Service

Residential/Commercial Generator Sets

Models:

15/30RES
15/30RESA
15/30REYG
15/30RYG

Controller:
Advanced Digital Control

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
Power Systems

TP-6198 3/15b

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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***.

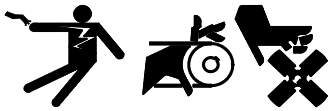
NOTICE

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

Risk of 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.

Engine Fluids and Chemical Products

⚠ WARNING

Handling caustic engine fluids and chemical products.
Can cause severe chemical burns, nausea, fainting, or death.

Most chemicals such as used engine oil, antifreeze/coolant, rustproofing agent, inhibiting oil, degreasing agent, spray paint, and adhesives are hazardous to health. Read and follow the user information found on the packaging. Avoid inhalation and skin contact. Use only in well-ventilated areas and use a protective mask when spraying. Store engine fluids and chemical products in a locked cabinet. Contact your local recycling center for disposal information and locations.

⚠ WARNING

Flammable engine solvents and cleaners.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near flammable engine solvents and cleaners. Read and follow the user information found on the packaging. Use only in well-ventilated areas. Never use gasoline or low flash-point solvents as cleaning agents.

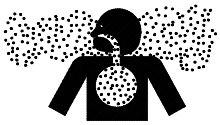
Leaking or accumulated engine fluids. A fire can cause severe injury or death. Clean up engine fluids including fuel, oil, grease, and coolant. Determine the source of engine leaks and correct before starting the generator set. Keep the generator set area clean and remove combustible materials.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in a responsible manner. Contact your local recycling center for disposal information and locations.

Fire-damaged or burned O-rings may cause the formation of hydrofluoric acid. Contact with hydrofluoric acid may cause severe skin irritation and chemical burns. O-rings and other fluoroelastomer seals exposed to fire or temperatures above 316°C (600°F) (i.e., during welding) may decompose forming hydrofluoric acid. Avoid inhalation or skin contact. Do not incinerate O-rings. Dispose of O-ring waste material in a responsible manner.

Exhaust System

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

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

Carbon monoxide detectors. Carbon monoxide can cause severe nausea, fainting, or death. Install carbon monoxide detectors on each level of any building adjacent to the generator set. Locate the detectors to adequately warn the building's occupants of the presence of carbon monoxide. Keep the detectors operational at all times. Periodically test and replace the carbon monoxide detectors according to the manufacturer's instructions.

Carbon monoxide detectors. Carbon monoxide can cause severe nausea, fainting, or death. Install carbon monoxide detectors on each level of the building. Locate the detectors to adequately warn the building's occupants of the presence of carbon monoxide. Keep the detectors operational at all times. Periodically test and replace the carbon monoxide detectors according to the manufacturer's instructions.

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

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

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

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

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

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

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

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

Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor 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.

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

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

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

Hazardous Voltage/ Moving Parts

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING

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

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

⚠ WARNING

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

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

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

This equipment must be installed and serviced by qualified electrical personnel.

⚠ 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.

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

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

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

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)

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.

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

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

Moving Parts

⚠ WARNING

Airborne particles.
Can cause severe injury or blindness.

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

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

Heavy Equipment

⚠ WARNING

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

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

Hot Parts

⚠ WARNING

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

Do not work on the generator set until it cools.

⚠ WARNING

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

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

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.

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

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.

Wiring Diagrams

Generator set wiring diagrams that were included in previous versions of this service manual have been moved to separate wiring diagram manuals. Refer to the wiring diagram manual for your model. The engine service manual also contains wiring diagrams for the engine only. The document part numbers are shown in the List of Related Materials.

List of Related Materials

Separate manuals contain operation, installation, and parts information not provided in this manual. A separate engine service manual is also available. Figure 1 lists the available manual part numbers.

Document Description	Part Number
Installation Manual, 15/30RES	TP-6341
Operation Manual, 15/30RES	TP-6344
Installation Manual, 15/30RYG	TP-6329
Operation Manual, 15/30RYG	TP-6197
Installation Manual, 15/30RESA	TP-6725
Operation Manual, 15/30RESA	TP-6726
Installation Manual, 15/30REYG	TP-6727
Operation Manual, 15/30REYG	TP-6728
Parts Catalog, 15/30RES/RYG *	TP-6319
Parts Catalog, 15/30RESA/REYG *	TP-6729
Wiring Diagram Manual, 15/30RES/RYG	TP-6437
Wiring Diagram Manual, 15/30RESA/REYG	TP-6719
Engine Service Manual	TP-6362
* One parts catalog combines generator and engine information.	

Figure 1 Related Literature

Routine Service Parts

Figure 2 contains part numbers for recommended spare parts. Refer to the generator set parts catalog for a complete list of service parts for your generator set.

Part Description	Part Number
Maintenance kit (includes air cleaner element, oil, and oil filter):	GM62348-SKP1-QS
Air cleaner element	GM16944
Belt 15RES/RESA/REYG/RYG 30RES/RESA/REYG/RYG	 GM28353 GM28352
Oil filter	GM28351
Spark plug	GM35826
Auxiliary winding fuse, 10 amp (F1)	358337
Relay interface board fuse, 10 amp (F2)	223316
Controller fuse, 10 amp (F3)	223316

Figure 2 Recommended Spare Parts

Service Assistance

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

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

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Latin America
Latin America Regional Office
Lakeland, Florida, USA
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1.1 Introduction

The spec sheets for each generator set provide specific generator and engine information.

See the generator set specification sheets for generator ratings and other generator set data not supplied in this manual. Consult the generator set nameplate for specific generator set ratings.

Consult the engine operation manual and engine service manual for engine specifications.

1.2 Controller Specifications

The generator set is equipped with the ADC 2100. For a specific description of the controller, see Section 2, Operation, in the operation manual.

Environmental Specification	
Operating temperature	-20° to 70°C (-4° to 158°F)
Storage temperature	-60° to 70°C (-76° to 158°F)
Humidity	0%-95% condensing
Power requirements:	
Voltage	12 VDC
Current	250 mA @ 12 VDC

1.3 Engine Specifications

Engine Specification	**15 kW**	**30 kW**
Manufacturer	GM	
Model	1.6L OHC	
Cycle	4	
Number of cylinders	4	
Compression ratio	9.4:1	
Displacement, L (cu. in.)	1.6 (98)	
Rated power, propane fuel, kWm (BHP)	19.0 (25.5)	37.2 (50)
Rpm, 60 Hz	1800	3600
Rpm, 50 Hz	NA	3000
Bore x stroke, mm (in.)	79 x 81.5 (3.11 x 3.21)	
Valve (exhaust) material	High alloy steel	
Cylinder head material	Aluminum	
Piston rings	2 compression/1 oil control	
Piston material	High silicon content aluminum	
Crankshaft material	Cast iron	
Main bearings: quantity, type	5, replaceable inserts	
Governor	Electronic	
Lubrication system	Full pressure	
Oil capacity (w/filter), L (qt.)	3.5 (3.7)	
Oil capacity with makeup kit, L (qt.)	5.4 (5.7)	
Oil pressure, kPa (psi)	150 (22)	
Fuel system	LP gas or natural gas	
LP/natural gas minimum supply pressure, oz./in.^{2} (in. H_2O)	4-6 (7.11)	
Battery voltage	12 VDC	
Battery ground	Negative	
Spark plug gap, mm (in.)	0.8-0.9 (0.031-0.035)	
Ignition system	Distributorless electronic	
Starter motor	Solenoid-actuated pinion	
Cooling system	Water-cooled	
Valve material Intake Exhaust	 Chrome/silicone steel Stellite F	

1.4 Torque Specifications

Follow the general torque specifications found in Appendix C of this manual unless noted below or listed in the engine service manual.

Torque Specifications	
Alternator overbolts	34 Nm (25 ft. lb.)
Drive disk to flywheel	16.5 Nm (12 ft. lb.)
Cylinder head nuts	25 Nm (18 ft. lb.)
Drive disk to rotor	38 Nm (28 ft. lb)
Muffler flange bolts	50 Nm (35 ft. lb.)
Spark plug	25 Nm (18 ft. lb.)
Radiator fan fasteners	22.5 Nm (17 ft. lb.)

1.5 Alternator Specifications

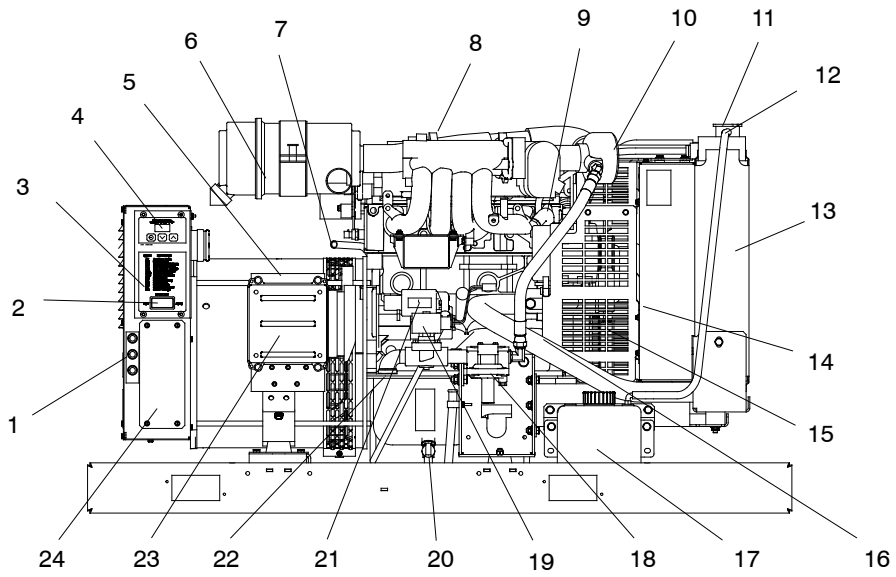
Alternator Specifications	
Frequency Hz	50 Hz (30 kW only) or 60 Hz
Excitation method	Brush type
Voltage regulator type	Digital
Coupling type	Flexible disc
Winding material	Class H
Bearing, quantity and type	1 sealed
Circuit protection	
Controller (F3)	10-amp fuse
Aux. winding (F1)	10-amp fuse
Relay Interface Board (F2)	10-amp fuse
Brush length, new	1.9 cm (0.75 in.)

Alternator Specification	15RES 15RESA 15REYG 15RYG	15REYG 15RYG	30REYG 30RYG	30REYG 30RYG	30RES 30RESA 30REYG 30RYG	30REYG 30RYG
Alternator model	4H7	4J7	2F5	2G5	2F7	2G7
Stator leads, qty.	4	12	4	12	4	12
Phase	1	3	1	3	1	3
Rotor resistance, ohms, cold	3.0	3.0	5.2	5.2	5.6	5.6
Stator resistance, ohms,* cold						
Main winding: 1-2, 3-4	0.07	—	0.06	—	0.02	—
Main winding: 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	—	0.04	—	0.09	—	0.06
Aux. winding: 55-66	1.26	1.3	0.60	0.19	0.44	0.18
Stator output AC voltage with separately excited rotor using 12-volt battery, minimum:						
Main winding: 1-2, 3-4	105	—	105	—	88	—
Main winding: 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	—	120	—	140	—	112
Aux. winding: 55-66	130	150	140	190	117	150
Rotor field DC voltage/current readings at rated output voltage, hot:						
No load	16V/4.5A	16V/4.5A	19V/3.2A	12V/2.5A	19V/3.9A	15V/2.2A
Full load	36V/8.6A	40V/9.5A	51V/7.6A	63V/9.8A	53V/7.4A	69V/9.6A

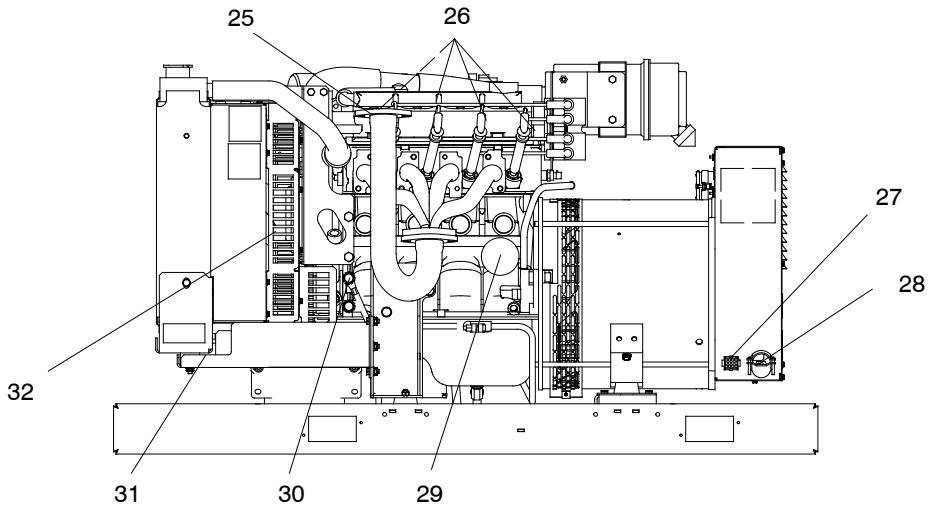
* Most ohmmeters do not give accurate readings when measuring less than 1 ohm. The stator can be considered good if a low resistance reading (continuity) is obtained and there is no evidence of shorted windings (discoloration). Do not confuse a low resistance reading with a reading indicating a shorted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

