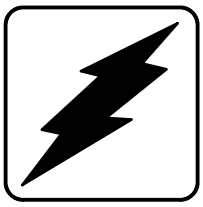
Service

Commercial Generator Sets



Models:

COM5 (36 VDC)
COM5 (48 VDC)
COM5 (96 VDC)
Alpha 5 (36 VDC)
Alpha 5 (48 VDC)
Alpha 5 (96 VDC)

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6092 3/02a

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

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

Table of Contents

Table of Contents, continued

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

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

DANGER

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

WARNING

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

CAUTION

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

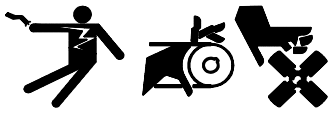
NOTICE

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

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

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

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

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Battery

WARNING

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

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

WARNING

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

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

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

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

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

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

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

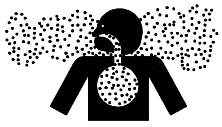
Do not smoke or permit flames or sparks near fuels or the fuel system.

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

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

Exhaust System

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building 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.

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.

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

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

Hazardous Voltage/ Electrical Shock

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ 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 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.

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

Hot Parts

⚠ WARNING

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

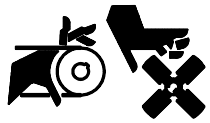
Do not work on the generator set until it cools.

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



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.

Notice

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

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

NOTICE

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

Introduction

This manual provides troubleshooting and repair instructions for model Alpha 5 and COM5 generator sets and controllers.

The generator sets use a Kohler® CV-14 engine with modified ignition, governor, and fuel systems. Refer to the engine service manual for engine information not covered in this manual.

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

Maintenance and Service Parts

Figure 1 lists some routine maintenance and service parts for your generator set. Parts Catalog TP-6091 provides a complete list of replacement parts.

Part Description	Part Number
Maintenance Parts:	
Air Cleaner Foam Element	12 083 07
Air Cleaner Paper Element	12 083 15
Exhaust gasket	12 041 03
Fuse, 150 amp (48 volt)	337123
Fuse, 200 amp (36 volt)	GM13492
Oil Filter	12 050 01
Spark Plug	24 132 03
Test Fixtures:	
Controller board	GM17820
Cover plate	GM23579
Exhaust extension with test port	GM23580
Extended wiring harness	GM23713
Generator set base	GM23578
Oxygen sensor	A-345052
Silencer	GM11509

Figure 1 Maintenance and Service Parts

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

Headquarters Europe, Middle East, Africa (EMEA)
Kohler Power Systems
ZI Senia 122
12, rue des Hauts Flouviers
94517 Thiais Cedex
France
Phone: (33) 1 41 735500
Fax: (33) 1 41 735501

Asia Pacific
Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 6264-6422
Fax: (65) 6264-6455

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

1.1 System Description

The generator set provides backup DC power to cable TV systems or telecommunication sites in place of, or in addition to, batteries. The generator set is available in 36-, 48-, and 96-volt DC models. The generator set nameplate lists the unit's rated voltage.

The system batteries provide power at 36, 48, or 96 VDC. When power fails, the control system signals the generator set to start. The generator set provides DC power for continued or reserve operation of the system.

The generator set has both local and remote annunciation and control capabilities. The unit runs on natural gas or LP vapor.

1.2 Generator Set Functional Description

The generator set system consists of the generator set (engine and generator) and the control system. The generator set provides regulated DC voltage to the telecommunications power system. The control system provides complete control of the engine and generator, accepts remote control commands, and delivers local and remote annunciation of unit status. Internal control functions include start and stop logic, fault monitoring, unit voltage control, engine speed governing, and local LEDs for fault annunciation. Status indicators include low oil pressure, high temperature, overspeed, overcrank, and engine running.

Under very light loads, the generator set operates at low speed. As loads increase, the control system maintains constant generator output voltage by increasing the generator set engine speed (rpm).

The Kohler CV14 engine drives a direct-connected, variable-speed, 3-phase, voltage-specific generator to produce high-frequency AC power. A 3-phase, full-wave rectifier converts the AC output into low-ripple, unfiltered DC power. The DC inline fuse provides protection for downstream devices in case of overload.

1.3 Specifications

The tables in Sections 1.3.1, 1.3.2, and 1.3.3 contain general generator set, engine, and alternator specifications.

1.3.1 Generator Set Specifications

	36 VDC	48 VDC	96 VDC
Manufacturer	Kohler		
Dimensions, L x W x H, mm (in.)	495 x 380 x 514 (19.5 x 15 x 20.24)		
Weight, dry, kg (lb.)	68 (150)		
Rated kW*	5	3.5 or 5†	5
Rated DC output voltage (VDC)	39	52	104
Rated amps	128	96	48

* Derate approximately 3.5% per 300 m (1000 ft.) over 600 m (2000 ft.) above sea level. Derate 1% for each 5.5°C (10°F) increase in temperature above 49°C (120°F).

