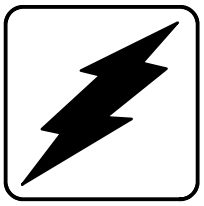
Service

Industrial Generator Sets



Models:

8.5RMY
11RMY

Controllers:
Relay

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-5867 11/02d

California Proposition 65

⚠ WARNING

Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Product Identification Information

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

Generator Set Identification Numbers

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

Model Designation _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Controller Identification

Record the controller description from the generator set operation manual, spec sheet, or sales invoice.

Controller Description _____

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

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Table of Contents, continued

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

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

DANGER

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

WARNING

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

CAUTION

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

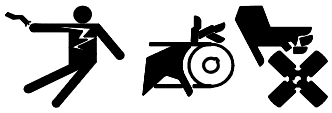
NOTICE

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

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

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

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

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

Battery

WARNING

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

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

WARNING

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

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

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

Battery 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.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

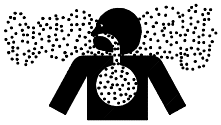
Do not smoke or permit flames or sparks near fuels or the fuel system.

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

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

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 symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide poisoning symptoms include but are not limited to the following:

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

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

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 (LP)—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 LP vapor gas or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

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

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

Hazardous Voltage/ Electrical Shock

⚠ WARNING


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

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

⚠ WARNING

Hazardous voltage.
Backfeed to the utility system can cause 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.

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

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.

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.

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.

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

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. 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.

Heavy Equipment

⚠ WARNING

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

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

Hot Parts

⚠ WARNING

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

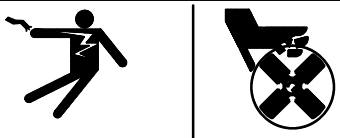
Do not work on the generator set until it cools.

Servicing the generator. Hot parts can cause severe injury or death. Avoid touching the generator set field or exciter armature. When shorted, the generator set 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.

Moving Parts

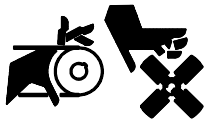
⚠ WARNING



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

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

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

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

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

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

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

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

NOTICE

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

NOTICE

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

NOTICE

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

This manual provides troubleshooting and repair instructions for the generator set models listed on the front cover. Refer to the engine service manual for generator set engine service information.

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

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

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

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

Routine Service Parts

The following tables contain part numbers for recommended spare parts. Contact your Kohler generator distributor/dealer for a complete list of service parts for your generator set or for models or spec numbers not listed here.

Part Description	Part Number
Air cleaner element	24 083 08
Precleaner element	24 083 02
Oil filter	12 050 01
Spark plug	12 132 02
Voltage regulator fuse, 10 amp	223316
Controller fuse, 10 amp	223316

Figure 1-1 Recommended Spare Parts

Model	Generator Set Spec Number	Circuit Breaker Part Number			
		X-506-43	X-506-38	358384	GM24928
8.5RMY	PA-195007	X			
	PA-195016				
	PA-195017				
	PA-195021			X	
	PA-195025				
	GM16902-GA1				
	GM24829-GA1				X
11RMY	PA-195008		X		
	PA-195018				
	PA-195019				
	PA-195022			X	
	PA-195026				
	GM16902-GA2				
	GM24829-GA2				

Figure 1-2 Circuit Breakers

Service Assistance

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

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

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

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

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

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

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

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

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

X:in:008:001a

1.1 Introduction

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

1.2 Controller Features

The generator set is equipped with a relay controller. For a specific description of the controller, see Section 2, Operation, in the operation manual. Controller features include the following:

- Fault shutdowns:
  - Overcrank
  - Overspeed
  - Pressure, low oil
  - High engine temperature
- Running time meter
- Switches and standard features:
  - Master switch, RUN/RESET-OFF/AUTO
  - Cranking, cyclic
- Line circuit breaker
- Common fault lamp (on some controllers)

1.3 Alternator

The generator is equipped with Kohler's PowerBoost™ voltage regulation system, which provides instant response to load changes.

PowerBoost™ is a unique system that ensures reliable motor starting and consistent voltage levels.

PowerBoost™ utilizes a voltage monitoring system that employs a winding independent of the field to monitor and stabilize voltage.

See Figure 1-1 for alternator specifications.

Alternator Specification	8.5/11RMY
Frequency Hz	50/60
Phase	Single-Phase
Number of leads	4
Excitation method	Static Excited
Voltage regulator type	PowerBoost™ IIIE
Coupling type	Direct
Thrubolt torque, Nm (ft. lb.)	38 (28)
Overbolt torque, Nm (in. lb.)	7 (60)
Insulation (rotor and stator)	Epoxy varnish, vacuum impregnated
Units built before 7/1/02	Class 155
Units built after 7/1/02	Class 180
Winding material	Copper
Bearing, number and type	1, replaceable ball
Circuit protection	
Controller	10 amps
Voltage regulator	10 amps
Generator AC output	Dependent on voltage configuration
Rotor resistance, ohms, cold	4.0
Stator resistance, ohms,* cold	
Leads: 1-2, 3-4	0.07
33-44	0.07
55-33	0.70
Stator output voltage with separately excited rotor using 12-volt battery, minimum	
Leads: 1-2, 3-4	132V
33-44	132V
55-33	145V
Rotor field voltage/current readings at rated output voltage, hot	
No load	8V/2.5 amps
Full load	47V/7.4 amps
Brush length, new	19.05 mm (0.75 in.)

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

Figure 1-1 Alternator Specifications

1.4 Generator Set Specifications

See Figure 1-2 for generator set specifications. Consult the generator set nameplate for specific generator set ratings.

1.5 Engine

The 8.5/11RMY generator sets are equipped with four-cycle, twin cylinder, air-cooled Kohler engines. Some of the engine features include:

- One-side serviceability of air cleaner, carburetor, oil fill, dipstick, and oil drain.
- Efficient overhead valve design and full pressure lubrication for maximum power, torque, and reliability under all operating conditions.
- Electronic governor to ensure AC power output is maintained at desired frequency.
- Overspeed shutdown to prevent governed frequency from exceeding 70 Hz.
- Low oil pressure cutout to prevent failure.
- Dependable, maintenance free electronic ignition.
- Parts subject to the most wear and tear made from precision formulated cast iron.
- Hydraulic valve adjusters to eliminate the need for valve adjustments.
- Multi-fuel models with field-convertible fuel systems that allow fuel changeover from natural gas to LP vapor (and vice-versa) while maintaining CARB certification. (This applies only to models with specification numbers starting with the letters GM.)

See Figure 1-3 for engine specifications.

For engine service information not covered in this manual, see the Engine Service Manual.

Model	Voltage	Phase	Hz	Generator Model	Standby kW/kVA Nat. Gas	Standby kW/kVA LP Gas
8.5RMY	120/240	1	60	2F4	7.0/7.0	8.5/8.5
8.5RMY	110/220	1	50	2F4	6.3/6.3	7.5/7.5
11RMY	120/240	1	60	2F4	9.5/9.5	11.0/11.0
11RMY	110/220	1	50	2F4	8.5/8.5	9.6/9.6

RATINGS: Standby ratings are continuous for the duration of any power outage. No overload capacity is specified at this rating. All single-phase units are rated at 1.0 power factor. DERATION: Maximum altitude before generator deration, ft. (m): 1000 (305). Altitude deration factor, % per 1000 ft. (305 m): 3.0. Maximum intake air temperature before generator deration, °F (°C): 60 (16). Temperature deration factor, % per 10°F (5.5°C): 2.0. Standard reference conditions are 25°C (77°F) and 100 kPa (29.5 in. Hg) total barometric pressure per ISO 85-28-1. GENERAL GUIDELINES FOR DERATING: Maximum altitude before generator deration, ft. (m): 1000 (305). Altitude deration factor, % per 1000 ft. (305 m): 3.0. Maximum intake air temperature before generator deration, °F (°C): 60 (16). Temperature deration factor, % per 10°F (5.5°C): 2.0.DERATING: *ALTITUDE*: Derate 4% per 305 m (1000 ft.) elevation above 153 m (500 ft.). *TEMPERATURE*: Derate 1% per 5.5°C (10°F) temperature increase above 25°C (77°F). Derate applies to actual conditions at the carburetor inlet. Availability is subject to change without notice. Kohler Co. reserves the right to change the design or specifications without notice and without any obligation or liability whatsoever. Contact your local Kohler Co. generator distributor for availability.

Figure 1-2 Generator Set Specifications

Engine Specification	8.5RMY (60 Hz)	11RMY (60 Hz)
Manufacturer	Kohler	
Model	CH20	CH25
Cycle	4	
Number of cylinders	2	
Compression ratio	8.5:1	9.0:1
Displacement, cc (cu. in.)	624 (38.0)	725 (44.0)
Rated horsepower (propane fuel)	12.3 (16.5)	14.6 (19.6)
Rpm	3600	
Bore x stroke, mm (in.)	77 x 67 (3.03 x 2.64)	83 x 67 (3.27 x 2.64)
Valve material	Steel/Stellite®	
Cylinder block material	Aluminum w/cast iron liners	
Cylinder head tightening torque, Nm (ft. lb.)	30 (40.7)	
Cylinder head material	Aluminum	
Piston rings	2 compression/1 oil	
Crankshaft material	Heat treated, Ductile Iron	
Main bearings: number, type	2, parent material	
Governor	Electronic	
Lubrication system	Full pressure	
Oil capacity (w/filter), L (qt.)	1.9 (2.0)	2 (2.1)
Oil pressure, kPa (psi)	172–241 (25–35)	
Fuel system	LP gas or natural gas	
LP/natural gas minimum supply pressure, in. H_2O (oz./in.^{2})	7–11 (4–6)	
Battery voltage	12 VDC	
Battery ground	Negative	
Spark plug gap, mm (in.)	0.76 (0.030)	
Spark plug tightening torque, Nm (ft. lb.)	24.4/29.8 (18/22)	
Ignition system	Capacitor Discharge	Smart Spark Capacitor Discharge
Starter motor cranking current at 70° F	Electric, solenoid shift	
Cooling system	Air-cooled	

Figure 1-3 Engine Specifications

1.6 Service Views

This section includes two generator set service views. See Figure 1-4 and the descriptions below to determine which service view applies to your generator set.

Figure 1-5 shows a single-fuel generator set, which can be identified in two ways:

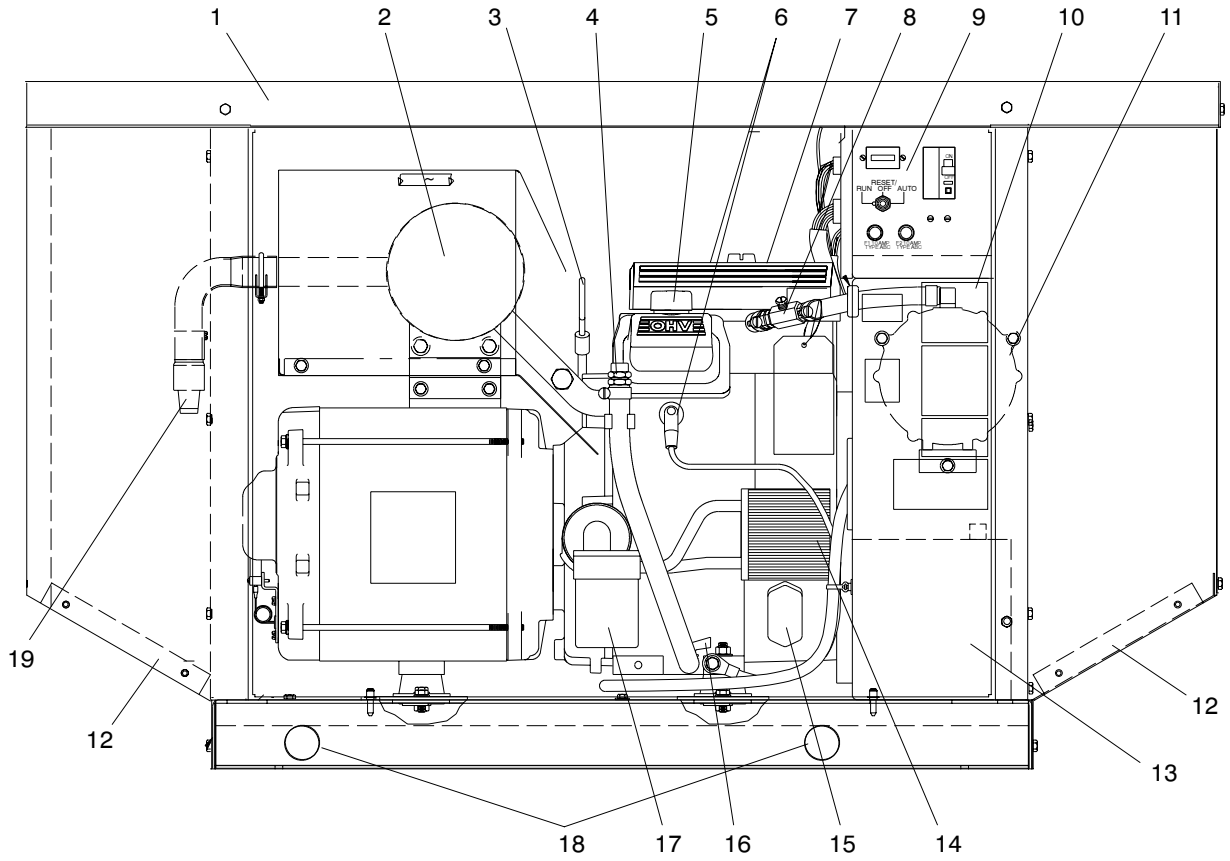
- Single-fuel model specification numbers begin with PA-. See the generator set nameplate for the spec number.
- Single-fuel models have the fuel valve shown in Figure 1-5.

Figure 1-6 shows a multi-fuel generator set, which can be identified in two ways:

- Multi-fuel model specification numbers begin with GM. See the generator set nameplate for the spec number.
- Multi-fuel models have the fuel block shown in Figure 1-6.

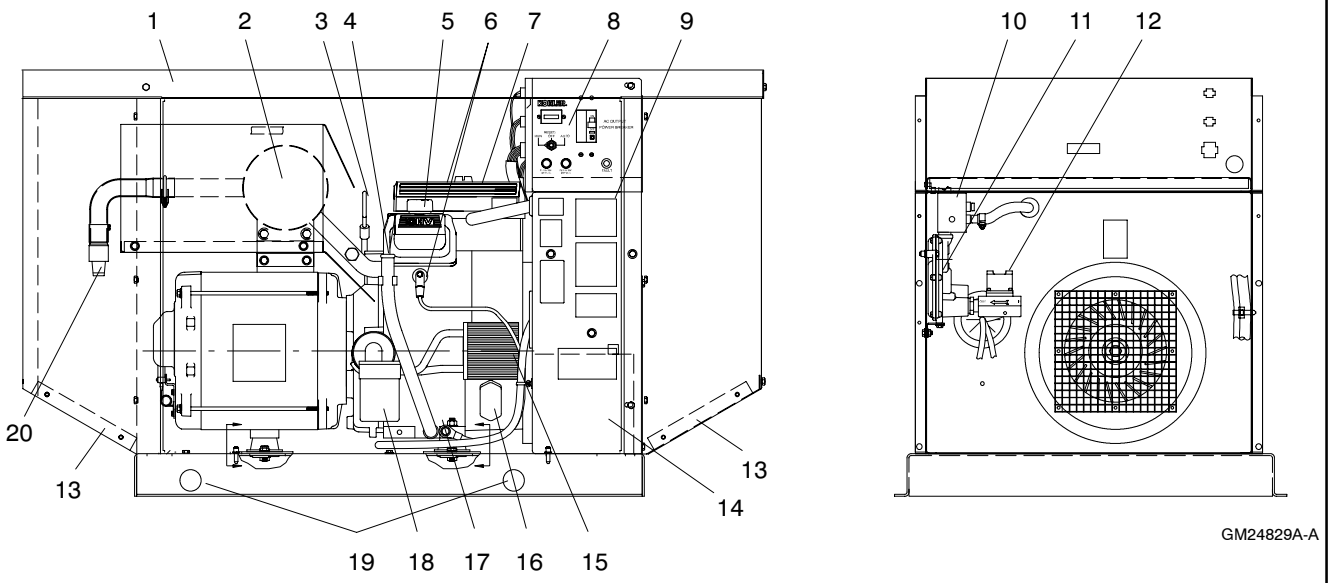
Spec Number Format	Fuel System	Service View
PA-xxxxxx	Single-fuel	Figure 1-5
GMxxxxx	Multi-fuel	Figure 1-6

Figure 1-4 Service View Identification



1. Generator set sound enclosure (weather housing not shown)
2. Muffler
3. Oil check
4. Oil drain hose
5. Oil fill
6. Spark plugs
7. Air cleaner
8. Fuel valve (Do not adjust on emission-certified models.)
9. Controller
10. Nameplate
11. Gas regulator assembly
12. Rodent screens
13. Engine starting battery location
14. Engine oil cooler
15. Engine battery charge regulator
16. Oil drain valve
17. Oil filter
18. Rodent plugs
19. Spark arrestor

Figure 1-5 Generator Set Service View, Single-Fuel Systems (spec numbers PA-)

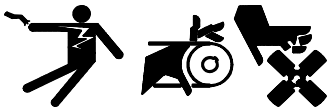


1. Generator set sound enclosure
2. Muffler
3. Oil check
4. Oil drain hose
5. Oil fill
6. Spark plugs
7. Air cleaner
8. Controller
9. Nameplate
10. Multi-fuel block
11. Gas regulator assembly
12. Fuel solenoid valve
13. Rodent screens
14. Engine starting battery location
15. Engine oil cooler
16. Engine battery charge regulator
17. Oil drain valve
18. Oil filter
19. Rodent plugs
20. Spark arrestor

Figure 1-6 Generator Set Service View, Multi-Fuel Systems (spec numbers GM)

Notes

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

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

Do not work on the generator set until it cools.

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

⚠ WARNING

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

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

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

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

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

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

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

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

Routine Maintenance. Refer to the following generator set service schedule, the engine service schedule, and the hourmeter located on the generator set controller to determine when to schedule routine maintenance. Service 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. Rough operation, lack of power, and excessive oil use indicate serious generator set problems.

2.2 Lubrication System

See Section 2.1, Scheduled Maintenance, for oil change and oil filter replacement intervals. See Section 1.6, Service Views, for the oil drain, oil check, oil fill, and oil filter locations.

The engine has a positive pressure lubrication system and low oil pressure shutdown.

2.2.1 Low Oil Pressure Shutdown

The low oil pressure shutdown feature protects the engine against internal damage if the oil pressure drops below preset limits because of oil pump failure or other malfunction. It does not protect against damage because of operating with the oil level below the safe range—it is not a low oil level shutdown.

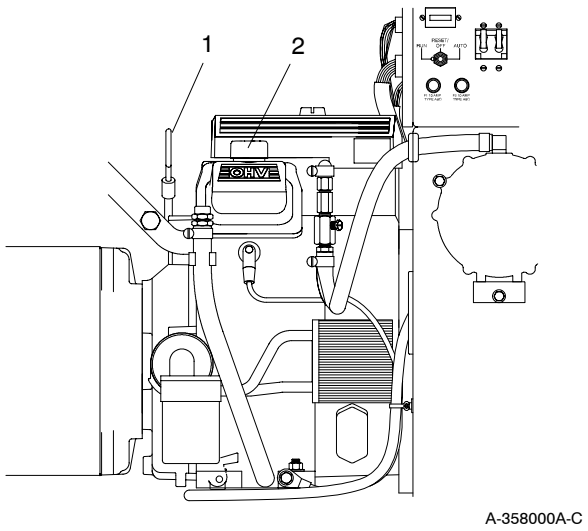
2.2.2 Oil Level Check

Check the oil level regularly and add oil as needed to protect against running out of oil. See Figure 2-1 for the dipstick and oil fill locations. Do not check the oil level when the generator set is running. Shut down the generator set and wait several minutes before checking the oil level.

2.2.3 Engine Oil Recommendation

Use synthetic oil of API (American Petroleum Institute) Service Class SG or SH. Synthetic oil oxidizes and thickens less and causes fewer deposits on the engine intake valves and pistons than other oils.

If nonsynthetic oil is used, select the viscosity based on the air temperature at the time of operation. See Figure 2-3.



1. Oil check dipstick
2. Oil fill

Figure 2-1 Oil Fill and Check

Model	L (Qt.)
8.5RMY	1.9 (2.0)
11RMY	2.0 (2.1)

Figure 2-2 Oil Capacity with Filter

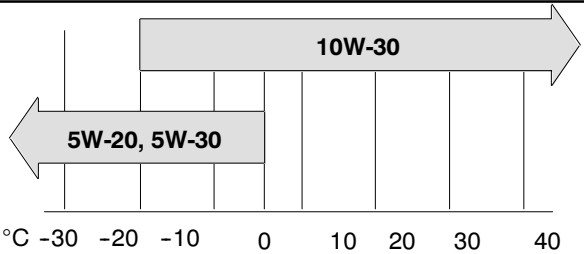


Figure 2-3 Engine Oil Selection

System—Component	Action					Interval
	Visually Inspect	Check	Change	Clean	Test	
Fuel						
Flexible lines and connections	X		R			Weekly
Main tank supply level		X				Weekly
Fuel piping	X					Yearly
Lubrication						
Oil level	●	●				Weekly
Crankcase breather	●		●			Quarterly
Change oil			●			Yearly or 50 Hrs
Replace filter(s)*			●			Yearly or 50 Hrs
Cooling						
Air cleaner to room/enclosure		X				Weekly
Air ducts, louvers		X		X		Yearly
Exhaust Line						
Leakage	X	X				Weekly
Insulation, fire hazards	X					Quarterly
Flexible connector(s)	X					Six Months
Hangers and supports	X					Yearly
DC Electrical System						
Battery charger operation, charge rate	X					Monthly
Recharge after engine start†		X				Monthly
Remove corrosion, clean and dry battery and rack	X			X		Monthly
Clean and tighten battery terminals	X	X				Quarterly
Tighten DC electrical connections		X				Six Months
AC Electrical System						
General inspection	X					Weekly
Wire abrasions where subject to motion	X	X				Quarterly
Safety and alarm operation		X			X	Six Months
Tighten control and power wiring connections		X				Yearly
Wire-cable insulation breakdown	X					3 Years or 500 Hrs
Engine And Mounting						
General inspection	●					Weekly
Air cleaner service		●	●			Six Months
Ignition components	●			●		Yearly
Valve clearance		●				3 Years or 500 Hrs.
Bolt torque		●			●	3 Years or 500 Hrs.
Generator						
Compartment condition	X			X		Weekly
Rotor and stator	X			X		Yearly
Measure and record resistance readings of windings with insulation tester (Megger, with SCR assembly or rectifier disconnected)					X	Yearly
Run generator set					X	Monthly
Remote control					X	Monthly
Blow dust out of generator*	X			X		2 Years or 300 Hrs
General Condition Of Equipment						
Any condition of vibration, leakage, noise, temperature, or deterioration	X	X		X		Weekly
Interior of equipment room or outdoor weather housing	X			X		Weekly

● Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual. If not indicated, follow this service schedule. Some items may not apply to all generator sets.
R Replace as necessary.
X Action
* Service more frequently if operated in dusty areas.
† Consult battery manufacturer's instructions.

Figure 2-4 Service Schedule

2.2.4 Oil Change Procedure

Whenever possible, drain the oil while it is still warm.

1. **Drain the oil.**

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

   b. Disconnect the power to the battery charger, if equipped.

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

   d. Remove the housing side panel.

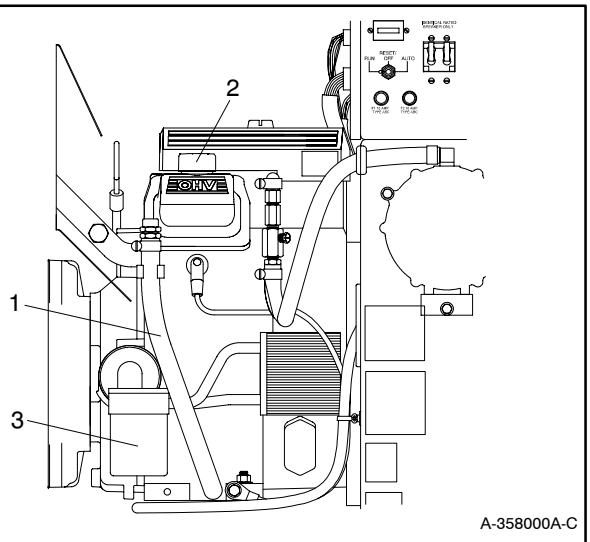
   e. Remove the oil drain hose from its retaining clip. See Figure 2-5. Remove the cap from the oil drain hose and lower the hose into an oil collection container.

   f. Open the oil drain valve on the engine.

   g. Allow time for the engine oil to drain completely.

   h. Close the oil drain valve.

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



1. Oil drain hose
2. Oil fill
3. Oil filter

Figure 2-5 Engine Service Side

2. **Replace the oil filter.**

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

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

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

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

3. **Fill with oil.** See Section 2.2.3 for oil selection and Figure 2-2 for oil capacity.

4. **Check for leaks.**

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

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

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

   d. Start the generator set and check for leaks around the oil filter.

   e. Stop the generator set and tighten the oil filter to stop any leaks.

   f. Reinstall the housing side panel.

2.3 Spark Plugs

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

Spark Plug Maintenance Procedure

1. Clean the area around the base of the spark plug to keep dirt and debris out of the engine.
2. Remove the spark plug and check its condition. Replace the spark plug if it is worn or if its reuse is questionable.
3. Check the spark plug gap using a wire feeler gauge. Adjust the gap to 0.76 mm (0.030 in.) by carefully bending the ground electrode. See Figure 2-6 and Figure 2-7.

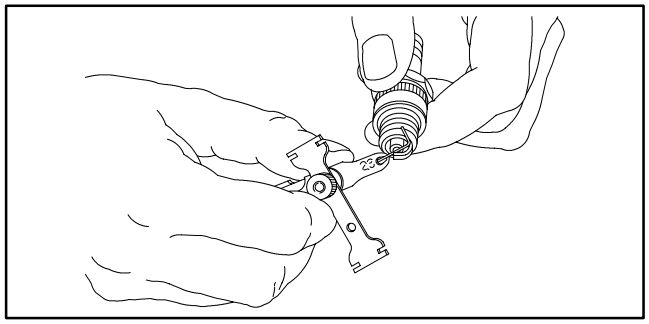


Figure 2-6 Checking the Spark Plug Gap

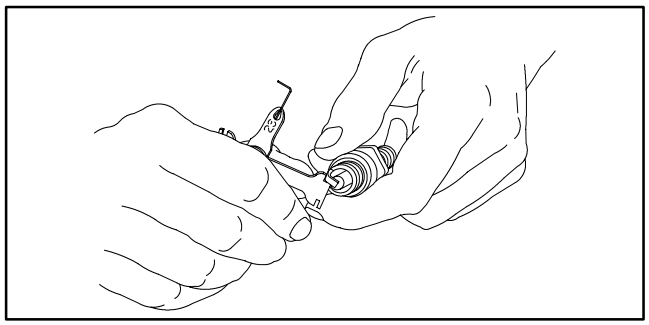


Figure 2-7 Adjusting the Spark Plug Gap

2.4 Air Cleaner Element and Precleaner

The engine has a replaceable high-density paper air cleaner element with an oiled foam precleaner. See Figure 2-8. Refer to Section 1.6, Service Views, for the air cleaner location.