1.6 Service Views

Service-Side View



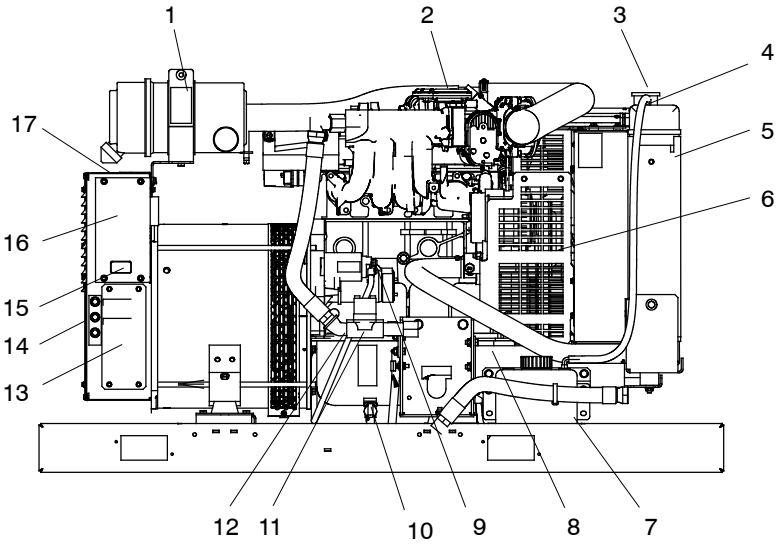
Non Service-Side View

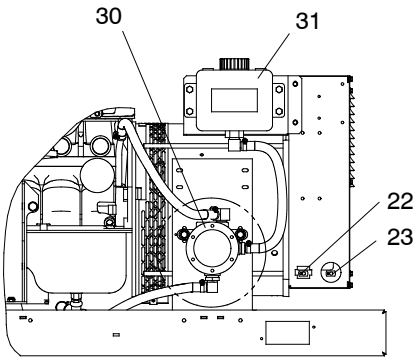


GM32850D-J

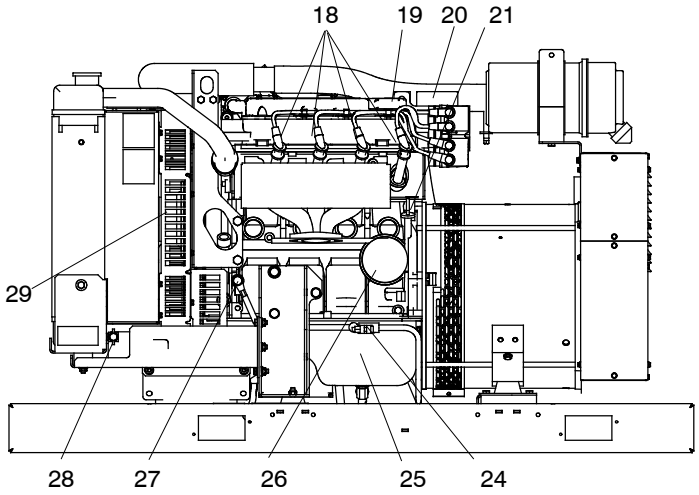
1. Fuses (F1, F2, and F3)
2. Generator set master switch (RUN\OFF/RESET\AUTO)
3. Advanced Digital Control (ADC 2100)
4. Runtime hour display
5. Nameplate
6. Air cleaner
7. Oil check
8. Oil fill (on valve cover)
9. Coolant temperature sender
10. Fuel/air mixer
11. Pressure cap (engine water fill)
12. Coolant overflow tube
13. Radiator
14. Belt guard
15. Battery charging alternator
16. Low oil pressure switch
17. Coolant overflow bottle (daily coolant check/fill location)
18. Secondary fuel regulator
19. Fuel solenoid valve
20. Oil drain valve
21. Positive (+) battery connection point
22. Fuel inlet
23. Engine control module (ECM)
24. AC line circuit breaker panel
25. Exhaust connection
26. Spark plugs
27. Remote customer interface connector
28. Customer load lead access
29. Oil filter
30. Negative (-) battery connection point
31. Coolant drain
32. Cooling air inlet

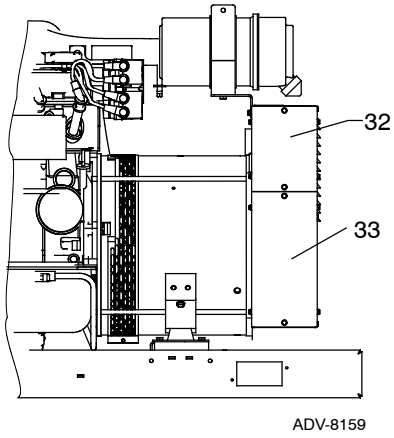
Figure 1-1 Generator Set Service View, RES/RYG Models





Oil Makeup Kit (optional, for 30 kW only)





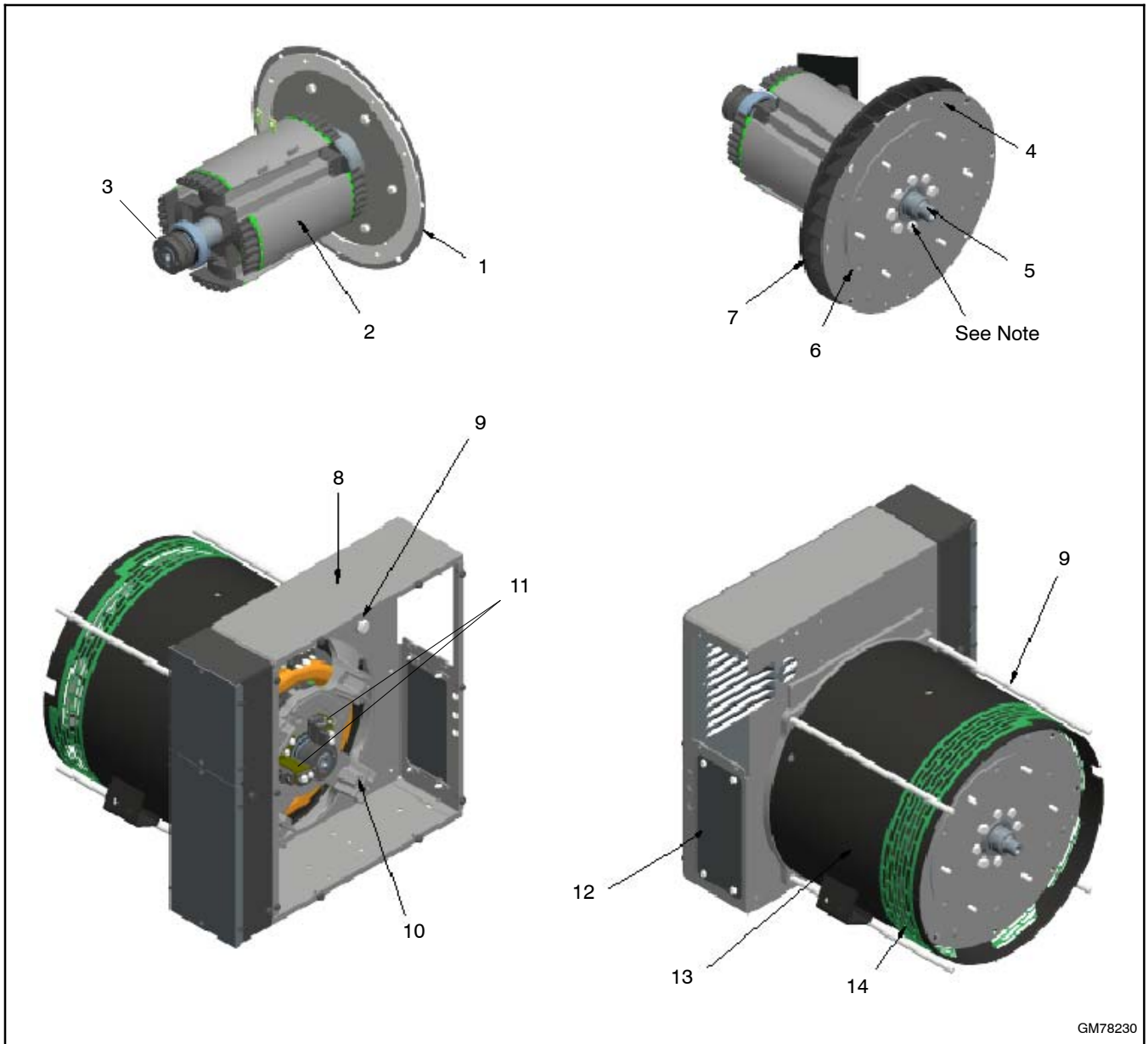
ADV-8159

Units with Customer Connection Box

Note: The enclosure is not shown in these service views.

1. Air cleaner
2. ECM and EPR (electronic fuel pressure regulator)
3. Pressure cap (engine coolant fill)
4. Coolant overflow tube
5. Radiator
6. Belt guard
7. Coolant overflow bottle
8. LOP switch location
9. Positive (+) battery connection point
10. Oil drain valve
11. Fuel solenoid valves (two required for UL 2200)
12. Fuel inlet
13. AC circuit breaker panel
14. Generator set fuses
15. Generator set master switch
16. Advanced Digital Control, ADC 2100
17. Nameplate
18. Spark plugs
19. Oil fill (on valve cover)
20. Engine fuses
21. Oil check (dipstick)
22. Remote customer interface connector
23. Customer load lead access
24. Battery cables
25. Battery location (battery not shown)
26. Lube oil filter
27. Negative (-) battery connection point
28. Coolant drain
29. Cooling air inlet
30. Oil makeup assembly with sight gauge (optional, for 30 kW)
31. Oil reservoir
32. Load lead access, behind panel
33. Customer interface connection, behind panel

Figure 1-2 Generator Set Service View, RESA/REYG Models



Note: See Section 1.4 for torque values. See Section 5 for alternator test procedures.

1. Drive disc
2. Rotor assembly
3. Slip rings. See Section 5.5.
4. Apply permabond HM-128
5. Apply anti-seize compound
6. Drive disc (qty. 2)
7. Fan
8. Junction box
9. Overbolts (qty. 4). Upper left overbolt (as viewed from inside the junction box) requires a lock washer.
10. End bracket assembly
11. Brushes. See Section 5.6.
12. Circuit breaker cover
13. Stator assembly
14. Fan guard

Figure 1-3 Alternator Assembly

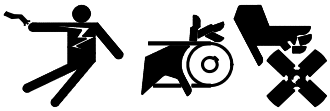
Notes

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

This equipment must be installed and serviced by qualified electrical personnel.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

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

⚠ 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.

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.

⚠ WARNING

Risk of 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.

Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor 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.

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® 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® 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 ADC 2100 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.

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

Perform Service at Intervals Indicated (X)	Before Starting	Weekly	100 Hr. (3 Mo.)	300 Hr. (6 Mo.)	400 Hr. (Yearly)
Fuel System					
Check the fuel level and fill as necessary (LP)	X				
Check the solenoid valve operation *		X			
Check the fuel lines and replace as necessary *				X	
Lubrication System					
Check the crankcase oil level and add oil as necessary	X 24 hr.				
Replace the oil in the crankcase			X 200 hr.		
Replace the lube oil filter element			X 200 hr.		
Cooling System					
Check the coolant level and fill as necessary	X				
Inspect the radiator and hoses	X				
Check the belt tension and condition *			X		
Check the coolant protection and tighten the hose clamps *					X
Flush the cooling system *					X 800 hr.
Ignition System					
Clean and regap the spark plugs				X	
Replace the spark plugs					X 800 hr.
Intake/Exhaust System					
Inspect the exhaust system components *	X				
Check the installation and operation of CO detectors	X				
Check the exhaust gas condition during operation	X				
Inspect and clean the air cleaner element			X		
Replace the air cleaner element				X	
Inspect the complete exhaust system ‡					X
Electrical System					
Keep the battery charged and in good condition §	X				
Check and tighten electrical connections		X			
Clean the battery cables as required *	X				
Engine and Mounting					
Check for fuel, coolant, and oil leakage *†	X				
Retighten all nuts and bolts as required	X				
Check tightness of mounting bolts/vibromounts			X		
Remote Control System					
Check the remote control operation		X			X
Generator Set					
Test run the generator set		X			
Blow dust out of the generator *					X
Clean collector ring and inspect brushes *					X 1000 hr.

* Consult your local distributor/dealer for service.
† Read WARNING found at the beginning of manual regarding moving parts.
‡ Should be performed by your local distributor/dealer.
§ Consult battery manufacturer's instructions.
Note: Hr. refers to hours of generator set operation.

Figure 2-1 Service Schedule

2.2 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.

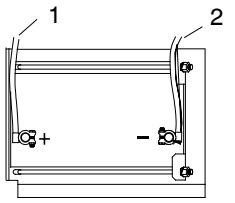
Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled 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.

Use a 12-volt battery with a minimum rating of 525 cold cranking amps at –18°C (0°F) The generator set uses a negative ground with a 12-volt engine electrical system. Make sure that the battery is correctly connected and the terminals are tight. See Figure 2-2.

Note: The generator set will not start and circuit board damage may result if the battery is connected in reverse.



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

Figure 2-2 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. Clean the battery by wiping it with a damp cloth. Keep the electrical connections dry and tight.

Consult the battery manufacturer's instructions for battery care and maintenance.

2.2.1 Cleaning Battery

To prevent dirt and grime buildup, occasionally wipe the battery with a damp cloth.

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. Do not allow the cleaning solution to enter the battery's cells. 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.

2.2.2 Checking Electrolyte Level

Check the electrolyte level of batteries with filler caps monthly. Remove filler caps and verify that electrolyte level reaches bottom of filler holes. Refill as necessary with distilled water. DO NOT add fresh electrolyte. Tighten all filler caps. If water is added during freezing temperatures, run the generator set for 20–30 minutes to mix the electrolyte and water to prevent battery damage from freezing.

