{2}) or 280 mm (11 in.) water column.

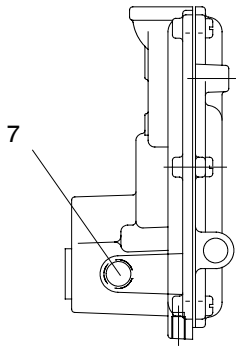
Note: Do not attempt to adjust the fuel mixture or engine speed by adjusting the regulators.

The fuel lockoff prevents fuel flow when the engine is not operating. See Figure 5-31. Do not try to adjust the fuel pressure, fuel mixture, or engine speed using the fuel lockoff.

Checking the Fuel Pressure

Use a gauge or manometer to check the fuel pressure at the secondary regulator inlet. See Figure 5-31. Measure the fuel pressure with the generator set running at rated load. The fuel pressure should be 178–280 mm (7–11 in.) water column or 1.7–2.7 kPa (4–6 oz./in.^{2}). Contact the fuel supplier if the inlet pressure is not within the specified range.





Regulator, side view

TP-6519

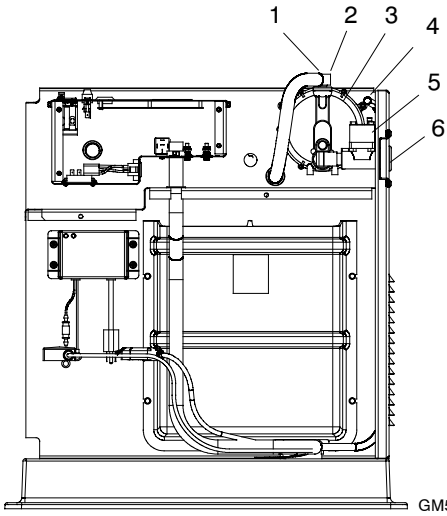
1. LP orifice fits inside hose fitting
2. Hose fitting
3. Secondary regulator
4. Fuel lockoff *(do not adjust)*
5. Fuel solenoid valve
6. Fuel inlet, 1/2 in. NPT
7. Inlet pressure check location

Figure 5-31 Fuel Regulator with LP Orifice and Fuel Solenoid Valve

5.12.3 Fuel Conversion

The multi-fuel system allows conversion from natural gas to LP vapor (or vice-versa) in the field while maintaining emissions-standard compliance. A trained technician or an authorized distributor/dealer can convert the fuel system.

For LP vapor fuel, an orifice is used in the fuel line. The unit is typically shipped set up for natural gas, with the loose orifice tied near the fuel line. To convert to LP vapor, install the orifice and disconnect the spark advance leads as described below. See Figure 5-31 and Figure 5-32.

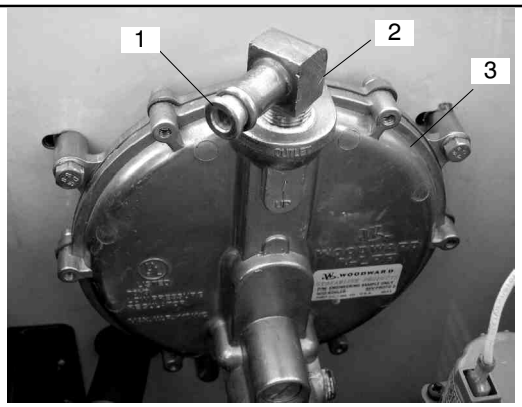


1. Fuel hose with clamp
2. Hose fitting (LP orifice fits inside; see Figure 5-33)
3. Regulator
4. DSAI connector location (see Figure 5-34)
5. Fuel valve
6. Fuel inlet, 1/2 in. NPT female

Figure 5-32 Fuel System Components, Air Inlet Side

Procedure to Convert from NG to LP

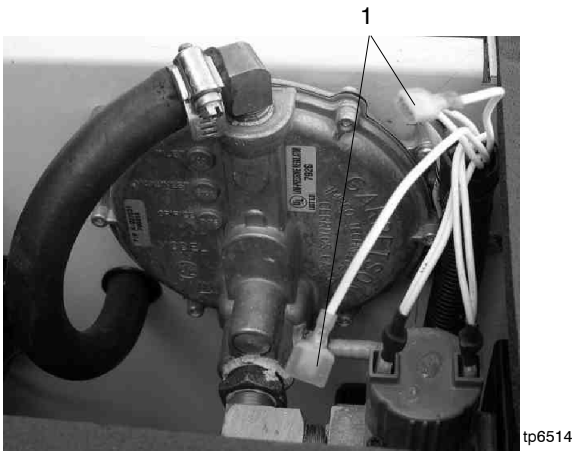
1. Place generator set master switch in OFF position.
2. Disconnect the power to the battery charger.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Turn off the fuel supply.
5. Remove the hose clamp and fuel hose from the hose fitting. See Figure 5-32.
6. Place orifice into the hose fitting. See Figure 5-33.



1. LP orifice
2. Hose fitting
3. Regulator

Figure 5-33 LP Fuel Orifice Installation

7. Slide the hose onto the hose fitting and secure it with the clamp.
8. Disconnect digital spark advance ignition (DSAI) timing leads 65 and N5 for LP. See Figure 5-34.



1. DSAI leads 65 and N5: connect for natural gas, disconnect for LP

Figure 5-34 Digital Spark Advance Ignition Timing Leads (located in generator set air intake area)

9. Connect and turn on the new fuel supply.
10. Check that the generator set master switch is in the OFF position.
11. Reconnect the generator set engine starting battery leads, negative (-) lead last.
12. Reconnect power to the battery charger.

13. Start the generator set by moving the generator set master switch to the RUN position.

14. Check for leaks using a gas leak detector.

15. Move the generator set master switch to the OFF/ RESET position to shut down the generator set.

To convert from LP vapor to natural gas, remove the fuel orifice and connect the DSAI leads together.

5.12.4 Digital Spark Advance Ignition (DSAI) Timing

The digital spark advance ignition (DSAI) optimizes the engine timing for the selected fuel, natural gas or LP. The location of the DSAI timing leads is shown in Figure 5-34. Connect the DSAI leads in the air intake compartment together for natural gas fuel. Disconnect the leads if LP is used. See Figure 5-34 and Figure 5-35.

See the engine service manual for ignition system service information.

DSAI Timing Lead Connection	
Natural Gas	Connect
LP	Disconnect

Figure 5-35 DSAI Lead Connection

5.13 Circuit Protection

If the generator set circuit breaker trips or the fuses blow repeatedly, see Section 3, Troubleshooting, for possible causes.

5.13.1 Line Circuit Breaker

A line circuit breaker interrupts the generator output in the event of a fault in the wiring between the generator and the load. The line circuit breaker location is shown in Figure 1-1. The circuit breaker rating is 70 amps. If the circuit breaker trips, reduce the load and switch the breaker back to the ON position. With the breaker in the OFF position the generator set runs but the generator output is disconnected from the load.

5.13.2 Fuses

Three panel-mounted fuses protect the alternator and electrical controls. See Figure 1-1 for fuse locations. A battery charger fuse is located in the positive battery lead. Always check for and replace any blown fuses before replacing other components.

See Figure 5-36 for fuse part numbers. Always identify and correct the cause of a blown fuse before restarting the generator set. Refer to Section 3, Troubleshooting, for conditions that may indicate a blown fuse. Replace blown fuses with identical replacement parts.

Fuse	Rating, Amp	Label	Part Number
Auxiliary winding	20	F1	292937
Relay interface board	10	F2	223316
Controller	10	F3	223316
Battery charger	10	—	AGS 10

Figure 5-36 Fuses

5.14 Starter Relay

The starter relay contains an internal diode across the relay coil. See Figure 5-37. Continuity checks across the coil terminals will show continuity (low resistance) in one direction and an open circuit in the other.

Figure 5-38 shows the starter relay connections.

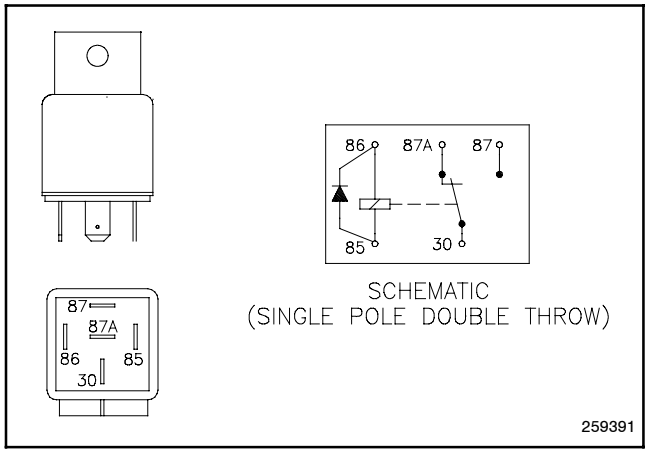


Figure 5-37 Starter Relay

Relay Terminal	Lead
30	14P
85	N7
86	71
87	14S
87A	NC

Figure 5-38 Starter Relay Connections

5.15 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 controller circuit board. Use an ohmmeter to check the continuity of the components listed in Figure 5-39. Also see Section 7, Wiring Diagrams.