† Check the generator set nameplate for the kW rating.

1.3.2 Engine Specifications

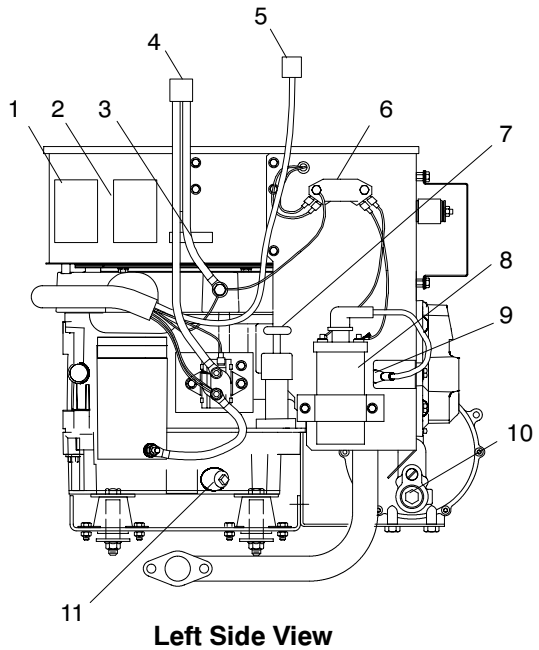
Item	Specification
Manufacturer	Kohler
Make/model	CV14
Cycle	4
Compression ratio	8.5:1
Displacement	398 cc (24.3 cu. in.)
Rated horsepower (using natural gas fuel)	10.5 HP
Engine speed	2800–3600 rpm
Overspeed shutdown	3750 rpm
Bore	87 mm (3.43 in.)
Stroke	67 mm (2.64 in.)
Valve train	Overhead Valve
Valve material: Intake Exhaust	 Steel Stellite® Face
Number of cylinders	1
Cylinder block material	Aluminum w/Cast Iron Liners
Cylinder head material	Aluminum
Piston rings	2 Compression, 1 Oil
Crankshaft material	Heat Treated, Ductile Iron Casting
Bearings, number and type	2, Replaceable Sleeve
Governor	Electronic
Starter motor	Electric, Solenoid Shift
Lubrication system	Full Pressure
Oil capacity (with filter and cooler)	2.0 L (2.1 qt.)
Oil type	Synthetic 5W-30
Oil pressure	172–241 kPa (25–35 psi)
Low oil pressure	13.8–34.5 kPa (2–5 psi)
Fuel type	Natural Gas or Propane
Fuel pressure	1.7 to 2.7 kPa (7 to 11 in. water column)
Fuel consumption at 5 kW: Natural gas, 1000 Btu/ft.^{3} Propane, 2516 Btu/ft.^{3}	 2.3 m^3/hr. (80 cfh) 1.1 m^3/hr. (40 cfh) 2.1 kg/hr. (4.66 lb./hr.) 4.2 Lph (1.1 gph)
Battery voltage	12 VDC
Battery ground	Negative
Battery recommendation (minimum)	425 CCA at –18°C (0°F) or 85 Amp-Hour Capacity Standby Gel Cell
Ignition system	Battery/Coil
Spark plug type (Kohler part no.)	24 132 03
Spark plug gap	0.75 mm (0.030 in.)
Spark plug tightening torque, Nm (ft. lb.)	24.4–29.8 Nm (18–22 ft. lb.)
Cooling system	Integrated Air Cooling
High engine temperature	152°C (305°F)