2.2.3 Checking Specific Gravity

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. While holding the hydrometer vertically, read the number on the glass bulb at the top of the electrolyte level or the number adjacent to the pointer. If the hydrometer used does not have a correction table, use the correction factors in Figure 2-5. Determine specific gravity and electrolyte temperature of battery cells. Locate temperature in Figure 2-5 and adjust the specific gravity by the amount shown.

The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 80°F (26.7°C). The difference between specific gravities of each cell should not exceed ±0.01. Charge the battery if the specific gravity is below 1.215 at an electrolyte temperature of 80°F (26.7°C). See Figure 2-3.

Specific Gravity, Corrected to 80°F (26.7°C)	Battery Condition
Below 1.215	Needs charging
1.260	Fully charged

Figure 2-3 Specific Gravity Interpretation

Some battery testers have four or five beads in the test tube. Draw electrolyte into the tube as performed with the battery hydrometer described previously. Use the manufacturer's instructions. Figure 2-4 interprets typical test results.

Number of Floating Beads	Battery Condition
5	Overcharged
4	Fully charged
3	Good charge
1 or 2	Low charge
0	Dead battery

Figure 2-4 Bead-Type Test Interpretation

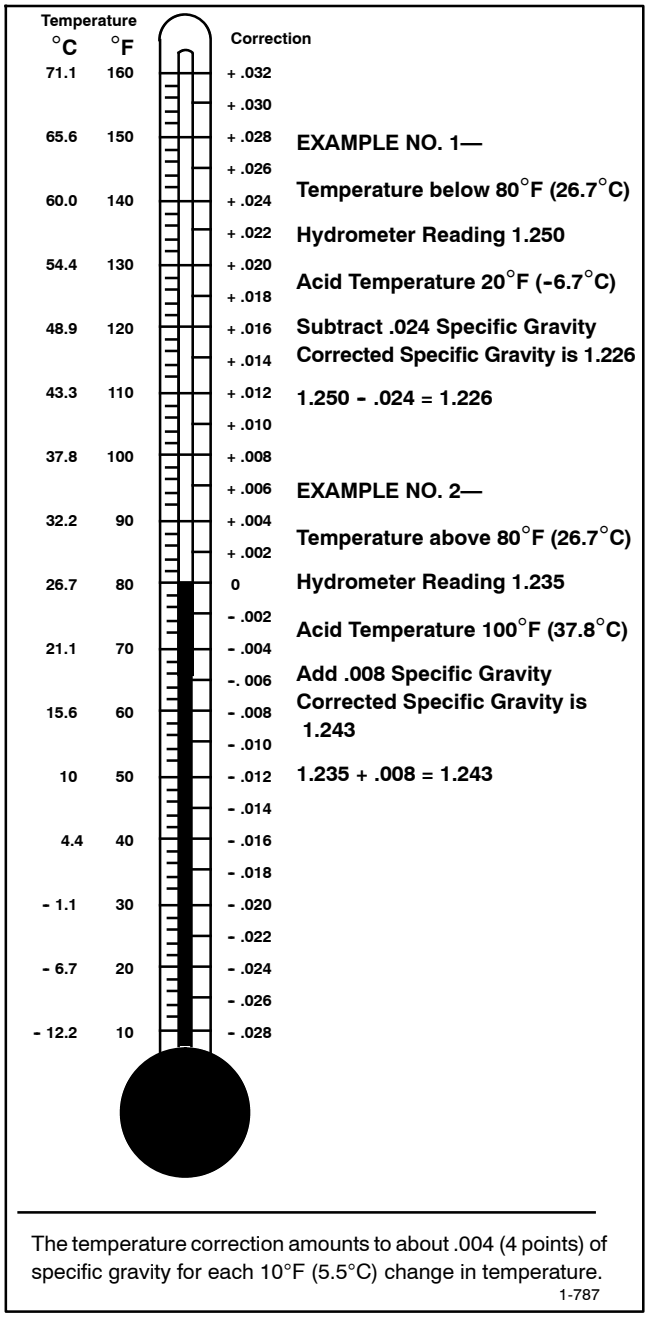


Figure 2-5 Specific Gravity Temperature Correction

2.2.4 Battery Charger

Generator sets may be equipped with a factory-installed battery charger to keep the starting battery fully charged. Observe the battery polarity when connecting the battery charger. Check the battery charger fuse and power supply.

See the instruction sheet supplied with the battery charger for information about battery charger operation and troubleshooting.

2.3 Fuel System Maintenance

Routine fuel system service items include draining water/sediment from piping at petcock or pipe end cap, checking for fuel leakage at pipe connections, checking flexible sections for cracking or chafing, and keeping components clean including fuel regulator vent holes.

A grease or wax residue tends to accumulate in the piping and fuel regulators over time. If fuel system problems persist, disassemble the fuel system components and check for residue buildup. Remove any residue with a brush and mild detergent.

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.

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

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

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 ADC 2100 display. Section 4.5 describes the warning and shutdown fault codes.
- **Blown fuses.** Fuses protect the controller, SCR module, and relay interface board. Always check and replace the fuses before replacing other components.
- **Incorrect controller settings.** *Always* check the controller configuration settings before replacing the controller. Section 4.9 explains how to check and change the controller settings.
- **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 5.11, 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. See the List of Related Materials for document part numbers.

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank	Weak or dead battery	Recharge or replace battery. If battery is weak or dead, check battery charger fuse, power supply, and operation.	O/M
	Battery connections	Check for reversed or poor battery connections.	—
	Open circuit in engine/ controller connections	Check for loose connections. Check the wire harness continuity.	W/D
	Blown fuse F3, controller	Replace fuse; if fuse blows again, check circuit and components.	Section 5.12; W/D
	Blown fuse F2, relay interface board (RIB)	Replace fuse.	Section 5.12
		If fuse blows again, disconnect the board leads one at a time to identify the cause of the blown fuse: Lead 70A at the fuel valve Lead 71A at P30 Leads FP and FN at the rotor Repair or replace the component causing the blown fuse.	W/D

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank, continued	Blown fuse F2, relay interface board (RIB), continued	If fuse continues to blow and the previous step did not identify the cause, check the continuity of leads FP and FN and the leads from the P14 connector. Replace any bad leads. Use a pin pusher, part #241918 (large) or #241919 (small) to remove leads from the connector, if necessary. If replacing the leads does not solve the problem, replace the RIB.	W/D Section 4.6
	Crank relay on relay interface board (RIB)	Check connections to the RIB. Check for 12VDC to the RIB on lead 71N.	Section 4.6 W/D
		Check for a good ground connection (lead N)	W/D
		Check crank relay K2 operation (LED3). Replace the RIB if relay does not operate.	Section 4.6
	Generator set master switch	Check connections to the master switch on the ADC 2100.	Section 4.3 Section 5.13
		Test function of switch.	Section 5.13
	Poor ground (–) connection	Clean and retighten.	—
	Starter	Check starter connections.	W/D
		Rebuild or replace starter.	Engine S/M
	Controller	Check controller connections and operation. Check for power to the controller. Move generator set master switch to OFF/ RESET and then to RUN.	Section 4; W/D
Cranks but does not start	No fuel	Open (turn on) manual fuel valve. Check 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.	I/M
	Fuel regulator/valve	Check regulator/valve operation.	I/M
	Spark plugs or spark plug connections	Check spark plug wires and connections. Replace or clean and regap spark plugs.	O/M
	Loose connection or open circuit	Check for loose or open connections at the fuel valve (lead 70A) and at the engine control module. Check controller/engine wiring continuity.	W/D
	Air cleaner clogged	Clean or replace.	O/M
	Incorrect controller configuration	Check for correct controller configuration parameters: unit configuration (UC) and engine configuration (EC).	Section 4.9
	Ignition system spark control or ignition coil	Test and/or replace components.	Engine S/M
	Fuel select leads 65 and 70A leads incorrectly connected or disconnected	Connect for natural gas. Disconnect for LP.	I/M
	No engine rotation sensed (check for an overcrank fault shutdown)	Check for locked rotor.	Section 5.4
Starts hard	Low battery voltage	Check battery voltage and battery charger connections, power supply, and operation.	O/M
	Air cleaner clogged	Replace element.	O/M
	Fuel mixture adjustment incorrect	Adjust fuel valve.	O/M
	Fuel select leads 65 and 70A leads incorrectly connected or disconnected	Connect for natural gas. Disconnect for LP.	I/M
	Spark plug(s)	Replace or regap spark plug(s).	O/M

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Starts hard, continued	Spark plug wire(s)	Check spark plug wires and connections. Replace spark plug wires.	Engine S/M
	Ignition components (spark control or ignition module)	Test/replace ignition components.	Engine S/M
	Insufficient fuel pressure	Check fuel pressure	I/M
	Worn piston rings, valves	Check compression.	Engine S/M
Starts but shuts down	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.5 Section 5.10
Stops suddenly	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.5 Section 5.10
	No fuel	Turn on fuel supply.	—
	Fuel line restriction	Inspect fuel lines.	—
	Fuel lines too long	Check fuel line length.	I/M
	Air cleaner clogged	Replace element.	O/M
	Blown controller fuse (F3)	Replace fuse.	Section 5.12
	Blown auxiliary winding fuse (F1)	Replace fuse. If fuse blows again, test generator components.	Section 5.12
	Blown relay interface board (RIB) fuse (F2)	Replace fuse.	Section 5.12
	Spark plug(s)	Replace and regap plug(s).	Engine S/M
	Engine overheated (hot engine only)	Check air intake, fuel adjustment, oil level, air inlet/outlet.	O/M and I/M
	Low oil pressure (LOP) switch	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.	Engine S/M
	Fuel valve/fuel regulator	Check regulator/valve operation.	O/M and I/M
	Engine overloaded	Reduce electrical load.	I/M
	Loss of generator output voltage to controller	Check connections at P15 plug. Check continuity of AC sensing leads 11 and 44 (1-phase models) or V7, V8, and V9 (3-phase models).	W/D
	Ignition module	Test and/or replace.	Engine S/M
	K3 (flash) relay	Check for Flash LED illumination. Check RIB fuse. Replace relay board.	Section 4.6

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Operates erratically	Air cleaner clogged	Replace element.	O/M
	Spark plug(s)	Replace and regap plugs.	O/M
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Fuel select leads 65 and 70A leads incorrectly connected or disconnected	Connect for natural gas. Disconnect for LP.	I/M
	Fuel line restriction	Check fuel lines.	—
	Fuel mixture adjustment incorrect	Check and/or adjust.	I/M
	Ignition system	Test and/or replace components.	Engine S/M
	Inadequate cooling (hot engine only)	Inspect air inlet and outlet.	—
	Carbon buildup in engine	Clean cylinder head.	Engine S/M
	Engine valves not seating correctly	Check cylinder pressures with leakdown test. Inspect valves and valve seats.	Engine S/M
Lacks power	Air intake restriction, inadequate cooling	Inspect air intakes and exhaust for obstructions. Check air cleaner.	—
	Generator overloaded	Reduce load.	—
	Spark plug(s)	Replace and regap plug(s).	O/M
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Fuel select leads 65 and 70A incorrectly connected or disconnected	Connect for natural gas. Disconnect for LP.	I/M
	Insufficient fuel pressure	Check fuel pressure at carburetor outlet.	I/M
	Fuel line restriction	Check fuel pipe size.	I/M
	Fuel regulator	Check function of fuel regulator.	I/M
	Engine not running at rated rpm	Check controller settings for unit configuration (UC) and engine type (EC).	Section 4.9.2
	Engine power loss	Refer to the engine service manual for troubleshooting and repair instructions.	Engine S/M
	Ignition system	Test and/or replace.	Engine S/M
Overheats	Inadequate cooling	Inspect cooling system for air intake obstructions.	—
	Fuel mixture adjustment incorrect	Readjust fuel mixture.	I/M

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Low output or excessive drop in voltage	Generator overloaded	Reduce load.	—
	Incorrect controller configuration	Check and adjust the controller configuration parameters.	Section 4.9.2
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 4.9.2
	Alternator or control system	Perform separate excitation procedure to isolate problem to the alternator or the control system.	Section 5.2
	SCR module	Check wiring and connections to the SCR module. Check auxiliary winding fuse F1 (lead 55). Replace SCR module and test voltage.	Section 5.12 Section 4.7
	Controller	Check controller settings. Check controller fuse, wiring and connections. Before replacing controller, replace SCR module and test voltage.	Section 4.9.2 Section 4.8
	Rotor (open, grounded, or shorted windings)	Test and/or replace.	Section 5.4
	Stator (open, grounded, or shorted windings)	Test and/or replace.	Section 5.3
	Brush connection	Check for loose brush connections. Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.	Section 5.6
	Low engine speed causing voltage roll-off	Check system voltage/frequency (Uu) and engine type (Ec) parameters Troubleshoot engine	Section 4.9.2 Engine S/M
Light flicker	Voltage stability (gain) setting	Check and adjust the voltage stability (gain) setting using the ADC 2100.	Section 5.7
High output voltage	Incorrect controller configuration	Check and adjust the controller configuration parameters.	Section 4.9.2
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 5.7
	Loose voltage sensing connections	Check connections: stator leads 11 and 44 (1-phase models) or V7, V8, and V9 (3-phase models) and P15 controller connection.	W/D
High output voltage, continued	SCR module	Check wiring and connections to the SCR module. Check auxiliary winding fuse F1 (lead 55). Replace SCR module and recheck voltage.	Section 4.7 Section 5.12 Section 4.7
	Controller	Check fuses, wiring and connections. Before replacing controller, replace SCR module and test voltage.	Section 4.8