Figure 5-39 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
Generator set master switch	RUN and VBAT (See Figure 5-30)	R x 100	RUN	Zero ohms (continuity). Any other reading indicates a faulty switch.
			OFF/RESET	No reading (open circuit). Any other reading indicates a faulty switch.
	AUTO and VBAT (See Figure 5-30)	R x 100	AUTO	Zero ohms (continuity). Any other reading indicates a faulty switch.
			OFF/RESET	No reading (open circuit). Any other reading indicates a faulty switch.
P1 wiring harness	P1-23 and ground	R x 1	OFF/RESET	Zero ohms (continuity) Any other reading indicates a poor ground connection.
	P9-1 and P9-2 (stator leads 11 and 44)	R x 1	OFF/RESET	Zero ohms (continuity). If no continuity, check wiring.
	P9-6 and P9-7 (YEL and ORG, stator leads 55 and 66)	R x 1	OFF/RESET	Zero ohms (continuity). If no continuity, check fuse F1 and wiring.
Controller fuse and wiring	P1-24 and battery positive (+)	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check fuse F3 and wiring.
Auxiliary winding fuse 20-amp fuse	P9-7 (ORG) and stator lead 55	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check for an open circuit and/or a blown fuse.
Low oil pressure (LOP) switch *	Lead 13 and ground (engine block)	R x 100	OFF/RESET	Zero ohms (continuity). No continuity indicates a faulty switch and/or wiring.
Temperature sensor (CTS) *	P1-17 and P1-18	R x 1000	OFF/RESET	180–2500 ohms, depending on engine temperature. See Section 5.10.2. Zero ohms or an open circuit indicates faulty wiring or a faulty switch.
* See Section 5.10.2, Fault Shutdown Switches				

Figure 5-39 Continuity Checks

This section provides instructions for the disassembly and reassembly of the generator set alternator. Before beginning the generator disassembly or reassembly procedure, carefully read all safety precautions at the beginning of this manual.

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

⚠ 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.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING

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

Do not work on the generator set until it cools.

6.1 Initial Steps

Perform the following steps before disassembling the generator set.

1. Disconnect AC power to the generator set by opening the upstream circuit breaker. (AC power is connected to the generator set for AC-powered accessories.)

2. Shut off the fuel supply. Disconnect the fuel system if necessary to tilt the generator set. Ventilate the area to clear fumes.

3. Allow the generator set and engine to cool.

4. Verify that any hoists or lifting devices used in the disassembly or reassembly procedure are rated for the weight of the generator set, which is approximately 227 kg (500 lb.).

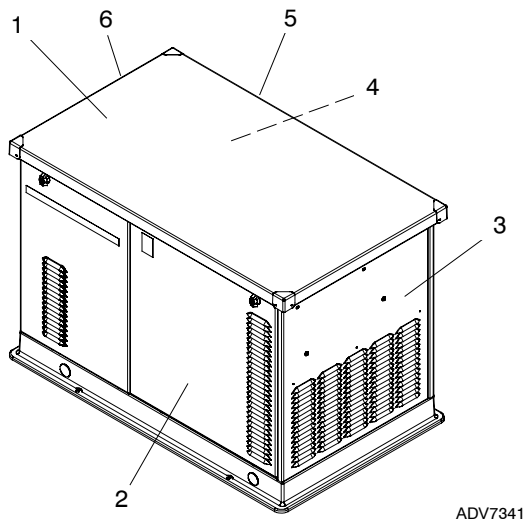
6.2 Disassembly

The disassembly procedure provides important information to minimize disassembly time and indicates where special configurations exist which may require taking notes.

Remove enclosure

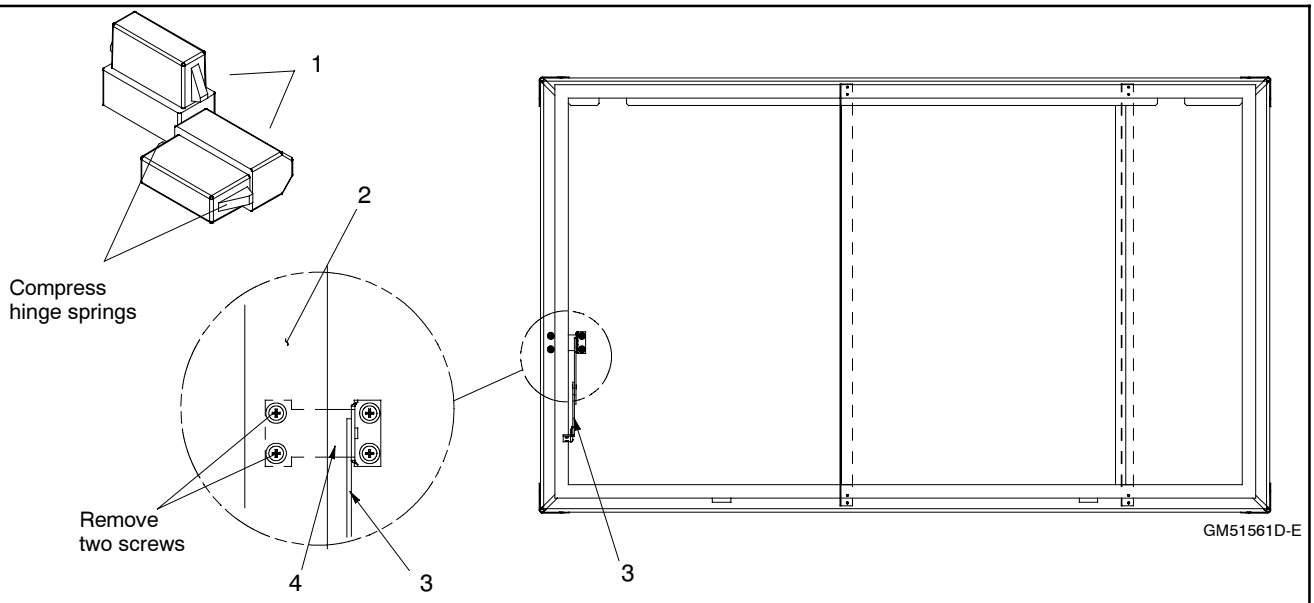
Remove the generator set enclosure as described in the following steps. See Figure 6-1.

1. Open the enclosure roof.
2. Place the generator set master switch in the OFF position.
3. Remove the screws on one end of the roof stay to disconnect the roof stay. See Figure 6-2.
4. Remove one roof hinge: Use two screwdrivers to compress the hinge springs. See Figure 6-2.
5. Remove the roof.



1. Roof
2. Right side door
3. Front panel
4. Heat shield (inside, not shown)
5. Left side panel
6. Rear panel

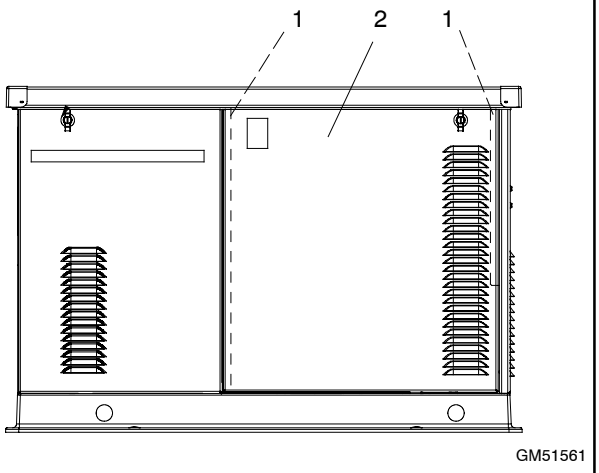
Figure 6-1 Enclosure Parts, Order of Disassembly



1. Hinges
2. Roof
3. Door stay (GM51973)
4. Bracket

Figure 6-2 Roof Stay and Hinges

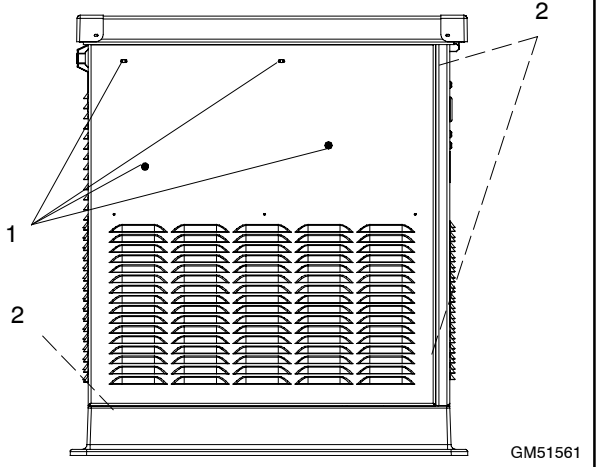
6. Remove two door screws. See Figure 6-3. Lift the service-side door up and off.



1. Door screws (2 ea.)
2. Right side door

Figure 6-3 Right Side Door

7. Remove the front panel. See Figure 6-4.



1. Screws, qty. 4 (outside)
2. Screws, qty. 3 (inside)

Figure 6-4 Front Panel Mounting Screw Locations

8. Unplug the carburetor heater (if equipped) from the 120VAC receptacle.

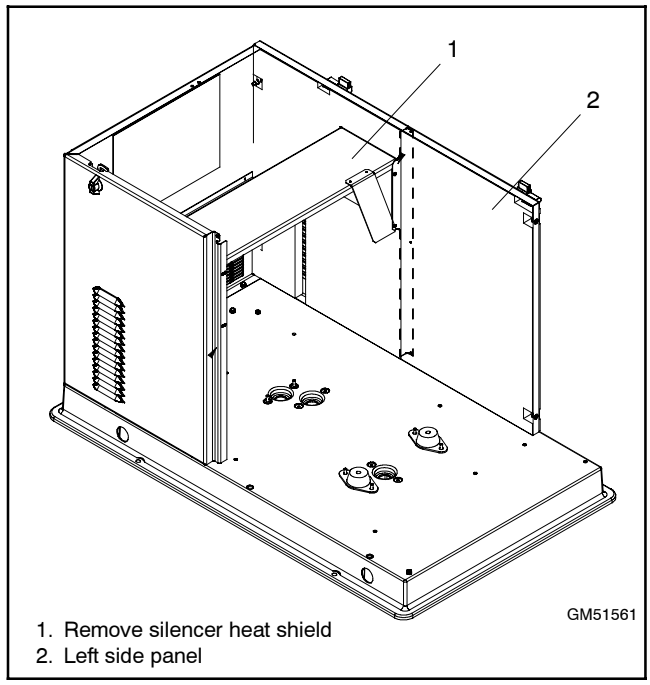
9. Unplug the battery charger from the 120VAC receptacle.