1.3.3 Generator Specifications

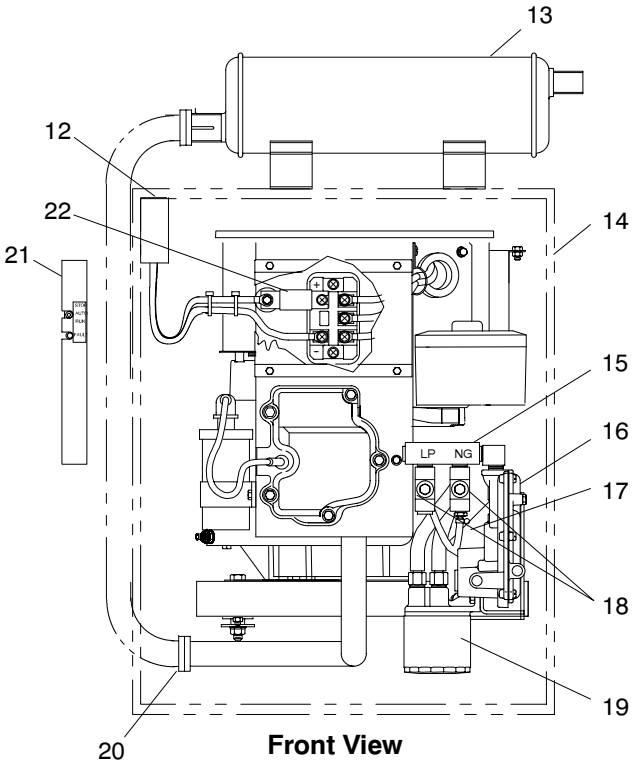
Item	36 VDC	48 VDC	96 VDC
Stator resistance	0.014 ohms	0.024 ohms	0.054 ohms
Stator type	3-Phase, 3-Lead, Ungrounded		
Excitation method (rotor)	Permanent-Magnet, Brushless		
Coupling type	Direct-to-Engine		
Insulation (stator)	Class 155, Epoxy Varnish, Vacuum-Impregnated		
Winding material	Copper		
Stator-to-alternator adapter bolt torque	11 Nm (8.1 ft. lbs.)		
Flywheel-to-shaft bolt torque	67 Nm (49.4 ft. lbs.)		
Rotor-to-flywheel bolt torque	38 Nm (28.0 ft. lbs.)		
Fan-to-flywheel bolt torque	25 Nm (18.4 ft. lbs.)		

1.4 Service Views

Record the specification (spec) number from the generator set nameplate and then find the corresponding service view for your unit below.

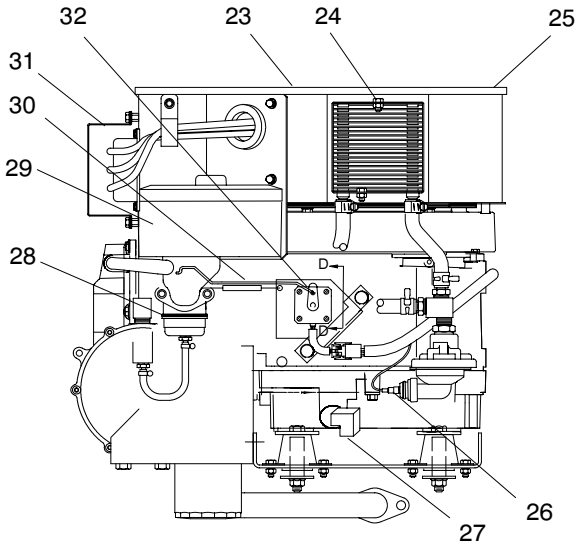


Left Side View



Front View

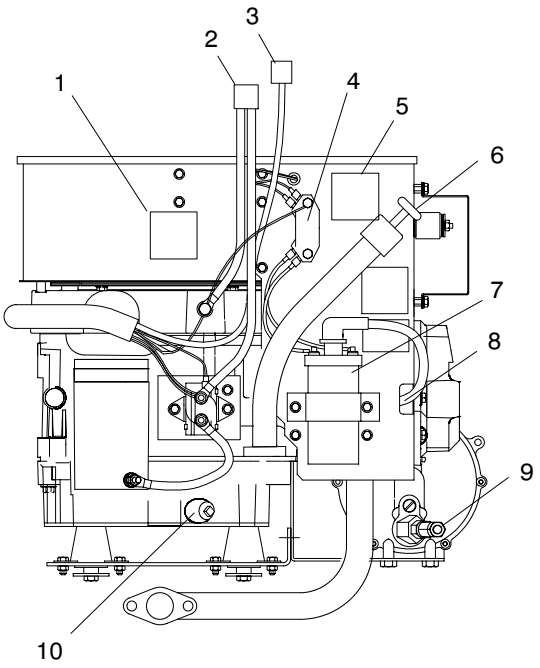
1. Decal, emission
2. Decal, generator set nameplate
3. Decal, engine serial number
4. Engine starting battery connector P9
5. Engine/controls interface connector P4
6. Ignition module
7. Engine oil fill and dipstick
8. Ignition coil
9. Spark plug
10. Fuel supply connection (3/4 in. NPT)
11. High engine temperature (HET) sensor
12. DC output connector P8
13. Muffler
14. Generator set compartment outline
15. Fuel block
16. Secondary fuel pressure regulator
17. Hourmeter location
18. Fuel metering valves (sealed)
19. Oil filter
20. Exhaust pipe connection
21. Generator set control circuit board (location may vary)
22. Fuse
23. Cooling fan (inside)
24. Engine oil cooler
25. Alternator (inside)
26. Low oil pressure (LOP) switch
27. Oil drain (3/8 in. NPT)
28. Carburetor
29. Air cleaner
30. Throttle linkage
31. Decal, CSA
32. Governor