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
No output voltage	AC output circuit breaker open	Check for AC voltage on the generator side of circuit breaker. If there is AC voltage on the generator side of the breaker, then a problem in the load circuits is causing the line circuit breaker to trip. Check for and correct short circuits or overloading on the load side before resetting the circuit breaker.	—
	Alternator or control system	Perform separate excitation procedure to isolate the problem to the alternator or the control system. Then troubleshoot the alternator or control system components as follows.	Section 5.2
	Aux. winding fuse blown (lead 55)	Replace blown fuse. If fuse blows again, check stator.	Section 5.3
	SCR module	Check auxiliary winding fuse F1 (lead 55). Replace SCR module and test voltage.	Section 5.12 Section 4.7
	Controller	Check controller settings. Check wiring and connections. Before replacing controller, replace SCR module and check voltage.	Section 4.9.2 Section 4.8
	Open wiring, terminal, or pin in buildup circuit or SCR module circuit	Check continuity.	Section 5.13 W/D
	Brushes	Inspect brushes and replace if worn	Section 5.6
		Check for brushes sticking in brush holder or broken brush spring	Section 5.6
	Rotor connections	Check for open circuit in rotor connection circuit (leads FN and FP to SCR and RIB)	W/D
	Rotor slip rings dirty or corroded	Check slip ring condition.	Section 5.4
	Rotor (open, grounded, or shorted windings)	Check voltage and continuity.	Section 5.4
	Stator (open, grounded, or shorted windings)	Check voltage and continuity.	Section 5.3
	Flash relay (K3) on relay interface board (RIB)	Check flash LED on RIB. Check fuse F2 and troubleshoot RIB.	Section 4.6
Noisy operation	Exhaust system leaks	Check and replace as necessary.	O/M
	Engine not running smoothly	See “Generator set operates erratically,” this table	—
	Broken or damaged vibromount(s)	Check and replace as necessary.	—
	Loose or vibrating sheet metal/housing	Retighten screws, replace rivets.	—
	Exhaust piping or air inlets/outlets not securely installed	Inspect for loose parts and secure, if necessary.	—
	Excessive engine/ generator vibration	Check, rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Engine S/M

Engine S/M: Engine Service Manual I/M: Generator Set Installation Manual O/M: Generator Set Operation Manual
W/D: Wiring Diagram Manual

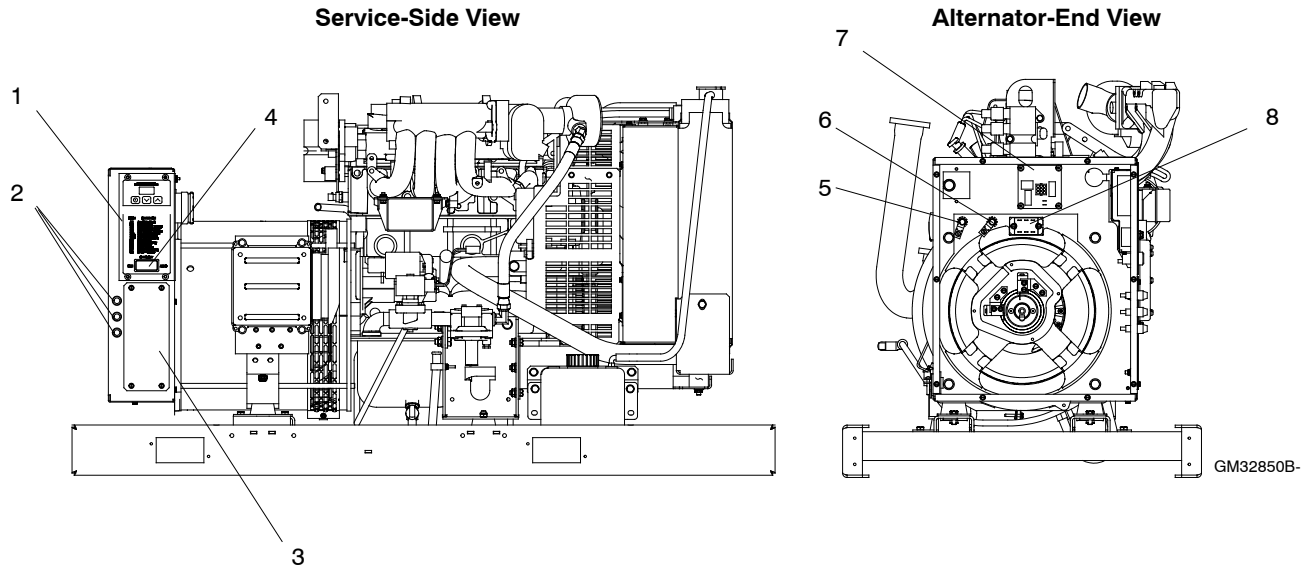
4.1 Introduction

This section describes the operation and replacement of the ADC 2100 controller. Controller configuration and adjustment are explained in Section 4.9. See Section 3 for troubleshooting procedures.

See Figure 4-1 for the locations of the ADC 2100 controller and related components.

A relay interface board (RIB) is used with the controller. Section 4.6 describes the standard and optional RIBs.

A silicon controlled rectifier (SCR) module works with the controller to regulate the output voltage. See Section 4.7.

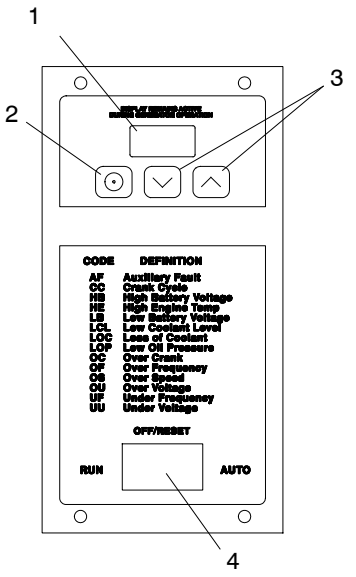


1. ADC 2100 controller
2. Fuse location (F1, F2, and F3) **Note:** Some earlier models had inline fuses located in the engine harness. See Section 5.12.
3. Line circuit breaker panel (load connection)
4. Generator set master switch
5. L0 stud
6. Ground stud
7. Relay interface board (RIB)
8. SCR module

Figure 4-1 Advanced Digital Control (ADC 2100)

4.2 Controller Display and Keypad

The controller has an LED display and a three-button keypad. See Figure 4-2. The LED display shows runtime hours, fault codes, application program version number, or controller parameters during configuration and adjustment. See Figure 4-3. The keypad is used to enter the controller's configuration and adjustment menus, and to change the controller settings.



GM28707A-C

1. LED display
2. Select button (for setup and adjustment only)
3. Up and down arrow buttons (for setup and adjustment only)
4. Generator set master switch

Figure 4-2 ADC Controller

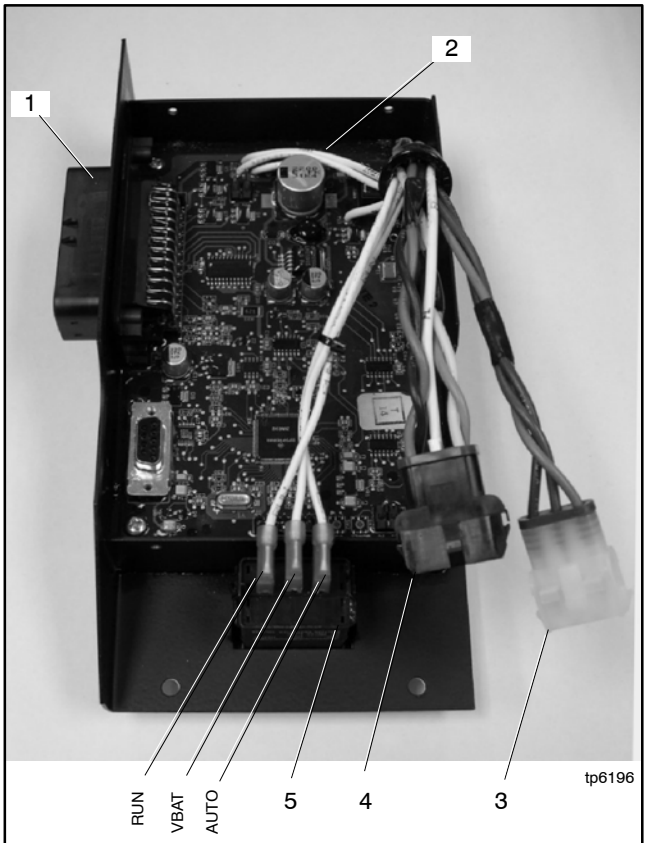
Item	Description
Crank indication	Displays CC_1, CC_2, or CC_3 to indicate the first, second, or third attempt to start the engine. The last digit flashes during the crank cycle rest periods.
Runtime hours	Displays total generator set runtime hours when no other code is displayed.
Fault codes	Flashes a 2- or 3-letter fault code to indicate various fault conditions. See Section 4.5.
System parameters	Displays 2-letter codes or 4-digit alphanumeric codes during system configuration or adjustment. See Section 4.9.2.
Application program version number	Displays the version number of the controller's application program before entering the configuration or adjustment mode. See Section 4.9.2.

Figure 4-3 ADC Controller LED Display

A password key sequence is required to enter the configuration and adjustment menus. Section 4.9 contains the instructions to enter the configuration and adjustment menus and change the settings using the controller keypad.

4.3 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 pink connectors are connected to the terminals on the back of the switch as shown in Figure 4-4. Be careful not to reverse the RUN and AUTO leads.



1. Engine wiring harness connector plug (P1)
2. Continuous power mode jumper location (P7)
3. J15 connector
4. J16 connector
5. Generator set master switch

Figure 4-4 Controller Connections

4.4 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 the generator set wiring diagram manual to assist in the troubleshooting procedure. Refer to the List of Related materials for the wiring diagram manual part numbers for the RES/RYG and the RESA/REYG models.

4.4.1 Starting Sequence, Master Switch Moved to RUN

When the master switch is moved to the RUN position, there is a delay of about 2 sec. before the controller attempts to start the engine. The run relay energizes and the run LED (1) turns on. The crank and flash relays energize and the corresponding LEDs (2 and 3) turn on 0.5 sec. later. 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 sec. crank and 15 sec. 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 controller's application code and is not adjustable in the field.

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

4.4.2 Starting Sequence, Remote Start

When the master switch is set to the AUTO position, the generator set starts when the remote start switch or transfer switch engine start contacts close.

The start sequence proceeds as described in Section 4.4.1, Starting Sequence, Master Switch Moved to RUN.

4.4.3 Running Sequence

When the engine speed reaches 750 rpm, the crank relay deenergizes and the crank LED (3) turns off. When the output voltage on leads 11 and 44 (1-phase models) or V7, V8, and V9 (3-phase models) reaches about 30 VAC, the flash relay deenergizes and the flash LED (2) turns off.

4.4.4 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.

4.4.5 Stopping Sequence, Remote Stop

When the remote start contacts open, the run relay deenergizes and the run LED (1) turns off, but the controller does not power down. The controller remains powered and displays the engine runtime hours.

Note: Disconnecting the P7 jumper inside the controller will allow the controller to power down 48 hours after generator set shutdown. See Section 4.10 for instructions.

4.5 Faults

4.5.1 Warnings

The fault conditions listed in Figure 4-5 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 10 sec. 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 sec.	Check the battery rating and condition. Replace the battery as needed.
LB	Low battery voltage warning	Fault code is displayed if the engine starting battery voltage falls below 9.5 VDC for a 12 VDC system or below 16 VDC for a 24 VDC system for more than 10 sec. 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 sec.	Check the battery rating and condition. Charge or replace the battery.

Figure 4-5 Fault Warning Codes

4.5.2 Shutdowns

Under the fault conditions listed in Figure 4-6, 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.

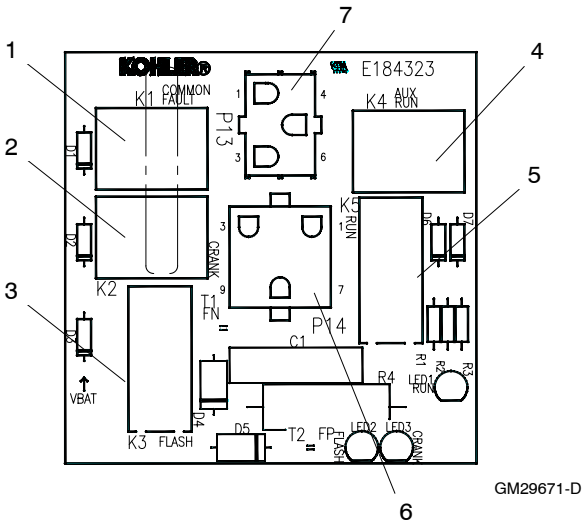
Move the generator set master switch to the OFF/ RESET position to reset the controller after a fault shutdown. Then move the switch to the AUTO or RUN position.