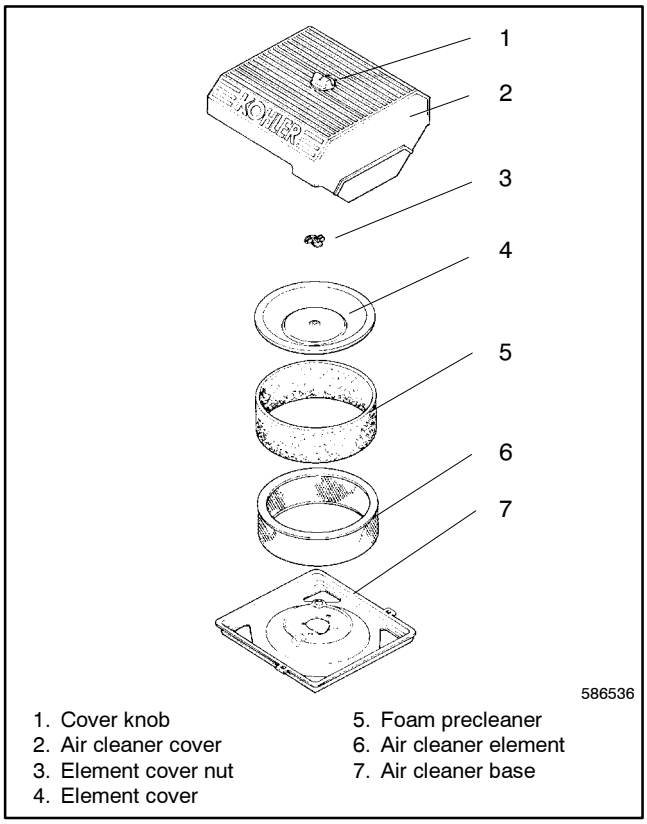
Wash and oil the precleaner and replace the paper element at the intervals shown in the service schedule. Service the air cleaner more often if the generator set operates under dusty or dirty conditions. Refer to Maintenance and Service Parts in the Introduction section of this manual for replacement part numbers.

Keep the area around the air cleaner housing free of dirt and debris.

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

Air Cleaner Service Procedure

1. Disable the generator set.
   a. Place the generator set master switch in the OFF/RESET position.
   b. Disconnect the power to the battery charger, if equipped.
   c. Disconnect the generator set engine starting battery, negative (–) lead first.
2. Remove the foam precleaner and paper element.
   a. Loosen the air cleaner cover retaining knob and remove the cover.
   b. Remove the element cover nut, element cover, and paper element with precleaner.
   c. Remove the precleaner from the paper element.



1. Cover knob
2. Air cleaner cover
3. Element cover nut
4. Element cover
5. Foam precleaner
6. Air cleaner element
7. Air cleaner base

Figure 2-8 Air Cleaner Components

3. Wash and oil the foam precleaner.

   a. Wash the precleaner in warm soapy water.

   b. Rinse the precleaner with warm water until the water runs clear.

   c. Squeeze out excess water and allow the precleaner to air dry.

      Note: Do not wring (twist) the precleaner or dry it with compressed air.

   d. Saturate the precleaner with new engine oil. Squeeze out the excess oil.

4. Replace the paper element if it is dirty, bent, or damaged.

   Note: Do not wash the paper element or clean it with compressed air, as both will damage the element.

5. Reinstall the air cleaner.

   a. Install the precleaner over the paper element.

   b. Check the air cleaner base. Make sure it is secure and not bent or damaged. Remove any dirt or debris from the air cleaner base. Wipe the base carefully so that no dirt falls into the intake throat.

   c. Check the element cover for damage and fit. Replace all damaged air cleaner components. Check the condition of the rubber seal on the air cleaner stud and replace the seal if necessary.

   d. Install the paper element, precleaner, element cover, element cover nut, and air cleaner cover. Secure the cover with the cover retaining knob (finger-tighten only).

   e. Check the element cover for damage and fit. Replace all damaged air cleaner components. Check the condition of the rubber seals and replace them if necessary.

6. Enable the generator set.

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

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

2.5 Cooling System

Fans in the engine and generator draw cooling air through the opening in the base next to the battery. The air flows through a duct in the skid to the alternator at the far end of the unit. UL-listed models have an air intake for the alternator on the back of the housing as shown in Figure 2-10. The air then flows over the exhaust system, mixes with the engine exhaust, and is discharged at the cabinet outlet. To prevent generator set damage caused by overheating, keep the housing cooling inlets and outlets clean and unobstructed at all times. See Figure 2-9 and Figure 2-10.

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

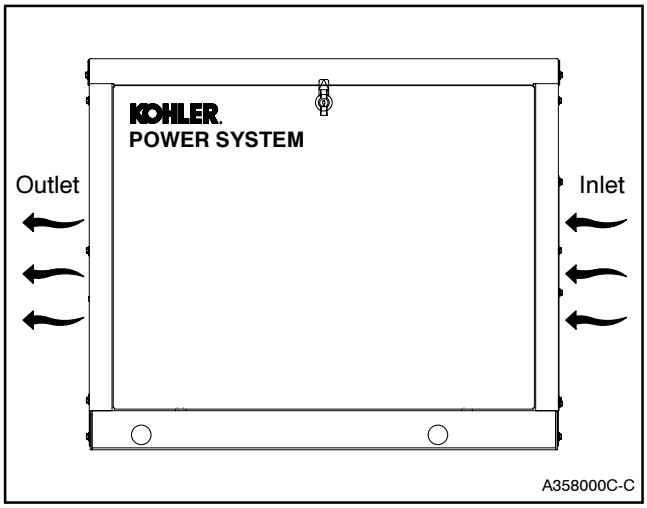


Figure 2-9 Cooling Air Intake and Exhaust, Weather Housing Models

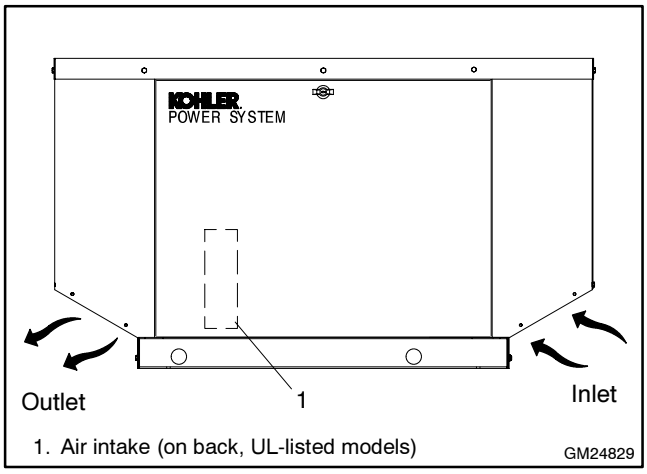


Figure 2-10 Cooling Air Intake and Exhaust, Sound Enclosure Models

2.6 Exhaust System

Remove combustible materials from the exhaust location. Combustible materials include building materials as well as natural surroundings. Keep dry field grass, foliage, and combustible landscaping material a safe distance from the exhaust outlet. Check the area periodically for accumulated debris and seasonal grass or foliage.

Inspect exhaust system components (exhaust manifold, exhaust line, flexible exhaust, clamps, silencer and outlet pipe) for cracks and corrosion.

- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace clamps and hangers as needed.
- Check that exhaust outlet is clear.

2.7 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.

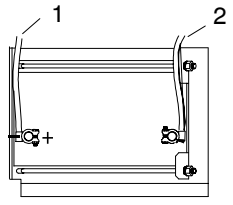
Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled 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 675 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 2-11.

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



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

Figure 2-11 12-Volt Engine Electrical System Single Starter Motor, Typical Battery Connection

Check the electrolyte level and specific gravity of batteries with filler caps. Maintenance-free batteries do not require electrolyte level checking or specific gravity testing.

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.

Generator sets that are used as a standby to utility power and not used regularly require an external battery charger to keep the starting battery fully charged. Observe the battery polarity when connecting the battery charger.

2.7.1 Cleaning the Battery

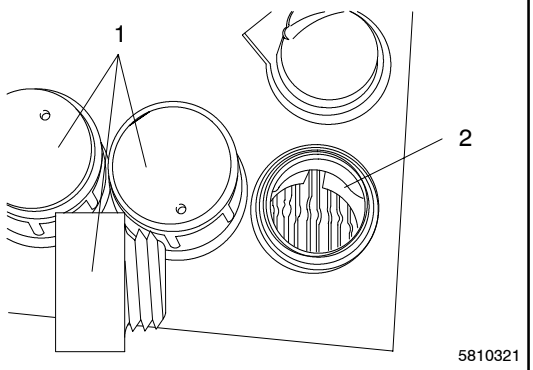
To prevent dirt and grime buildup, occasionally wipe the battery with a damp cloth.

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.

2.7.2 Checking Battery Electrolyte Level

Check the battery electrolyte level before each startup. Remove the filler caps and verify that the electrolyte level reaches the bottoms of the filler holes; see Figure 2-12. Refill as necessary with distilled water or clean tap water. Do not add electrolyte. Install and tighten filler caps. After adding water to the battery in freezing temperatures, run the generator set 20–30 minutes to mix the added water and the battery electrolyte. Mixing the water and the electrolyte prevents the added water from freezing and damaging the battery.



1. Filler caps
2. Electrolyte level

Figure 2-12 Checking Electrolyte Level

2.7.3 Checking Electrolyte Specific Gravity

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. Use the hydrometer's test instructions, if available, or Figure 2-13 for bead-type testers.

Temperature affects specific gravity; correct the indicated hydrometer readings for temperature. If the hydrometer does not have a correction table, use Figure 2-14. A fully charged battery should have a specific gravity of 1.260 with the electrolyte at 26.7°C (80°F). Charge the battery if the specific gravity from cell to cell varies by more than 0.01. Charge the battery if the specific gravity is less than 1.215 with the electrolyte at 26.7°C (80°F).

Number of Beads Floating	Battery Condition
5	Overcharged
4	Full Charge
3	Adequate Charge
1, 2	Low Charge
0	Battery Dead

Figure 2-13 Electrolyte Testing Chart

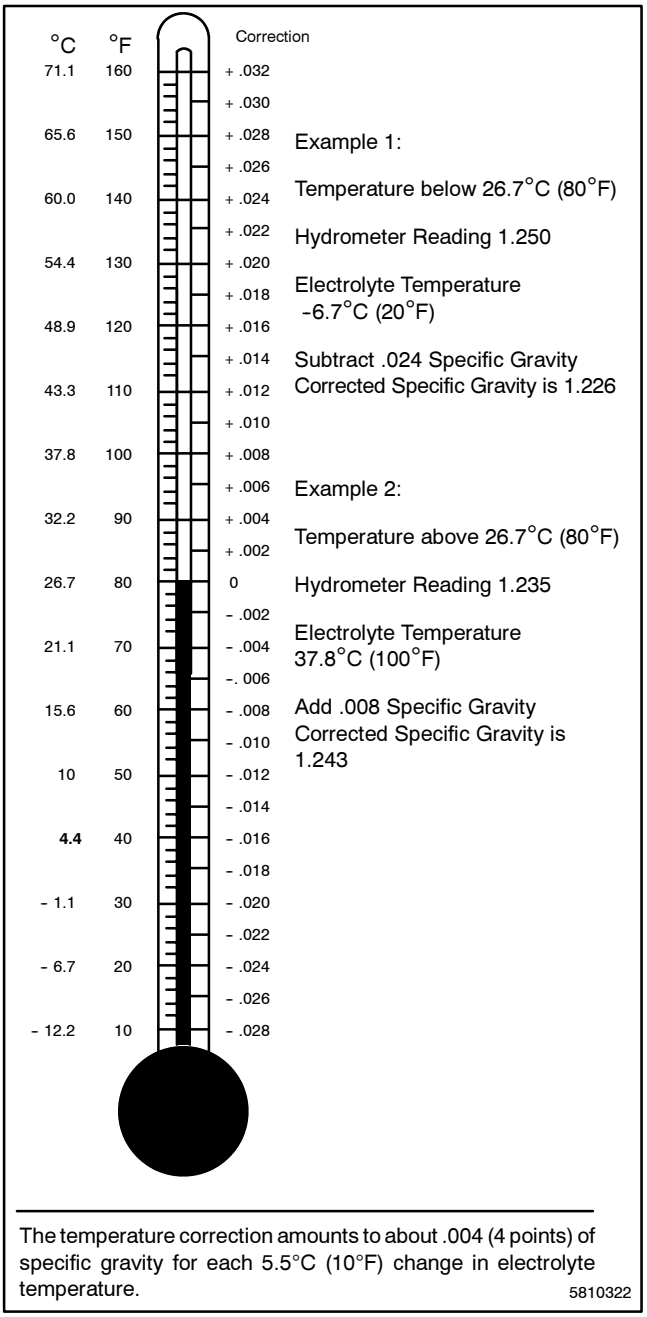


Figure 2-14 Specific Gravity Temperature Correction

2.8 Storage Procedure

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

2.8.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

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

2.8.2 Fuel System

Prepare the fuel system for storage as follows:

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

2.8.3 Internal Engine Components (Gas/Gasoline-Fueled Engines)

If you have access to a fogging agent or SAE 10 oil, prepare the pistons and cylinders for storage as follows:

1. While the engine is running, spray a fogging agent or SAE 10 engine oil into the air intake for about two minutes until the engine stops.
2. Place the generator set master switch in the OFF/RESET position.

If a fogging agent is not available perform the following:

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

2.8.4 Exterior

Prepare the exterior for storage as follows:

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

2.8.5 Battery

Perform battery storage after all other storage procedures.

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the battery(ies), negative (–) lead first.
3. Clean the battery. Refer to 2.7, Battery, for the battery cleaning procedure.
4. Place the battery in a cool, dry location.
5. Connect the battery to a float/equalize battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.

   Maintain a full charge to extend battery life.

Use the following tables as a quick reference in troubleshooting individual problems. Generator set faults are listed in groups and include likely causes and remedies. The reference column provides additional sources of information in this and related manuals regarding the problem and solution. Corrective action and testing in many cases requires knowledge of electrical and electronic circuits. Have an authorized service distributor/dealer perform service work.

General Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank	Weak or dead battery	Recharge or replace battery.	Operation Manual (O/M)
	Reversed or poor battery connections	Check connections.	—
	Defective starter relay	Check continuity of circuit.	Sections 6, Component Testing and Adjustment, and 9, Wiring Diagrams
	Defective starter	Rebuild or replace.	Engine Service Manual (S/M)
	Defective controller start/stop switch	Test function of switch.	Sections 4, Controller Troubleshooting and 9, Wiring Diagrams
	Fuse blown in controller	Replace fuse; if fuse blows again, check circuit and components.	Section 4, Controller Troubleshooting, and O/M
	Open circuit in wiring, terminals pin, circuit board, etc.	Check continuity.	Sections 4, Controller Troubleshooting and 9, Wiring Diagrams
	Defective controller circuit board	Check circuit board operation.	Section 4, Controller Troubleshooting
	Overcrank shutdown	Check engine fuel and ignition systems. Shutdown occurs after 30 seconds of cyclic cranking.	Section 6.11, Fuel Systems, and Engine S/M for ignition system information
	Faulty spark plugs or loose connections	Replace and regap spark plugs.	Section 2.3, Spark Plugs
	Defective fuel regulator/valve	Check regulator/valve operation.	Sections 6.11, Fuel Systems, and 4, Controller Troubleshooting
	Faulty ground (–) connection	Clean and retighten.	—
	Insufficient fuel pressure on LP/natural gas systems	Check fuel pressure	Section 6.11.3, Fuel Regulators
	Weak or dead battery	Recharge or replace.	Section 2.7, Battery
Generator set cranks but does not start	Fuel not turned on	Turn on fuel valve.	—
	Air cleaner clogged	Clean or replace.	Section 2.4, Air Cleaner Element and Precleaner
	Defective ignition system spark control or ignition coil	Test and/or replace components.	Engine S/M
	Blown voltage regulator fuse	Replace fuse. If fuse blows again, check generator components.	O/M
	Blown controller fuse	Replace fuse; if fuse blows again, check circuit and components.	Section 4, Controller Troubleshooting, and O/M
	Open wiring terminal or pin (P2 connector)	Check continuity.	Section 9, Wiring Diagrams
	Overspeed setting on electronic governor board set too low	Readjust overspeed on governor board.	—

General Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Generator set starts but shuts down	Low oil pressure (LOP) shutdown	Correct cause of shutdown. Check oil level, oil pump, etc.	Sections 4, Controller Troubleshooting, 6.8, Fault Shutdown Test Procedure, and Engine S/M
	No generator output voltage	Check AC voltage. Separately excite unit. Check stator continuity.	Sections 6, Component Testing and Adjustments, and 9, Wiring Diagrams
	Voltage regulator fuse blown	Replace fuse.	Section 4, Controller Troubleshooting
Generator set starts hard	Air cleaner clogged	Replace element.	Section 2.4, Air Cleaner Element and Precleaner
	Fuel mixture adjustment incorrect	Adjust fuel valve.	Section 6.11, Fuel Systems
	Faulty spark plug(s)	Replace and regap spark plug(s).	Section 2.3, Spark Plugs
	Defective ignition components (spark control or ignition module)	Test/replace ignition components.	Engine S/M
	Worn piston rings, valves	Check compression.	Engine S/M
	Insufficient fuel pressure	Check fuel pressure	Section 6.11.3, Fuel Regulators
	Defective spark plug(s)	Replace spark plugs.	Engine O/M
	Defective spark plug wire(s)	Replace spark plug wires.	Engine S/M
Generator set stops suddenly	No fuel	Turn on fuel supply.	—
	Fuel line restriction	Inspect fuel lines.	—
	Fuel lines too long	Check fuel line length.	Section 6.11.1, Gas Piping
	Air cleaner clogged	Replace element.	Section 2.4, Air Cleaner Element and Precleaner
	Fuse blown in controller	Replace fuse.	O/M
	Faulty 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.	Sections 2.5, Cooling System, 2.2, Lubrication System, and 6.11, Fuel Systems
	Overspeed shutdown	Check electronic governor and voltage regulator.	Section 6.9, Electronic Governor
	Low oil pressure (LOP) shutdown	Check engine oil level, oil pressure, and oil pump.	Sections 2.2.1, Low Oil Pressure Shutdown, 4.2.4, Low Oil Pressure (LOP) Shutdown, 6.8, Fault Shutdown Test Procedure, and Engine S/M
	Defective low oil pressure (LOP) shutdown 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:** Verify engine oil pressure before performing test and/or replacing LOP shutdown switch.	Sections 2.2.1, Low Oil Pressure Shutdown, and 4.2.4, Low Oil Pressure (LOP) Shutdown
	Defective fuel valve/fuel regulator	Check regulator/valve operation.	Sections 2, Scheduled Maintenance, and 6, Component Testing and Adjustments
	Blown voltage regulator fuse	Replace fuse. If fuse blows again, test generator components.	Section 6.3, Voltage Regulator
	Engine overloaded	Reduce electrical load.	O/M
	Overcrank shutdown	Check rotor.	Section 6.4, Main Field (Rotor)

General Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Generator set stops suddenly, continued	Loss of generator output voltage to K1 relay (LED1 not lit)	Check AC voltage at rectifier (BR1). Check continuity of B1/B2 stator leads.	Sections 6, Component Testing and Adjustment, and 9, Wiring Diagrams
	Defective ignition module	Test and/or replace.	Engine S/M
	Defective K3 relay (field flashing)	Test/replace controller circuit board.	Section 4, Controller Troubleshooting
Generator set operates erratically	Air cleaner clogged	Replace element.	Section 2.4, Air Cleaner Element and Precleaner
	Faulty spark plug(s)	Replace and regap plugs.	Section 2.3, Spark Plugs
	Fuel mixture adjustment incorrect	Check and/or adjust.	Section 6.11, Fuel Systems
	Governor adjustment incorrect	Adjust electronic governor.	Section 6.9, Electronic Governor
	Carbon buildup in engine	Clean cylinder head.	Engine S/M
	Engine valves not seating correctly	Inspect valves and valve seats.	Engine S/M
	Defective ignition system	Test and/or replace components.	Engine S/M
	Defective spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Incorrect cooling (hot engine only)	Inspect air inlet and outlet.	Section 2.5, Cooling System
	Fuel line restriction	Check fuel lines.	Section 6.11.1, Gas Piping
	Carburetor adjustment incorrect	Adjust carburetor.	Section 6.9.3, Hunting/Surging
Generator set lacks power	Air intake restriction	Check air cleaner, air intake.	Section 2.4, Air Cleaner Element and Precleaner
	Generator overloaded	Reduce load.	O/M
	Faulty spark plug(s)	Replace and regap plug(s).	Section 2.3, Spark Plugs
	Faulty spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Engine not running at rated rpm	Adjust governor.	Section 6.9, Electronic Governor
	Governor defective or misadjusted	Test/readjust governor.	Section 6.9, Electronic Governor
	Incorrect cooling	Inspect cooling system for obstructions.	Section 2.5, Cooling System
	Defective ignition system	Test and/or replace.	Engine S/M
	Insufficient fuel pressure	Check fuel pressure at carburetor outlet.	Section 6.11,Fuel Systems
	Fuel line restriction	Check fuel pipe size.	Section 6.11, Fuel Systems
	Defective fuel regulator	Check function of fuel regulator.	Section 6.11, Fuel Systemss
Generator set overheats	Incorrect cooling	Inspect cooling system for obstructions.	Section 2.5, Cooling System
	Air cleaner clogged	Replace element.	Section 2.4, Air Cleaner Element and Precleaner
	Fuel mixture adjustment incorrect	Readjust fuel mixture.	Section 6.11, Fuel Systems
Generator set is noisy	Exhaust system leaks	Check and replace as necessary.	Section 2.6, Exhaust System
	Engine not running smoothly	See “Generator set operates erratically,” this table	See “Generator set operates erratically,” this table
	Broken or damaged vibromount(s)	Check and replace as necessary.	Section 8, Disassembly/ Reassembly
	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.	Section 2.6, Exhaust System
	Excessive engine/generator vibration	Check, rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Section 8, Disassembly/ Reassembly and Engine S/M

General Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Emits black or gray smoke	Fuel mixture adjustment incorrect	Adjust fuel mixture.	Section NO TAG, Fuel System
	Air intake restriction	Check air cleaner and intake.	Engine O/M
	Worn piston rings, valves, etc.	Check compression.	Engine S/M
	Oil level high	Check oil level.	Section 2.2, Lubrication System
High oil consumption	External leakage/defective gaskets	Replace gaskets.	Engine S/M
	Worn piston rings, valves, etc.	Check compression.	Engine S/M
Engine knocks	Excessive load	Reduce load	Section 1.4, Generator Set Specificaitons
	Low oil level	Check oil level and add oil if low	Section 2.2, Lubrication System
Low output or excessive drop in voltage	Engine speed too low	Check engine speed using tachometer or frequency meter. Adjust governor as necessary.	Section 6.9, Electronic Governor
	Generator overloaded	Reduce load.	Section 1.4, Generator Set Specificaitons
	Defective voltage regulator	Test/readjust voltage regulator.	Section 6.3, Voltage Regulator
	Voltage regulator incorrectly adjusted	Test/readjust voltage regulator.	Section 6.3, Voltage Regulator
	Defective rotor	Test and/or replace.	Section 6.4, Main Field (Rotor)
	Defective stator	Test and/or replace.	Section 6.5, Stator
No battery charging output	Defective battery charging	Test/replace alternator.	Engine S/M
	Loose or corroded battery connections	Clean and tighten battery connections.	
	Defective battery	Check battery electrolyte level and specific gravity (batteries with filler caps only).	Section 2.7, Battery
High generator output voltage	Engine speed too high	Check engine speed using tachometer or frequency meter. Adjust governor as necessary.	Section 6.9, Electronic Governor
	Defective voltage regulator	Test/readjust voltage regulator.	Section 6.3, Voltage Regulator
	Voltage regulator incorrectly adjusted	Test/readjust voltage regulator.	Section 6.3, Voltage Regulator
	Loose voltage regulator connections (including 33 and 44 sensing leads).	Check voltage regulator connections.	Section 6.3, Voltage Regulator
No generator output voltage	AC output circuit breaker open or defective	Check position of circuit breaker. Check AC voltage on generator side of circuit breaker.	Section 9, Wiring Diagrams, and O/M
	AC circuit breaker tripping because of overload on generator set	Reduce load, reset and attempt startup.	—
	Transfer switch or other power source in OFF position.	Turn handle to correct position.	Transfer Switch Operation Manual
	No battery voltage to terminal (+) and (-) of voltage regulator during cranking	Check for 12VDC at voltage regulator (+) and (-).	Section 9, Wiring Diagrams
	Fuse blown in voltage regulator circuit (lead 55)	Replace blown fuse. If fuse blows again, check voltage regulator and stator auxiliary windings.	Section 6, Component Testing and Adjustment and 9, Wiring Diagrams
	Short circuit in wiring causing circuit breaker to trip open	Reset circuit breaker. If breaker trips again, check wiring.	Section 9, Wiring Diagrams
	Defective rotor (open, grounded, or shorted windings)	Test and/or replace.	Section 6, Component Testing and Adjustment

Problem	Possible Cause	Corrective Action	Reference
No generator output voltage	Defective stator (open, grounded, or shorted windings)	Test and/or replace.	Section 6, Component Testing and Adjustment
	K1 relay (NC) contact open	Check continuity.	Section 4, Controller Troubleshooting and 9, Wiring Diagrams
	Brushes sticking in holder	Check springs and alignment.	Section 6.6, Brushes
	Rotor slip rings dirty or corroded	Check and/or service.	Section 6.6, Brushes
	Worn brushes	Replace worn brushes.	Section 6.6, Brushes
	Defective or misadjusted voltage regulator	Excite (rotor) separately.	Section 6, Separate Excitation, and 6.3.1, Voltage Regulator Test
	Low engine rpm	Check engine speed using a tachometer or frequency meter. **Note:** Hz x 60 = rpm (Example 57 x 60 = 3420 rpm)	—
No AC output	Circuit breaker open or defective, if equipped	Reset breaker to ON position. Check AC voltage on generator side of circuit breaker.	Section 1.6, Service Views, for location
	Circuit breaker tripping because of overload on generator set	Reduce load.	O/M
	No battery voltage to voltage regulator during cranking: (+) and (–) terminals on regulator	Check for DC voltage at voltage regulator terminals listed.	Sections 6.3, Voltage Regulator, and 9, Wiring Diagrams
	Blown voltage regulator fuse	Replace fuse; if fuse blows again, check voltage regulator and/or stator auxiliary windings.	Sections 6.3, Voltage Regulator, and 9, Wiring Diagrams
	Open wiring, terminal, or pin in buildup circuit or voltage regulator circuit	Check continuity.	Sections 6.3, Voltage Regulator, and 9, Wiring Diagrams
	Brushes sticking in brush holder or broken brush spring	Check brush position and condition.	Section 6.6, Brushes
	Rotor slip rings dirty or corroded	Check slip ring condition.	Section 6.4, Main Field (Rotor)
	Defective rotor (grounded windings)	Check voltage and continuity.	Section 6.4, Main Field (Rotor)
	Defective stator (open, grounded, or shorted windings)	Check voltage and continuity.	Section 6.5, Stator
	Defective or misadjusted voltage regulator	Excite rotor separately and check for AC output. Readjust voltage regulator.	Section 6.3, Voltage Regulator
	Defective K3 relay (field flashing) in relay controller circuit board	Test/replace relay controller circuit board.	Section 4, Controller Troubleshooting

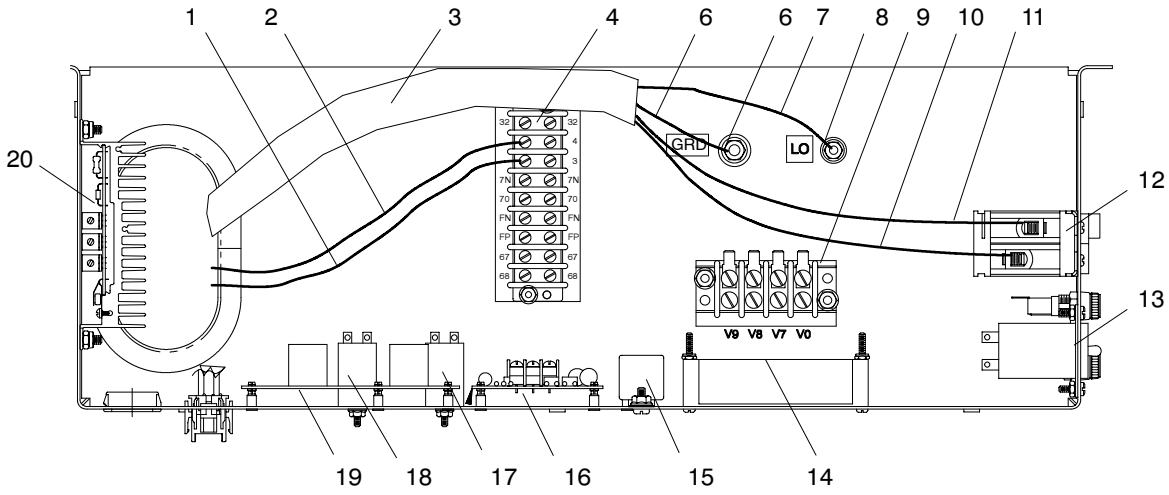
Notes

4.1 Relay Controller

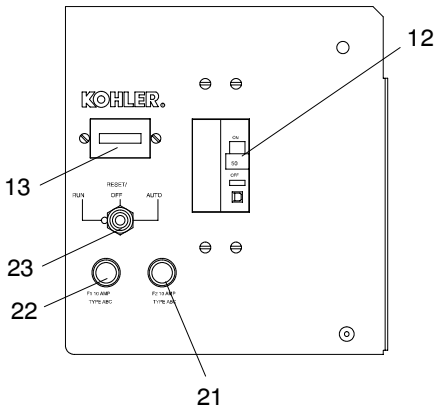
This section covers controller troubleshooting procedures for 8.5/11RMY generator sets equipped with relay controllers and related engine components. Refer to the generator set Operation Manual for operating instructions. Refer to Figure 4-2 or Figure 4-3 to identify the controller internal components. Some controllers use a different circuit breaker than the one shown in Figure 4-2. The integrated controllers shown in Figure 4-3 have the cyclic crank circuits integrated into the main circuit board and have a fault lamp on the front face.