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

11. Disconnect output leads or load circuit cables at the field-connection terminal block.

12. Remove the heat shield over the silencer by removing four screws. See Figure 6-5.

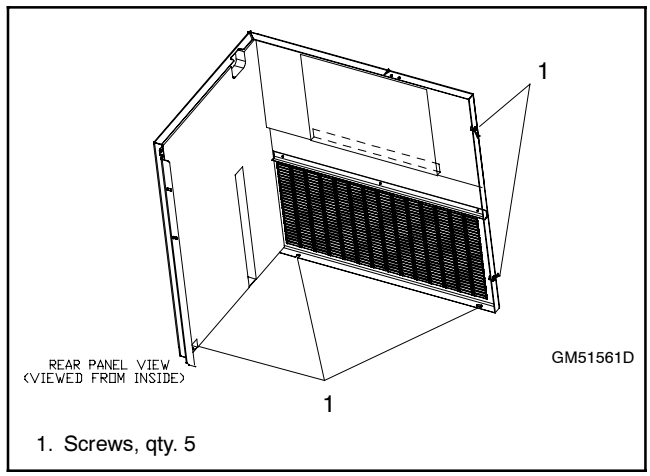
13. From the inside of the enclosure, remove the remaining screws to remove the non-service side housing panel. See Figure 6-5.



1. Remove silencer heat shield
2. Left side panel

Figure 6-5 Left Side Panel (bulkhead and generator set not shown)

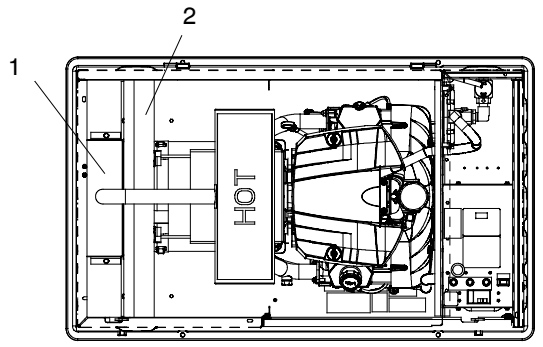
14. From the inside of the enclosure, remove five screws to remove the rear (exhaust end) panel. See Figure 6-6.



1. Screws, qty. 5

Figure 6-6 Rear Panel Mounting Screw Locations (viewed from inside the enclosure)

15. Remove the exhaust shield and alternator air inlet duct. See Figure 6-7.



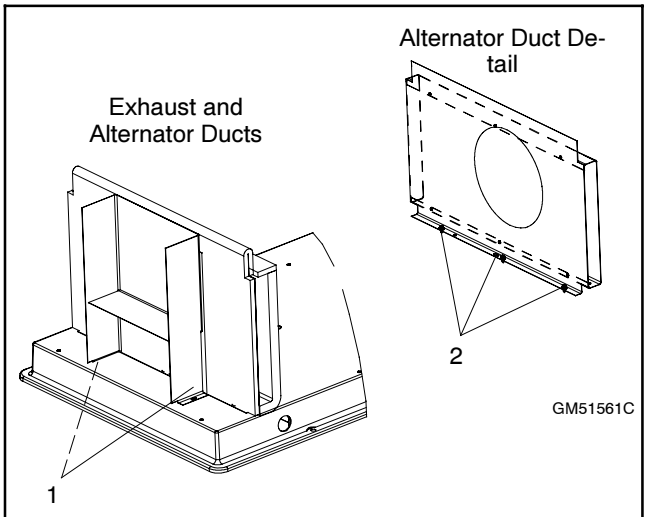
1. Exhaust shield
2. Alternator air inlet duct

Figure 6-7 Shield and Alternator Air Inlet Duct, Top View

a. Remove two bolts securing the exhaust shield at the exhaust end and remove the shield. See Figure 6-8.

b. Remove three bolts securing the alternator air inlet duct to the base and remove the duct. See Figure 6-8.

c. Remove the bolts securing the heat shield to the alternator and remove the heat shield.



1. Exhaust duct mounting screws, qty. 2
2. Alternator duct mounting screws, qty. 3

Figure 6-8 Exhaust and Alternator Ducts

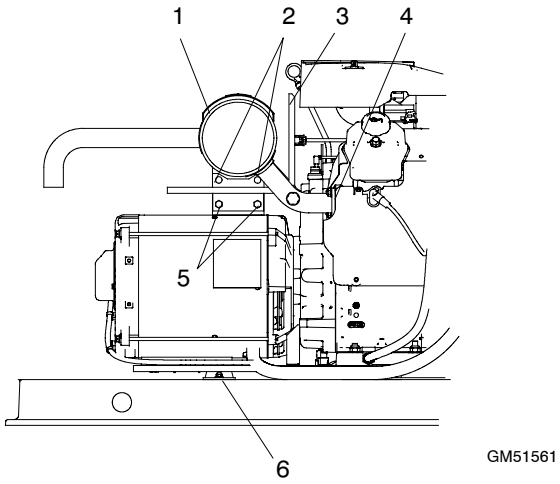
Generator Disassembly

16. Remove the engine exhaust muffler and alternator heat shield. See Figure 6-9.

a. Disconnect the muffler from the engine at the two flange connections.

b. Remove the bolts holding the muffler to the alternator heat shield and remove the muffler.

c. Remove the bolts holding the heat shield to the alternator stator shell and remove the heat shield.



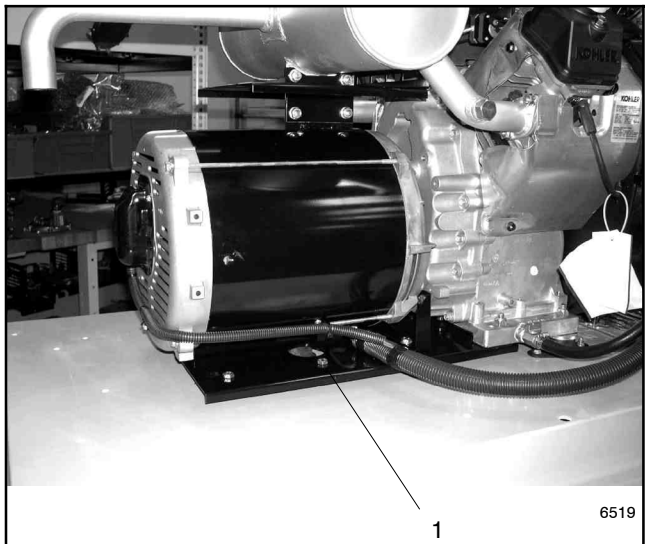
1. Engine exhaust muffler
2. Muffler bolts
3. Heat shield
4. Flange connection
5. Heat shield bolts
6. Alternator end vibromount

Figure 6-9 Muffler and Heat Shield

17. Remove the nuts securing the alternator end vibromount mounting plate to the skid. See Figure 6-9.

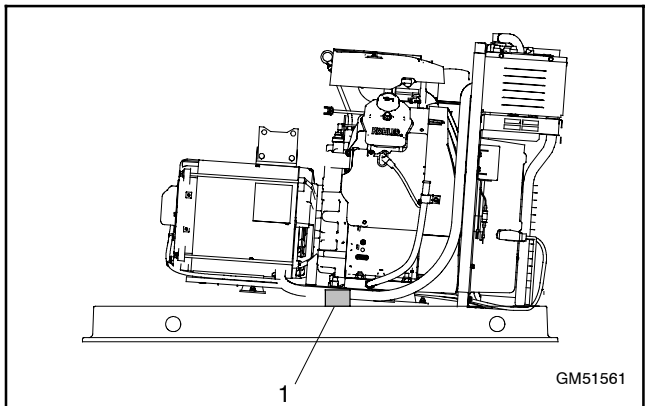
18. If the unit is not equipped with the stiffening plate shown in Figure 6-10, raise the alternator end of the generator set enough to place a thin block of wood beneath the rear of the engine. See Figure 6-11.

    Note: Use a hoist or lifting device that is rated for the weight of the generator set. See Section 6.1.



1. Stiffening plate

Figure 6-10 Stiffening Plate (if equipped)

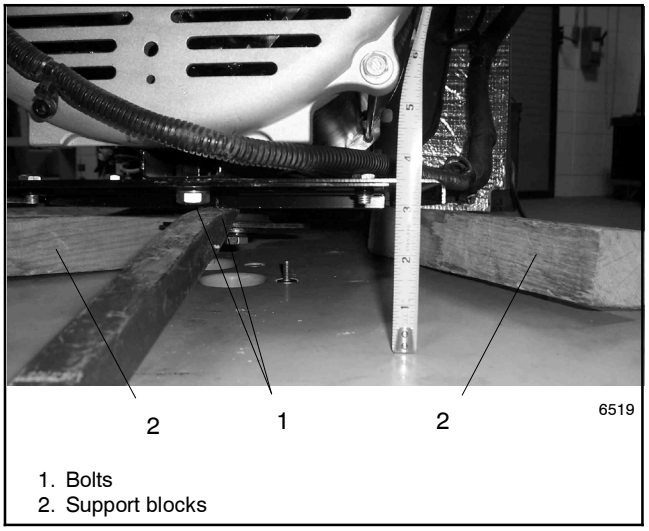


1. Engine support block

Figure 6-11 Generator Set, Right Side

19. If the unit is equipped with a stiffening plate as shown in Figure 6-10, raise the alternator end 75–90 mm (3–3.5 inches). Place wood blocks under both sides of the plate. See Figure 6-12.