Code	Fault	Description	Check	Reference
AF	Auxiliary fault	Input from a user-supplied switch that closes when the fault is active. The generator set shuts down 0.3 sec. after the fault is detected and will not start when the fault is active (input is grounded). This protection becomes active 3 sec. after crank disconnect.	Check the condition and operation of the customer-supplied equipment connected to the auxiliary fault input P21-6.	—
HE	High engine temperature	Shutdown occurs if the engine coolant temperature exceeds the maximum temperature for more than 5 sec. This protective becomes active after engine reaches the crank disconnect speed.	Check for blocked air inlets and exhaust outlets.	Section 1.6
LCL	Low coolant level	Not used.	—	—
LOC	Loss of coolant	Not used.	—	—
LOP	Low oil pressure	Shutdown occurs if a low oil pressure condition exists for more than 5 sec. This protective becomes active 30 sec. after the engine has reached crank disconnect speed (30-sec. 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 O/M Section 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 sec. cranking and 15 sec. rest.	Check the fuel supply valves and pressure. Check spark plug and battery. See Troubleshooting Chart, generator set cranks but does not start.	I/M O/M Section 3.3
		The generator set shuts down on an overcrank fault if no engine rotation is sensed. Shuts down after 3 sec. of cranking or 1 sec. after the fault is detected.	Check for a locked rotor.	Section 5.4
OF	Overfrequency	Shutdown occurs when the governed frequency exceeds 110% of the system's frequency setpoint for more than 5 sec. This protective becomes active 10 sec. after engine start (10-sec. inhibit).	Check system frequency setting (parameter UU) on controller.	Section 4.9
			Check engine governing system, controlled by the engine ECM.	Engine S/M
OS	Overspeed	Shutdown occurs if the engine speed exceeds 115% of the normal running speed for more than 0.3 sec.	Check engine governing system, controlled by the engine ECM.	Engine S/M
OU	Overvoltage	Shutdown occurs if the voltage exceeds 120% of the system nominal voltage for more than 2 sec.	Check AC voltage. Check wiring and connections.	Section 5.7 W/D
UF	Underfrequency	Shutdown occurs when the governed frequency falls blow 90% of the nominal system frequency for more than 5 sec. or below 59 Hz for more than 60 sec. This protective becomes active 10 sec. after engine start. (10-sec. inhibit).	Reduce the load and restart the generator set.	—
UU	Undervoltage	Shutdown occurs if the voltage falls below 80% of the nominal system voltage for more than 10 sec.	Reduce the load and restart the generator set.	—
			Check wiring and connections.	W/D
			Check controller configuration, system voltage and frequency (parameter UU).	Section 4.9
			Check AC voltage and adjust, if necessary.	Section 5.7
			Replace the SCR module and test voltage again.	Section 4.7
			Separately excite unit.	Section 5.2
			Check stator continuity.	Section 5.3
SCF0	Software Communication Fault 0	Indicates a software or communication problem within the ADC 2100.	Replace the controller.	Section 4.8
Note: O/M = Generator Set Operation Manual; I/M = Generator Set Installation Manual; W/D = Wiring Diagram Manual				

Figure 4-6 Fault Shutdown Codes

4.6 Relay Interface Board

The standard Relay Interface Board (RIB) contains the K2 crank, K3 flash, and K5 run relays. Three LEDs indicate relay operation. See Figure 4-7.



1. K1 common fault relay (optional)
2. K2 crank relay (standard)
3. K3 flash relay (standard)
4. K4 auxiliary run relay (optional)
5. K5 run relay (standard)
6. P14, engine harness connection (standard)
7. P13, connection to optional relay harness (optional)

Figure 4-7 Relay Board

Refer to the schematic diagram in the generator set wiring diagram manual for the standard relay board connections.

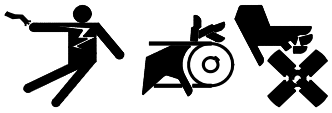
The RIB is protected by a 10 amp fuse (F2). If the fuse blows repeatedly, disconnect the board loads one at a time to identify the cause of the blown fuse:

- Lead 70A at the fuel select QCON2 connector
- Lead 71A starter lead at the engine ECM connector
- Leads FP and FN at the rotor

If fuse continues to blow and disconnecting components did not identify the cause, remove the leads from the P14 connector using a pin pusher, part #241918 (large) or #241919 (small). If replacing the leads does not solve the problem, replace the RIB.

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.

Procedure to Replace the RIB:

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 P14 and the brush leads FP and FN.
5. Pull the board straight off the mounting stand-offs.
6. Snap the new board onto the stand-offs and reconnect P14 and the brush leads.

The generator set may be equipped with an optional RIB, which contains the K4 auxiliary run relay and K1 common fault relay in addition to the standard relays. The optional relay board kit includes a wiring harness for

connection of customer equipment to the K1 and K4 relays. See Figure 4-8 for optional relay connections.

Harness Lead Number	Connector Pin Number	Connection
88	6	Common fault normally open
89	2	Common fault common
90	3	Common fault normally closed
91	4	Run relay normally open
92	1	Run relay common
93	5	Run relay normally closed

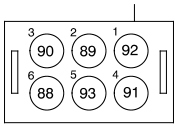


Figure 4-8 Optional Common Fault and Run Relay Board Harness Connections

4.7 Silicon Controlled Rectifier Module

The silicon controlled rectifier (SCR) module works with the ADC 2100 to regulate the output voltage. The ADC 2100 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 4-9 and the wiring diagrams in the wiring diagram manual.

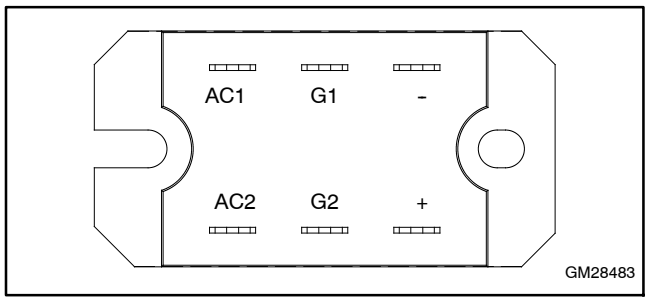


Figure 4-9 Silicon Controlled Rectifier (SCR) Module

The SCR module is protected by a 10-amp fuse (F1) in lead 55 in the wiring harness. 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.

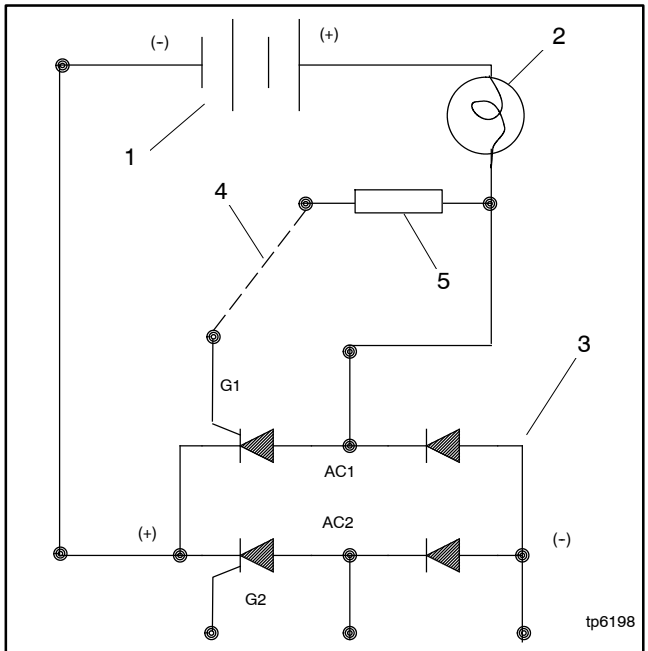
SCR Module Test Procedure

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 4-10. 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. 12VDC power source
2. 12 VDC test lamp
3. SCR module
4. Jumper
5. 100–500 ohm resister

Figure 4-10 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.

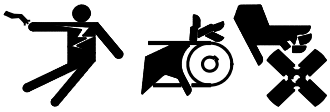
10. Connect the jumper, with the resistor in series, from the positive lead of the DC power source to terminal G1 on the SCR module. The lamp should glow.

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 bad SCR module, replace the module.

4.8 Controller Replacement

⚠ 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.

If the troubleshooting procedures in Section 3 identify a bad 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 and frequency, unit configuration, engine type, engine data input types, battery voltage, and communications settings. Refer to Section 4.9 for instructions to check the controller configuration and to change the settings, if necessary.

After the controller configuration has been checked and set to match the generator set, use a voltmeter to check the generator set output voltage. If the output voltage needs adjustment, use the Voltage Adjustment Procedure in Section 5.7.2 and the controller voltage adjustment instructions in Section 4.9.

ADC 2100 Controller Replacement 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 four mounting screws from the front of the controller.

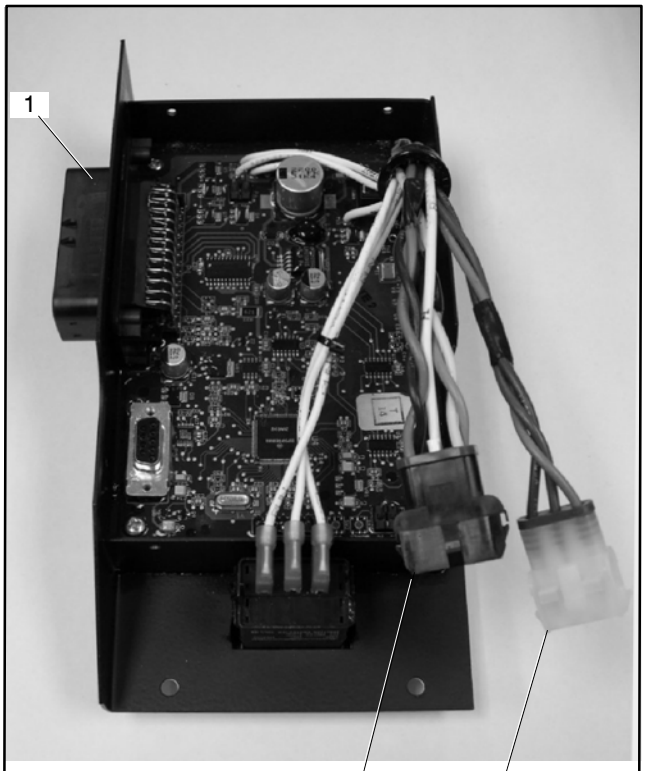
5. Carefully pull the controller forward, angling it so that the P1 connector on the right side clears the opening in the mounting plate.

6. Disconnect plugs P1, P15, and P16 from the ADC controller. See Figure 4-11.

7. Attach plugs P1, P15, and P16 to the new controller.

8. Place the new controller into position and install the four mounting screws.

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



1. Engine wiring harness connector plug (P1)
2. J15 connector
3. J16 connector

Figure 4-11 Controller Connections

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

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

12. Follow the instructions in Section 4.9 to change the new controller's configuration settings to match the generator set system voltage and frequency, unit configuration, engine type, engine data input types, battery voltage, and communications settings.

13. Use a voltmeter to check the output voltage. Follow instructions in Section 5.7.2, Voltage Adjustment, to adjust the output voltage and stability.

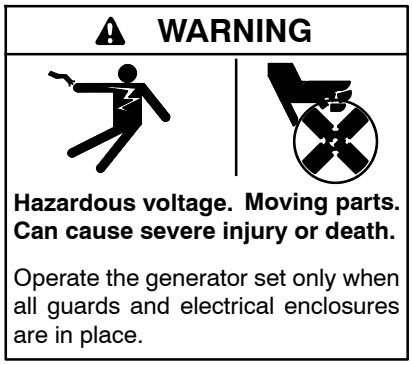
14. Place the generator set master switch in the AUTO position if an ATS or remote start/stop switch is used.

4.9 Controller Configuration and Adjustment

This section contains instructions for using the controller's password-protected menus to check and adjust the generator output and controller configuration. The controller configuration and generator set output are factory-set and should not require field adjustment under normal circumstances. Check and adjust the configuration and/or output in the following cases:

- Check and adjust the controller configuration and generator output after generator set reconnection to a different voltage.
- Check controller configuration when troubleshooting generator set problems.
- Check and adjust the generator set output after installation if the voltage requires adjustment for a particular application.

4.9.1 Voltage Adjustments



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.

The controller's adjustment mode allows adjustment of the output voltage, if necessary. Have adjustments performed by an authorized distributor/dealer or service technician.

Note: A digital voltmeter is required for these adjustments.

Use a voltmeter to check the output voltage. If the output voltage is not within specifications, use the ADC controller to adjust the output voltage while the generator set is running. The flowcharts in Figure 4-13 and Figure 4-14 outline the adjustment procedures.

Note: Be sure to save your settings before exiting the configuration mode.

Voltage changes are 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 if the changes have not been saved.

Pressing the Select button when SAVE is displayed returns to the first parameter, voltage adjust (1P).

Note: Refer to the flowcharts in Figure 4-13 and Figure 4-14 during the voltage adjustment procedure.

Voltage Adjustment Procedure

1. With the generator set off, connect a digital multimeter to the output leads or an electrical outlet on the load side of the generator set. Set the meter to measure AC voltage.
2. Start the generator set by moving the generator set master switch to the RUN position.
3. Use the ADC controller to adjust the voltage (parameter 1P) until the output voltage reaches the desired value. See Figure 4-12 for the approximate change in voltage per step in parameter 1P.

Measured Voltage, VAC	Voltage Change per Step, VAC	
	Coarse Adjust	Fine Adjust
85–132	5	0.5
180–251	7	0.7

Figure 4-12 Voltage Adjustment (approximate)

4. Adjust the voltage stability (gain, parameter 2P) to minimize light flicker.
5. Readjust the voltage, if necessary.
6. Stop the generator set.

Output Voltage 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.

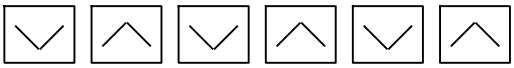
X X X X

Hold:

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

X X X

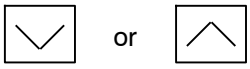
Press the down arrow key and then the up arrow key 3 times to enter the adjustment mode. (This is the controller "password.")



1 P X X

The controller is now in the voltage coarse adjustment mode.

Press:

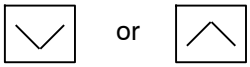


To raise or lower the voltage in large increments (approximately 5–7 volts per step).

1 P X X

To enter fine voltage adjustment mode.

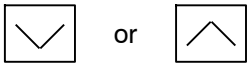
1 P X X



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

To enter coarse voltage stability (gain) adjustment mode.

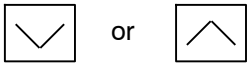
2 P X X



To raise or lower the voltage stability (gain) in large increments.