Model No.	Spec. No.	Controller	
		Basic 358076	Integrated GM10615
8.5RMY	PA-195021	X	
	PA-195025		X
	GM16902-GA1		X
	GM24829-GA1		X
11RMY	PA-195022	X	
	PA-195026		X
	GM16902-GA2		X
	GM24829-GA2		X

Figure 4-1 Generator Set Controllers



Top View



Front View

A-358076-L

1. Remote start lead 3
2. Remote start lead 4
3. AC load leads
4. TB1 interconnect terminal block
5. Ground lead GND
6. Ground (GRD) terminal
7. Neutral lead L0
8. Neutral (L0) terminal
9. TB2 AC terminal block
10. Load lead L1
11. Load lead L2
12. Circuit breaker (type may vary)
13. Hourmeter
14. Electronic governor circuit board
15. Control power relay (K25)
16. Cyclic cranking circuit board
17. Cyclic cranking relay (K21)
18. Ignition relay (K5)
19. Controller circuit board
20. Voltage regulator
21. Voltage regulator fuse (10 amp)
22. Controller fuse (10 amp)
23. Generator set master switch

Figure 4-2 Basic Relay Controller 358076 with Separate Cyclic Crank Board (shows field-installed wiring)

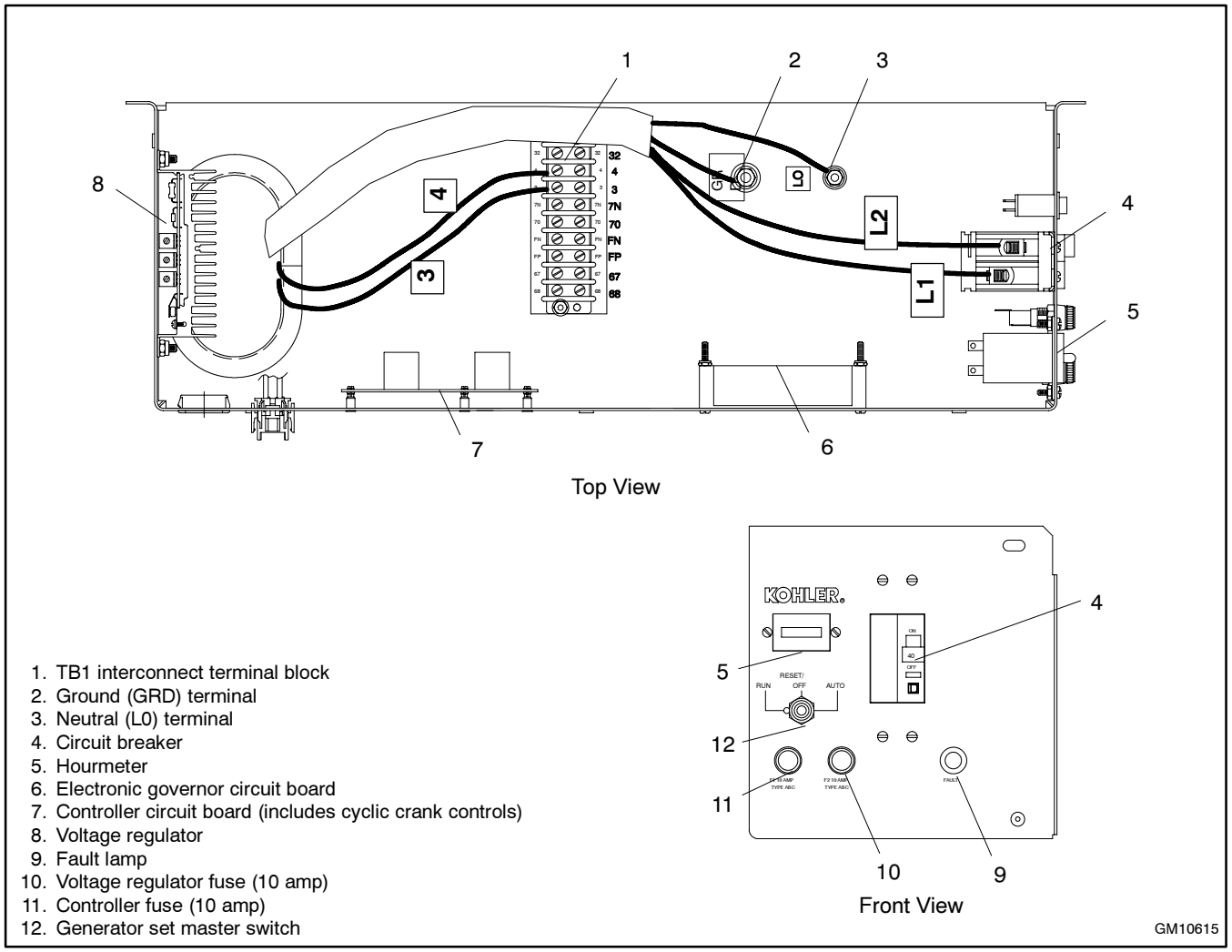


Figure 4-3 Integrated Relay Controller GM10615 with Fault Lamp and Cyclic Crank Control (shows field-installed wiring)

4.2 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 fault identification. Use the LEDs on the controller circuit board to assist in the troubleshooting process. Refer to the wiring diagrams in Section 9 to assist in the troubleshooting procedure.

An illuminated LED indicates that the corresponding relay is receiving power; the LED does not indicate whether the relay is functioning. The relays on the controller circuit board are not replaceable. Replace the circuit board if one or more relays are faulty.

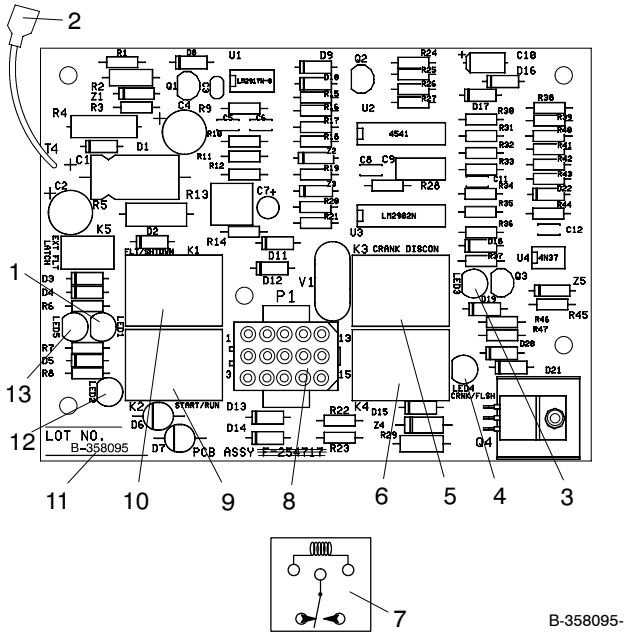
Identify the circuit board installed in the controller by the number printed on the edge of the board. Then see Figure 4-4 through Figure 4-7 for relay descriptions and locations.

Relay Description	Basic Relay Controller (Figure 4-2)	Integrated Relay Controller (Figure 4-3)
External Fault Latch	K5	K1
Fault Shutdown	K1	K2
Start/Run	K2	K3
Crank Disconnect	K3	K4
Crank/Flash	K4	K5
Ignition Kill	—	K6

Figure 4-4 Controller Circuit Board Relays

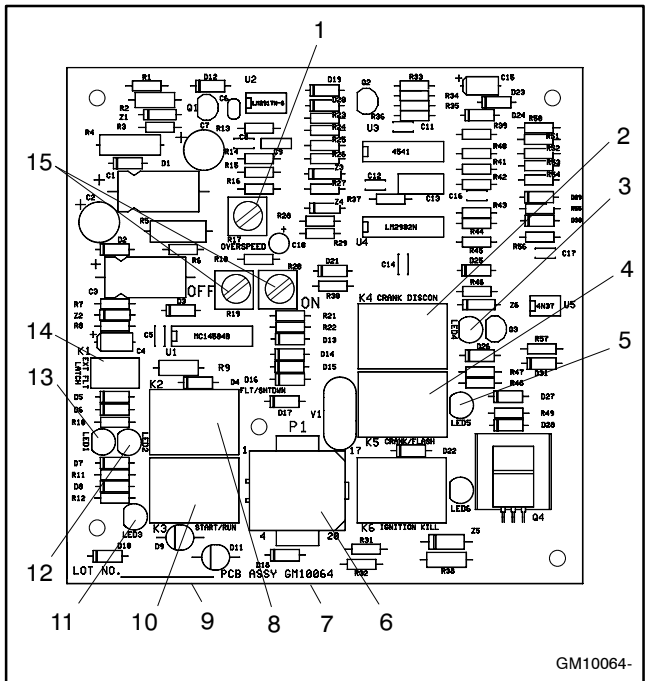
Relay Description	Relay Label
Starter	K1 or SR
Ignition	K5 or IR
Control Power	K25
Crank	CC
Cyclic Crank	K21
Off/Reset	O/RS

Figure 4-5 System Relays (not located on the controller circuit board)



1. LED1
2. Fault latching in AUTO lead 4
3. LED3
4. LED4
5. K3 relay
6. K4 relay
7. K1, K2, K3, K4 relay schematic
8. P1 connector
9. K2 relay
10. K1 relay
11. Circuit board part number
12. LED2
13. LED5

Figure 4-6 Basic Controller Circuit Board 358095



1. Overspeed adjustment potentiometer, R17
2. K4 crank disconnect relay
3. LED4
4. K5 crank/flash relay
5. LED5
6. P1 connector
7. Circuit board ID number
8. K2 fault shutdown relay
9. Circuit board ID number (alternate location)
10. K3 start/run relay
11. LED3
12. LED2
13. LED1
14. K1 external fault latch relay
15. Cyclic crank potentiometers

Figure 4-7 Integrated Controller Circuit Board GM10064

4.2.1 Starting Sequence

Placing the generator set master switch in the RUN position closes the contact between wires N and 47, starting the generator set locally. With the generator set master switch in the AUTO position, closing contacts 3 and 4 starts the generator set remotely.

The start/run relay energizes, supplying power to the relay board and control power relay K25. The crank/flash relay energizes and the hourmeter receives power.

The crank/flash relay supplies field flash current to the rotor and energizes cyclic crank relay CCR to provide the on/off crank cycle. The CCR relay energizes starter relay SR, which supplies power to the starter.

The K25 control power relay energizes the ignition module, coil, governor, and gas valve.

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.

4.2.2 Running Sequence

When generator winding 1-2 produces AC output or the engine speed reaches 1100 rpm, the crank disconnect relay energizes to disconnect the field flash current. The crank/flash relay deenergizes on crank disconnect, deenergizing the starter relay and the starter. The crank disconnect relay energizes the fault shutdown circuit after a 5-second delay.

Note: The generator set shuts down on overcrank fault if the controller does not obtain AC output within 30 seconds.

4.2.3 Stopping Sequence

Place the generator master switch in the OFF/RESET position. The start/run relay deenergizes the relay board and the control power relay, deenergizing engine components. The generator set stops.

4.2.4 Fault Shutdown

Under the fault conditions listed below, the fault shutdown relay energizes and the corresponding LED lights. The relay's normally open contacts close. The normally closed relay contacts open to deenergize the K25 relay. The K25 relay normally open contacts open to deenergize engine components. The generator set shuts down. To restart the generator set, first move the generator master switch to the OFF/RESET position to reset the controlller.

Low Oil Pressure (LOP) Shutdown

Five to eight seconds after engine lube oil pressure falls below a safe level and the LOP switch closes, fault shutdown occurs.

Overspeed Shutdown

When the frequency exceeds 72 Hz (or 62 Hz for 50 Hz models), overspeed shutdown occurs.

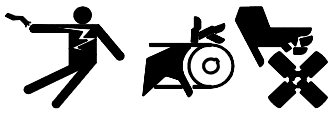
Overcrank Shutdown

If the generator set does not start after three crank cycles (crank/rest, crank/rest, crank), fault shutdwon occurs.

Note: If the generator set stops from lack of fuel, the generator set cranks in the cyclic crank procedure for 30 seconds before shutting down on overcrank. The generator set attempts restart whenever speed sensor detects no rotor rotation or AC disconnect circuit detects no AC.

4.3 Controller Circuit Board

⚠ 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.

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

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

Some controller circuit board components can be tested without removing the component from the board. Perform these checks prior to installing a new board and attempting start-up. Section 3, Troubleshooting, lists most of the tests. Use a high-quality multimeter and follow the manufacturer's instructions. To obtain accurate readings when testing, remove all circuit board connectors and conformal coating (transparent insulation) from component terminals. Use Figure 4-9 and the controller circuit board illustration; see Figure 4-6 or Figure 4-7.

The controller circuit board has light-emitting diodes (LEDs) that indicate relay coil power and aid in circuit board and generator fault detection. When the K1, K2, K3, or K4 relays receive power, the corresponding LED lights. The LED does not indicate whether the relay coil is functioning. Determine if the relay coil is functioning by analyzing generator faults by performing a continuity test on the relay coil.

Overspeed Setting

A potentiometer on the relay controller circuit board adjusts the overspeed setting. See Figure 4-6 or Figure 4-7 and the table in Figure 4-8 to identify the potentiometer used to adjust the overspeed setting.

When investigating a shutdown problem or when replacing the controller circuit board, verify that the overspeed shutdown setting is 72 Hz for 60 Hz models and 62 Hz for 50 Hz models. See Section 6.9.6, Overspeed Verification and Adjustment.

Relay Controller Circuit Board	Overspeed Potentiometer
B-358095	R12
GM10064	R17

Figure 4-8 Overspeed Potentiometer Identification

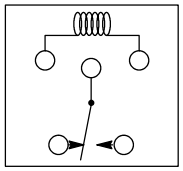
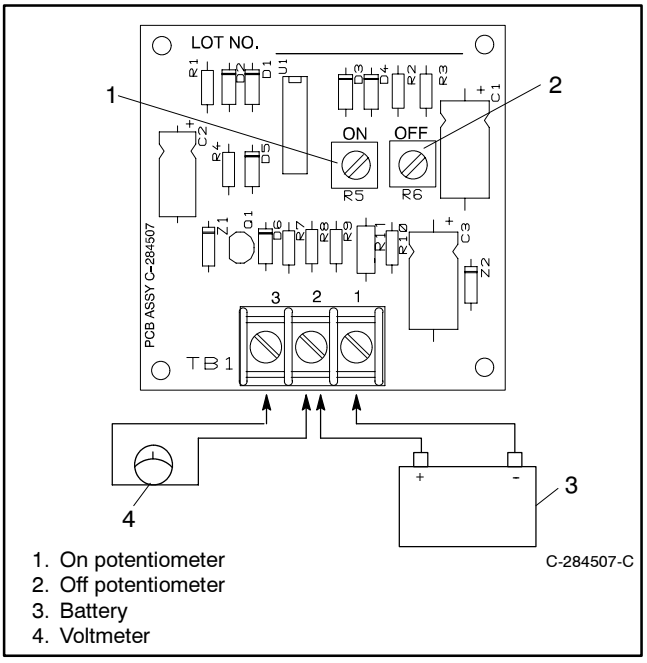
Component	Ohmmeter Connections	Remarks	Results
K1, K2, K3, K4, Relay Coil	K1 Coil Terminals (see relay schematic)  Relay Schematic	Ohmmeter on R x 10 scale	If good, approx. 400 ohms. Low resistance (continuity) indicates a shorted coil. High resistance indicates an open coil.

Figure 4-9 Controller Circuit Board Component Test

4.4 Cyclic Cranking

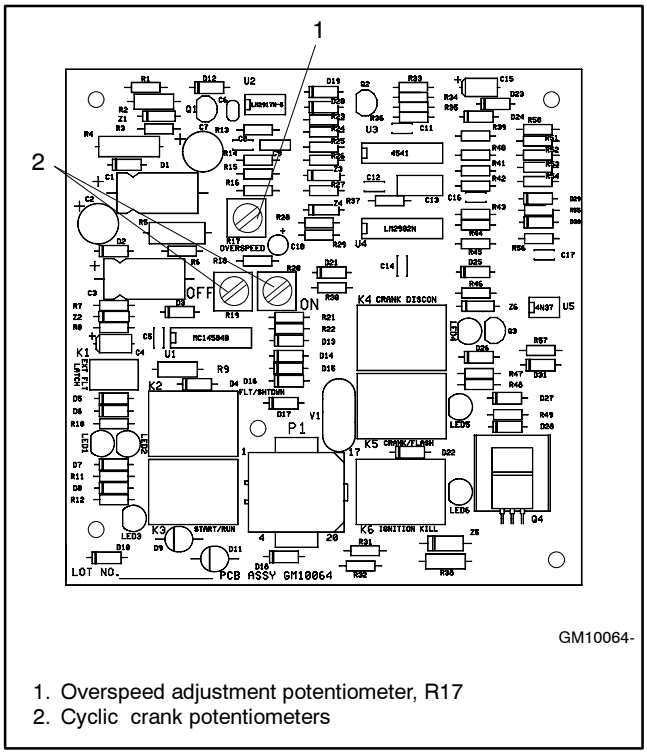
The cyclic cranking adjustment potentiometers located in the controller allow adjustment of the cranking cycle for improved starter motor engagement. The basic controller has a separate cyclic cranking circuit board. See Figure 4-10. The integrated controller has the adjustment potentiometers mounted on the controller circuit board. See Figure 4-11.

The factory sets the cranking cycle for eight seconds on time and three seconds off time. If the cranking cycle seems shorter than the factory setting, check the engine starting battery before readjusting the potentiometers. The timing decreases if the battery charge is too low.



1. On potentiometer
2. Off potentiometer
3. Battery
4. Voltmeter

Figure 4-10 Cyclic Cranking Board Test Connections



1. Overspeed adjustment potentiometer, R17
2. Cyclic crank potentiometers

Figure 4-11 Integrated Controller Circuit Board Cyclic Crank Potentiometer Location

4.4.1 Adjustment

The ON and OFF potentiometers allow adjustment of the on and off cycles from 1 to 60 seconds. See Figure 4-10 or Figure 4-11. If the generator set engine does not perform the cyclic crank routine during starting, verify that the cyclic cranking is correctly adjusted. Rotate the corresponding potentiometer clockwise (cw) to increase the time period or counterclockwise (ccw) to decrease it. The cyclic crank feature does not operate when both potentiometers are in the full ccw position.

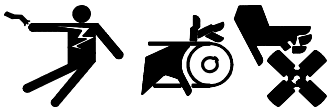
4.4.2 Testing

The cyclic cranking board in the basic controller can be removed and tested on the bench. If the cyclic crank circuit board is correctly adjusted but the engine does not go through the preferred crank cycle, test the board using the following cyclic crank board test procedure.

Test equipment needed:

- 12-volt battery or DC power supply
- DC voltmeter

⚠ 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.

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

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

Cyclic Cranking Board Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the generator set housing roof to gain access to the controller.
5. Disconnect the leads connected to terminals 1, 2, and 3 of the cyclic crank circuit board. Remove the cyclic crank board from the controller. See Figure 4-2 for the location of the circuit board.
6. Connect a voltmeter across cyclic crank board terminals 2 and 3 with the voltmeter on the 12–15 volt DC scale. See Figure 4-10.
7. Connect the positive (+) battery terminal to circuit board terminal 2. Connect the negative (-) battery terminal to cyclic crank terminal 1. Verify that the voltmeter shows 12 volts DC for approximately eight seconds (factory crank setting) and then no voltage for approximately three seconds (factory rest setting). This sequence should continue for 30 seconds (8 on, 3 off, 8 on, 3 off, 8 on).

   Note: The cyclic crank board may have been customer-adjusted to provide longer or shorter crank/rest cycles.
8. Adjust the on and off times, if necessary, by turning the adjustment potentiometers cw to increase the time or ccw to decrease it.
9. If there is no voltage at the cyclic cranking board, check the battery voltage and the cyclic cranking adjustments. The cyclic crank feature does not operate at low battery voltage or when both circuit board potentiometers are in the full ccw position. If there is no voltage with the battery fully charged and the cyclic crank board correctly adjusted, replace the cyclic crank circuit board.
10. Reinstall or install the new cyclic crank circuit board into the controller.
11. Reconnect leads 1, 2, and 3 to terminal strip TB1 on the cyclic crank circuit board. See Figure 4-10.
12. Check that the generator set master switch is in the OFF position.
13. Reconnect the generator set engine starting battery, negative (-) lead last.
14. Reconnect power to the battery charger, if equipped.

Notes

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

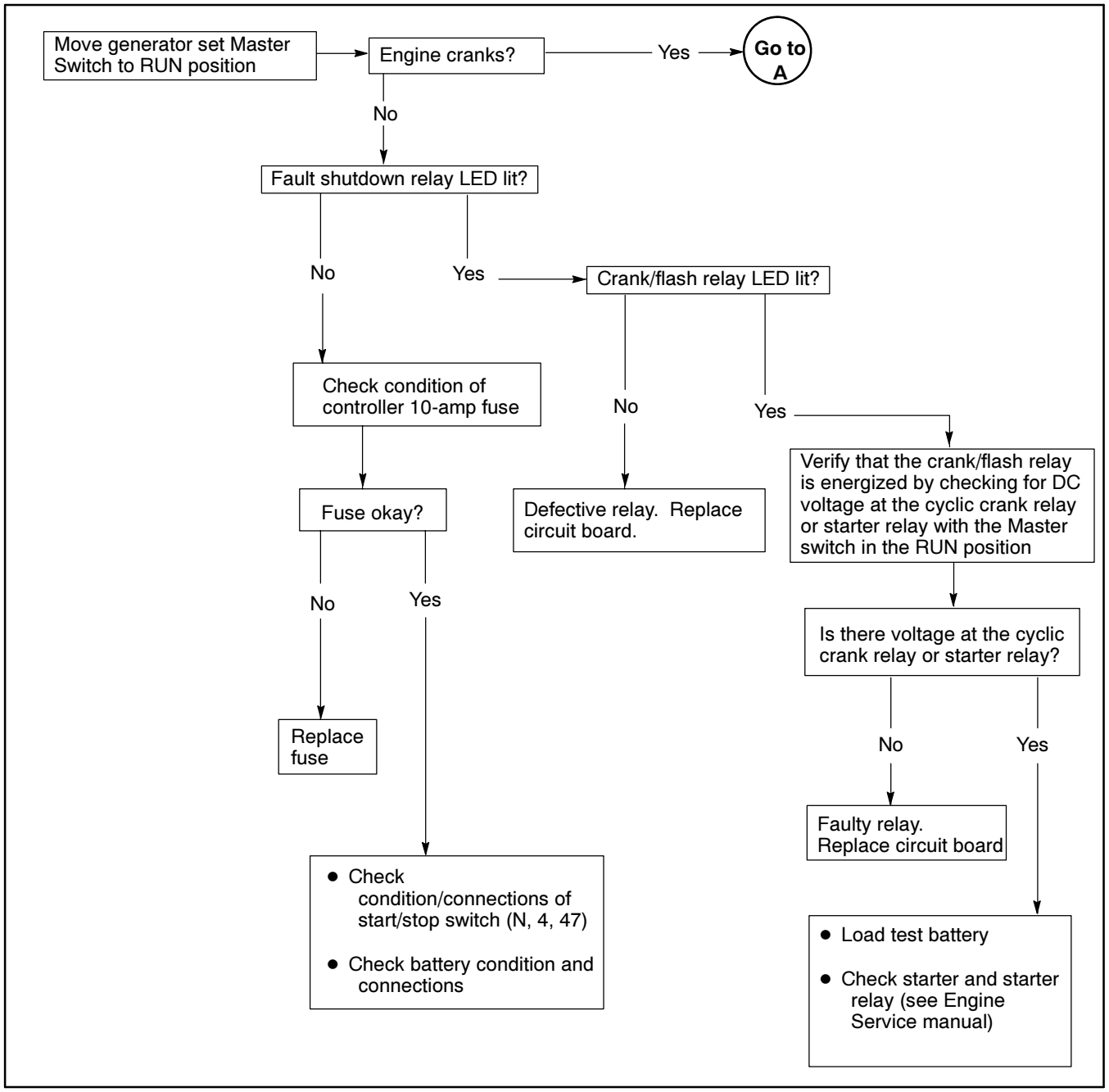


Figure 5-1 Troubleshooting the Relay Controller Circuit Board (1 of 3)

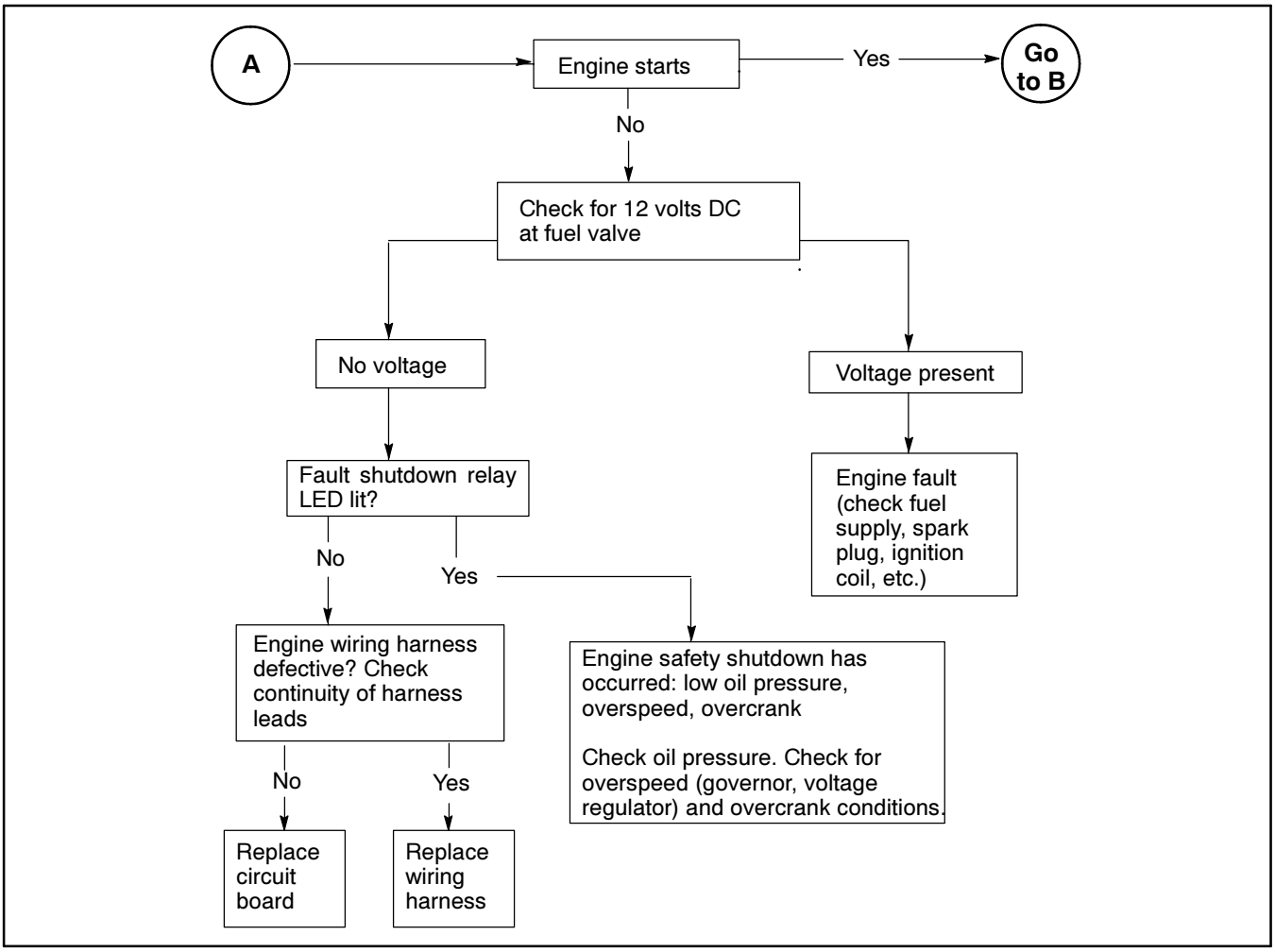


Figure 5-2 Troubleshooting the Relay Controller Circuit Board (2 of 3)