20. Remove the bolts holding the vibromount and the stiffening plate to the bottom of the alternator. See Figure 6-12.



1. Bolts
2. Support blocks

Figure 6-12 Supporting the Alternator

21. Disconnect the alternator harness wiring inside the controller junction box. See the wiring diagrams in Section 7.

    a. Disconnect brush leads FP and FN and stator lead 66 from the SCR module.

    b. Disconnect lead 55 from fuse F1.

    c. Single-phase models: Disconnect leads 11 and 44 at quick connects 5 and 6.
    Three-phase models: Disconnect leads V7, V8 and V9 at quick connects 5, 6 and 7.

    d. Disconnect leads 2 and 3 from neutral stud L0.

    e. Disconnect leads 1 and 4 from the circuit breaker.

22. Remove 4 screws securing the brush cover to the alternator end bracket. See Figure 6-13.

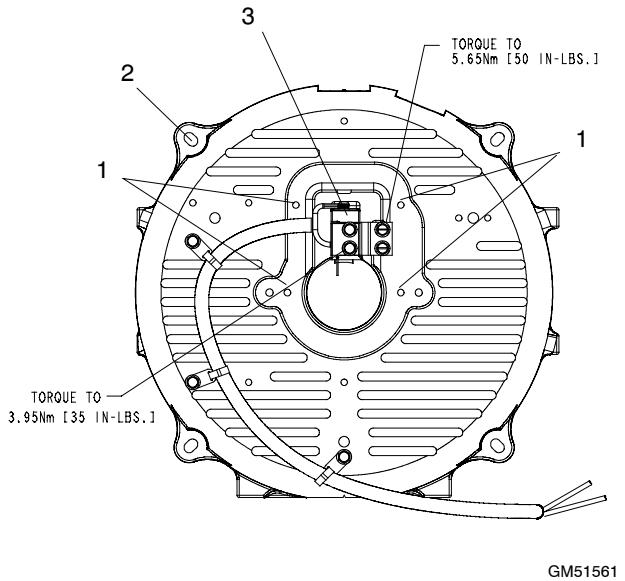
23. Disconnect brush leads FP and FN.

24. Raise the brushes in the brush holder and insert a small piece of wire into the brush holder retainer wire hole. See Figure 6-13 and Figure 6-15.

25. Check the brushes.

    a. Remove the brush holder from the end bracket. See Figure 6-13.

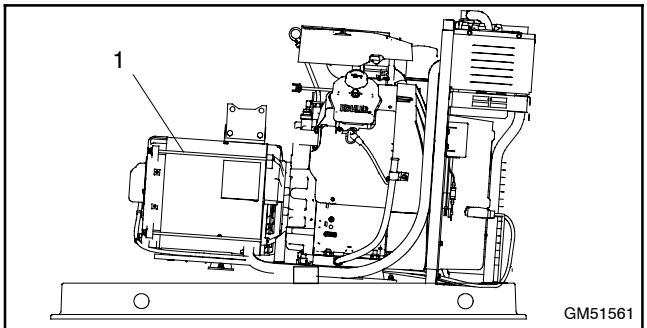
    b. Inspect the brushes. Replace brushes when they are worn to half of their original size. See Figure 6-15 and Section 5.6, Brushes.



1. Brush cover screws
2. Alternator overbolts and centering washers (4 places)
3. Brush holder (See Figure 6-15 for details)

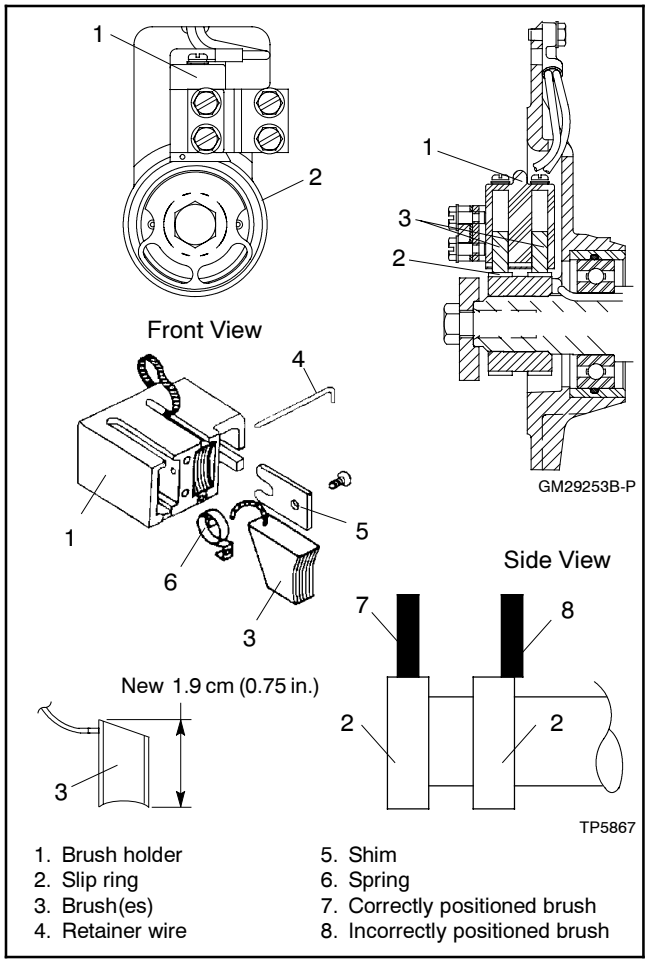
Figure 6-13 Alternator End Bracket and Brush Assembly

26. Remove the alternator overbolts and centering washers. See Figure 6-13 and Figure 6-14.



1. Alternator overbolts (4 places)

Figure 6-14 Alternator Overbolts



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

Figure 6-15 Brush Details

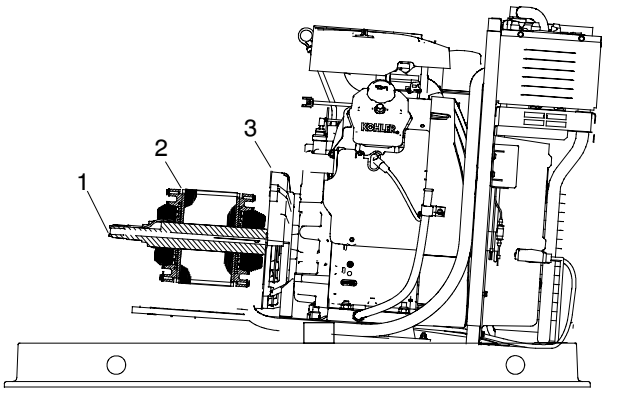
27. Using a soft-faced hammer, strike the sides of the end bracket with medium-force blows to remove the end bracket from the stator or remove the end bracket from the stator using a puller.

28. Remove the leads connected to the end bracket from the convoluted conduit leading to the controller. Set the end bracket assembly aside.

29. Remove the stator and rotor.

    a. Remove the stator from the rotor.

    b. Loosen but do not remove the rotor thrubolt. Use a strap wrench on the rotor to keep the rotor from turning during loosening, if necessary. See Figure 6-16.



1. Thrubolt
2. Rotor and fan assembly
3. Generator adapter

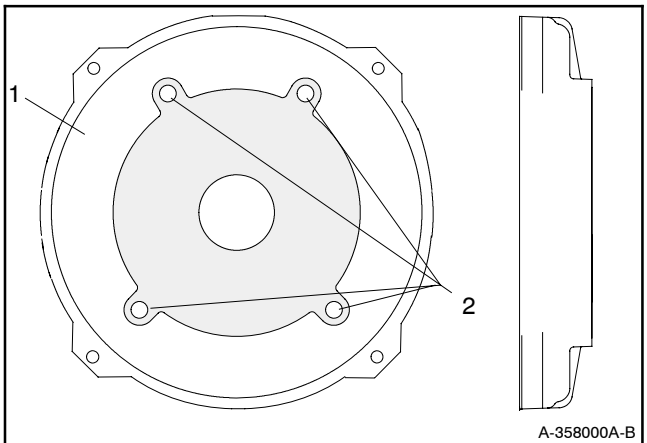
Figure 6-16 Rotor and Thrubolt

    c. Loosen the rotor assembly by striking the side of the rotor with a soft-faced hammer to loosen it from the tapered crankshaft fitting. See Figure 6-16. Rotate the rotor and strike it on alternate sides until it can be rocked slightly back and forth.

    Note: Do not strike the slip rings.

    d. Remove the thrubolt and the rotor. Set the rotor assembly aside.

30. Remove the four generator adapter mounting bolts to remove the generator adapter. See Figure 6-17.



1. Generator adapter
2. Adapter mounting holes

Figure 6-17 Generator Adapter

6.3 Reassembly

1. Reinstall the generator adapter onto the engine.

    a. Attach the generator adapter to the engine using four 7/16-14 x 1.0 in. hex cap bolts and washers. See Figure 6-17.