To enter fine voltage stability (gain) adjustment mode.

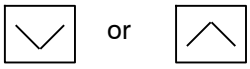
2 P X X



To raise or lower the voltage stability (gain) in smaller increments.

To enter volts/Hz adjustment mode.

3 P 0 X



To raise or lower the volts/Hz:
0.5% per step 00=0; 09 = 4.5%

Continued on Figure 4-14.

* 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 4-13 Output Voltage Adjustments

Continued from Figure 4-13:

Display : *

To enter SAVE mode. | 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.

There are 3 options when the display says SAVE:
Press: | S A V E

To return to the first parameter, coarse voltage adjustment, to check or change settings before saving. See Figure 4-13. | 1 P *x* *x*

or

To save changes. | Y E S

or

To discard changes without saving. | n o

"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. | *x* *x* *x* *x*

Now move the master switch to OFF/RESET.

* *X* in the examples above denotes any number from 0 to 9. The actual values may vary from model-to-model.

Figure 4-14 Output Voltage Adjustments, Continued

4.9.2 Controller Configuration

The controller configuration for each generator model is set at the factory and should not normally require changes. The controller's configuration mode allows adjustment of the system parameters listed in this section. Use the instructions in this section to check the configuration after installation and change them to match the settings shown in Figure 4-15, if necessary.

Parameter	Setting	Definition
Unit's system voltage and frequency	Uu01	Single phase, 60 Hz, 120/240 VAC
	Uu04	Three phase, 60 Hz, 138/277 or 240/480 VAC
Unit configuration	Uc01 *	Standby
Engine type	Ec03 *	15RYG/RES
	Ec06 *	30RYG/RES
Engine data input types **See Figure 4-16.**	Ed01 *	15/30RYG/RES
	Ed02	15/30RYG/RES with Remote Digital Gauge
Battery voltage	Bt12 *	Battery voltage 12 VDC
	Bt24	Battery voltage 24 VDC
Communications	Cn00 *	No CAN communications
	Cn01	J1939 (use for Remote Digital Gauge)
* Factory settings.		

Figure 4-15 Configuration Parameters

Parameter	Low Coolant Level Sensor	Pressure Sensor	Temperature Sensor	Magnetic Pickup
Ed00	Digital Switch	Digital Switch	Digital Switch	No
Ed01	Digital Switch	Digital Switch	Analog Sender	No
Ed02	Digital Switch	Analog Sender	Digital Switch	No
Ed03	Digital Switch	Analog Sender	Analog Sender	No
Ed04	Digital Switch	Digital Switch	Digital Switch	Yes
Ed05 *	Digital Switch	Digital Switch	Analog Sender	Yes
Ed06	Digital Switch	Analog Sender	Digital Switch	Yes
Ed07	Digital Switch	Analog Sender	Analog Sender	Yes
Ed08	Analog Sender	Digital Switch	Digital Switch	No
Ed09	Analog Sender	Digital Switch	Analog Sender	No
Ed10	Analog Sender	Analog Sender	Digital Switch	No
Ed11	Analog Sender	Analog Sender	Analog Sender	No
Ed12	Analog Sender	Digital Switch	Digital Switch	Yes
Ed13	Analog Sender	Digital Switch	Analog Sender	Yes
Ed14	Analog Sender	Analog Sender	Digital Switch	Yes
Ed15	Analog Sender	Analog Sender	Analog Sender	Yes
* Factory setting for replacement controllers. See Figure 4-15 for the default settings for certain models. The installation of optional sender kits (available for some models) may require a different Ed setting.				

Figure 4-16 Engine Data Input Types, Parameter Ed

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 over again from the beginning if the controller exits the configuration mode before the settings have been saved.

Follow the instructions in Figure 4-17 to enter the configuration mode while the engine is not running and then step through the following parameters. Use the up (∧) and down (∨) arrow buttons to select the appropriate setting for the application.

Voltage/frequency setting (Uu). Select the system voltage and frequency from the table in Figure 4-15. For system voltages not listed in the table, select the setting closest to the system voltage and then adjust the output voltage to the desired level using the instructions in Section 4.9.1.

Note: This parameter sets the nominal system voltage and frequency. To adjust the output (measured) voltage, see Section 4.9.

Unit configuration (Uc). This parameter sets the generator set type: marine, standby, or mobile.

Engine configuration (Ec). The engine configuration must match the generator set engine type.

Advanced configuration mode (Adnc). The data input types, battery voltage, and communications setting can be changed in the advanced configuration mode. Press the up arrow button when *Adnc* is displayed to enter the advanced configuration mode.

Engine data input types (Ed). This setting defines the type of senders used on the generator set engine. Use Ed01 for the 15/30RYG/RES.

The remote digital gauge requires the optional analog oil pressure sender. Install the optional sender and change the Ed parameter to Ed02.

Battery voltage (Bt). This setting toggles between 12 and 24 VDC for the engine starting battery voltage.

Communications setting (Cn). This setting allows the user to set the controller for communication with optional meters. The 15/30RYG/RES is factory-set for no CAN communications, Cn00. Change this setting to Cn01 if the optional Remote Digital Gauge is used.

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.

Controller Configuration Mode:

Hold the Select button:

Display:

Move the generator set master switch to the RUN position. (The generator set engine will not start.)

Display: . 0

Wait about 5 sec. until the display shows the program version number. (The number may be different than the one shown here.)

Display: 104

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

Display: Uu01

Now release the Select button.

Press:

or — To set the voltage/frequency setting. See Figure 4-15. Display: Uu01

To step to the next parameter, unit configuration Uc.

or — To set the unit configuration setting to Uc01, if necessary. Display: Uc01

To step to the next parameter, engine type Ec.

or — To set the engine type, if necessary. See Figure 4-15. Display: Ec06

To step to the next parameter, advanced configuration mode or save mode selection. Display: Adnc

Now either save your settings or enter the Advanced Configuration Mode to set the engine data inputs, battery voltage, and communications.

Press:

To enter advanced configuration mode. **Go to Figure 4-18.** Display: Ed01

or

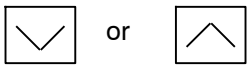
or — To proceed to the save mode without entering the advanced configuration mode. **Go to Figure 4-19.** Display: SAVE

Note: Shaded boxes show which number in the controller display changes when the up or down arrow key is pressed.

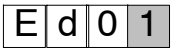
Figure 4-17 Configuration Mode (system voltage/frequency, unit configuration, and engine type parameters)

Pressing the up arrow key at the Adnc display (See Figure 4-17) puts you into the Advanced Configuration Mode.

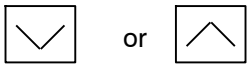
Press:



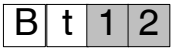
To set the engine data input type to Ed01. See Figure 4-15.



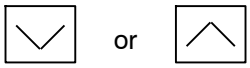
To enter battery voltage selection mode.



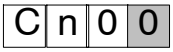
To toggle between 12 and 24 VDC. Set this parameter to 12 VDC.



To enter communications selection mode.



To set the communications parameter to Cn00 or Cn01. See Figure 4-15.



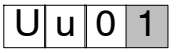
To enter SAVE mode. Go to Figure 4-19.

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.

Figure 4-18 Advanced Configuration Mode (engine data input types, battery voltage, and engine communications)

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

To return to the first parameter, system voltage/frequency Uu, to check or change settings before saving. See Figure 4-17.

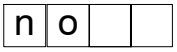


or

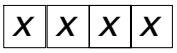
To save changes.

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.

* *X* in the runtime hours display above denotes any number from 0 to 9.

Figure 4-19 Save Mode (after configuring generator set parameters)

4.10 Continuous Power Mode Jumper

A jumper across controller pins P7-1 and P7-2 maintains power to the controller at all times. See Figure 4-20. Controllers are shipped with the jumper connected for continuous power.

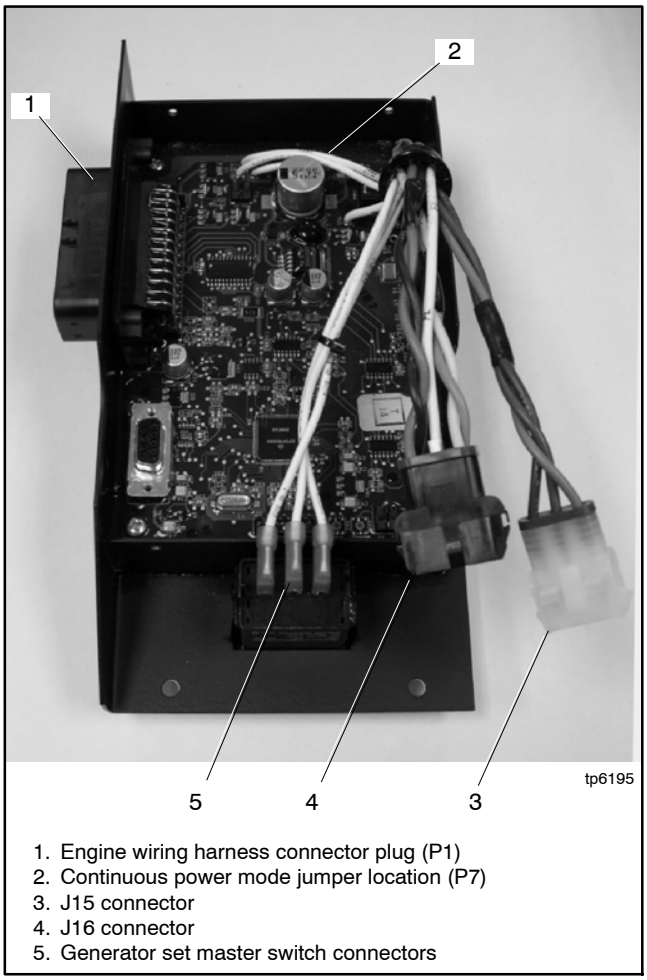
The P7 connector has either 2 or 3 pins. Disconnecting the jumper or moving the jumper to pins P7-2 and P7-3 allows the controller to power down automatically 48 hours after the generator set shuts down if the generator set master switch is in the AUTO position. A remote start signal (from a transfer switch or a remote start/stop switch connected to controller leads 3 and 4) or moving the generator set master switch to the RUN position turns the controller back on.

Note: The jumper must be connected for continuous power if the optional Remote Digital Gauge is used.

Use the following procedure to disconnect the jumper, if desired.

Procedure to disconnect the continuous power mode jumper (optional).

1. Prevent the generator set from starting.
   a. Move the generator set master switch to the OFF/RESET position.
   b. Disconnect power to the battery charger, if equipped.
   c. Disconnect the generator set engine starting battery, negative (–) lead first.
2. Remove the controller from the generator set housing.
   a. Disconnect the engine wiring harness connector P1 plug (35-pin) from the controller. Disconnect the J15 and J16 connectors. See Figure 4-20.
   b. Remove controller from generator set housing in order to access the back of the controller.
3. Remove controller's back cover to access jumper.
   a. Note the labels on the three leads connected to the generator set master switch for reconnection later. Disconnect the leads at the pink connectors. See Figure 4-20.
   b. Remove the cover screws and remove the controller's back cover. See Figure 4-20.
4. Locate the P7 connector near the top of the controller. See Figure 4-20. Remove the jumper from pins 1 and 2 of the P7 connector. If the P7 connector has three pins, connect the jumper across pins 2 and 3 for storage.
5. Replace the controller's back cover and secure the cover screws.
6. Reconnect the three pink connectors to the generator set master switch.
7. Reconnect the P1, J15, and J16 connectors.
8. Reinstall the controller in the generator set.
9. Reconnect the generator set engine starting battery, negative (–) lead last.
10. Reconnect power to the battery charger, if equipped.
11. Place the generator set master switch in the AUTO position.

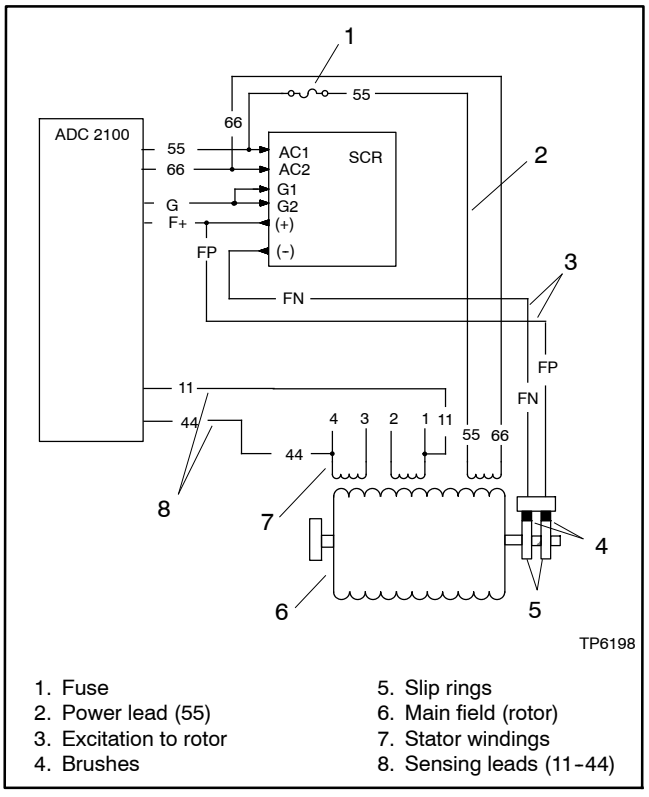


1. Engine wiring harness connector plug (P1)
2. Continuous power mode jumper location (P7)
3. J15 connector
4. J16 connector
5. Generator set master switch connectors

Figure 4-20 Advanced Digital Control Connections

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 2100 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.