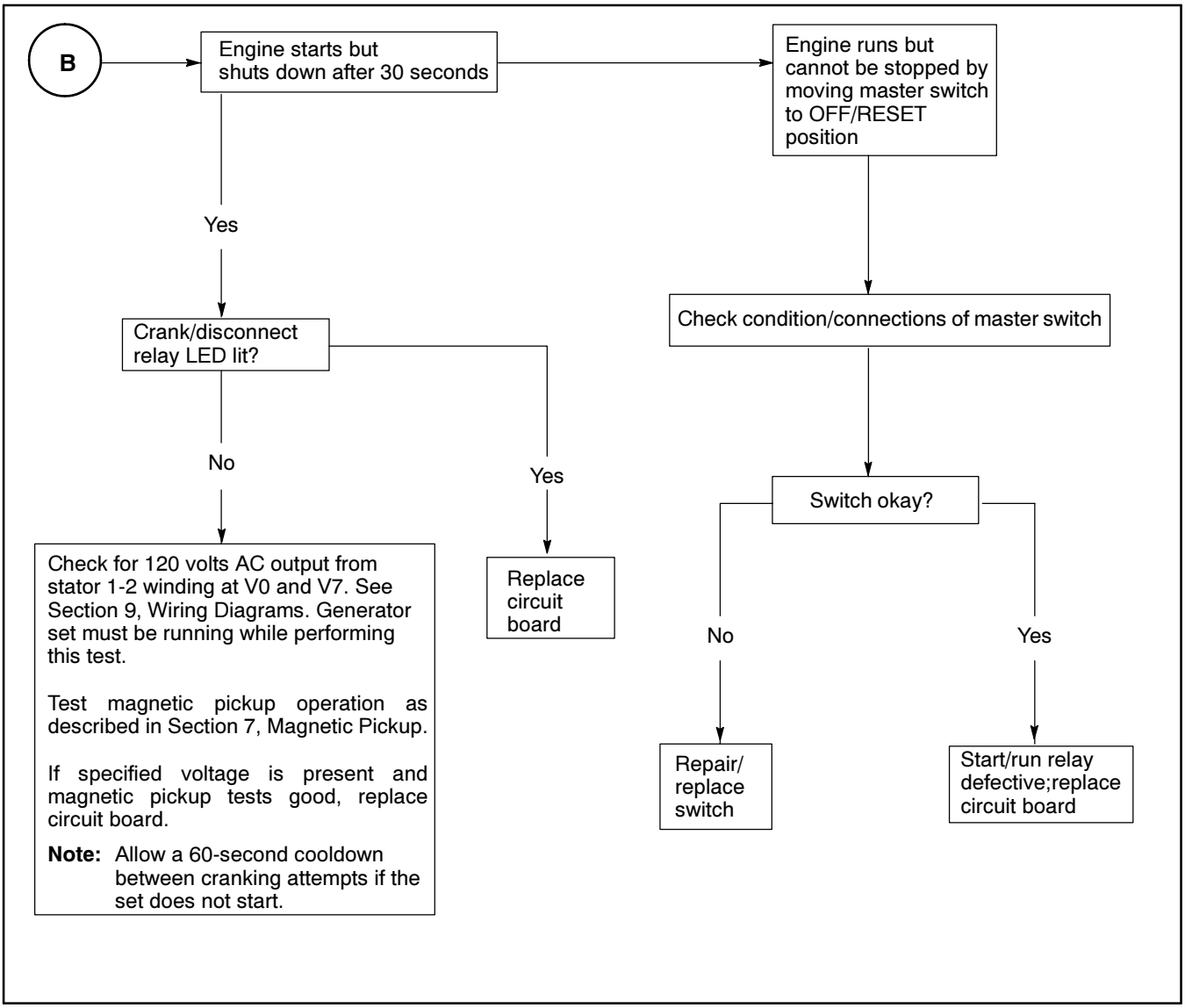
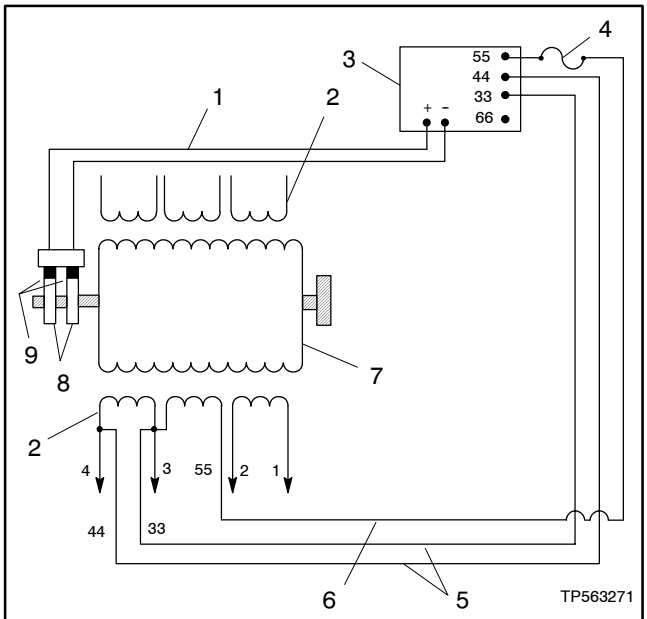


Figure 5-3 Troubleshooting the Relay Controller Circuit Board (3 of 3)

Notes

6.1 Theory of Operation, 1-Phase Generator Sets with Power Boost IIIE Voltage Regulator

Single-phase 8.5/11RMY generator sets utilize a rotating-field alternator to produce AC current. 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 current develops within the stator. As engine speed and generator output increase, the voltage regulator 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 Power Boost™ IIIE voltage regulator monitors the generator output voltage through leads 33 and 44 and allows the DC current to flow to the rotor to meet load requirements. See Figure 6-1.



1. Excitation to rotor
2. Stator windings
3. Voltage regulator PowerBoost™IIIE
4. 10-amp voltage regulator fuse (controller front panel)
5. Sensing leads (33–44)
6. Power lead (55)
7. Main field (rotor)
8. Slip rings
9. Brushes

Figure 6-1 Single-Phase Generator Schematic

6.2 Generator Troubleshooting

To determine the cause of no or low AC output, refer to the troubleshooting flow chart in Figure 6-2. Before beginning the test procedures, read all safety precautions at the beginning of this manual. Many of the test procedures include additional safety precautions.

Check the condition of the voltage regulator's 10-amp fuse before performing the separate excitation procedure. See Figure 4-2 or Figure 4-3 for the fuse location. If the fuse is not blown, use the following procedure to separately excite the generator using an external voltage source (a 12-volt automotive battery).

Separately exciting the generator can determine the presence of a faulty voltage regulator 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 regulator using the tests in Section 6.3.

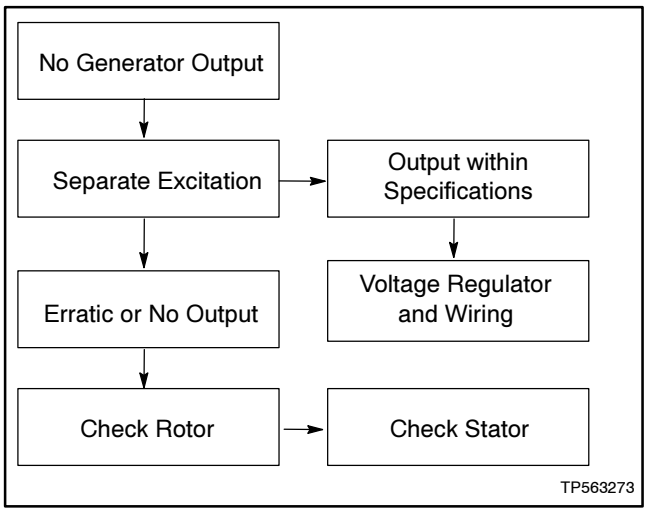


Figure 6-2 Generator Troubleshooting

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

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

Separate Excitation Procedure

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

1. Disconnect the six pin connector from the voltage regulator.

2. Connect a DC ammeter, 10-amp fuse, and a 12-volt automotive battery to the positive (+) and negative (–) brush leads as shown in Figure 6-3. Note and record the ammeter reading.

   Note: The approximate ammeter reading should be the battery voltage divided by the specified rotor resistance.

   Example:

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

   Note: See Section 1, Specifications, for specified rotor resistance values.

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 6.4.2, Main Field (Rotor), to test the rotor. If the ammeter reading is stable, proceed to step 4.

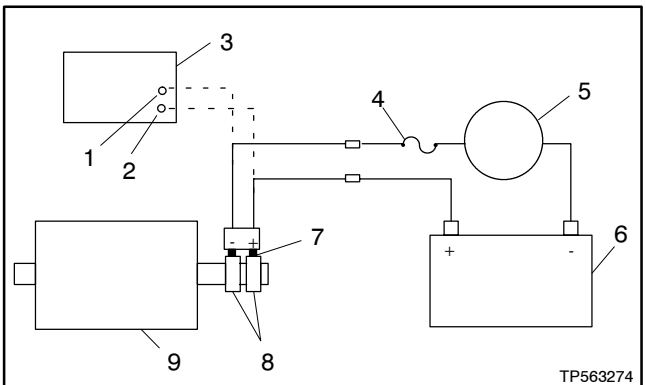
4. Check for AC output across the stator leads; see Section 6.5, Stator. Compare the readings to the AC output values shown in Section 1, Specifications. If the readings vary considerably, a faulty stator is likely. Refer to Section 6.5, Stator, for further information.

5. If this test shows that the rotor and stator are in good condition, check the voltage regulator. See Section 6.3, Voltage Regulator.

6.3 Voltage Regulator

Single-phase generator sets use the Power-Boost™ IIIE voltage regulator. See Figure 6-4.

The PowerBoost™IIIE voltage regulator monitors generator output voltage and provides excitation current to the rotor. PowerBoost™IIIE 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 regulator 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.



1. (–) Terminal—1-phase (12) Terminal—3-phase
2. (+) Terminal—1-phase (10) Terminal—3-phase
3. Voltage regulator
4. 10-amp fuse
5. DC ammeter
6. 12V battery
7. Brushes
8. Slip rings
9. Main field (rotor)

Figure 6-3 Separate Excitation Connections

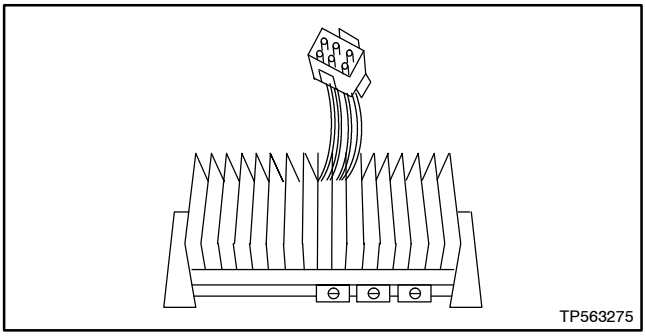


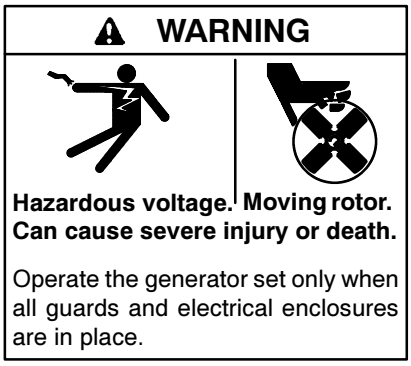
Figure 6-4 PowerBoost™IIIE Voltage Regulator

6.3.1 Voltage Regulator Test

If the regulator 10-amp fuse blows, the generator set shuts down. Verify that the regulator fuse is good before proceeding with the test. A failed voltage regulator can cause either high voltage output or little or no voltage output from the generator.

The voltage regulator test requires the following components:

- Variable transformer, 0–140 volts (0.5-amp minimum)
- Plug, 120 volt AC
- Lamp, 120 volt, 100-watt
- Voltmeter, AC
- Copper Wire, #14 AWG, minimum



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

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

Voltage Regulator Test Procedure

1. Connect the components as shown in Figure 6-5.
2. Turn the variable transformer setting to zero. Plug in the variable transformer.
3. Turn the variable transformer on. Slowly increase the variable transformer voltage to 100 volts. The lamp should light. If the lamp does not light, turn the voltage adjustment potentiometer clockwise (cw). If the lamp still does not light, replace the voltage regulator.
4. Slowly increase the voltage to 120 volts. The lamp should go out and stay out as the voltage increases. If the lamp stays lit, turn the voltage adjustment potentiometer counterclockwise (ccw). If the lamp does not go out, replace the voltage regulator.
5. Turn the variable transformer to zero and unplug the AC cord.

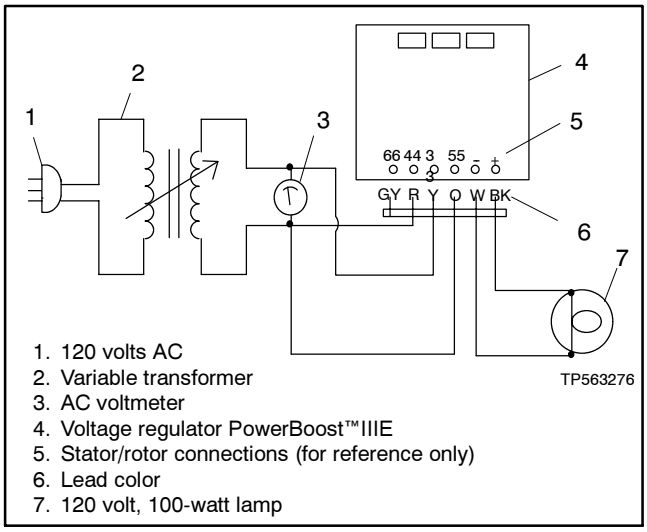


Figure 6-5 Voltage Regulator Test Connections

6.3.2 Voltage Regulator Adjustment

The factory sets the voltage regulator for correct generator operation under a variety of load conditions. Usually, the voltage regulator needs no further adjustment. Adjust the regulator according to the following procedure after voltage reconnection or if the regulator has been tampered with or replaced.

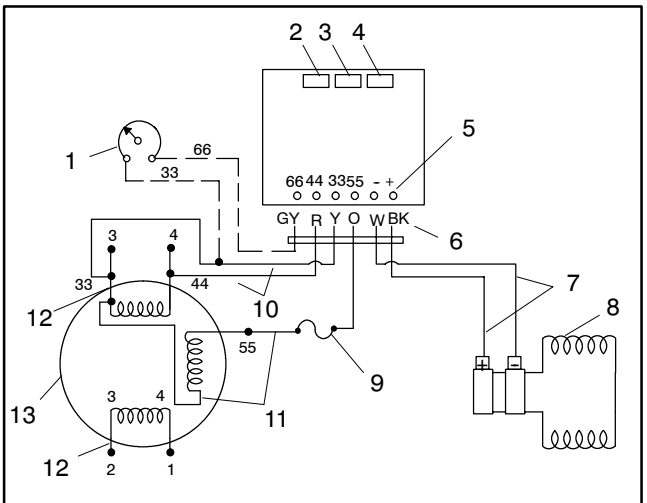
The voltage adjustment procedure uses three potentiometers located on the voltage regulator. See Figure 6-4 and Figure 6-7. The procedure also requires a meter that can measure voltage and frequency.

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

Stabilizer Potentiometer Fine tunes regulator circuitry to reduce light flicker.

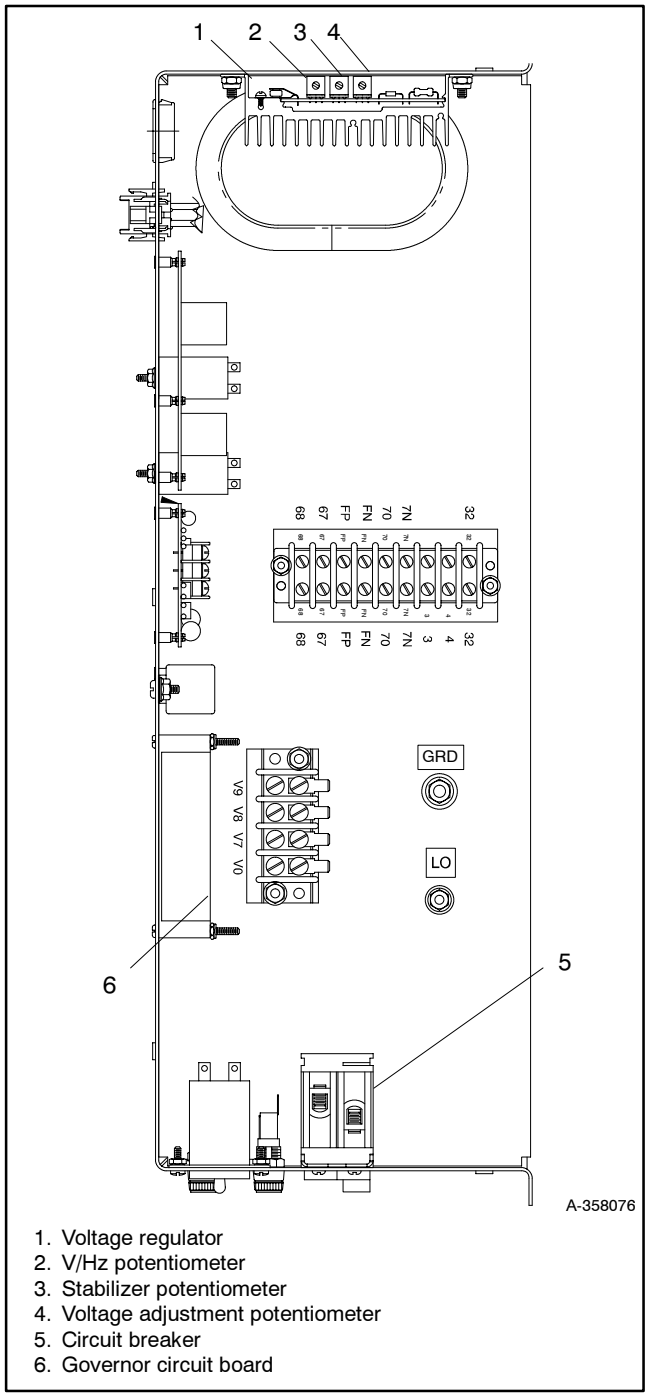
Volts/Hz Potentiometer Determines frequency (Hz) at which generator output voltage begins to drop.

Note: In applications requiring fine voltage adjustment, connect a 10 kOhm, 1/2 watt minimum rheostat (customer-provided) across terminals 33 and 66 on the PowerBoost™IIIE voltage regulator. See Figure 6-6. The rheostat provides a 5-volt adjustment range.



1. Remote rheostat (customer-provided)
2. Voltage adjustment potentiometer
3. Stabilizer potentiometer
4. Volts/Hz potentiometer
5. Stator/rotor connections (for reference only)
6. Lead color
7. DC output
8. Main field (rotor)
9. 5-amp fuse
10. Sensing leads (33-44)
11. AC power input (auxiliary) lead (55)
12. Main leads (1-2, 3-4)
13. Stator

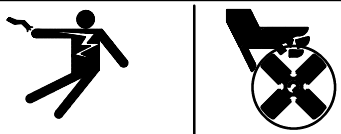
Figure 6-6 PowerBoost™IIIE Voltage Regulator Test and Adjustment Setup



1. Voltage regulator
2. V/Hz potentiometer
3. Stabilizer potentiometer
4. Voltage adjustment potentiometer
5. Circuit breaker
6. Governor circuit board

Figure 6-7 Controller Top View, Typical

⚠ WARNING



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

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

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

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

Voltage Regulator Adjustment Procedure

1. With the generator set off, turn the remote rheostat, if equipped, and stability potentiometers to midpoint. Turn the voltage and volts/Hz potentiometers fully counterclockwise.

2. Connect a digital voltmeter from one side to the circuit breaker to the L0 terminal inside the controller assembly. See Figure 6-7. 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.

3. Start the generator set.

4. Rotate the voltage adjustment potentiometer clockwise to increase voltage or counterclockwise to decrease voltage until the regulator reaches the desired output voltage.

5. Rotate the stability potentiometer clockwise until the light flicker minimizes.

6. Readjust the voltage adjustment potentiometer, if necessary.

7. Set the voltmeter to measure frequency. Adjust the engine speed to the cut-in frequency shown in Figure 6-8 by adjusting the speed potentiometer on the electronic governor. See Section 6.9, Electronic Governor. Rotate the potentiometer counterclockwise to decrease the engine speed.

8. Set the voltmeter to measure voltage. Rotate the volts/Hz adjustment potentiometer on the voltage regulator clockwise until the voltage level measured by the voltmeter begins to drop. When set, the generator (as load is applied) attempts to maintain normal output until the engine speed drops below the cut-in frequency set in step 7.

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

Figure 6-8 Cut-In Frequencies

9. Set the voltmeter to measure frequency. Adjust the engine speed to the operating frequency (50 or 60 Hz) by rotating the speed adjustment potentiometer on the governor. Rotate the potentiometer clockwise to increase the engine speed.

10. Readjust the stability potentiometer on the voltage regulator, if necessary.

11. Check the voltage. Readjust the voltage adjustment potentiometer on the voltage regulator, if necessary.

12. Stop the generator set.

6.4 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.

6.4.1 Rotor Continuity and Resistance Tests

⚠ WARNING

Hazardous voltage.

Moving rotor.

Can cause severe injury or death.

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

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

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

Rotor Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect the generator set engine starting battery, negative (-) lead first.
3. Disconnect power to the battery charger, if equipped.
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 6-9. See Section 1.3, Generator, 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.

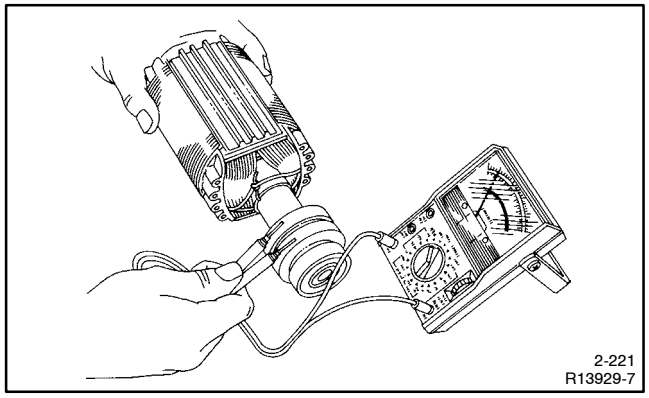


Figure 6-9 Rotor Resistance Check

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 6.6, Brushes.

   e. Reinstall the brush cover on the end bracket.

6.4.2 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.

6.5 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 the it for heat discoloration and visible damage to housing lead wires, exposed coil windings, and exposed areas of frame laminations. Be sure the stator is securely fastened to the stator housing.

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

⚠ WARNING

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

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

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

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

Stator Continuity and Resistance Tests

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

2. Disconnect power to the battery charger, if equipped.

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 6-10.

   Note: Leads 1, 2, 3, and 4 are the generator output leads. Leads 33, 44, and 55 are the voltage regulator sensing and supply leads. Refer to the schematic in Figure 6-11 when performing the following steps.

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

7. Check the cold resistance of the stator windings by connecting the meter leads to stator leads 1-2, 3-4, 33-44, and 55-33. See Section 1.3, Alternator, for stator winding resistances. Most ohmmeters do not provide accurate readings below 1 ohm. Low resistance readings (continuity) and no evidence of shorted windings (heat discoloration) indicate a stator in good condition.

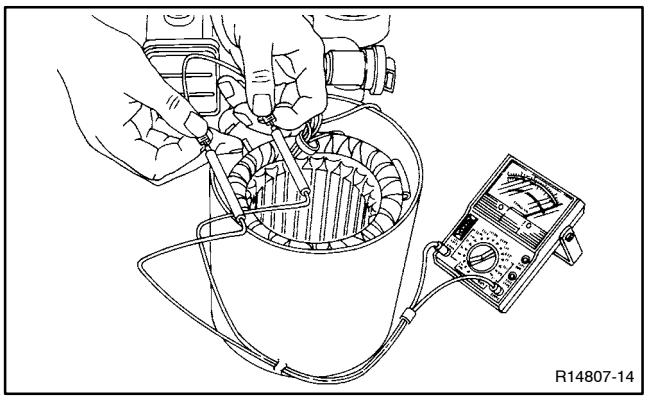


Figure 6-10 Testing Stator Windings

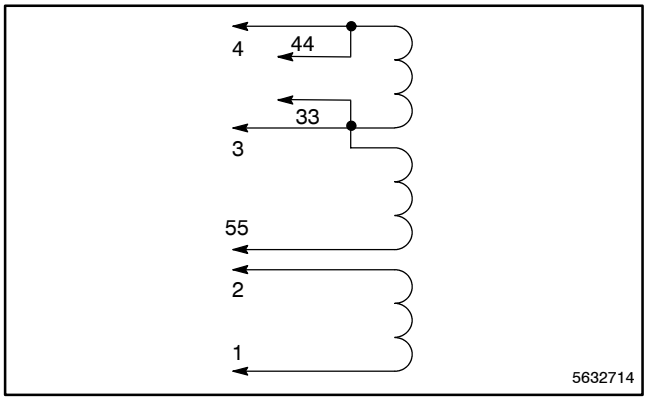


Figure 6-11 Alternator Stator Leads

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.

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.

Leads	Continuity
1 and 2	Yes
3 and 4	Yes
33 and 44	Yes
3 and 44	Yes
55 and 3	Yes
55 and 33	Yes
1 and 3, 4, 33, 44, 55	No
Any stator lead and ground on stator housing or frame laminations	No

Figure 6-12 Continuity Test Results on a Good Stator

6.6 Brushes

The brushes transfer current from the voltage regulator 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 voltage regulator. 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 6-13 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.