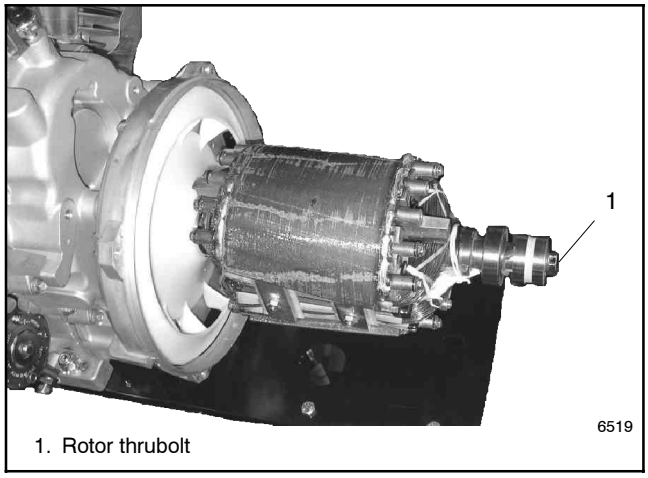
    b. Torque the bolts to 40 Nm (28 ft. lb.).

2. Install the rotor. See Figure 6-16 and Figure 6-18.

    a. Clean the crankshaft stub and mating surface on the fan hub. Do not use antisieze compound when reassembling the rotor.

    b. Install the rotor onto the engine crankshaft.

    c. Thread the thrubolt through the actuator and rotor into the crankshaft. Do not tighten the thrubolt at this time.



1. Rotor thrubolt

Figure 6-18 Rotor with Thrubolt

3. Install the stator and end bracket.

   a. Align the stator so that the alternator frame vibromount points down toward the generator base. See Figure 6-19. Install the stator assembly around the rotor.

   b. Align the alignment mark on the top of the stator with the center of the slot in the generator adapter.

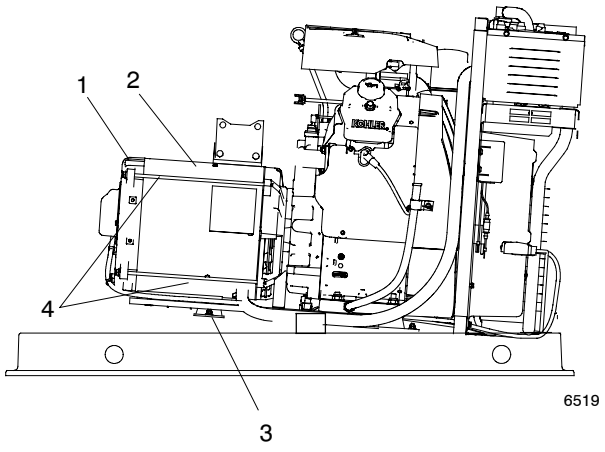
   c. Route the leads connected to the alternator end bracket through the opening in the base of the alternator frame.

   d. Place the end bracket onto the stator assembly, lining up the alignment marks on the top of the stator and end bracket.

   e. Thread the four overbolts with locating washers through the end bracket and into the generator adapter. Position the locating tab of each washer to the outer edge of the oblong (OBROUND) hole on the end bracket. See Figure 6-20. The overbolts should be parallel to the outside of the alternator. If the overbolts are slanted, rotate the locating washer 1/2 turn. Do not final tighten the overbolts at this time.

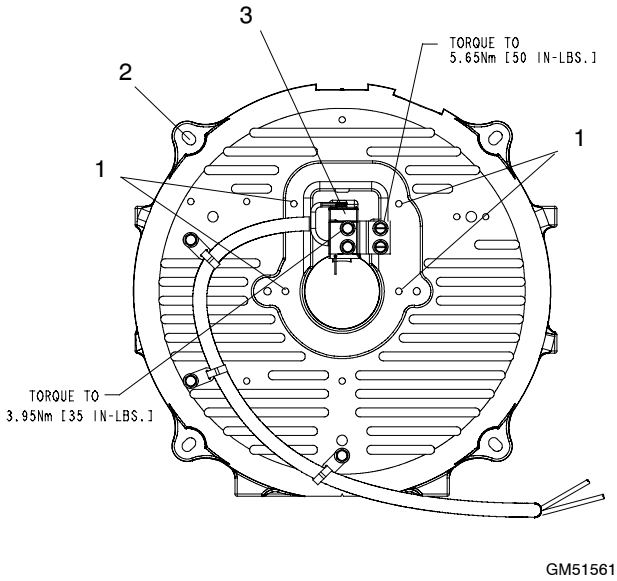
4. Secure the generator set to the skid.

   a. Attach the vibromount to the alternator through the hole in the stiffening plate. See Figure 6-21.



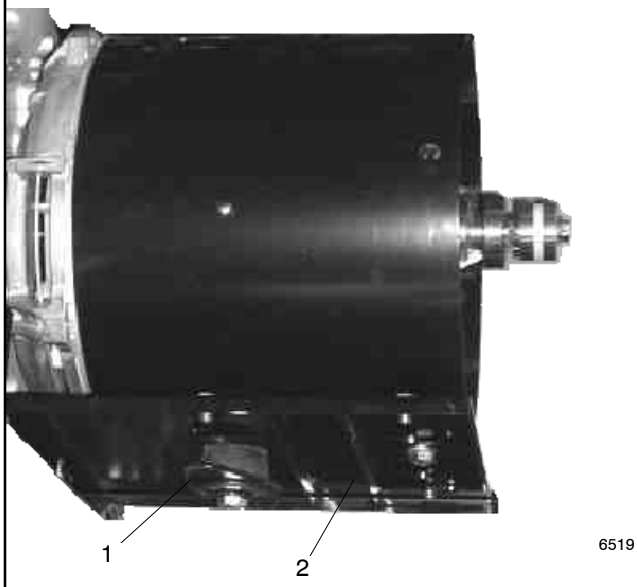
1. End bracket
2. Alternator
3. Alternator frame vibromount
4. Overbolts

Figure 6-19 Generator Set, Right Side



1. Brush cover screws
2. Alternator overbolts and centering washers (4 places)
3. Brush holder (See Figure 6-15 for details)

Figure 6-20 End Bracket and Brush Assembly



1. Vibromount
2. Stiffening plate

Figure 6-21 Stiffening Plate and Vibromount

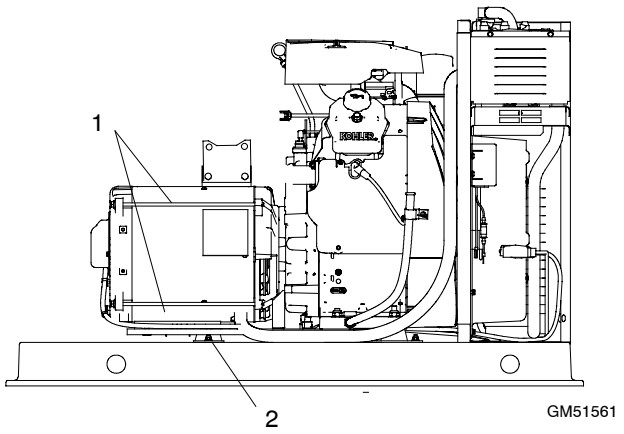
   b. Attach the stiffening plate to the alternator using the mounting screw.

   c. Raise the alternator end of the generator set and remove the wood support block(s).

d. Lower the end of the generator set and reinstall the screws and washers that secure the vibromount mounting plate to the generator set skid. See Figure 6-22.

5. Tighten the four alternator assembly overbolts to 7 Nm (60 in. lb.). See Figure 6-22.

6. Tighten the rotor thrubolt to 53 Nm (39 ft. lb.). It may be necessary to keep the engine flywheel from turning while torquing the rotor thrubolt.



1. Alternator assembly overbolts
2. Vibromount

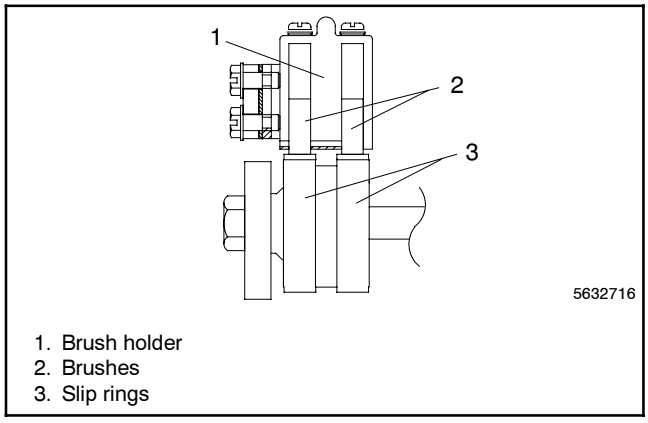
Figure 6-22 Generator Set, Right Side

7. Reinstall the end bracket components.

   a. Install the brush holder onto the end bracket. Torque the mounting screws to the values shown in Figure 6-20. Verify that the brushes are not sticking in the holder. See Figure 6-15.

   b. Verify that the brushes are centered on the slip rings. If required, insert spacers between the mounting surface and brush holder to center the brushes on the slip rings. See Figure 6-23. See Section 5.6, Brushes, for more information.

   c. Reinstall the brush cover onto the alternator end bracket. See Figure 6-20. Verify that the brush leads are not pinched between the brush cover and end bracket.