1. Fuse
2. Power lead (55)
3. Excitation to rotor
4. Brushes
5. Slip rings
6. Main field (rotor)
7. Stator windings
8. Sensing leads (11–44)

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 flow chart 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.

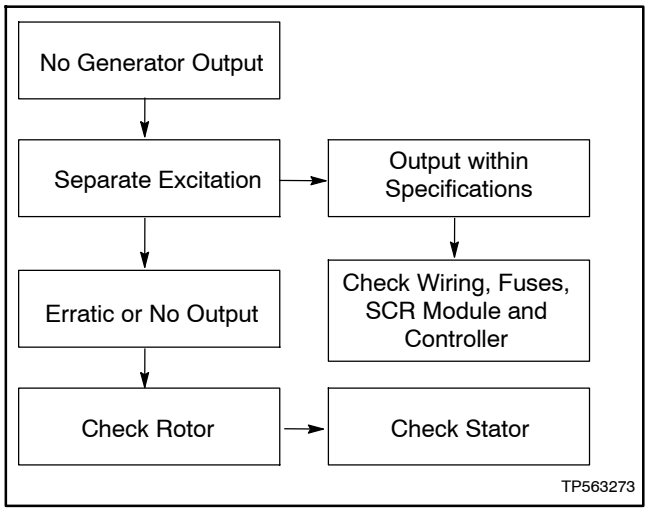


Figure 5-2 Generator Troubleshooting

Check the condition of the alternator fuse before performing the separate excitation procedure. See Figure 5-1. The inline fuse is located in lead 55 of the wiring harness (for earlier models) or on the fuse panel (for later models). See Figure 4-1 for the fuse panel location. If the fuse is not blown, use the following procedure to separately excite the generator using an external voltage source (a 12-volt automotive battery).

Separately exciting the generator can identify faulty voltage regulation by the ADC 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 5.12.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

This equipment must be installed and serviced by qualified electrical personnel.

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)

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, 10-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.

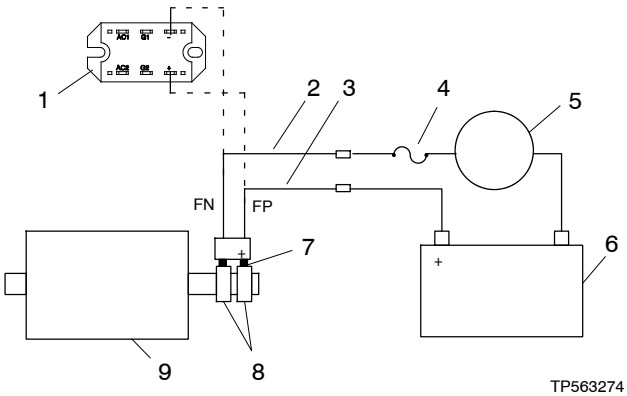
   Example:

   $$\frac{\text{12 volts (battery voltage)}}{\text{3.0 ohms (rotor resistance)}} = \text{4.0 amps (rotor current)}$$

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 4.7, 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)

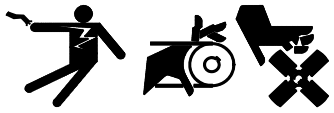
Figure 5-3 Separate Excitation Connections

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



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.

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.

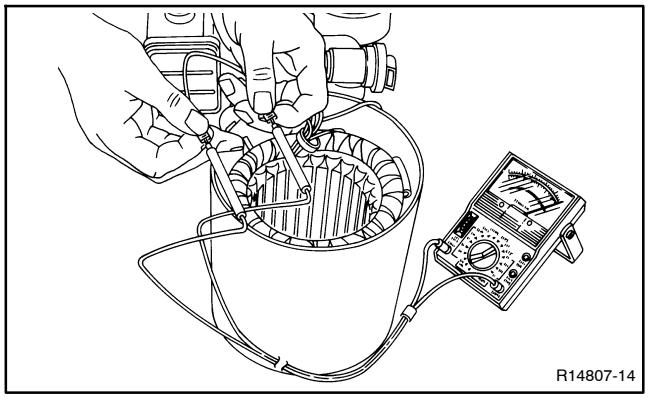


Figure 5-4 Testing Stator Windings

Note: For single-phase models, leads 1-4 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: When taking an ohmmeter reading using lead 55, make the connection before the inline fuse.

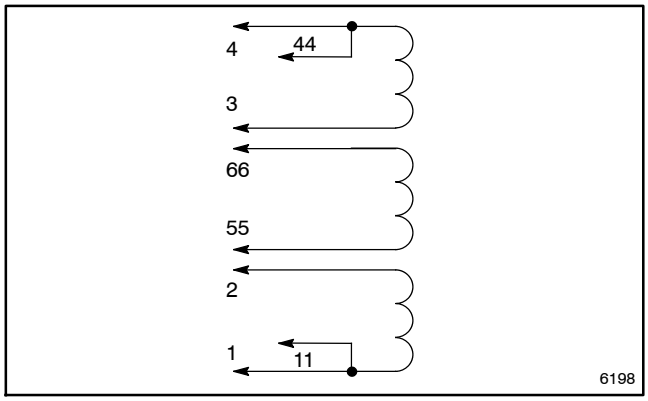


Figure 5-5 Single-Phase Alternator Stator Leads

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.

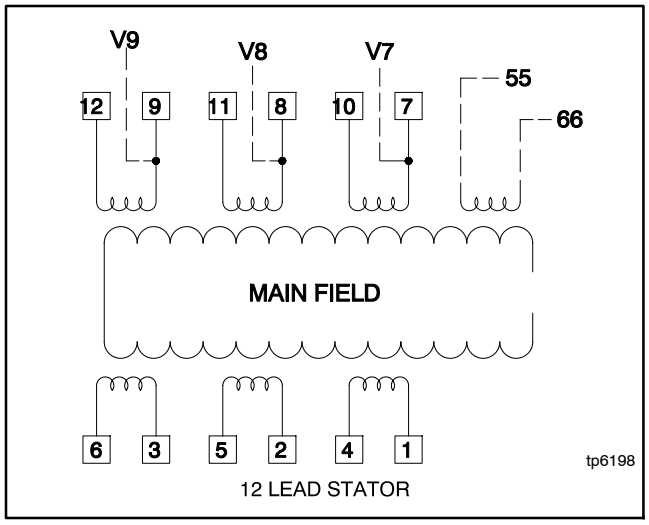


Figure 5-6 Three-Phase Alternator Stator Leads

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 the stator leads. See Section 1.5, Alternator Specifications, for stator winding resistances.

   Note: 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 or Figure 5-8.

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.

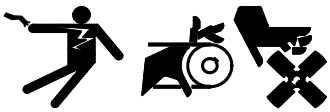
   c. Repair or replace the stator if any reading is less than approximately 500 kOhms. A reading of less than 500 kOhms indicates deterioration of the winding insulation and possible current flow to ground.

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.

Rotor Continuity and Resistance Tests

⚠ 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.

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.

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, Alternator Specifications, 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.

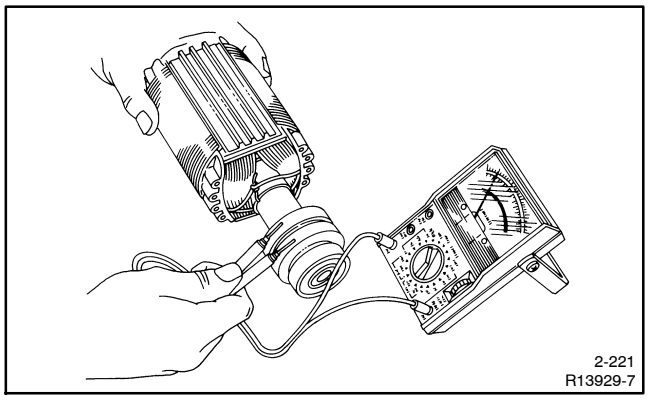


Figure 5-9 Rotor Resistance Check

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

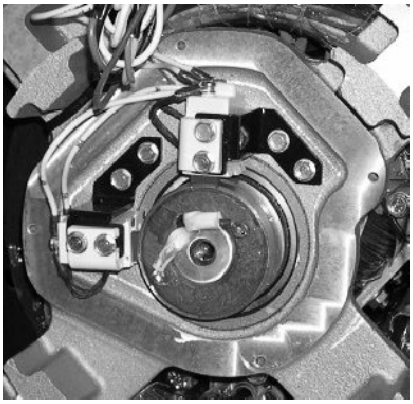
Slip rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly-machined appearance on the slip rings. Cleaning with a dry, lint-free cloth is usually sufficient. Use very fine sandpaper (#00) and apply light pressure to remove roughness. Do not use emery or carborundum 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.

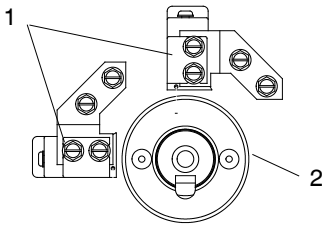
5.6 Brushes

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

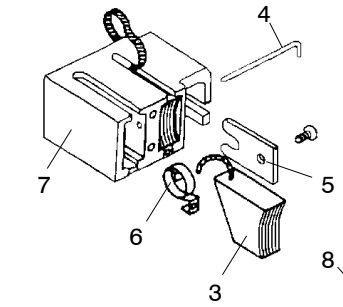
Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.



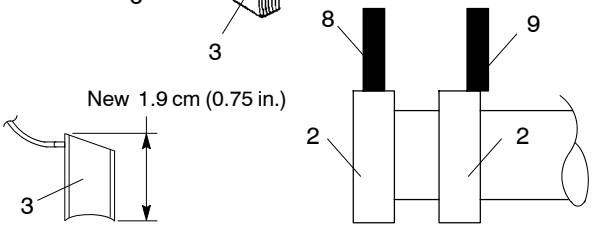


Front View

GM32849A-D



Side View



TP5867

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

Figure 5-10 Brush Assembly

5.7 Voltage

5.7.1 Voltage Regulation

Voltage regulation is performed by the Advanced Digital Control (ADC) and the SCR module. The ADC monitors generator output voltage and adjusts the excitation current to the rotor through the SCR module.

5.7.2 Voltage Adjustment

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 controller to adjust the voltage, gain, and volts/hertz (Hz). Refer to Section 4.9.2 for instructions to adjust each parameter and save changes using controller keypad.

Note: The ADC 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 4.9.2 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. 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 (factory setting 57.5 Hz on 60 Hz models and 47.5 Hz on 50 Hz models). 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.

Voltage Adjustment Procedure

⚠ 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.

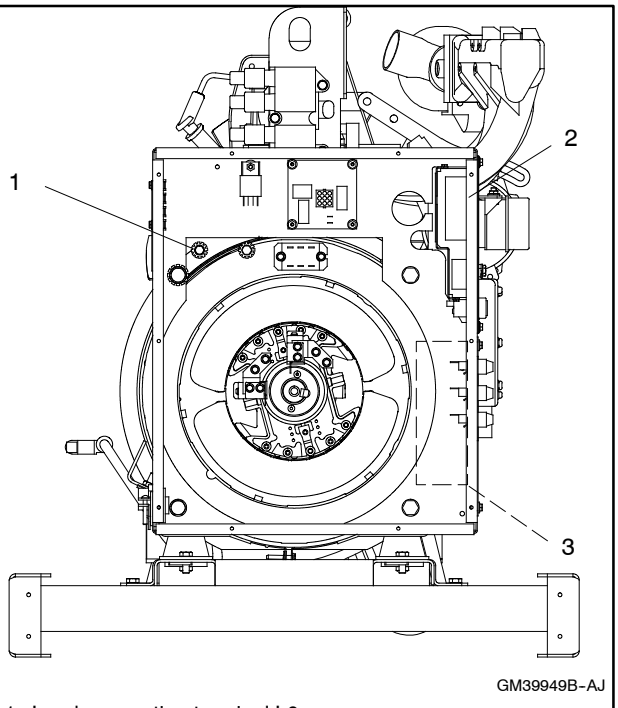
Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment 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)

1. Connect a digital voltmeter from one side of the circuit breaker to the L0 terminal on the end bracket casting. See Figure 5-11. Set the meter to measure voltage.

   Note: For 120- or 240-volt systems the voltage measured from one side of the breaker to L0 should be approximately 120 VAC. For 240-volt systems, the voltage measured from one side of the circuit breaker to the other should be approximately 240 VAC.

2. Start the generator set.

3. Follow the controller instructions in Section 4.9.2 to enter the adjustment mode and increase voltage or decrease voltage (parameter 1P) until the output reaches the desired voltage.



1. Load connection terminal L0
2. Controller location
3. Line circuit breaker location (circuit breaker not shown)

Figure 5-11 Circuit Breaker and L0 Terminal Location

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

5. Check and readjust the voltage if necessary.

6. Save the settings.

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

7. Stop the generator set.

Volts per Hertz Adjustments

The cut-in frequency is set at 57.5 Hz (60 Hz system) or 47.5 Hz (50 Hz system) and is not adjustable. When the frequency falls below the cut-in, output voltage is reduced to relieve the engine. The amount 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.

The amount of voltage droop is approximately 0.5% of system voltage for each step of 3P.

3P	Voltage Droop for Each Cycle (Hz) 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 5-12 Voltage Droop Adjustments

1. Readjust the voltage stability (gain, parameter 2P), if necessary.

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

3. Stop the generator set.

5.8 Voltage Reconnection

Voltage Reconnection is covered in the generator set Installation Manual. See the List of Related Materials for the document number.

5.9 Governor System

The frequency of the alternator output is determined by the speed of the engine. A four-pole alternator must be driven at 1800 rpm to provide 60 Hz. A two-pole alternator must be driven at 3600 rpm to provide 60 Hz. The engine speed is maintained by the Engine Control Module (ECM). See the engine documentation for ECM information.