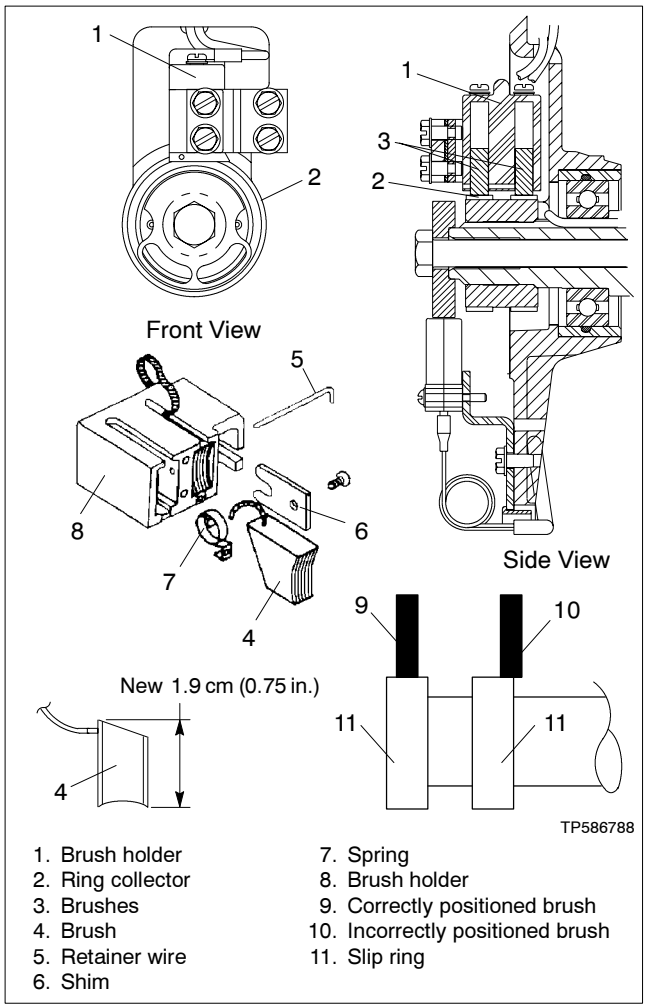


Figure 6-13 Brush Assembly

6.7 Engine/Generator Components

⚠ WARNING

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

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

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.

6.7.1 Gas Valve Operation Check

Use the following procedure to check the operation of the gas valve.

Gas Valve Operation Test Procedure

1. Disconnect the positive (+) 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.

6.7.2 Voltage Checks

The wiring harness and some engine/generator components can be checked with the generator set battery connected. See Figure 6-14. Place the controller master switch in the prescribed position and use a voltmeter to check for voltage at each component. This verifies that the switches function and that voltage is present at each component.

6.7.3 Continuity Checks

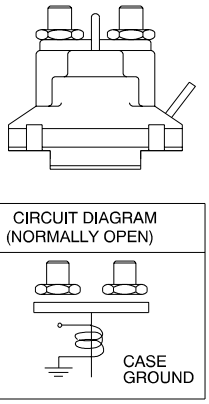
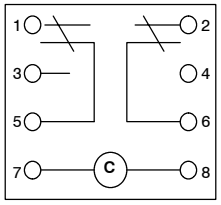
To further check generator set components, disconnect the battery and remove wiring harness plugs from the controller circuit board. Use an ohmmeter to check the continuity of the components listed in Figure 6-15. Also see Section 9, Wiring Diagrams.

Figure 6-15 gives resistance readings for functional components. A zero reading on the ohmmeter indicates continuity. No ohmmeter reading indicates very high resistance or an open circuit. A measurement that varies significantly from the value shown in the table indicates a faulty component; replace faulty components.

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

Component	Voltmeter Connections	Voltmeter Scale	Generator Set Master Switch Position	Results
Hourmeter and wiring	Read lead to hourmeter positive (+) terminal, black lead to hourmeter (–) terminal.	12 VDC	RUN	12 VDC. No or low voltage indicates a faulty wiring harness. Hourmeter functions.
Stator 1-2 winding, 1 phase (control winding)	V0 and V7 terminals on TB2 (AC terminal block) in controller.	150 VAC	RUN (Allow generator set to reach rated speed)	120 VAC (approx.) A significantly different reading indicates a faulty stator winding.

Figure 6-14 Voltage Checks

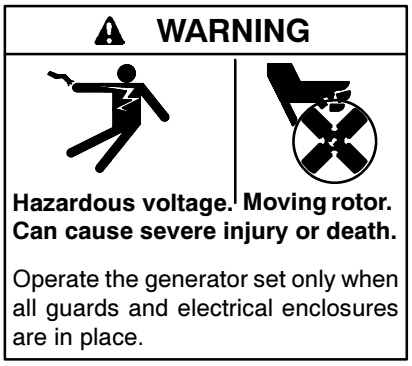
Component	Ohmmeter Connections	Ohmmeter Scale	Generator Set Master Switch Position	Ohmmeter Readings for Operative Components*
Generator set master switch	P1-2 (47) and P1-14 (N)	R x 1000	RUN	Zero ohms (continuity). Any other reading indicates a defective switch.
			OFF/RESET	No reading (open circuit). Any other reading indicates a defective switch.
Hourmeter	(+) and (-) terminals	R x 1	OFF/RESET	Continuity (low resistance). If no continuity is found, replace the hourmeter.
P1 wiring harness	P1-14 and ground	R x 1	OFF/RESET	Zero ohms (continuity) Any other reading indicates a poor ground connection.
	P1-12 and P1-15 (stator leads 1 & 2, 1 phase)	R x 1	OFF/RESET	Zero ohms (continuity).
Controller 10-amp fuse and wiring	P1-10 and battery positive (+) cable	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check for an open circuit and/or a blown fuse.
Voltage regulator circuit 10 amp fuse	P10-5 and stator lead 55 at the fuse holder (relay controller)	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check for an open circuit and/or a blown fuse.
Low oil pressure switch*	Lead 13 and ground (engine block)	R x 1000	OFF/RESET	Zero ohms (continuity). No continuity indicates a defective switch and/or wiring.
High engine temperature switch	Lead 37 and ground (engine block)	R x 1000	OFF/RESET	No reading (open circuit). Any other reading indicates a defective switch.
Starter relay (See illustration below) 	Starter relay terminal and relay base (ground)	R x 1	OFF/RESET	5–6 ohms. Lower resistance indicates a shorted relay coil and/or wiring. High resistance indicates an open relay coil and/or wiring.
Cyclic crank relay and wiring 	Disconnect the relay and remove it from the controller. Connect the ohmmeter to relay terminals 7 and 8.	R x 1	—	160 ohms

* See Section 6.8, Fault Shutdown Test Procedure

Figure 6-15 Continuity Checks

6.8 Fault Shutdown Test Procedure

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 (circuit board, wiring harness, switch, etc.) as described earlier in this section.



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.

6.8.1 Controller Fault Shutdown Functions

Overspeed

Open the generator set output circuit breaker before beginning the test. (See Figure 4-2 or Figure 4-3 for the circuit breaker location.)

Start the generator set and manually adjust the engine speed (by moving the throttle linkage) to exceed the rated engine speed (3600 rpm @ 60 Hz and 3000 rpm @ 50 Hz). Verify that the generator set shuts down when the output frequency reaches 8 to 12 Hz above the rated frequency. See Section 6.9.6 for more information about the overspeed setting.

Low Oil Pressure (LOP) Shutdown

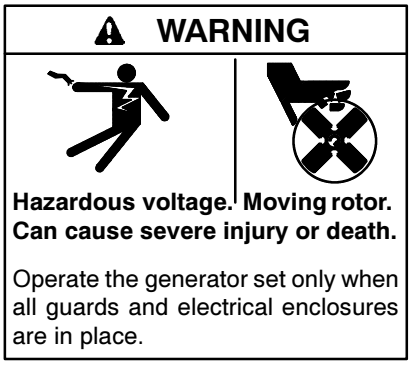
Connect a jumper wire from the LOP switch (lead 13) to the generator set ground. See Section 4.2, Sequence of Operation. Start the generator set. Verify that the generator set shuts down after approximately 25–35 seconds of operation. Remove the jumper wire from the LOP switch and ground. Start the generator set and run it for at least 25–35 seconds to verify that the generator set does not shut down.

Overcrank Shutdown

Disconnect the starter motor lead at the starter solenoid (K20) terminal. Move the controller master switch to the RUN position. Observe that the generator set simulates cranking for 15 seconds and then rests for 15 seconds. Check that the generator set shuts down after the third crank/rest cycle. If the controller is set for continuous cranking, verify that overcrank shutdown occurs after 45 seconds of continuous simulated cranking.

6.8.2 Fault Shutdown Switches

Check the low oil pressure and high engine temperature shutdown switches by performing the following tests.



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

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

Low Oil Pressure (LOP) Switch

Refer to the engine service manual for the low oil pressure (LOP) switch location. Remove the LOP switch and install an oil pressure gauge to verify that the engine oil pressure is within the range specified in Section 1, Specifications, before testing or replacing the LOP switch. To test the LOP switch, reinstall the switch and start the generator set. If the unit shuts down, disconnect lead 13 from the LOP switch and reset the

controller. Restart the generator set and verify that it does not shut down. A successful restart indicates a faulty LOP switch. Replace the switch.

High Engine Temperature (HET) Switch

Sound-enclosure models use a normally open high engine temperature switch. See Section 1.6, Service Views, for the switch location. Set the generator set master switch to the OFF position and allow the generator set to cool. Disconnect the high engine temperature switch and use an ohmmeter to check the continuity from the switch center terminal (lead 37) to ground. The ohmmeter should show no reading, indicating an open circuit. Any other reading indicates a shorted switch.

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

6.9 Electronic Governor

The governor system consists of an electronic isochronous governor controller, an electromechanical stepper motor (actuator), and a magnetic pickup. See Section 9, Wiring Diagrams, for the governor connections.

6.9.1 Operation

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

The electronic governor controller is energized with a 12 VDC supply from the K25 start/run relay contacts.

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

At cranking speed a properly adjusted pick-up should produce a minimum of 1.75 VAC. The magnetic pick-up air gap is factory-set to 1.02 mm (0.040 in.). Failure or loss of the input speed signal from the magnetic pick-up will result in a low or idle speed condition.

A potentiometer on the governor controller allows adjustment of the engine speed within the 50/60Hz range. See Section 6.9.3.

A gain adjustment may be required if an unstable (hunting/surging) condition occurs. Adjusting the gain may require readjustment of the engine speed. See Section 6.9.3.

6.9.2 Initial Checks and Operation Test

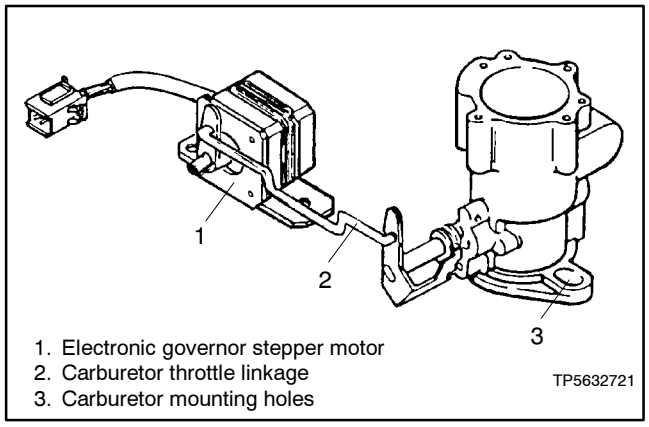
The factory sets the electronic governor. Under normal circumstances the electronic governor requires no further adjustment. Verify that the governor stepper motor moves smoothly and steadily during operation. If the engine operates erratically check the following connections and conditions *before*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

- Verify that the electrical connections, including the stepper motor and governor connector (inside the generator set controller), are clean and tight.
- Check the magnetic pickup connections. Poor connections may cause an erratic signal. An erratic signal causes the generator set to govern poorly but not shut down.
- Check the electrical ground connections. Provide a good DC ground to the controller assembly and governor circuit.
- Verify that the battery connections are clean and tight.
- Check for dirt buildup on the magnetic pickup. Metal filings or caked-on dirt or grease decreases the output signal of the magnetic pickup.
- Check for a loose or worn stepper motor/throttle shaft coupling.
- Check the carburetor for dirt, grime, or misadjustment. Also, check the idle-adjustment screw. The screw should not prevent the throttle plate from closing completely. Also, check the throttle linkage for any binding, dirt, damage, or other visible problems.
- Check whether the positive voltage supply is unstable or below 8 volts DC, causing the control unit to function erratically.
- Check for electronic governor faults. The fuel shutoff solenoid deenergizes and the generator set shuts down under the following conditions:
  - Closed throttle
  - Engine overspeed
  - Broken fuel shutoff solenoid lead
  - Lost DC power to governor assembly
  - Broken stepper motor leads (erratic performance)
  - Failed actuator linkage (erratic performance)

6.9.3 Hunting/Surging

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

1. Open the generator set line circuit breaker.
2. Start the generator set.
3. Hold the throttle linkage steady while the engine is running. See Figure 6-16. If the engine runs at a steady speed with no hunting or surging when the throttle is held steady, then the hunting/surging problems during operation are probably caused by the governor. Proceed to Section 6.9.4.
4. If the engine speed hunts or surges while the throttle is held steady, check the carburetor position and engine operation.
   a. Check the carburetor position. Slotted mounting holes in the base of the carburetor determine the carburetor position, which affects the throttle operation. Verify that the carburetor is mounted as close to the governor actuator (stepper motor) as the mounting holes allow.
   b. Refer to the Engine Service Manual for other engine diagnostic and service information.



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

Figure 6-16 Stepper Motor and Carburetor

6.9.4 Governor System Operation Test

If the engine continues to operate erratically after the previous checks, test the governor system operation using the following procedure. The procedure is summarized in the flowchart in Figure 6-18.

Governor System Operation Test Procedure

1. Verify that the carburetor throttle linkage is connected to the stepper motor as shown in Figure 6-16.
2. Look for broken or loose wiring or plug connections if the stepper motor moves erratically. Check the condition of the throttle linkage, and verify that the throttle plate closes completely.
3. Check the operation of the stepper motor at startup.
   a. If the throttle moves to the full open throttle position and then moves to and remains in the fully closed position, the speed sensor input is probably missing. Proceed to step 4 to check the magnetic pickup.
   b. If the throttle linkage moves erratically or not at all at startup, proceed to step 7 to check the stepper motor and the governor control board.
4. Verify the operation of the sensor by connecting a voltmeter to the sensor leads. See Figure 6-17.

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

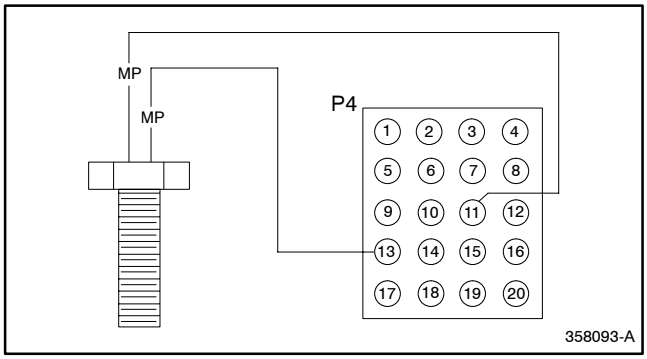


Figure 6-17 Magnetic Pickup Leads

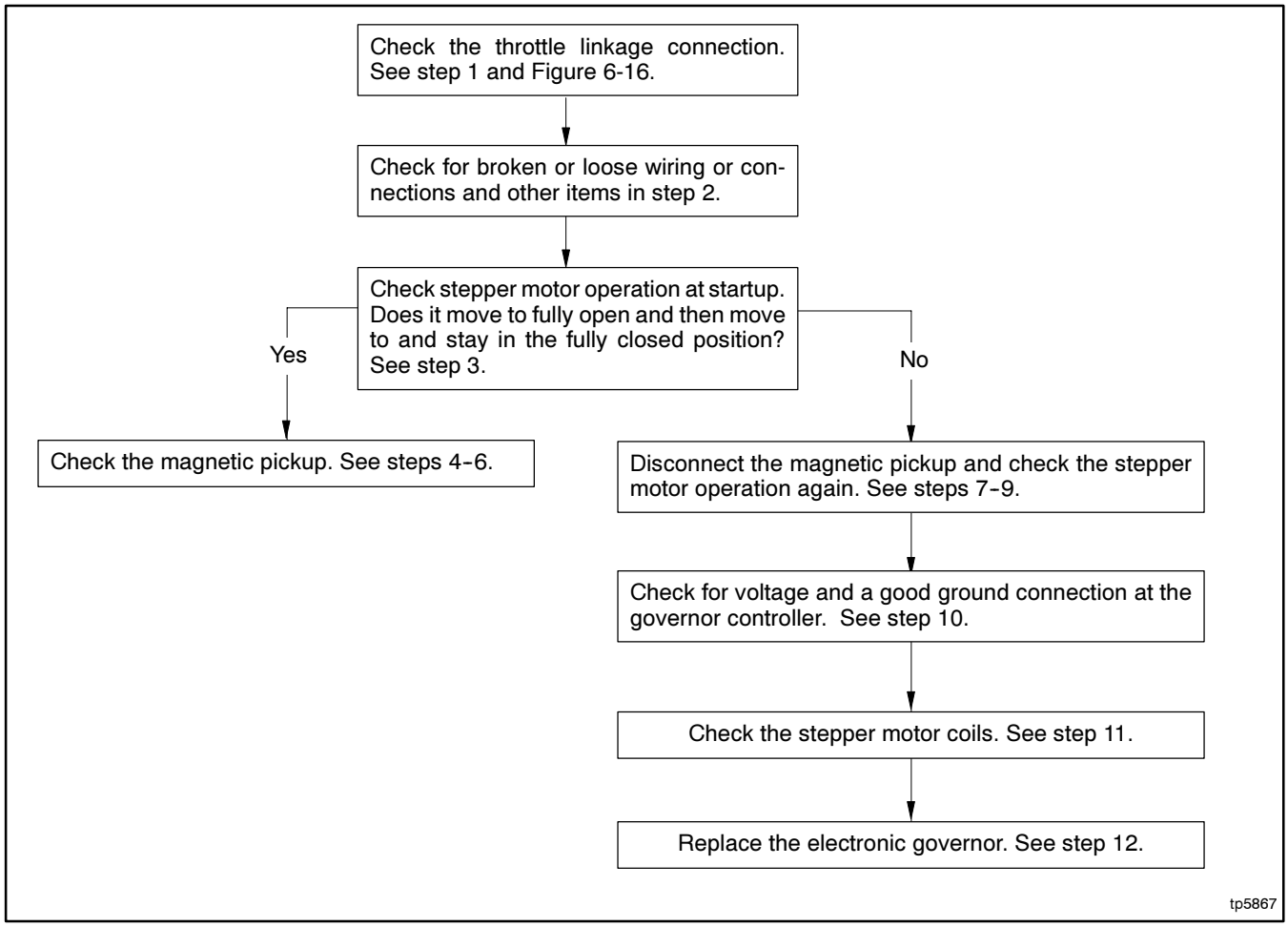


Figure 6-18 Governor System Operation Test Procedure Summary

5. If the voltmeter displays less than 1.75 volts AC, check the air gap as described in the following steps before replacing the sensor. Verify that the magnetic pickup air gap is 1.02 mm (0.040 in.). Measure the air gap at 3 or 4 places to get an accurate reading. See Figure 6-19.

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

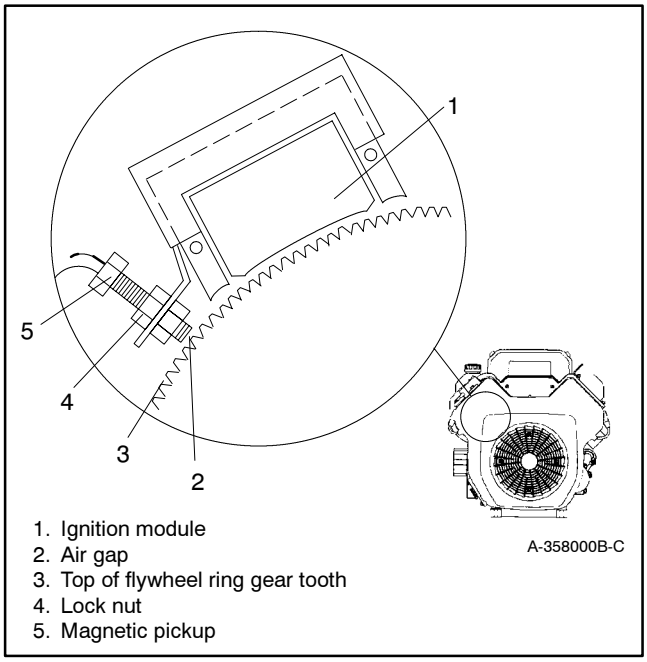
   b. Remove the engine blower housing.

   c. Use a feeler gauge to check the gap. The gap should be 1.02 mm (0.040 in.).

   d. Adjust the air gap, if necessary, by loosening the locknut and turning the pickup. See Figure 6-19.

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

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



1. Ignition module
2. Air gap
3. Top of flywheel ring gear tooth
4. Lock nut
5. Magnetic pickup

Figure 6-19 Magnetic Pickup Air Gap

g. Reinstall the engine blower housing.

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

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

7. To test the governor controller operation, disconnect the magnetic pickup leads and open the generator set circuit breaker.

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

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

10. Place the generator set master switch in the STOP position. Check for 12 volts at pin 6 and a good ground connection to pin 10 on the electronic governor controller.

11. Check the stepper motor coil resistance across pins 2 and 3 and across pins 1 and 4. Only two stepper motor leads of each coil group are used (BLK-YEL and RED-WHT). See Figure 6-20. The resistance per phase is 38.5 ohms. If one of the coils has a significantly higher resistance or is shorted, replace the stepper motor.

12. If there is power and a good ground connection to the governor controller board and the stepper motor coil resistances are good, replace the electronic governor controller.

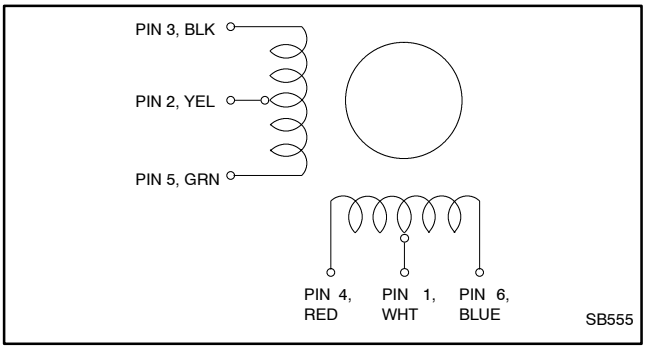


Figure 6-20 Actuator Coil Group

6.9.5 Frequency Adjustment

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

Frequency Adjustment Procedure

1. Open the generator set line circuit breaker.

2. Attach a frequency meter to the AC output leads.

3. Start and run the generator set until it reaches normal operating temperature (at least 10 minutes).

4. Adjust the electronic governor speed potentiometer to obtain a frequency reading of 60 Hz (or 50 Hz on 50 Hz models). The governor potentiometers are shown in Figure 6-21. Turn the speed potentiometer clockwise to increase the frequency and counterclockwise to decrease the frequency.

   Note: Often hunting/surging problems thought to be caused by the governor are actually caused by engine or carburetor problems. If the generator set speed is unstable, hunts, or surges, check for the cause using the procedure in Section 6.9.3 before proceeding.

5. Check stability with the generator set running and with no load applied. If the generator set speed is unstable, hunts, or surges, turn the gain potentiometer approximately 1/8 turn counterclockwise or until the generator set becomes stable with no hunting or surging. Observe the frequency reading.

6. Repeat steps 4 and 5 to obtain the rated frequency and stable operation.

7. Apply rated load to the generator set and observe the frequency reading. The no load and full load frequencies should be within 0.4 Hz of the rated generator frequency; if not, check that the carburetor throttle plate opens completely without sticking and check the carburetor adjustment. If these procedures do not correct the problem, replace the circuit board.

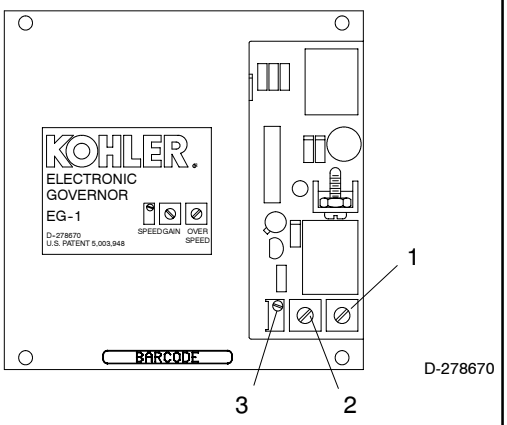
8. Check for hunting and surging at full load. Turn the gain potentiometer clockwise in 1/8 turn increments until the engine hunts and surges. Then turn the gain potentiometer counterclockwise

in 1/8 turn increments until the engine operation stabilizes.

9. Remove the load and observe the frequency. The frequency should return to the value stated in step 4. Gain adjustment may affect the generator set speed/frequency. If the frequency has changed, repeat step 4.

   Note: Speed adjustments have no effect on gain adjustments. It is not necessary to repeat the gain adjustments (steps 5 and 7) after adjusting the engine speed.

10. Check the overspeed setting using the procedure in the following section.



1. Overspeed potentiometer (not used—use control board potentiometer)
2. Gain potentiometer
3. Speed potentiometer

Figure 6-21 Governor Adjustment Potentiometers

6.9.6 Overspeed Verification and Adjustment

Check the overspeed setting when investigating a shutdown problem. Also check it after adjusting the speed or replacing the controller circuit board.

A potentiometer on the relay controller circuit board adjusts the overspeed setting. See Figure 4-6 or Figure 4-7 to identify the potentiometer used to adjust the overspeed setting. Do not use the overspeed potentiometer on the governor.

Perform the following procedure with the generator set running. Move the stepper motor linkage shown in Figure 6-16 to increase the engine speed. *Do not use the speed adjustment potentiometer to increase the engine speed.*

Overspeed Verification and Adjustment Procedure

1. Carefully move the throttle shaft/governor stepper motor linkage to raise the engine speed. Note the frequency indicated by the meter when the generator set shuts down. The factory setting is 120% of the rated speed/frequency (68–72 Hz for 60 Hz models and 58–62 Hz for 50 Hz models).

2. Turn the overspeed potentiometer on the controller circuit board counterclockwise to increase the overspeed cutout point or clockwise to decrease the cutout point.

3. Repeat steps 1 and 2 as necessary to obtain the desired overspeed cutout point.

4. Place the generator set master switch in the STOP position.

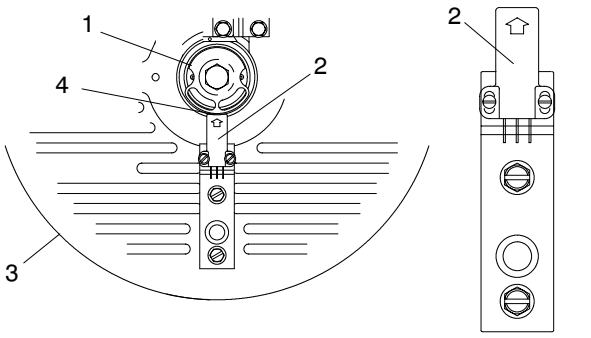
If the generator set does not operate within the stated specifications after the governor adjustment, repeat the frequency and overspeed adjustment procedures. If these adjustments fail to bring the generator set to correct electronic governor specifications, replace the governor controller circuit board.

6.10 Speed Sensor

Use the following test procedure to verify that the speed sensor operates correctly.

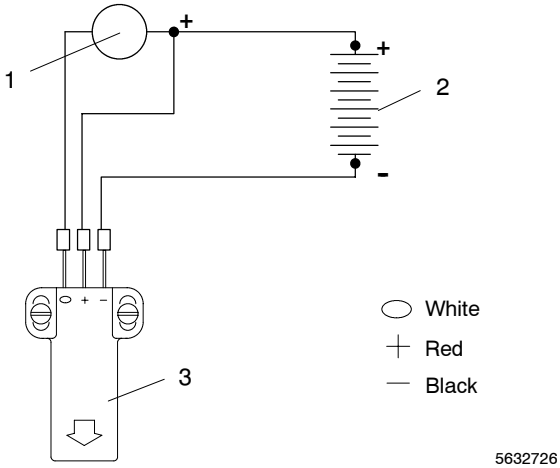
Speed Sensor Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the speed sensor from the alternator end bracket. See Figure 6-22.
5. Connect the speed sensor, voltmeter, and DC voltage source as shown in Figure 6-23.
6. Touch the sensing surface with a flat piece of iron or steel. The contact surface area of the iron or steel piece should be at least 4 sq. cm (1/4 sq. in.). The voltmeter reading should equal the source voltage.
7. Remove the iron or steel from the sensing surface. The voltmeter should indicate no voltage.
8. Reinstall the speed sensor onto the end bracket using all original hardware. See Figure 6-22. Set the air gap between the speed sensor and magnetic actuator to 0.25–0.51 mm (0.010–0.020 in.).
9. Check that the generator set master switch is in the OFF position.
10. Reconnect the generator set engine starting battery, negative (-) lead last.
11. Reconnect power to the battery charger, if equipped.