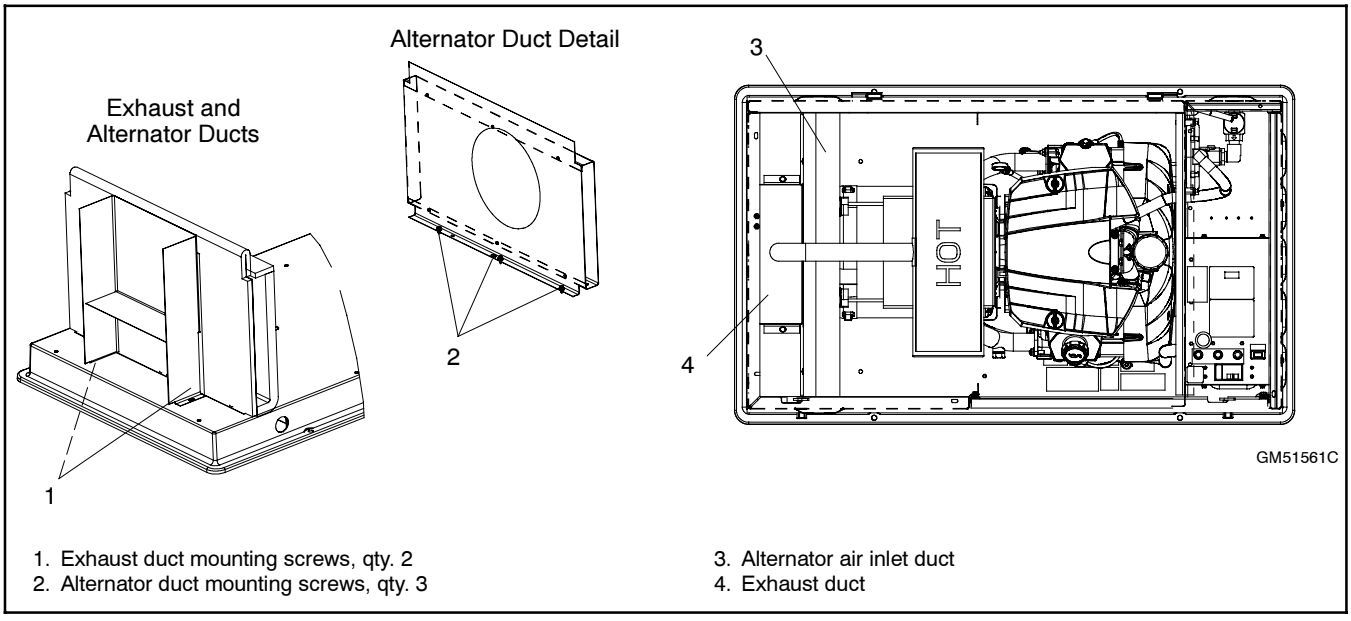


1. Brush holder
2. Brushes
3. Slip rings

Figure 6-23 Brush Positioning

8. Reinstall the alternator air inlet duct. Orient the duct as shown in Figure 6-24.

9. Install the exhaust duct. See Figure 6-24.



1. Exhaust duct mounting screws, qty. 2
2. Alternator duct mounting screws, qty. 3
3. Alternator air inlet duct
4. Exhaust duct

Figure 6-24 Alternator Air Inlet Duct

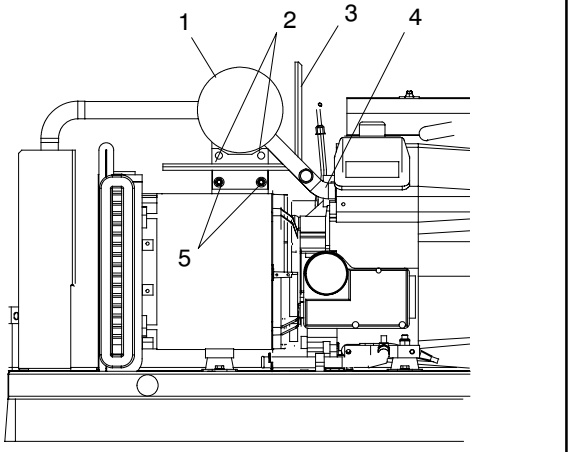
10. Install the exhaust system. See Figure 6-25.

    a. Install the heat shield onto the alternator exhaust support.

    b. Using new gaskets, connect the engine exhaust muffler to the engine at the flanges. Do not final tighten the mounting hardware.

    c. Secure the muffler mounting tab to the heat shield.

    d. Torque the nuts securing the engine muffler flange to the engine to 24 Nm (17.7 ft. lb.).



1. Engine exhaust muffler
2. Muffler bolts
3. Heat shield
4. Flange connection
5. Heat shield bolts

Figure 6-25 Exhaust System

11. Connect the alternator leads inside the controller box. Refer to the wiring diagrams in Section 7 and see Figure 6-26.

    a. Connect alternator leads 1 and 4 to the line circuit breaker.

    b. Connect alternator leads 2 and 3 to the load connection stud L0.

    c. Single-phase models: Reconnect leads 11 and 44 at quick connects 5 and 6.
    Three-phase models: Reconnect leads V7, V8 and V9 at quick connects 5, 6 and 7.

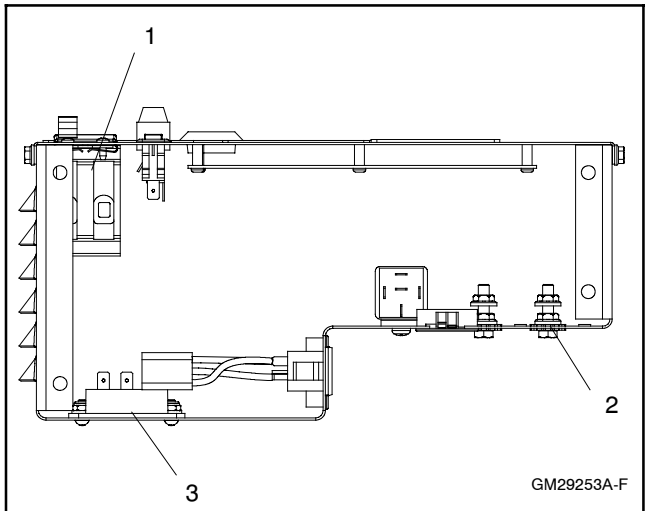
    d. Connect brush leads FP and FN and stator leads 55 and 66 to the SCR module. See the wiring diagrams in Section 7 for the SCR module connections.

    e. Reconnect all other controller connections that were removed during disassembly.

12. Check that the generator set master switch is in the OFF position.

13. Reconnect the generator set engine starting battery, negative (-) lead last.

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



1. Line circuit breaker
2. Neutral terminal (L0)
3. SCR module

Figure 6-26 Controller

15. Reinstall the enclosure panels in reverse order of removal. See Figure 6-27 and refer to the disassembly instructions, if necessary.

    a. Install the rear (alternator end) housing panel.

    b. Install the left (non-service side) housing panel.

    c. Install the heat shield over the muffler.

    d. Install the front panel.

    e. Install the generator set housing service side door.

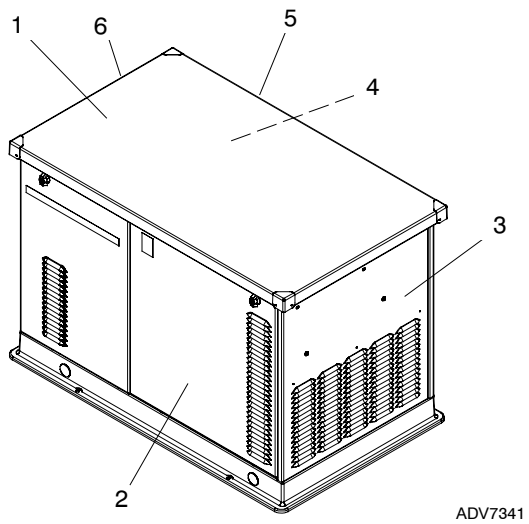
    f. Install the generator set housing roof.

16. Reconnect the 120VAC power supply to the generator set.

17. Turn on the fuel supply. Move the generator set master switch to the RUN position and check for leaks with the engine running.

18. Move the generator set master switch to the OFF/ RESET position. Move the switch to the AUTO position if an automatic transfer switch or remote start/stop switch is used.

19. Lower and secure the roof.



1. Roof
2. Right side door
3. Front panel
4. Heat shield (inside, not shown)
5. Left side panel
6. Rear panel

Figure 6-27 Generator Set Enclosure

Notes

Section 7 Wiring Diagrams

Figure 7-1 lists the wiring diagram numbers and locations.