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.

5.10.1 Controller Fault Shutdown Functions

Check the operation of the fault functions programmed in the ADC 2100 by performing the following tests. If the ADC 2100 does not operate as described, check the controller configuration settings; see Section 4.9. Also check the controller wiring and connections.

Low Oil Pressure (LOP) Shutdown

Oil Pressure Switch: 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 on an LOP fault 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.

Oil Pressure Sender (OPS, optional): Remove connector P7 from the oil pressure sensor. Connect a jumper between pins A and C on the connector. Start the generator set and run for at least 35 seconds Verify that the generator set shuts down and the ADC display indicates an LOP fault. If the ADC does not shut down on an LOP fault, test the OPS harness and connectors.

Overcrank Shutdown

Disconnect the starter motor lead at the starter solenoid. 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

Remove the connector from the coolant temperature sensor (CTS) and connect a jumper across terminals A and B (black and white leads). Start the generator set. Verify that the generator set shuts down and the ADC display indicates fault HE 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.

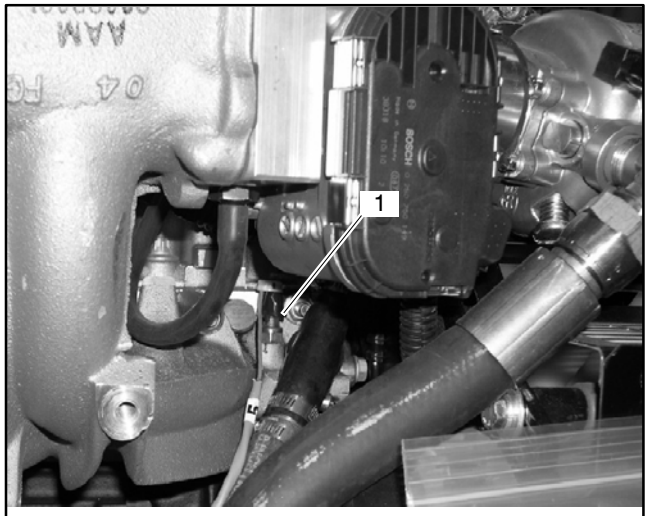
Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Temperature Sensor (CTS)

The coolant temperature sensor (CTS) is used to monitor engine temperature for the high engine temperature fault shutdown (HE). See Figure 5-14 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 5-13. If the resistance is very low (indicating a short circuit) or very high (indicating an open circuit) replace the CTS.

Temperature, °C (°F)	Resistance, Ohms
30 (86)	2100–2500
100 (212)	180–200

Figure 5-13 Coolant Temperature Sensor Resistance Readings



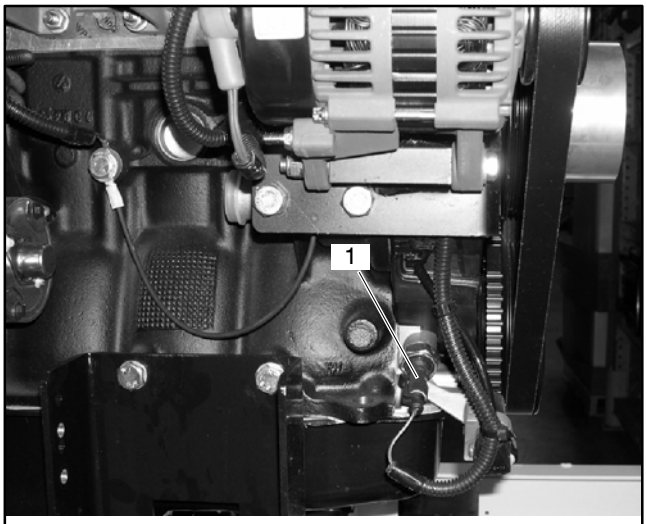
tp6198

1. Coolant temperature sensor (CTS)

Figure 5-14 Coolant Temperature Sensor (CTS)

Low Oil Pressure (LOP) Switch

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. See Figure 5-15. 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 bad LOP switch. Replace the switch.



1. Low oil pressure switch

tp6198

Figure 5-15 Low Oil Pressure Switch Location (fan guard removed)

5.11 Fuel Systems

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

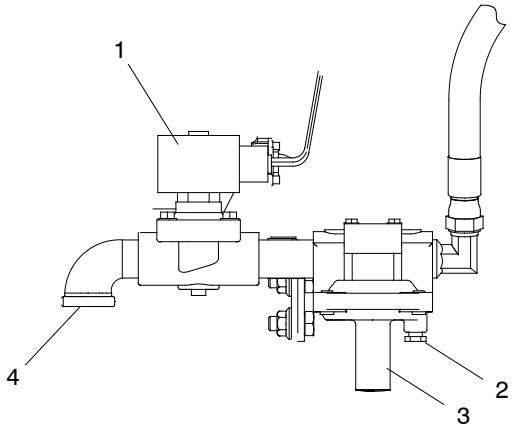
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do 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.

The fuel supplier provides and maintains manual shut-off valves and the primary regulator. 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. See Figure 5-16 and the service views in Section 1.6. 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 to the carburetor in a gaseous state. The carburetor mixes the fuel with intake air for consumption by the engine.

Use a Universal Exhaust Gas Oxygen (UEGO) sensor to check the fuel mixture after replacing the fuel regulator, fuel mixer, or silencer. The engine should be warm when the fuel mixture is checked. See the generator set Installation Manual for instructions to check the fuel mixture.

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.



1. Solenoid valve
2. Check inlet fuel pressure here
3. Secondary regulator (shown pointing down for LP)
4. Fuel supply connection

Note: UL-listed models use a second fuel solenoid valve, not shown.

Figure 5-16 Fuel System (LP gas setup shown)

5.11.1 Fuel System Troubleshooting

Most problems with gas fuels involve either fuel pressure or fuel regulator function. Basic troubleshooting consists of verifying fuel pressures and checking each fuel system component.

Check the following items:

- Check primary fuel regulator outlet pressure. This is the line pressure.
- Check the primary regulator vent for obstructions and clean, if necessary.
- Check fuel shutoff inlet pressure.
- Check secondary fuel regulator inlet pressure.
- Check fuel inlet pressure at the gas mixer.
- Perform fuel system maintenance if necessary. See Section 2.3, Fuel System Maintenance.

5.11.2 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.

5.11.3 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.

Checking Fuel Pressure

Use a gauge or manometer to check the fuel pressure at the secondary regulator inlet. See Figure 5-16. 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.

5.11.4 Fuel Conversion

The fuel system can be converted from natural gas to LP vapor (or vice-versa) in the field. See the generator set Installation Manual for fuel system conversion and fuel mixture adjustment procedures.

5.12 Fuses

Three fuses protect the controller, SCR module, and relay interface board. See Figure 5-17 for fuse locations. See Figure 5-18 for fuse ratings and 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.

Note: Some earlier models had inline fuses located in the engine harness.

1. Fuses

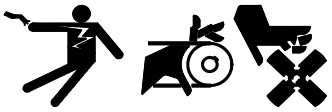
Figure 5-17 Fuse Location

Fuse	Label	Part Number	Location *
Auxiliary Winding, 10 amps	F1	358337	Lead 55
Relay Interface Board, 10 amps	F2	223316	Lead PF2
Controller, 10 amps	F3	223316	Lead PF3
* In engine harness on earlier models			

Figure 5-18 Fuses

5.13 Continuity Checks

⚠ 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.

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.

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

To further check generator set components, disconnect the battery and remove wiring harness plugs from the controller circuit board. Refer to the wiring diagrams in the wiring diagram manual and use an ohmmeter to check for continuity and good ground connections. A zero reading on the ohmmeter indicates continuity. No ohmmeter reading indicates very high resistance or an open circuit.

Figure 5-19 illustrates the generator set master switch continuity with the switch in the RUN and AUTO positions.

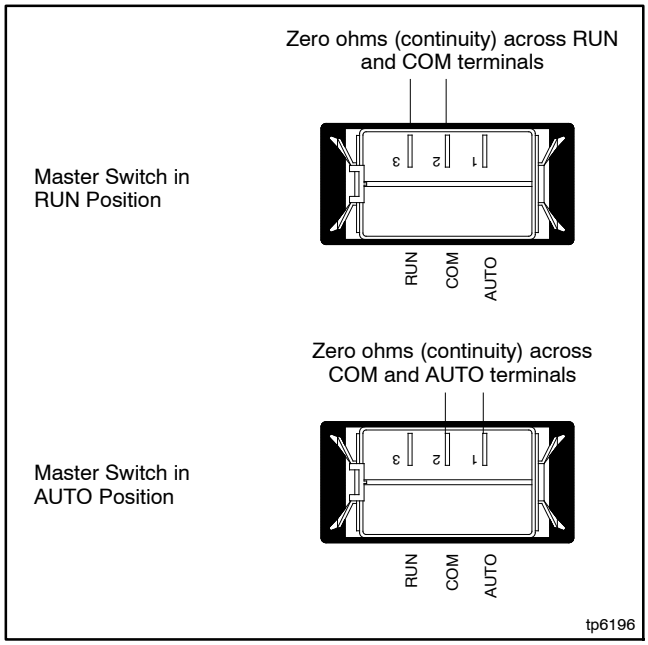


Figure 5-19 Generator Set Master Switch Continuity Checks (back view of switch)

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
APU	Auxiliary Power Unit
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
CAT5	Category 5 (network cable)
CB	circuit breaker
CC	crank cycle
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)
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
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
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^2PROM, EEPROM	electrically-erasable programmable read-only memory
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
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)
IBC	International Building Code
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	internet protocol
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
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
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
RO	read only
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTDs	Resistance Temperature Detectors
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
SMTP	simple mail transfer protocol
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
SMS	short message service
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TB	terminal block
TCP	transmission control protocol
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
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UIF	user interface
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
URL	uniform resource locator (web address)
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
WO	write only
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

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

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

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

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

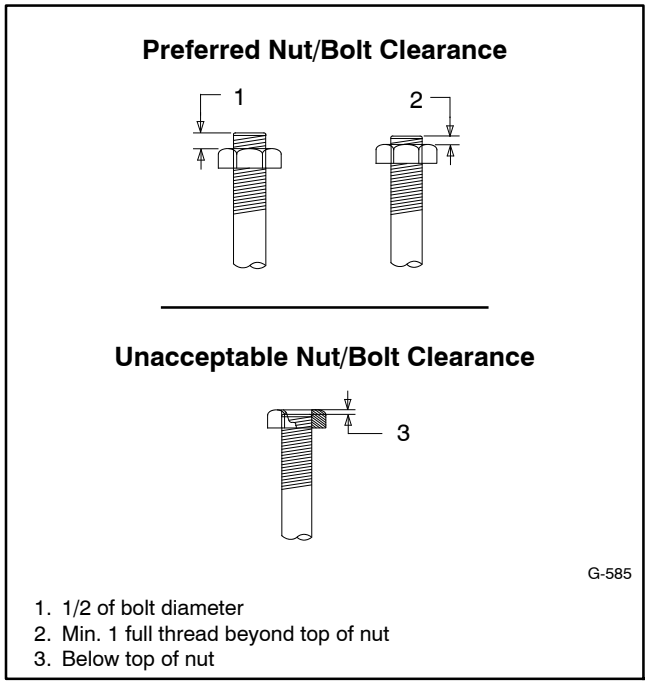


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

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

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

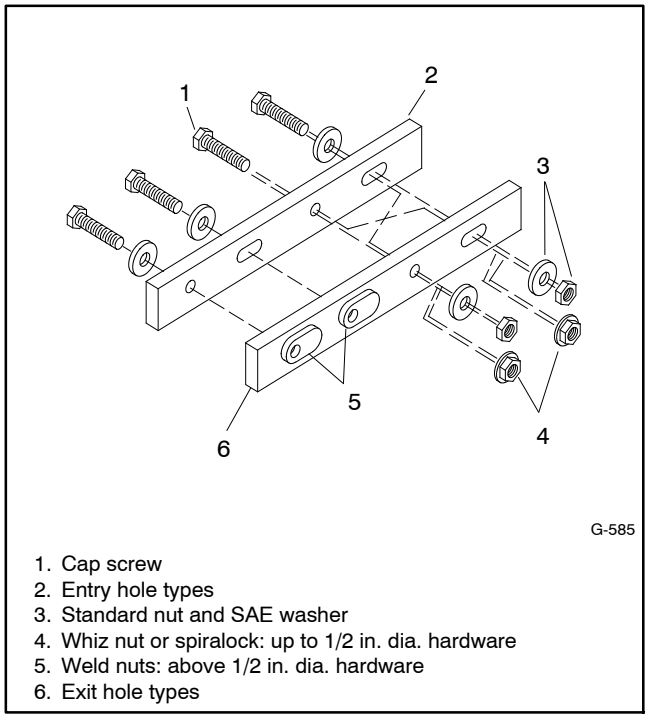


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

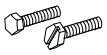
American Standard Fasteners Torque Specifications								
Size	Torque Measurement	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 2 or 5
		Grade 2		Grade 5		Grade 8		
8-32	Nm (in. lb.)	1.8	(16)	2.3	(20)	—		See Note 3
10-24	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
10-32	Nm (in. lb.)	2.9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

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

Notes:

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

Appendix D Common Hardware Identification

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

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

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

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

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

Sample Dimensions

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

1/4-20 x 1

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

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

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

Plain Washers

9/32 x 5/8 x 1/16

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

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

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

American Standard

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

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

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

Washers

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

Metric

Hex head bolts are hardness grade 8.8 unless noted.

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)

Part No.	Dimensions
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

Part No.	Dimensions
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

Part No.	Dimensions
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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