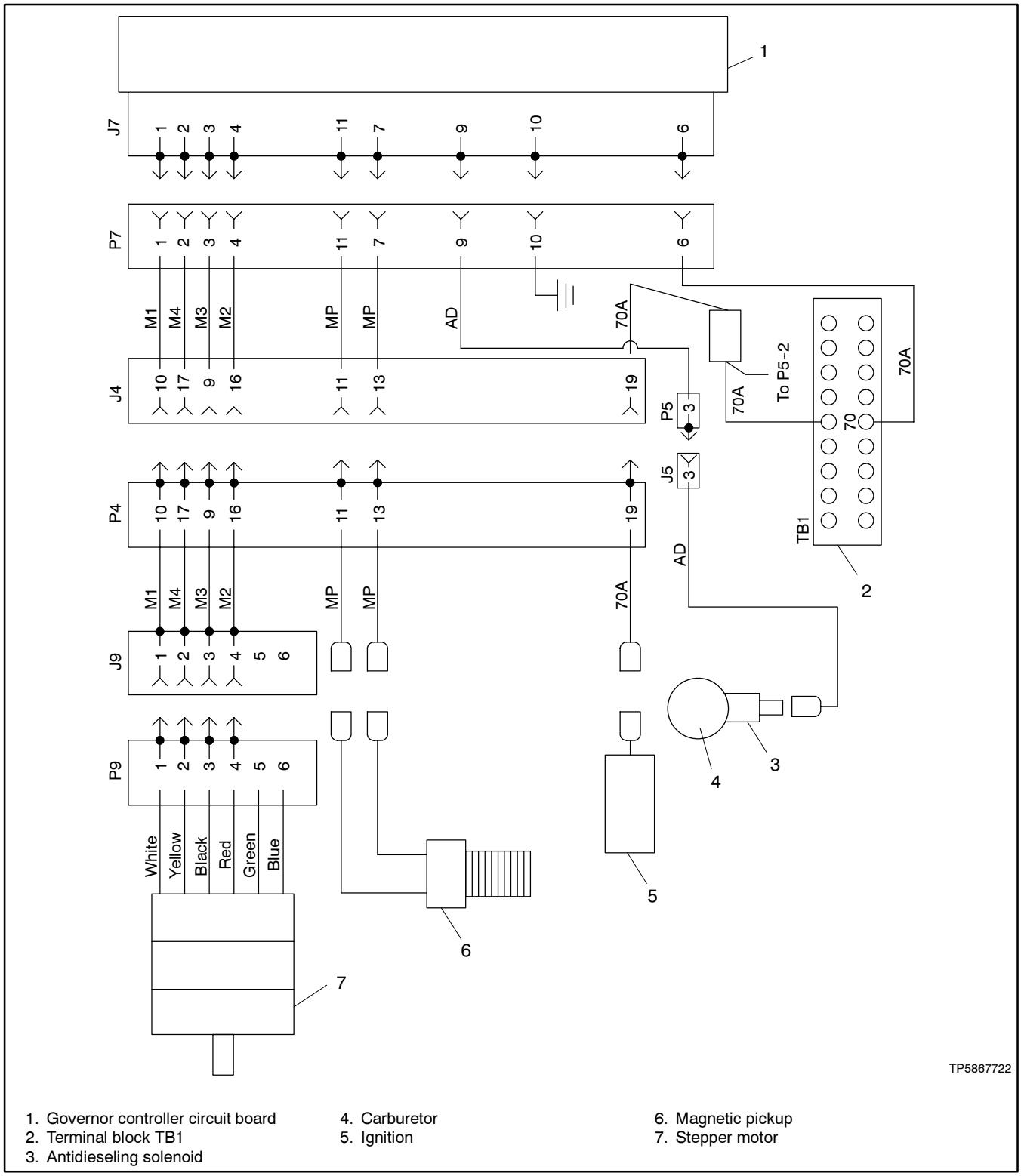
1. Magnetic actuator
2. Speed sensor
3. End bracket
4. Air gap

Figure 6-22 Speed Sensor Air Gap



1. DC voltmeter
2. 12-volt DC power supply
3. Speed sensor sensing surface

Figure 6-23 Speed Sensor Test Connections



1. Governor controller circuit board
2. Terminal block TB1
3. Antidieseling solenoid
4. Carburetor
5. Ignition
6. Magnetic pickup
7. Stepper motor

Figure 6-24 Electronic Governor Wiring

6.11 Fuel Systems

Single-fuel systems are factory-adjusted for either natural gas or LP vapor. Check the generator set nameplate to determine which fuel the unit uses. Multi-fuel systems are factory-adjusted for both natural gas and LP vapor.

The fuel supplier provides and maintains manual shut-off valves and the primary regulator. A factory-installed secondary regulator and 12 VDC solenoid valve are located in the front inlet air compartment. The controller energizes the fuel solenoid valve to open at start and deenergizes the valve to close at shutdown. The secondary fuel regulator reduces fuel pressure for delivery to the fuel metering (fuel mixture adjustment) valve. The fuel flows from the metering valve to the carburetor in a gaseous state. The carburetor mixes the fuel with intake air for consumption by the engine.

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

6.11.1 Gas Piping

Verify that the gas pipe size meets the size specifications in Figure 6-25. Measure the pipe length from the gas utility pressure regulator to the end of the pipe where it connects to the fuel inlet of the generator set. Add 2.4 m (8 ft.) for each bend in the pipe. Compare the total length with the chart in Figure 6-25. Replace piping longer than the listed maximum length with the larger pipe size shown in the chart. Bleed the air from the gas lines after installation.

Figure 6-26 lists the maximum natural gas flow rate for each model.

	Maximum Pipe Length m (ft.)	
Pipe Size	**8.5RMY**	**11RMY**
3/4 in. NPT	18.3 (60)	9.2 (30)
1 in. NPT	61 (200)	30 (100)
1 1/4 in. NPT	91.5 (300)	68.6 (225)

Figure 6-25 Maximum Natural Gas Pipe Length

Generator Set Model	Gas Flow Rate, Btu/hr.
8.5RMY	132,000
11RMY	192,000

Figure 6-26 Maximum Natural Gas Flow Rate

6.11.2 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.

6.11.3 Fuel Regulators

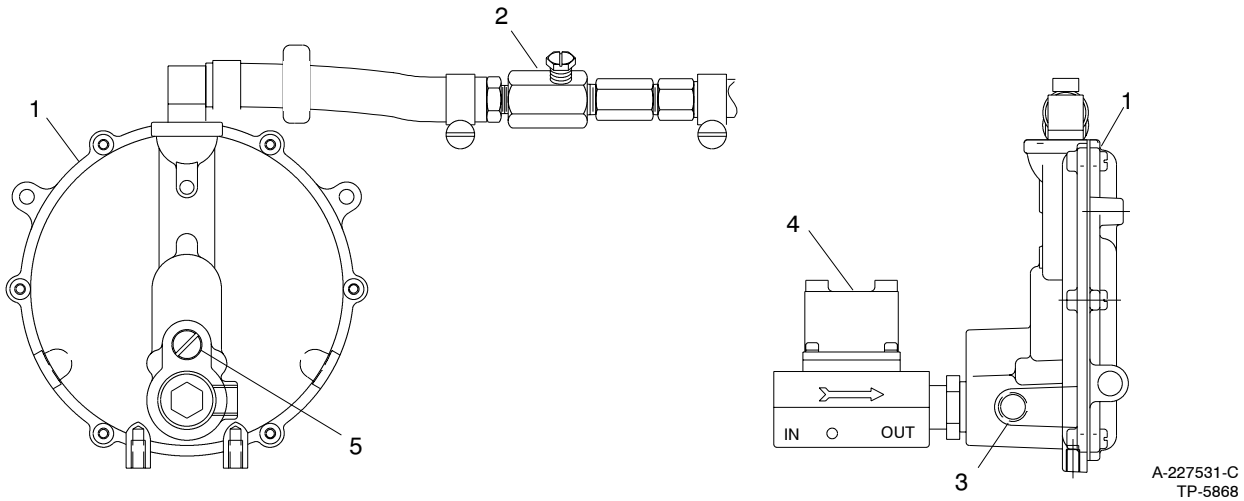
The typical gaseous fuel system uses two regulators. The primary regulator reduces the line pressure to an allowable inlet pressure for the secondary regulator. The fuel supplier provides and maintains the primary regulator. The secondary regulator is factory-installed on the generator set and is designed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

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

The fuel lock-off prevents fuel flow when the engine is not operating. See Figure 6-27. Do not try to adjust the fuel pressure, fuel mixture, or engine speed using the fuel lock-off.

Checking the Fuel Pressure

Use a gauge or manometer to check the fuel pressure at the secondary regulator inlet. See Figure 6-27. Measure the fuel pressure with the generator set running at full 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.



1. Secondary pressure regulator
2. Fuel metering valve (single-fuel models)
3. Inlet pressure check location (plug)
4. Fuel solenoid valve
5. Fuel lockoff

Figure 6-27 Fuel Regulator and Valve

6.11.4 Fuel Conversion, Single-Fuel Models

Do not change the fuel on emission-certified single-fuel generator sets. The fuel systems on emission-certified units are factory-set and sealed to meet EPA and California emissions regulations. Emission-certified units bear a decal similar to the one shown in Figure 6-28.

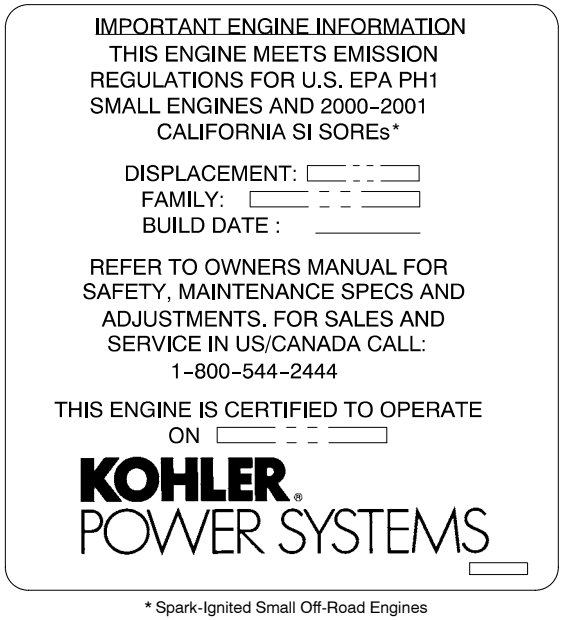


Figure 6-28 Emission-Certification Decal, Typical

Generator sets that do not have emission-certified engines can be converted from natural gas to LP or vice-versa in the field. Follow the procedure in Section 6.11.5 to adjust the fuel metering valve when changing fuels. When switching from natural gas to LP gas or vice-versa, verify that the engine speed meets specifications. The electronic governor should compensate for different types of fuel and maintain the rated engine speed. If the engine speed is incorrect, refer to Section 6.9, Electronic Governor, to make adjustments.

6.11.5 Fuel Metering Valve Adjustment

Note: Do not adjust the fuel metering valves on emissions-certified generator sets.

The fuel system is factory-adjusted to comply with applicable emission standards and to provide the best possible hot and cold starting. The fuel metering valves are sealed to discourage field adjustments. If the fuel system requires adjustment, only trained, authorized service technicians may adjust the fuel metering valves. The adjustment procedure requires a digital volt meter (DVM), oxygen sensor (A-345052) for the engine, and a load bank capable of the rated kW for the fuel being used. Always use an oxygen sensor when adjusting the fuel metering valves.

Observe the following safety precautions while performing the procedure.

⚠ WARNING

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

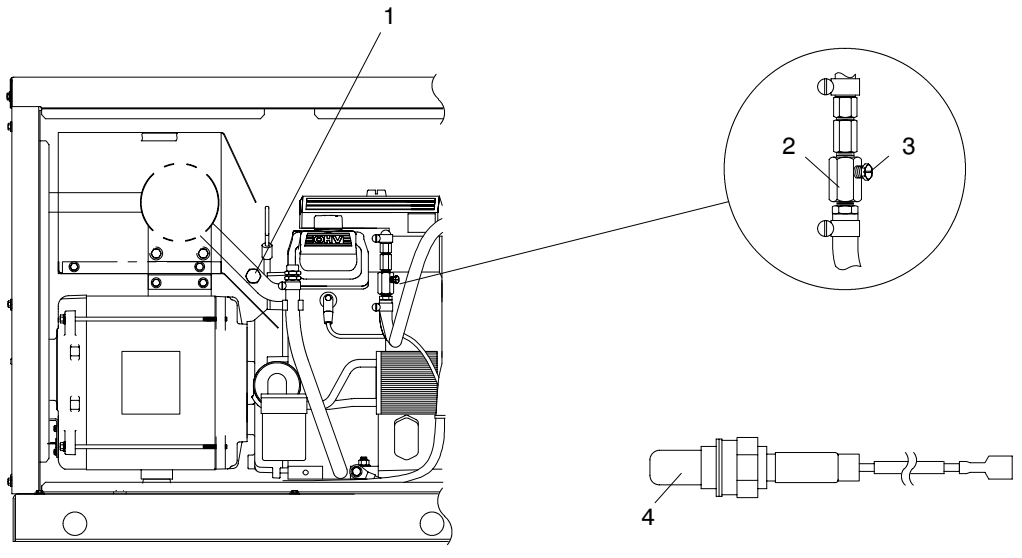
Do not work on the generator set until it cools.

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.

Fuel Metering Valve Adjustment Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the oxygen sensor plug from the exhaust manifold. See Figure 6-29 for location.
5. Install the oxygen sensor in the exhaust manifold where the plug was removed.
6. Check that the generator set master switch is in the OFF position.
7. Reconnect the generator set engine starting battery, negative (-) lead last.
8. Place the controller master switch in the RUN position to start the generator set.
9. Allow the generator set to run until the engine reaches normal operating temperature.
10. With the generator set at normal operating temperature, apply 90–100% of rated load.
11. Connect one of the DVM leads to the oxygen sensor lead. Connect the other DVM lead to ground and measure the output voltage of the oxygen sensor (potential to ground).

    The output of the oxygen sensor reads high when the mixture is rich and close to zero volts when the mixture is lean.
12. Adjust the fuel metering valve as required to obtain an average of 0.5 ± 0.3 VDC output from the oxygen sensor. See Figure 6-29.
13. Remove the load and allow the generator set to run unloaded to cool for at least 5–10 minutes.
14. Place the generator set master switch in the OFF position.
15. Disconnect the generator set engine starting battery, negative (-) lead first.
16. Allow the generator set exhaust system to cool.



1. Oxygen sensor plug
2. Fuel metering valve
3. Fuel metering valve adjustment screw
4. Oxygen sensor (Kohler part number A-345052)

Figure 6-29 Fuel Metering Valve Adjustment Components, Single-Fuel Models Only

17. Disconnect the DVM leads from the oxygen sensor.

18. Remove the oxygen sensor from the exhaust manifold.

19. Apply a small amount of antiseize compound to exhaust plug and reinstall the plug into the exhaust manifold.

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

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

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

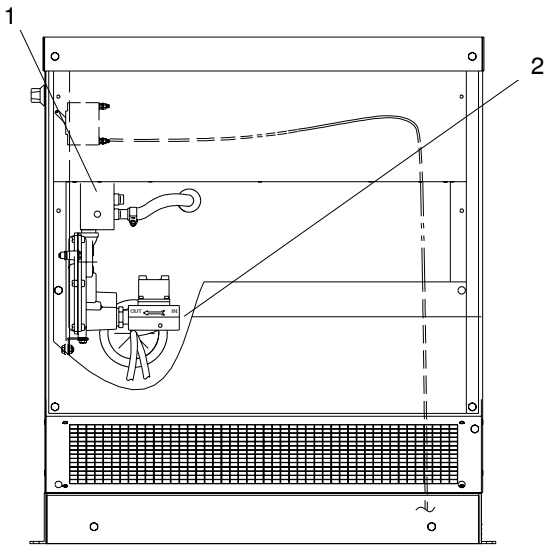
6.11.6 Fuel Conversion, Multi-Fuel Systems

Generator sets with multi-fuel systems are CARB- and EPA-certified for both natural gas and LP vapor fuels. The multi-fuel system allows conversion from natural gas to LP vapor (or vice-versa) in the field while maintaining emissions-standard compliance.

Two fuel connections on the fuel block allow field-conversion between natural gas and LP vapor. The fuel metering valves are factory-set and sealed to comply with applicable emission standards and to provide the best possible hot and cold starting.

Note: Do not adjust the factory-sealed fuel-metering adjustments on the fuel block. Changing the fuel-metering adjustments on these units may violate federal or state laws.

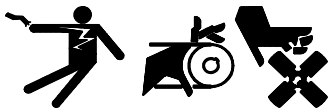
The manufacturer ships the generator set with the fuel system connected for natural gas. To convert to LP gas, use the following procedure to move the fuel line from the natural gas outlet port to the LP outlet port in the fuel block (or from the LP outlet to the natural gas outlet to convert from LP to natural gas). See Figure 6-30 for the fuel block and fuel inlet locations.



1. Multi-fuel block
2. Fuel inlet, 1/2 in. NPT female

Figure 6-30 Multi-Fuel Generator Set Fuel Block Location, Air Inlet Side

⚠ 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

Explosive fuel vapors.
Can cause severe injury or death.

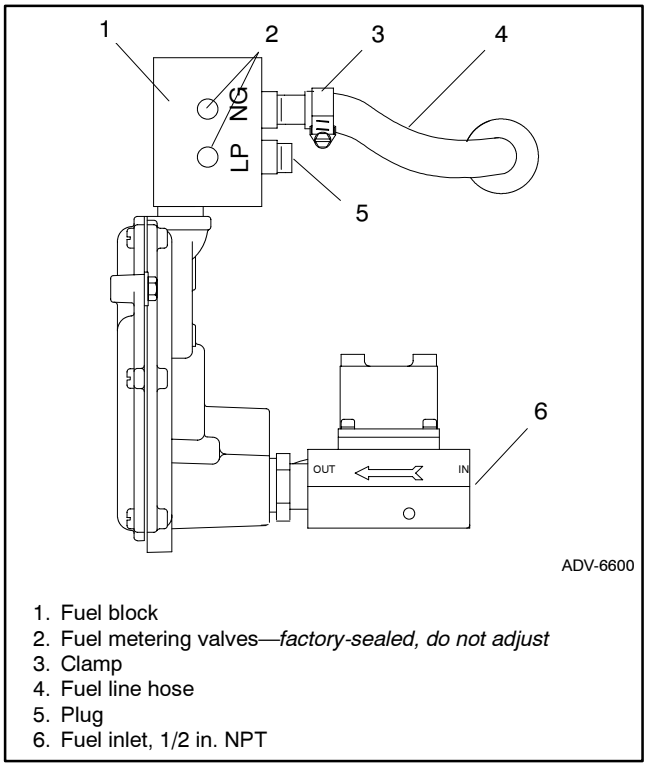
Use extreme care when handling, storing, and using fuels.

Fuel Conversion Procedure for Multi-Fuel Systems

1. Place the generator set master switch in the OFF position.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Turn off the fuel supply.
5. Remove the hose clamp and fuel hose from the hose fitting in the fuel block. See Figure 6-31.
6. Remove the hose fitting from the natural gas (or LP) outlet port in the fuel block.
7. Remove the plug from the LP (or natural gas) port in the fuel block. Clean the plug with a dry cloth or brush, apply fresh pipe sealant, and install the plug into the natural gas (or LP) outlet port.
8. Clean the hose fitting with a dry cloth or brush, apply fresh pipe sealant to the threads, and install the fitting into the LP (or natural gas) port.

   Note: Do not adjust the fuel metering valves.
9. Slide the hose onto the hose fitting and secure it with the clamp.
10. Connect the new fuel supply.
11. Disconnect both wires at the fuel solenoid valve.
12. Apply ±12 VDC to the fuel solenoid valve to actuate the valve.
13. Turn on the fuel supply and check for leaks at the fuel block using a gas leak detector or a soap solution.
14. Check that the generator set master switch is in the OFF position.
15. Reconnect the generator set engine starting battery leads, negative (-) lead last.
16. Reconnect power to the battery charger, if equipped.

The secondary regulator operates with either natural gas or LP gas with no modifications.



1. Fuel block
2. Fuel metering valves—*factory-sealed, do not adjust*
3. Clamp
4. Fuel line hose
5. Plug
6. Fuel inlet, 1/2 in. NPT

Figure 6-31 Fuel Block Connections, Natural Gas System Shown

Notes

7.1 Voltage Reconnection

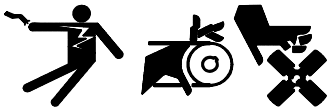
The reconnection procedure explains voltage reconnections only. Adjust the governor and voltage regulator at the time of frequency adjustment.

The following information illustrates the reconnection of 4-lead generator sets. In all cases, follow the National Electrical Code (NEC) requirements.

Refer to the following procedure and the connection schematics. Follow all the safety precautions and instructions at the beginning of this manual and in the text below while performing the reconnection procedure.

Note: Order voltage reconnection decal 246242 and affix the decal to the generator set after reconnecting to a voltage different from the nameplate.

⚠ 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 rotor.
Can cause severe injury or death.

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

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

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

7.2 Four-Lead (Single-Phase) Generator Sets

The following information illustrates the reconnection of 4-lead generator sets. Always follow the National Electrical Code (NEC) requirements.

7.2.1 Factory Connections, 110/220 Volts 50 Hz or 120/240 Volts 60 Hz

Generator sets are available from the factory connected for 110/220 Volts 50 Hz or 120/240 Volts 60 Hz. See Figure 7-1 for the factory connections.

Leads L1 and L2 are of different phases. Never connect leads L1 and L2 together. After connection adjust the voltage regulator to obtain the desired voltage.

Note: Use a circuit breaker manufacturer's two-pole circuit breaker. Two single-pole circuit breakers do not conform to NEC requirements when supplying a 220 or 240 volt load. This is true even if they are mechanically attached together.

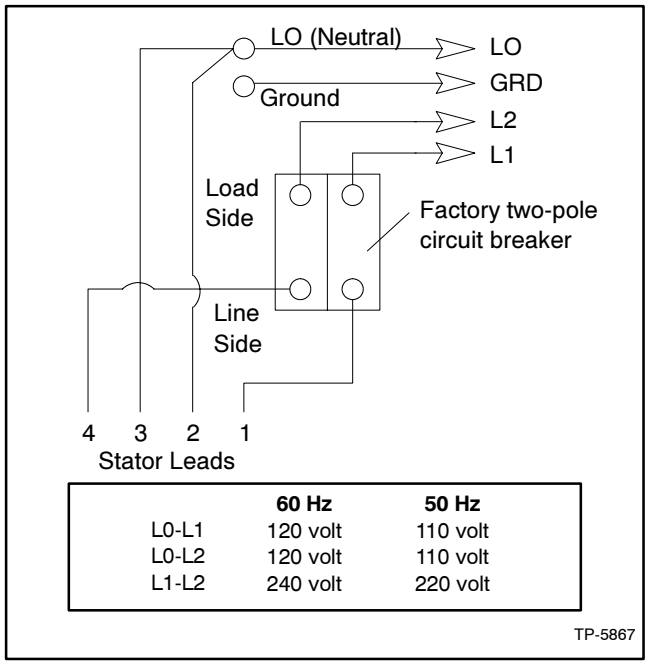


Figure 7-1 110/220 and 120/240 Volt, 3-Wire Configurations

7.2.2 Reconnection Options

The following reconnections can be made using the factory two-pole circuit breaker provided. It is the responsibility of the individual performing the reconnection to meet all the electrical codes.

See Figure 7-2 for four-lead reconnectable (single-phase) generator set voltage options.

60 Hz	50 Hz
120 Volts	110 Volts
120/240 Volts	110/220 Volts
240 Volts	220 Volts

Figure 7-2 Four-Lead, Single-Phase Generator Set Voltage Connection Options

110 and 120 Volt Configurations

When connecting stator phase leads, size output lead (L1) accordingly. Use a jumper lead with the same ampere rating as the output lead L1 on the side of the circuit breaker shown. After connection adjust the voltage regulator to obtain the desired voltage.

Note: Electrical Codes: The 110 and 120 Volt reconnection configurations require a jumper lead on one end of the circuit breaker. This configuration is acceptable per the National Electrical Code, NFPA #70. **Never jumper both the line and load ends of the circuit breaker. A jumper on both the line and load ends violates the National Electrical Code by paralleling the breaker poles**. On occasion local electrical inspectors have objected to a jumper on the load side of the circuit breaker. It is the responsibility of the individual who is reconnecting the output to make certain the reconnection satisfies the local inspector. The purchase and installation of a single pole breaker to replace the two-pole breaker may be necessary.

Note: Jumper Sizing: Use a jumper lead with the same ampere rating as the output lead L1 on the side of the circuit breaker shown.

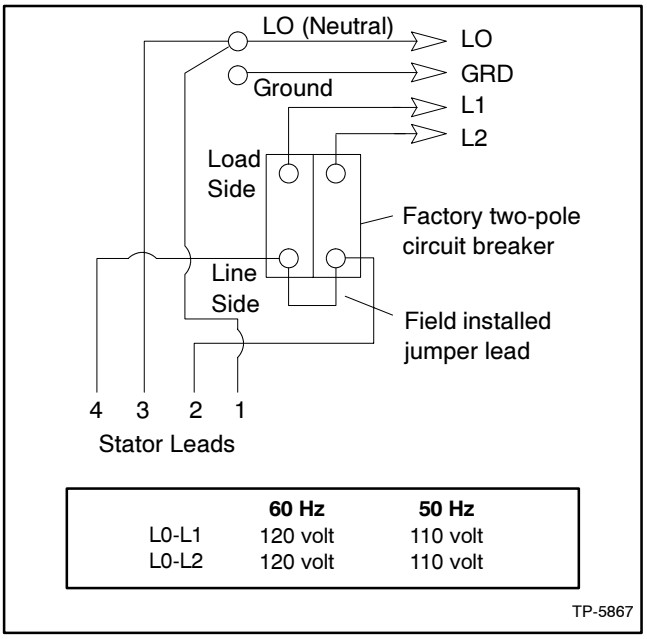
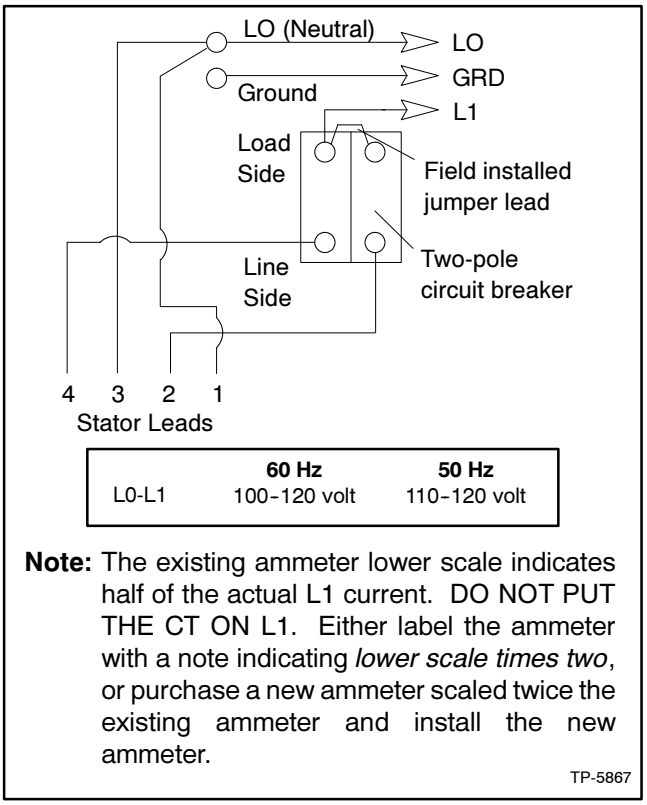


Figure 7-3 110 and 120 Volt, 3-Wire Configurations



Note: The existing ammeter lower scale indicates half of the actual L1 current. DO NOT PUT THE CT ON L1. Either label the ammeter with a note indicating *lower scale times two*, or purchase a new ammeter scaled twice the existing ammeter and install the new ammeter.