Wiring Diagram Description	Drawing Number	Page
Schematic Diagram, Single-Phase	ADV-7353	86
Point-to-Point Wiring Diagram, Single-Phase	GM52541	87
Schematic Diagram, Three-Phase	ADV-7637	88
Point-to-Point Wiring Diagram, Three-Phase	GM65661	89

Figure 7-1 Wiring Diagrams and Schematics

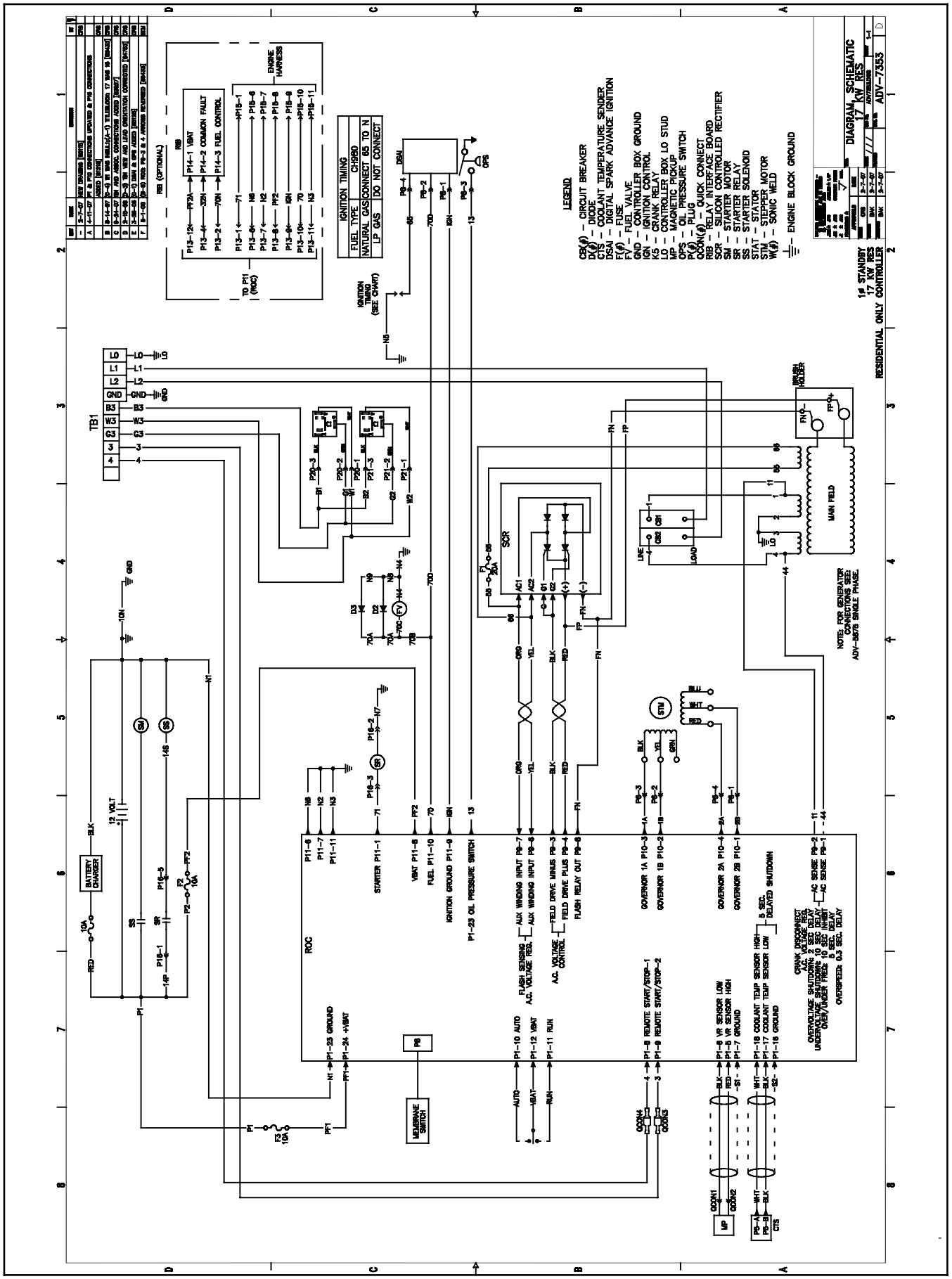


Figure 7-2 Schematic Diagram, Single Phase, ADV-7353-F

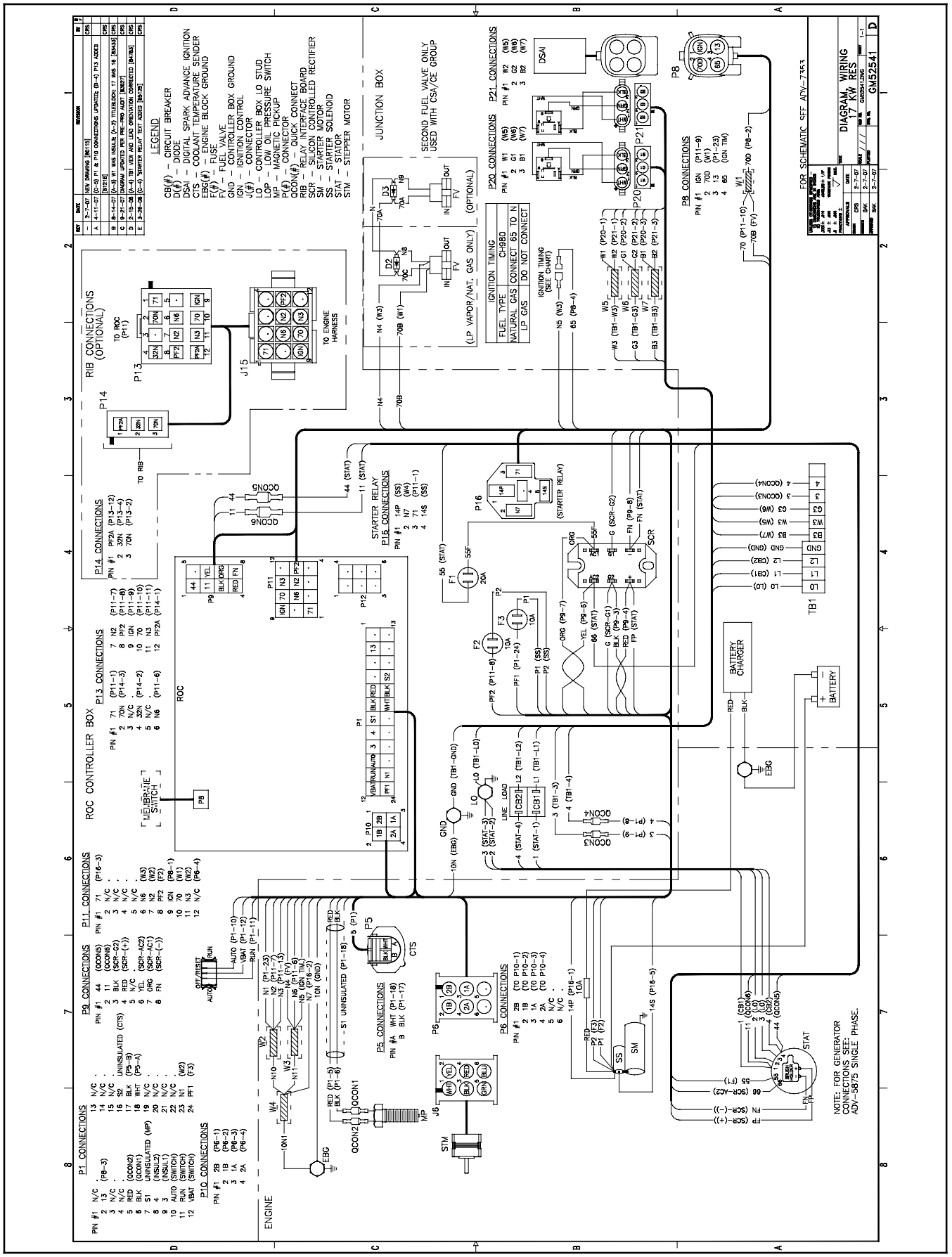


Figure 7-3 Point-to-Point Wiring Diagram, Single Phase, GM52541-E

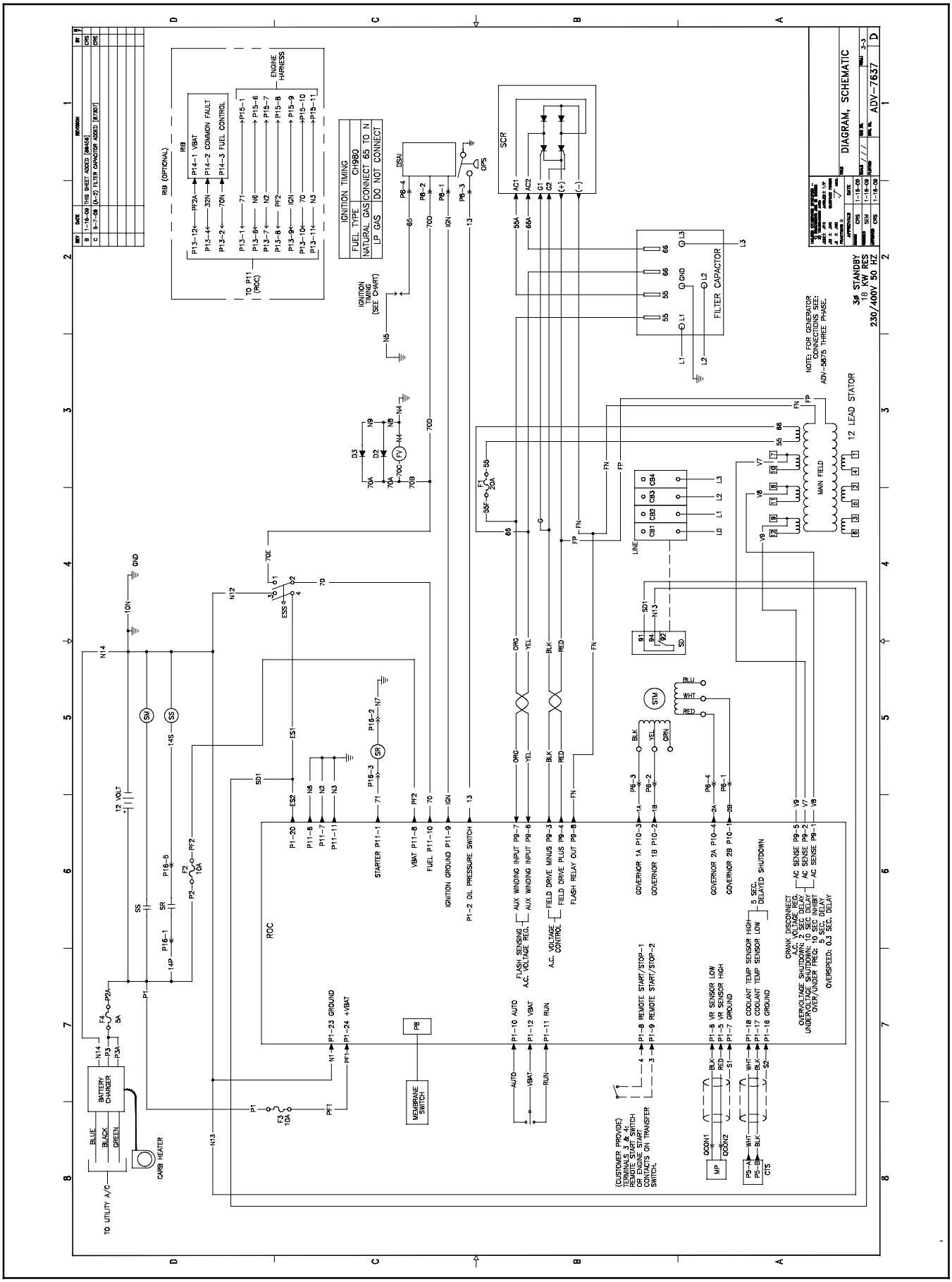


Figure 7-4 Schematic Diagram, Three-Phase (TRES Models), ADV-7637

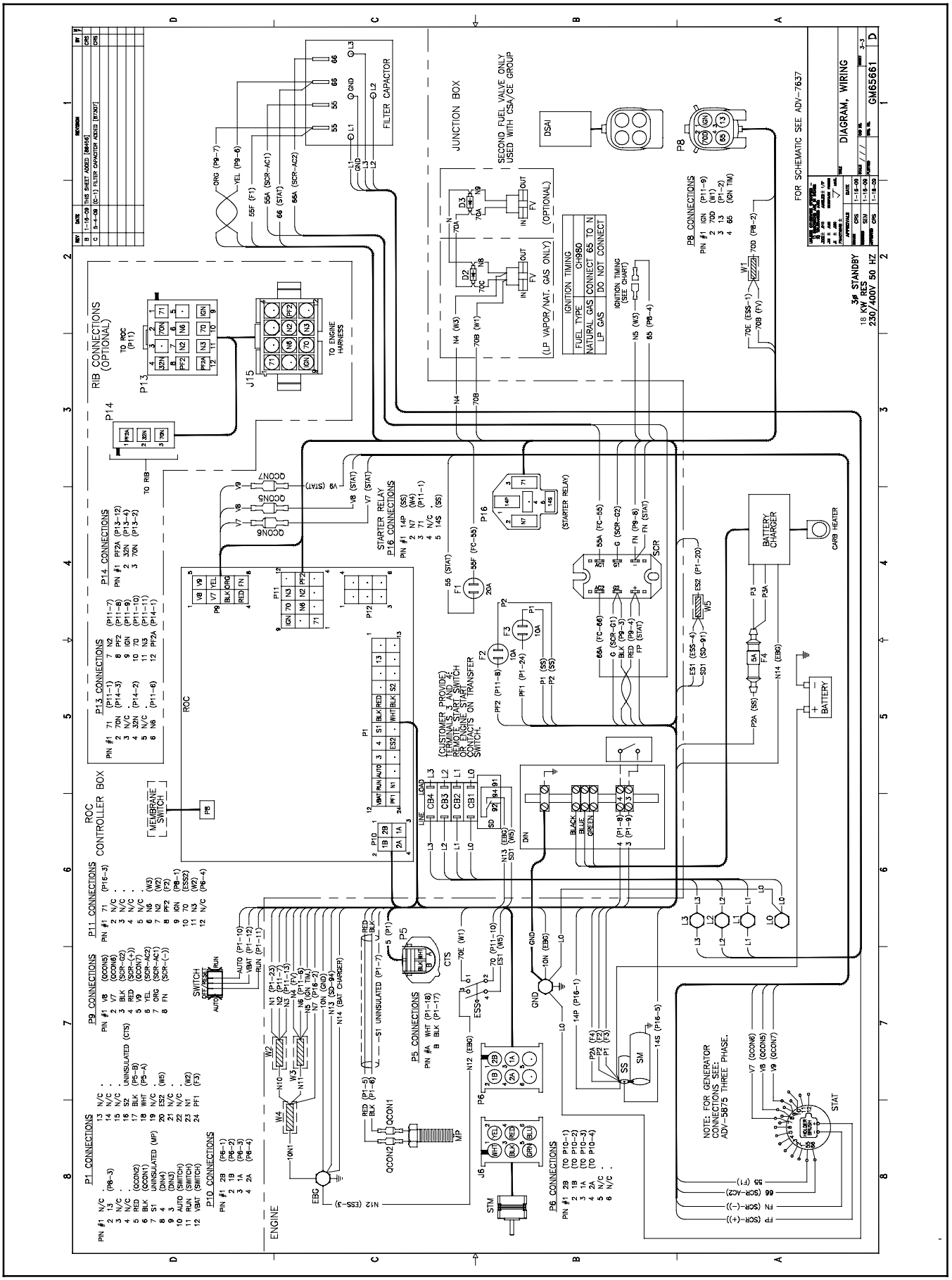


Figure 7-5 Point-to-Point Wiring Diagram, Three-Phase (TRES Models), GM65661

Notes

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.

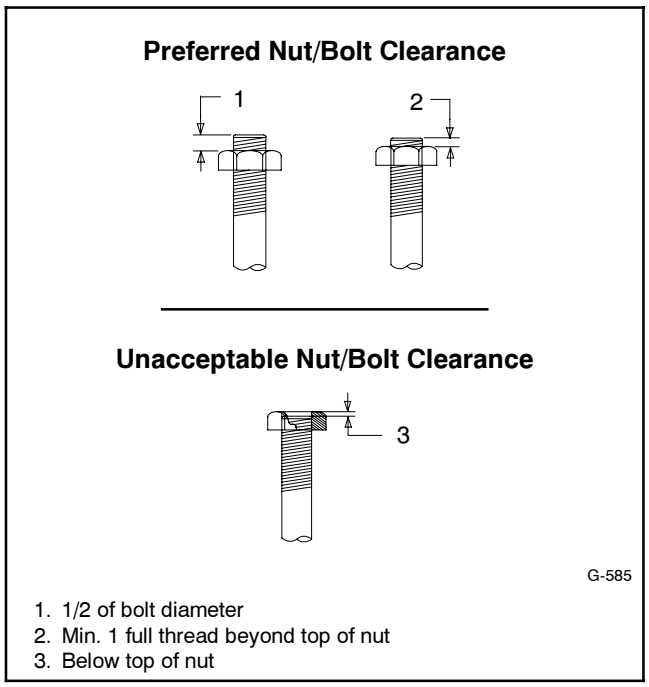


Figure 1 Acceptable Bolt Lengths

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.

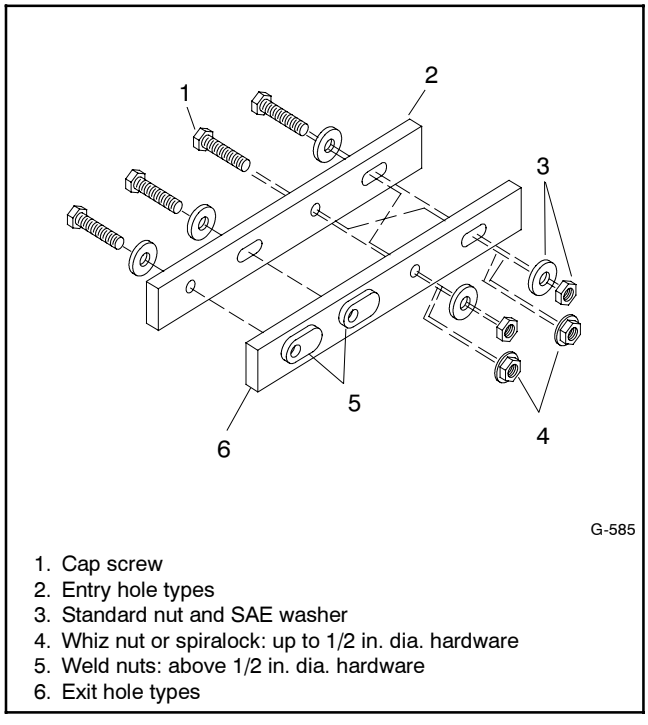


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

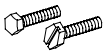
American Standard Fasteners Torque Specifications								
Size	Torque Measurement	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 2 or 5
		Grade 2		Grade 5		Grade 8		
8-32	Nm (in. lb.)	1.8	(16)	2.3	(20)	—		See Note 3
10-24	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
10-32	Nm (in. lb.)	2.9	(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)	

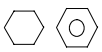
Notes:

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

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

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

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

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

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

American Standard

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

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

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

Washers

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

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (Partial Thread)

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

Hex Head Bolts (Partial Thread), continued

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

Hex Head Bolts (Full Thread)

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

Hex Head Bolts (Full Thread), continued

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

Pan Head Machine Screws

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

Flat Head Machine Screws

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

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

Metric, continued

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

Washers

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

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

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