Figure 7-4 110 and 120 Volt, 2-Wire Configurations

220 and 240 Volt Configuration

A jumper lead is not used. After connection adjust the voltage regulator to obtain the desired voltage.

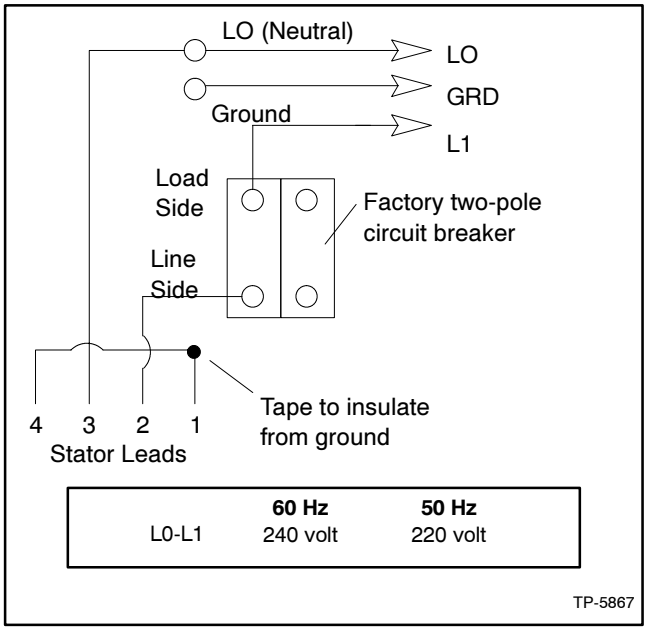


Figure 7-5 220 and 240 Volt, 2-Wire Configurations

Notes

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

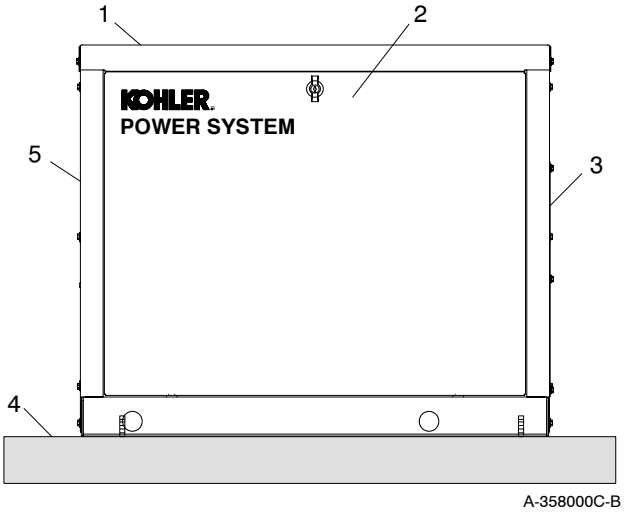
8.1 Disassembly

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

NOTICE

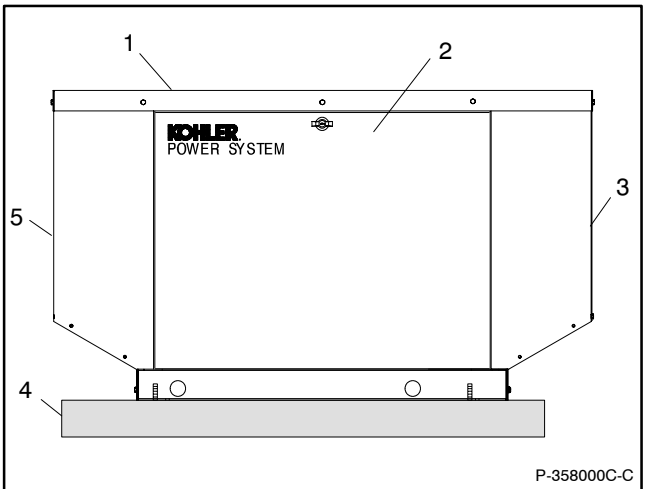
Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

1. Remove the generator set from service.
   a. Place the generator set master switch in the OFF position.
   b. Remove eight screws to remove the battery compartment panel.
   c. Disconnect power to the battery charger, if equipped.
   d. Disconnect the generator set engine starting battery, negative (-) lead first.
   e. Turn off the fuel supply to the generator set.
2. Open the enclosure.
   a. Remove the service side door from the generator set housing. See Figure 8-1 or Figure 8-2.
   b. Remove the generator set housing roof. See Figure 8-1 or Figure 8-2.
   c. Remove the alternator end housing panel. See Figure 8-1 or Figure 8-2.
   d. Remove the non-service side housing panel. See Figure 8-1 or Figure 8-2.



1. Housing roof
2. Service side door
3. Battery compartment panel
4. Mounting pad
5. Alternator end housing panel

Figure 8-1 Generator Set Weather Housing



1. Housing roof
2. Service side door
3. Battery compartment panel
4. Mounting pad
5. Alternator end housing panel

Figure 8-2 Generator Set Sound Enclosure

3. Disconnect the alternator wiring. See Figure 8-3.

   a. Disconnect alternator leads 1, 2, 3, and 4. Note the locations of the lead connections for reconnection later.

   b. Disconnect brush leads FP and FN.

   c. Disconnect the speed sensor harness.

4. Disconnect the exhaust system. See Figure 8-4.

   a. Remove the four screws securing the top of the exhaust duct.

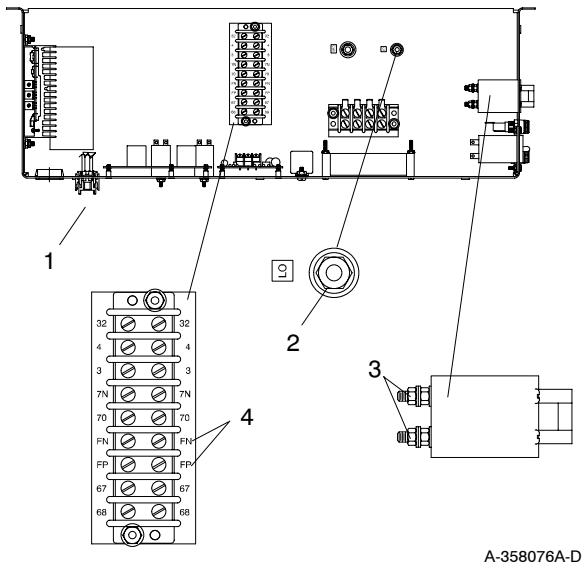
   b. Remove the engine exhaust muffler.

   c. Remove the lower portion of the exhaust duct.

5. Remove the alternator end bracket.

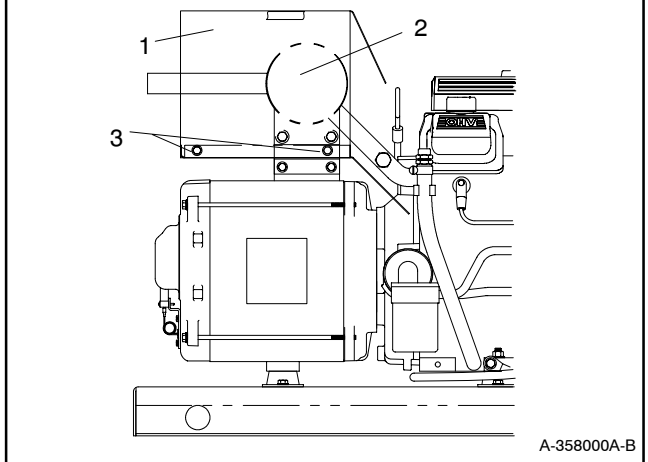
   a. Remove two bolts securing the alternator vibromount mounting plate to the skid. See Figure 8-5.

   b. Raise the alternator end of the generator set enough to place a thin block of wood beneath the rear of the engine. See Figure 8-6.



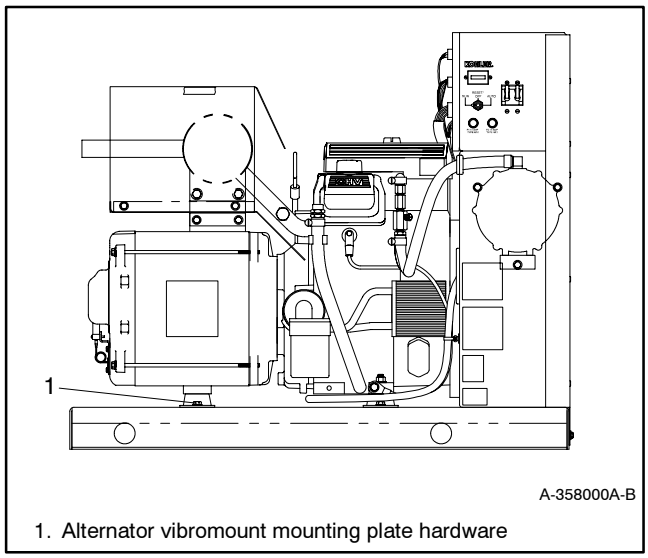
1. Speed sensor harness connector
2. L0 lead connection point
3. Circuit breaker connections
4. Brush leads FP and FN terminal block connections

Figure 8-3 Controller Top View, Typical



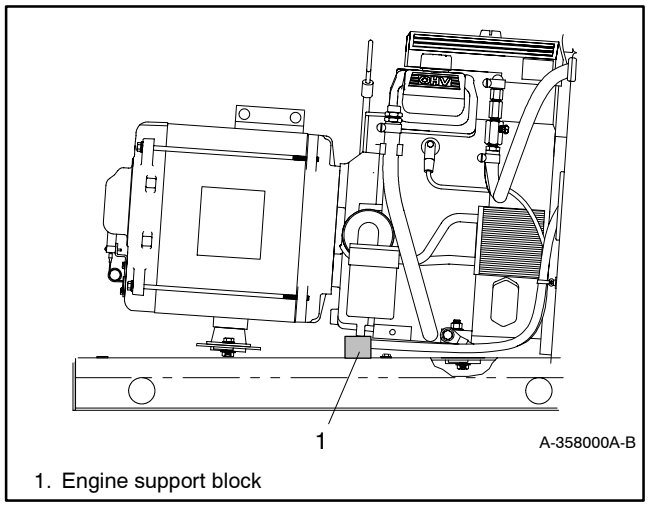
1. Exhaust duct
2. Engine exhaust muffler
3. Exhaust duct screws

Figure 8-4 Exhaust Muffler Duct



1. Alternator vibromount mounting plate hardware

Figure 8-5 Generator Set, Right Side



1. Engine support block

Figure 8-6 Generator Set, Right Side

c. Remove the screws securing the brush cover to the alternator end bracket. See Figure 8-7.

d. Disconnect the white, red, and black leads connected to the speed sensor. See Figure 8-8.

e. Raise the brushes in the brush holder and insert a small piece of wire into the brush holder retainer wire hole. See Figure 8-7 and Figure 6-13.

f. Remove the alternator overbolts and centering washers. See Figure 8-7.

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

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

6. If the speed sensor must be tested or replaced, remove it from the end bracket. See Figure 8-8.

   a. Mark the leads connected to the speed sensor and disconnect the leads.

   b. Remove the screws and washers securing the speed sensor to the speed sensor bracket.

   c. Install the new speed sensor using the screws and washers removed in step b. Do not tighten the screws at this time.

7. Check the brushes.

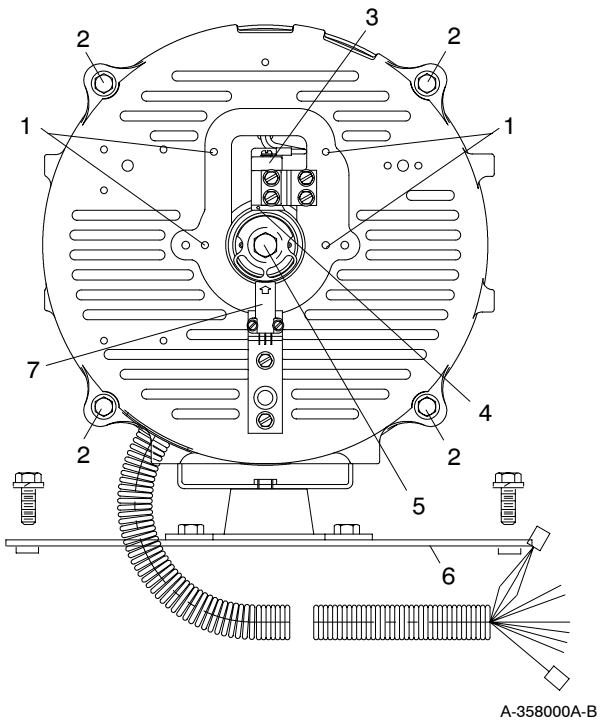
   a. Remove the brush holder from the end bracket. See Figure 8-7.

   b. Inspect the brushes. Replace brushes that are worn to half of their original size. See Section 6.6, Brushes.

8. Remove the stator and rotor.

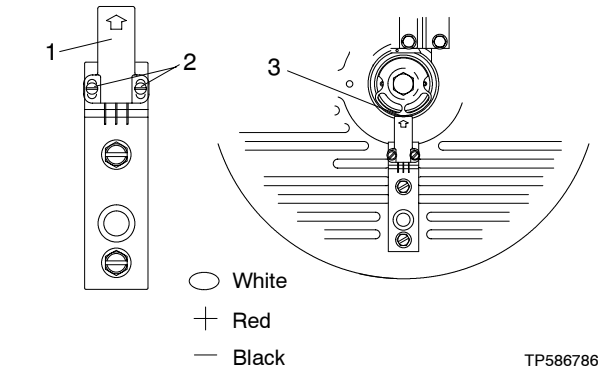
   a. Remove the stator from the rotor.

   b. Loosen and remove the thrubolt. Use a strap wrench on the rotor to keep the rotor from turning during loosening, if necessary. See Figure 8-9.



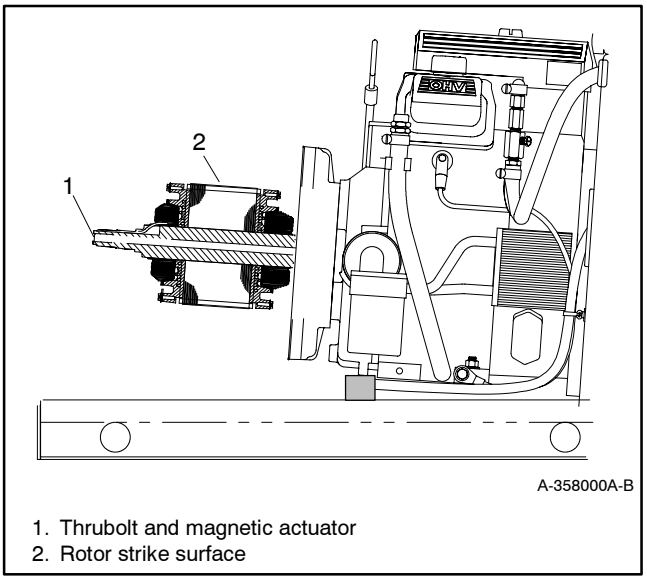
1. Brush cover screws
2. Overbolt and centering washer
3. Brush holder
4. Brush retainer wire hole
5. Thrubolt
6. Alternator mounting plate
7. Speed sensor

Figure 8-7 Alternator End Bracket



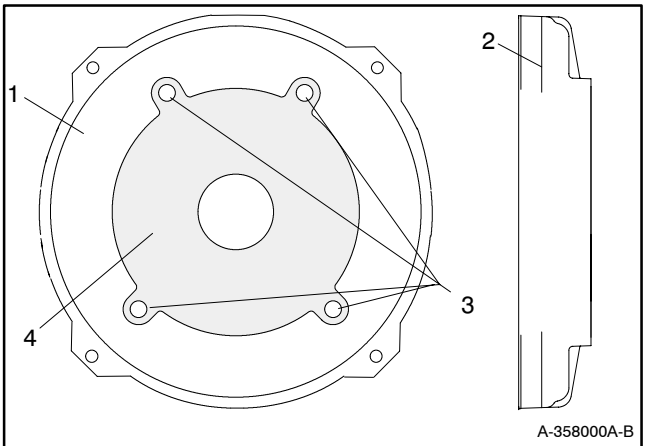
1. Speed sensor
2. Speed sensor mounting screws and washers
3. Speed sensor gap

Figure 8-8 Speed Sensor Assembly



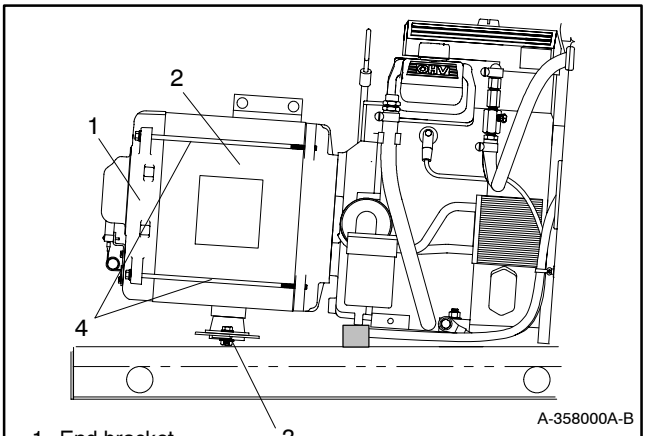
1. Thrubolt and magnetic actuator
2. Rotor strike surface

Figure 8-9 Rotor, Side View



1. Generator adapter
2. Generator fan guard
3. Engine adapter engine mounting holes
4. Alternator adapter guard

Figure 8-10 Generator Adapter



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

Figure 8-11 Generator Set, Right Side

c. Remove the rotor assembly by striking the side of the rotor repeatedly with a soft-faced hammer to loosen it from the tapered crankshaft fitting. See Figure 8-9. Rotate the rotor and strike it on alternate sides. Set the rotor assembly aside.

9. Remove the four bolts securing the adapter to the engine. See Figure 8-10. Remove the generator adapter.

8.2 Reassembly

1. Reinstall the generator adapter onto the engine.

   a. Attach the generator adapter and alternator adapter guard to the engine using four 7/16-14 x 1.0 hex cap bolts and washers.

   b. Torque the bolts to 28 ft. lb. (38 Nm). See Figure 8-10.

2. Install the rotor. See Figure 8-9.

   a. Apply a small amount of antisieze compound to the end of the engine crankshaft for rotor assembly installation.

   b. Install the rotor onto the engine crankshaft.

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

3. Install the stator and end bracket.

   a. Install the stator assembly around the rotor. Align the stator so that the alternator frame vibromount points down toward the generator skid. See Figure 8-11.

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

   c. Place the end bracket onto the stator assembly. align the overbolt holes with the holes in the generator adaptor.

   d. Thread the four overbolts with centering washers through the end bracket and into the generator adapter. Position the centering tab of each washer in the slot on the end bracket. Do not final tighten the overbolts.

4. Secure the generator set to the skid.

   a. Raise the alternator end of the generator set and remove the block of wood from beneath the rear of the engine.

b. Reinstall the screws and washers that secure the alternator frame vibromount mounting plate to the generator set skid. See Figure 8-12.

5. Tighten the hardware to the specified torques.

   a. Tighten the rotor thrubolt to 28 ft. lb. (38 Nm). It may be necessary to keep the engine flywheel from turning while torquing the rotor thrubolt. See Figure 8-12.

   b. Tighten the four alternator assembly overbolts to 60 in. lb. (7 Nm). See Figure 8-12.

6. Reinstall the end bracket components.

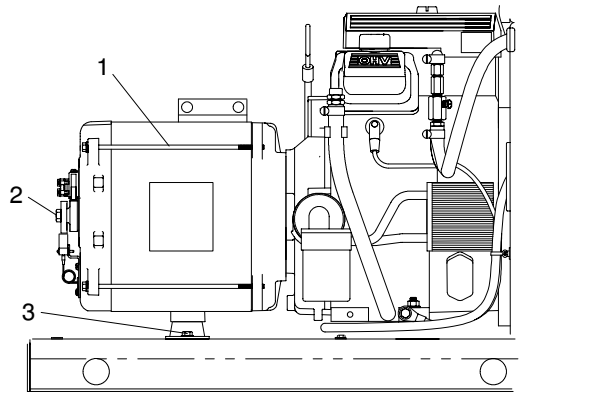
   a. Install the brush holder onto the end bracket. Verify that the brushes are not sticking in the holder.

   b. Verify that the brushes are centered on the slip rings. If required, insert spacers between the mounting surface and brush holder to center the brushes on the slip rings. See Figure 8-13. See Section 6.6, Brushes, for more information.

   c. Set the gap between the magnetic actuator and the speed sensor to 0.010-0.020 in. (0.25-0.51 mm) and final tighten the sensor mounting screws. See Figure 8-14.

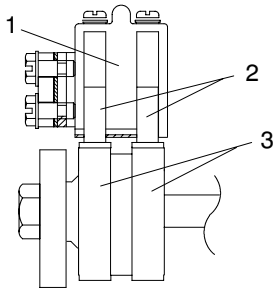
   d. Reconnect the white (0), red (+), and black (-) speed sensor leads to the speed sensor terminals.

   e. Reinstall the brush cover onto the alternator end bracket. Verify that the brush leads are not pinched between the brush cover and end bracket.



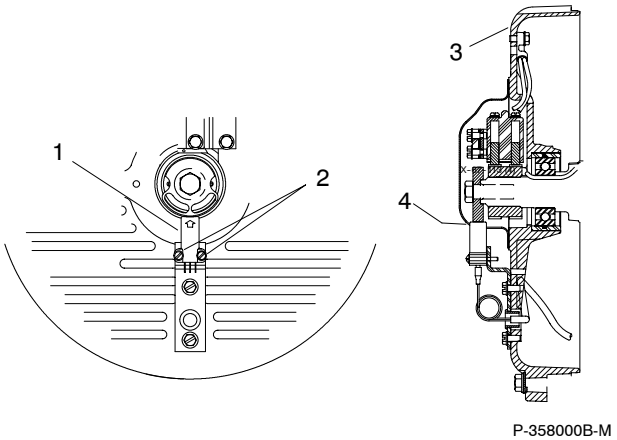
1. Alternator assembly overbolts
2. Rotor thrubolt
3. Alternator vibromount plate mounting hardware

Figure 8-12 Generator Set, Right Side



1. Brush holder
2. Brushes
3. Slip rings

Figure 8-13 Brush Positioning



1. Speed sensor
2. Speed sensor mounting screws and washers
3. End bracket
4. Speed sensor gap

Figure 8-14 Speed Sensor Assembly

7. Install the exhaust system. See Figure 8-15.

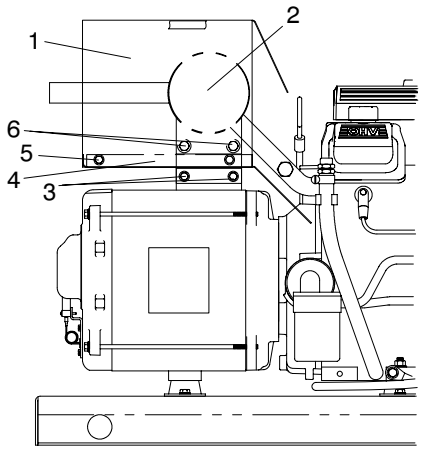
   a. Secure the lower portion of the exhaust duct to the alternator exhaust support with 1/4-20 hardware.

   b. Secure the engine exhaust muffler to the engine. Do not final tighten the mounting hardware.

   c. Secure the muffler mounting tab to the alternator exhaust support with 3/8-16 hardware.

   d. Install the exhaust duct top. Secure the exhaust duct top to the exhaust duct bottom with four 1/4-20 x 0.625 in. bolts and washers.

   e. Torque the nuts securing the engine muffler flange to the engine to 88 in. lb. (10 Nm).



1. Exhaust duct, top
2. Engine muffler
3. 1/4-20 hardware
4. Exhaust duct, bottom
5. 1/4-20 x 0.625 in. bolts and 1/4 washers
6. 3/8-16 hardware

Figure 8-15 Exhaust Muffler Duct

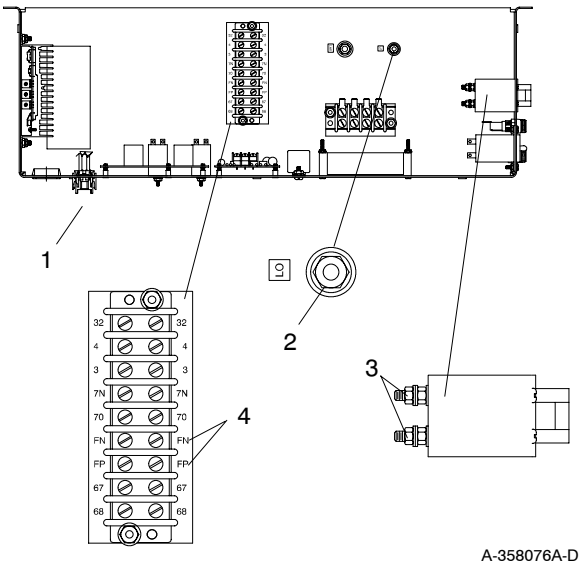
8. Reconnect leads to the controller.

   a. Insert the leads from the alternator assembly into the convoluted conduit leading to the controller.

   b. Connect the speed sensor harness to the controller. See Figure 8-16 for the plug location.

   c. Route brush leads FP and FN into the controller and connect them to the controller terminal strip. See Figure 8-16.

   d. Reconnect the alternator leads.



1. Speed sensor harness connection
2. L0 lead connection point
3. Circuit breaker connections
4. Brush leads FP and FN terminal block connections

Figure 8-16 ControllerTop View, Typical

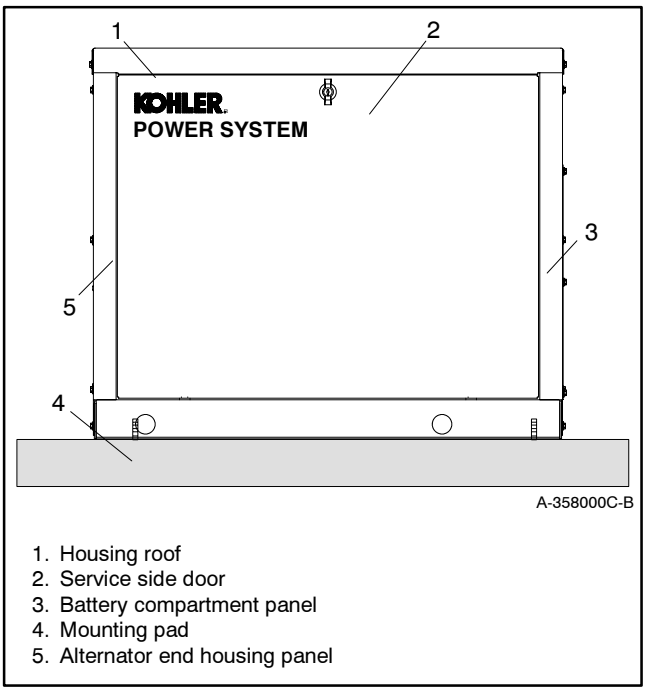
9. Reinstall the enclosure panels. See Figure 8-17 or Figure 8-18.

   a. Install the non-service side housing panel.

   b. Install the alternator end housing panel.

   c. Install the generator set housing roof.

   d. Reinstall the generator set housing service side door.



1. Housing roof
2. Service side door
3. Battery compartment panel
4. Mounting pad
5. Alternator end housing panel

Figure 8-17 Generator Set Weather Housing

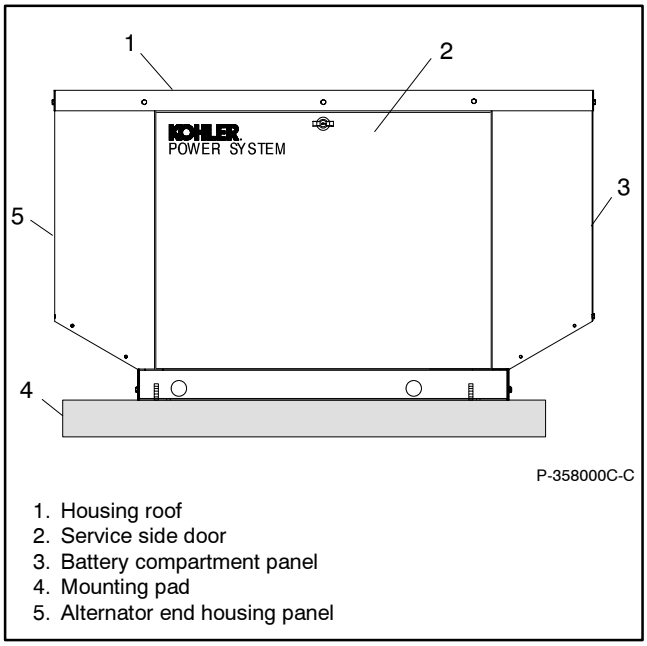
10. Return the generator set to operation.

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

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

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

    d. Turn on the fuel supply and check for leaks.



1. Housing roof
2. Service side door
3. Battery compartment panel
4. Mounting pad
5. Alternator end housing panel

Figure 8-18 Generator Set Sound Enclosure

Notes

9.1 General

At the time of print, this manual applied to the model numbers and specification (spec) numbers following. On occasion this manual may be applicable to specs not listed below, such as when similar new specs are created prior to the updated reprint or in cases where the manual is deemed an acceptable substitute for a manual under development.

Use the Wiring Diagram Cross-Reference to determine the correct version number for a given model number and spec number. Find that version number in the Controller Wiring Diagrams Reference and determine the wiring diagrams by choosing the type of controller on the unit.

9.2 Wiring Diagram Cross-Reference

Model No.	Spec. No.	Wiring Diagram Version No.
8.5RMY	195007 195016 195017	1
	195021	2
	195025 GM16902-GA1 GM24829-GA1	3
11RMY	195008 195018 195019	1
	195022	2
	195026 GM16902-GA2 GM24829-GA2	3

9.3 Controller Wiring Diagrams Reference

Controller Description	Version 1	Version 2	Version 3
Relay Controller			
Schematic Diagram	ADV-6297-B	ADV-6297-E	ADV-6524
Point-to-Point Wiring Diagram	358093-E	GM10164-A	GM10619

Notes

REV	DATE	REVISION	BY	M F
-	3-26-96	NEW DRAWING [50018]	DFS	
A	12-16-97	(B,C-4,-5) SMART SPARK MODULE & CH20/25 IGNITION		
		OPTIONS ADDED; (C,D-2,-3) EMISSION CONTROL UNIT REMOVED		
		[53117]	KAR	
B	6-26-98	DRAWING COMPLETELY UPDATED [55210]	LDS	

GENERATOR CONNECTIONS

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

50/60 HZ 120V 1 PH, 2 WIRE

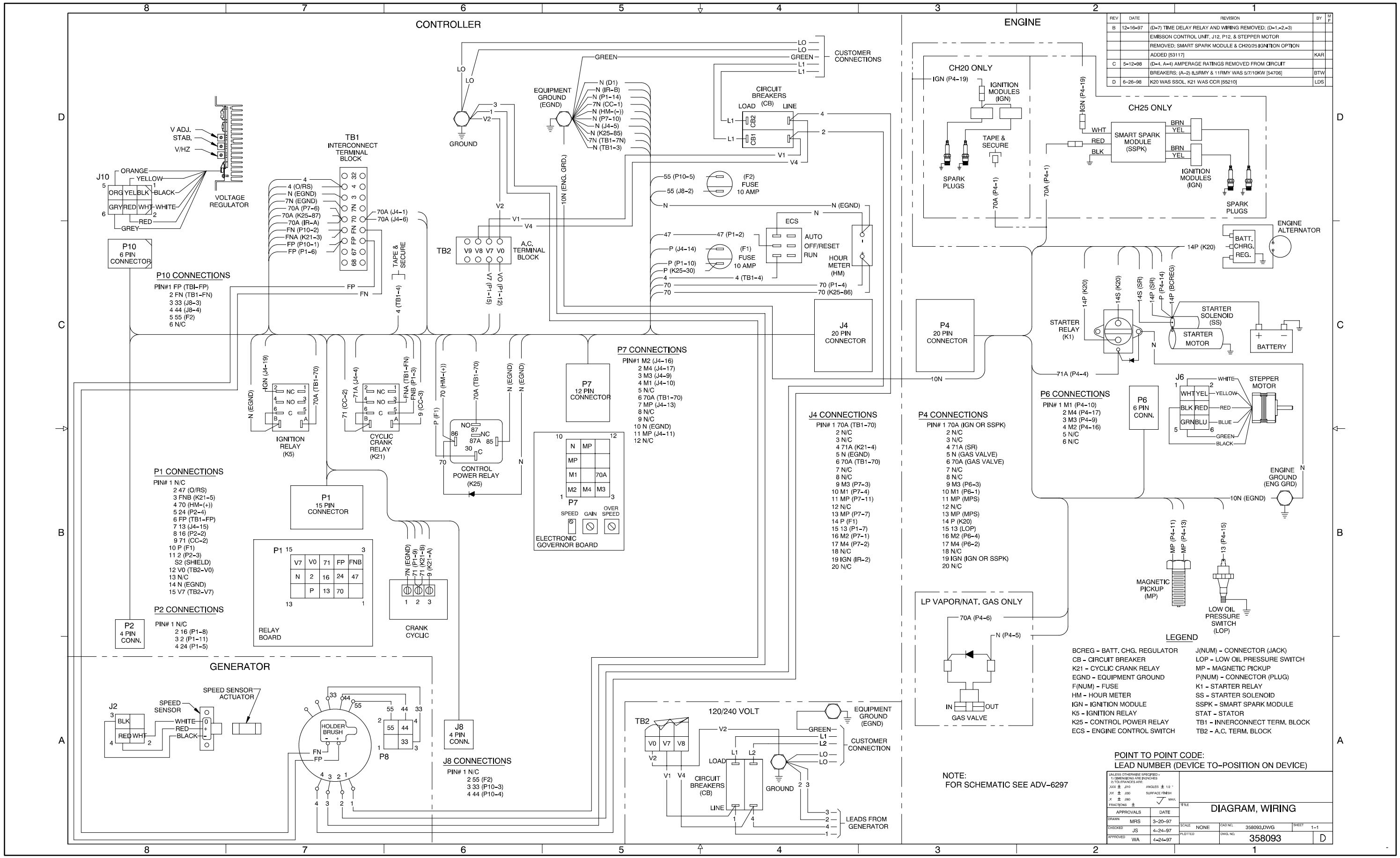
LEGEND

ECS – ENGINE CONTROL SWITCH
K21 – CYCLIC CRANK RELAY
F1, F2 – FUSE
GV – GAS VALVE
K5 – IGNITION RELAY
K25 – CONTROL POWER RELAY
K1 – STARTER RELAY
SS – STARTER SOLENOID
STM – STEPPER MOTOR
TB1 – INNERCONNECT TERMINAL BLOCK
TB2 – A.C. TERMINAL BLOCK
LOP – LOW OIL PRESSURE SWITCH
SSPK – SMART SPARK MODULE
SM – STARTER MOTOR

EQUIPMENT GROUND
ENGINE ALTERNATOR
BATTERY CHARGING REGULATOR
12 VOLT
SM
SS
K1
14S
14P
HOUR METER
ECS
AUTO
OFF/RESET
RUN
K25
CYCLIC CRANK RELAY (K21)
CRANK CYCLIC
TB1
ENGINE GROUND
MAGNETIC PICKUP (MP)
STM
BLUE
WHITE
RED
BLACK
YELL
GREEN
ELECTRONIC GOVERNOR
GV
CH20 ONLY
TAPE & SECURE
IGNITION MODULE
SMART SPARK MODULE
WHT
RED
BLK
LOP
CONTROLLER BOARD LOGIC
START SWITCH
RUN
CRANK
CONTROLLER POWER +
OVERSPEED
+12VDC
GROUND
FAULT SHUTDOWNS INHIBIT DURING CRANKING, THEN 5 SECONDS
CONTROLLER POWER -
CRANK DISCONNECT OVERCRANK (30 SEC.)
FLASH -
FLASH +
ENERGIZED ON A FAULT
ENERGIZED WHEN CONTROL SWITCH IS IN FIELD FLASH POSITION
REMOTE START CONTACTS CLOSED
ENERGIZED ON CRANK DISCONNECT
ENERGIZED WHEN CRANKING
ENERGIZED ON A FAULT
TB2
CIRCUIT BREAKERS
CB1
CB2
LINE
LOAD
GROUND
VOLTAGE REGULATOR
WHITE
BLACK
YELLOW
RED
ORANGE
GRAY
F2 10 AMP
MAIN FIELD
BRUSH HOLDER
SPEED SENSOR
SPEED SENSOR ACTUATOR

UNLESS OTHERWISE SPECIFIED - 1) DIMENSIONS ARE IN INCHES 2) TOLERANCES ARE:			
XXX ± .010	ANGLES ± 1/2 °		
.XX ± .030	SURFACE FINISH		
.X ± .060	MAX.		
FRACTIONS ±			
APPROVALS	DATE	TITLE	DIAGRAM, SCHEMATIC
DRAWN DFS	3-27-97		
CHECKED JS	4-24-97	SCALE ///	CAD NO. ADV6297.DWG SHEET 1-1
APPROVED WA	4-24-97	PLOTTED	DWG. NO. ADV-6297 D

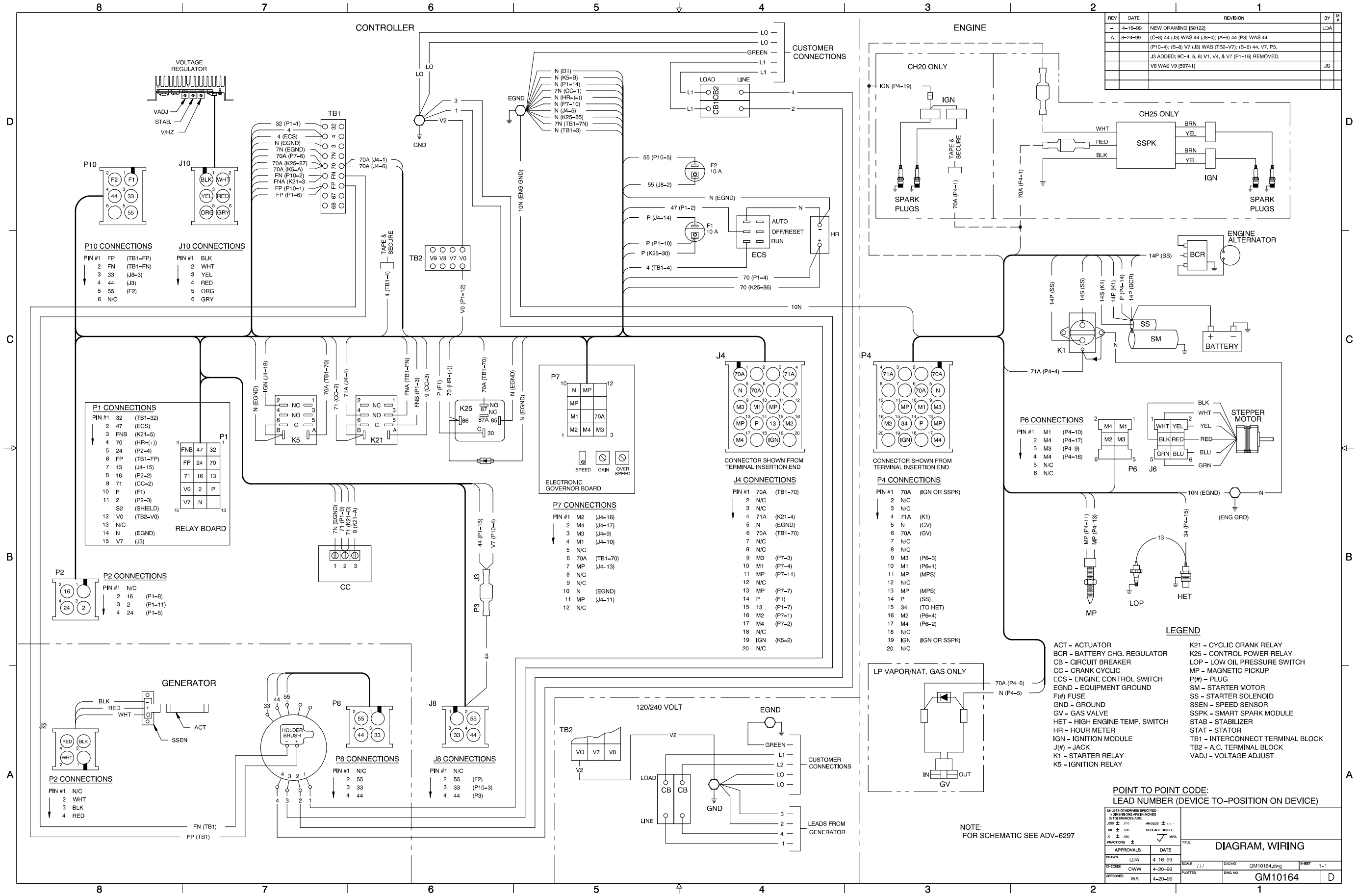
Relay Controller, Schematic Diagram, 1 Phase, ADV-6297-B



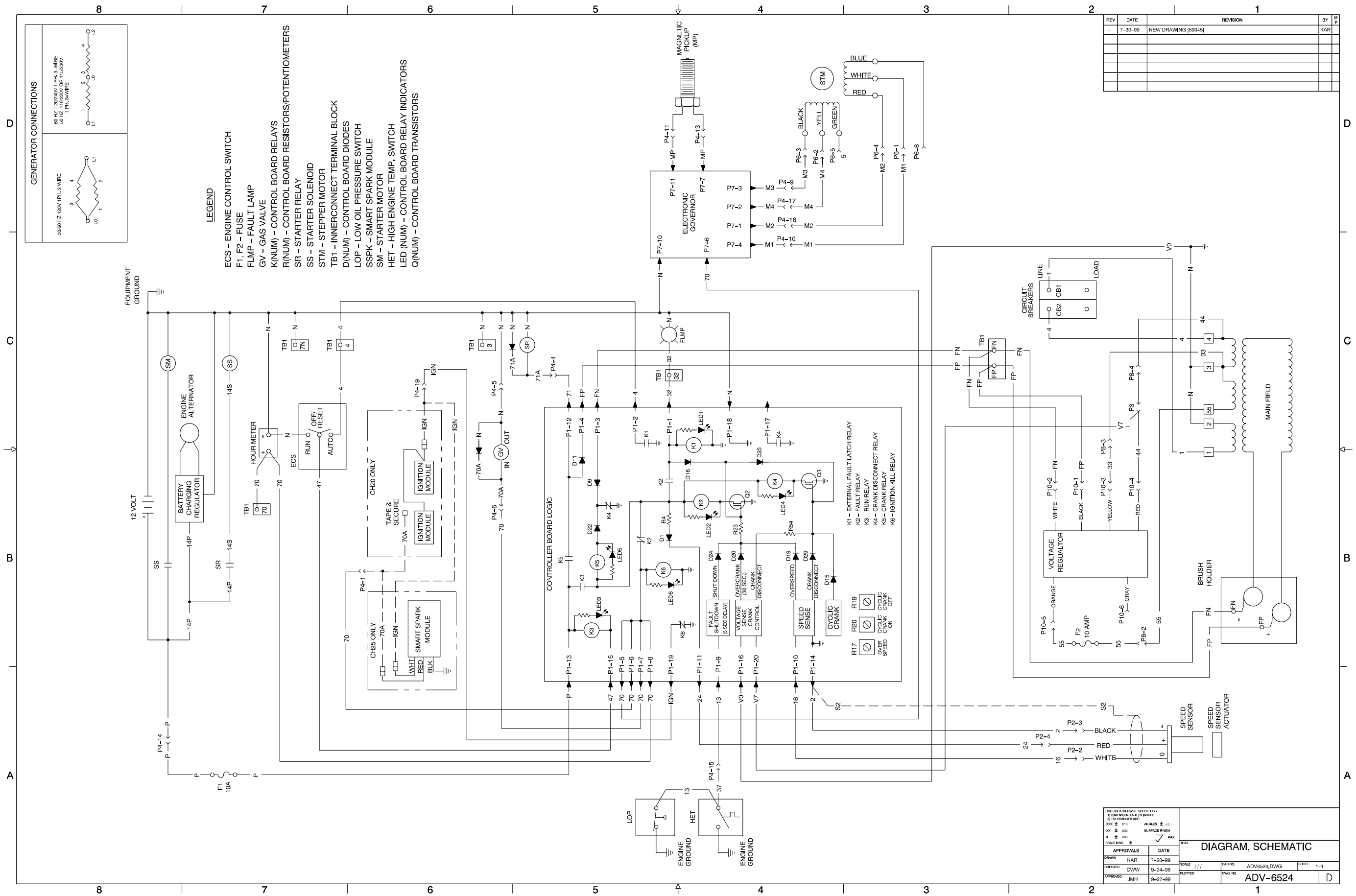
Relay Controller, Point-to-Point Wiring Diagram, 1 Phase, 358093-E

REV	DATE	REVISION	BY	TM
C	4-20-99	(C-4) HET ADDED [58122]	LDA	
D	8-25-99	(C-3) V1, V4 & V7 CONNECTION TO TB2 REMOVED; (B-2) P3		
		ADDED; (C-6) LEGEND UPDATED [59741]	JS	
E	7-15-02	(B-7) ECS; RUN WAS AUTO & AUTO WAS RUN. [67669]	RAC	

Relay Controller, Schematic Diagram, 1 Phase, ADV-6297-E

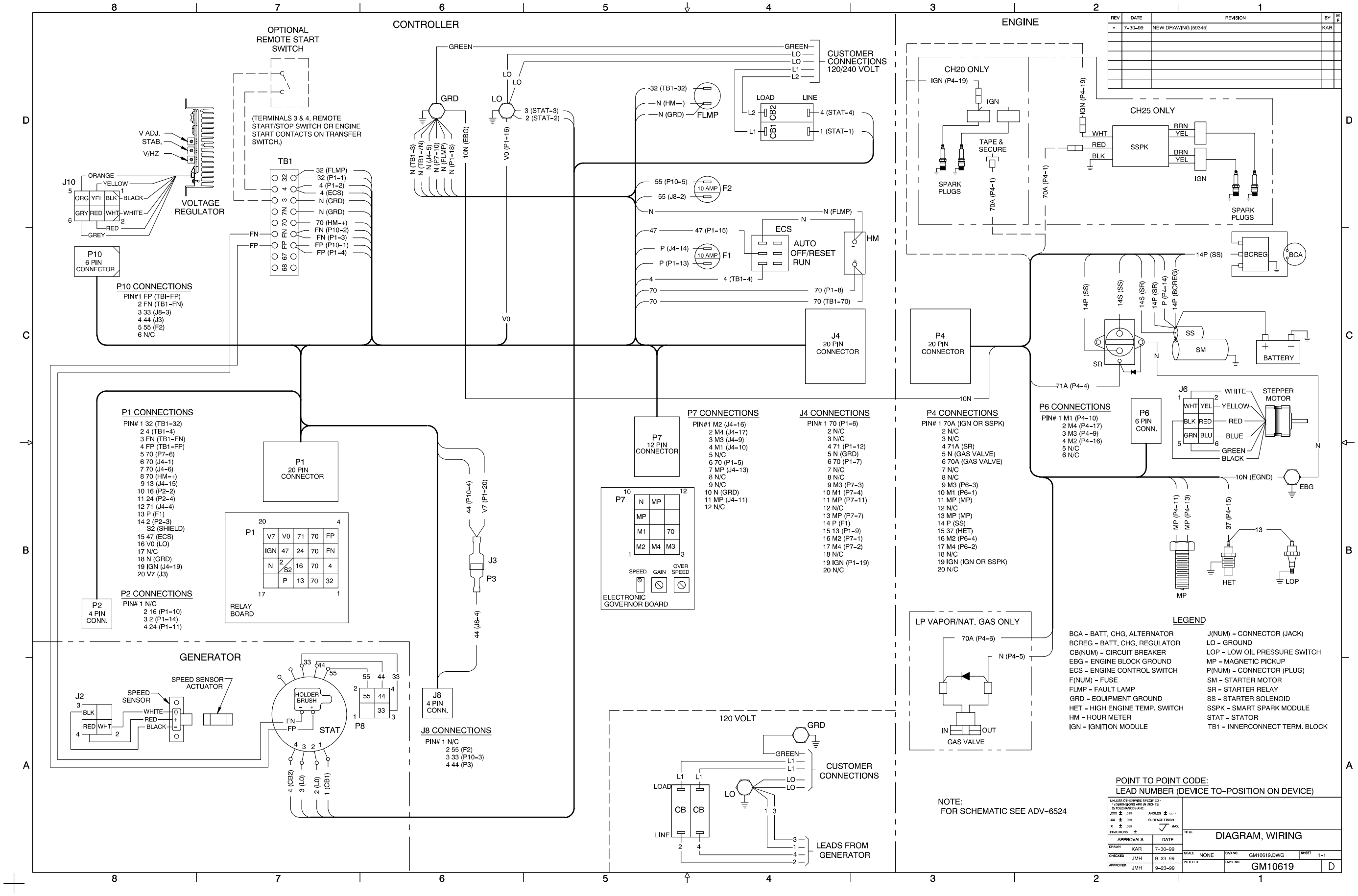


Relay Controller, Point-to-Point Wiring Diagram, 1 Phase, GM10164-A



REV	DATE	REVISION	BY	M π
-	7-30-99	NEW DRAWING [59345]	KAR	

Relay Controller, Schematic Diagram, ADV-6524-



Relay Controller, Point-to-Point Wiring Diagram, GM10619-

Appendix A Abbreviations

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

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

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

Appendix B Common Hardware Application Guidelines

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

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

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

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

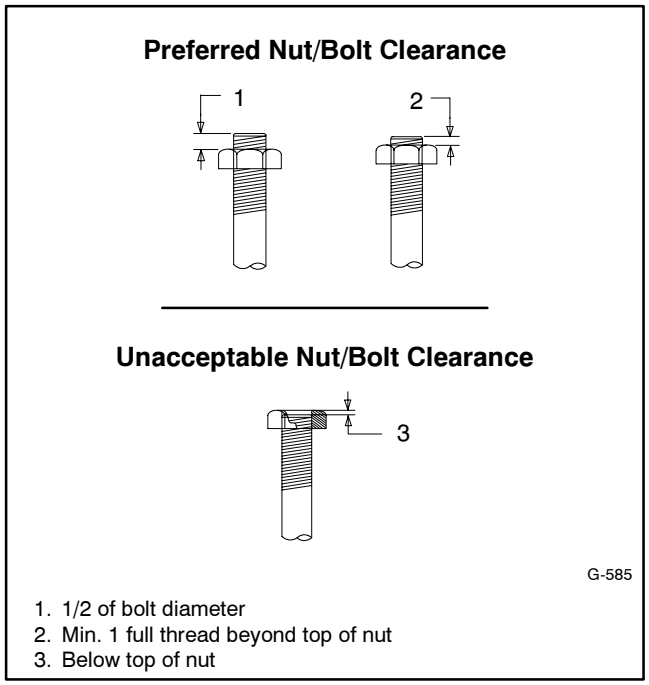


Figure 1 Acceptable Bolt Lengths

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.

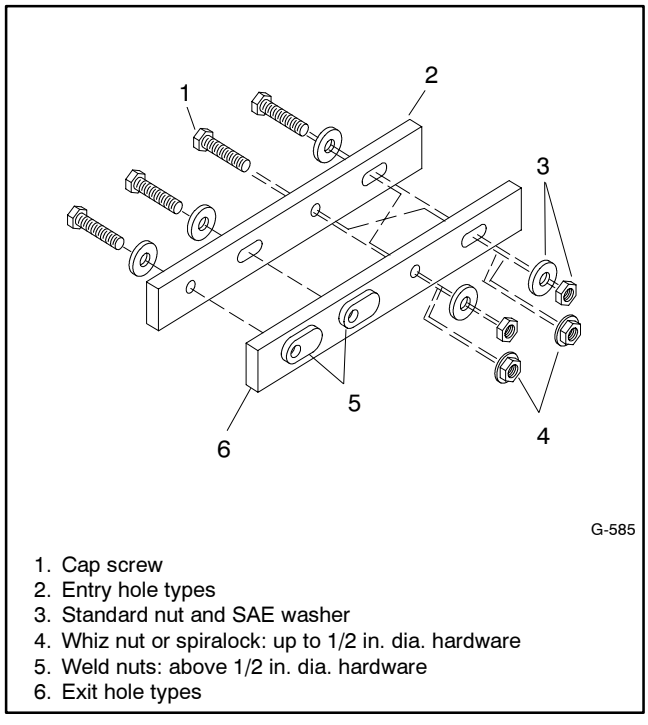


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

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

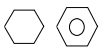
American Standard Fasteners Torque Specifications					
		Assembled into Cast Iron or Steel			Assembled into Aluminum
Size	Torque Measurement	Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	1.8 (16)
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	6.8 (60)
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	8.1 (72)
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	13.6 (120)
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	14.9 (132)
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	24.0 (18)
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	27.0 (20)
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.)				
	Assembled into Cast Iron or Steel			Assembled into Aluminum
Size (mm)	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	5.6 (4)	9.9 (7)	14.0 (10)	5.6 (4)
M8 x 1.25	13.6 (10)	25.0 (18)	35.0 (26)	13.6 (10)
M8 x 1.00	21.0 (16)	25.0 (18)	35.0 (26)	21.0 (16)
M10 x 1.50	27.0 (20)	49.0 (35)	68.0 (50)	27.0 (20)
M10 x 1.25	39.0 (29)	49.0 (35)	68.0 (50)	39.0 (29)
M12 x 1.75	47.0 (35)	83.0 (61)	117.0 (86)	—
M12 x 1.50	65.0 (48)	88.0 (65)	125.0 (92)	—
M14 x 2.00	74.0 (55)	132.0 (97)	185.0 (136)	—
M14 x 1.50	100.0 (74)	140.0 (103)	192.0 (142)	—
M16 x 2.00	115.0 (85)	200.0 (148)	285.0 (210)	—
M16 x 1.50	141.0 (104)	210.0 (155)	295.0 (218)	—
M18 x 2.50	155.0 (114)	275.0 (203)	390.0 (288)	—
M18 x 1.50	196.0 (145)	305.0 (225)	425.0 (315)	—

Appendix D Common Hardware Identification

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

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

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

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

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

Sample Dimensions

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

1/4-20 x 1

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

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

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

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

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

American Standard

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

Part No.	Dimensions
Hex Head Bolts, cont.	
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
M931-06070-60	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
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
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
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10090-60	M10-1.50 x 90
M931-10090-82	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
M931-12045-60	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
M931-12055-60	M12-1.75 x 55
M931-12060-60	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
M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Hex Head Bolts (full thread)

Part No.	Dimensions
M933-04006-60	M4-0.70 x 6
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-08012-60	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
M961-10030-60	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
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 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
M961-16025-60	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
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18035-60	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

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04020-20	M4-0.70 x 20
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-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100

Flat Head Machine Screws

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

Hex Nuts

Part No.	Dimensions	Type
M934-03-50	M3-0.50	Standard
M934-035-50	M3.5-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-05-50	M5-0.80	Standard
M982-05-80	M5-0.80	Elastic Stop
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
M982-14-80	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
M982-18-80	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
M982-24-80	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 bolt's hardness is grade 10.9.
† This metric hex nut's hardness is grade 8.

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