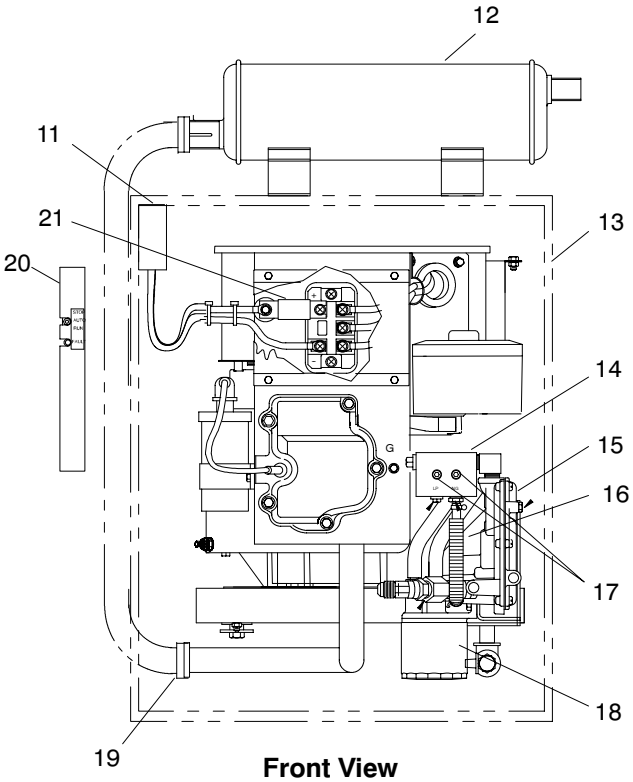
Right Side View

M-337000B-D

Figure 1-1 Service Views, Specification Numbers PA-195023 and PA-195027



Left Side View



Front View

1. Decal, engine serial number
2. Engine starting battery connector P9
3. Engine/controls interface connector P4
4. Ignition module
5. Decal, emission
6. Engine oil fill and dipstick
7. Ignition coil
8. Spark plug (not visible)
9. Fuel supply connection (3/4 in. NPT)
10. High engine temperature (HET) sensor
11. DC output connector P8
12. Muffler
13. Generator set compartment outline
14. Fuel block
15. Secondary fuel pressure regulator
16. Hourmeter location
17. Fuel metering valves (sealed)
18. Oil filter
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20. Generator set control circuit board (location may vary)
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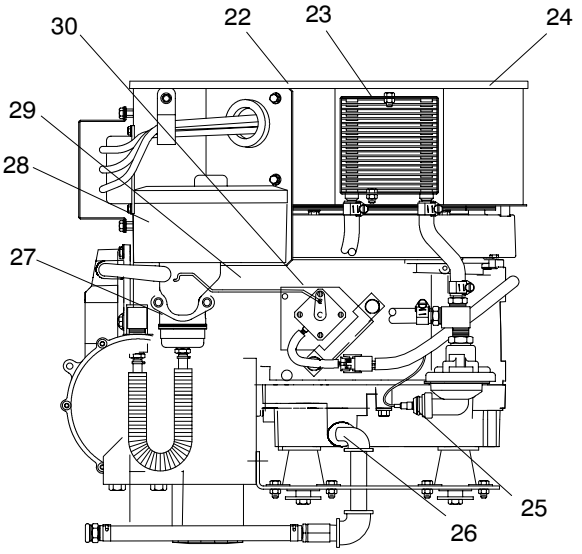
26. Oil drain (3/8 in. NPT)
27. Carburetor
28. Air cleaner
29. Throttle linkage
30. Governor

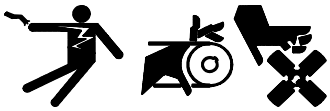


Right Side View

GM14140B-V

Figure 1-2 Service Views, Specification Numbers GM14140-GA1 through -GA6

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

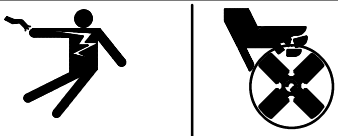
⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ 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 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.

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

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

2.1 Routine Maintenance

Refer to the service schedule in the operation manual and the hourmeter located on the generator set to schedule routine maintenance. Perform maintenance on each item in the service schedule at the designated interval for the life of the generator set. Service units subject to extreme weather, long operating hours, or dusty or dirty conditions more frequently.

Refer to the operation manual for detailed maintenance information.

2.2 Service Schedule

Perform the service listed in Figure 2-3 at the designated intervals for the life of the generator set. Refer to the service views in Section 1.4 for system component locations.

2.3 Service Access

⚠ 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.

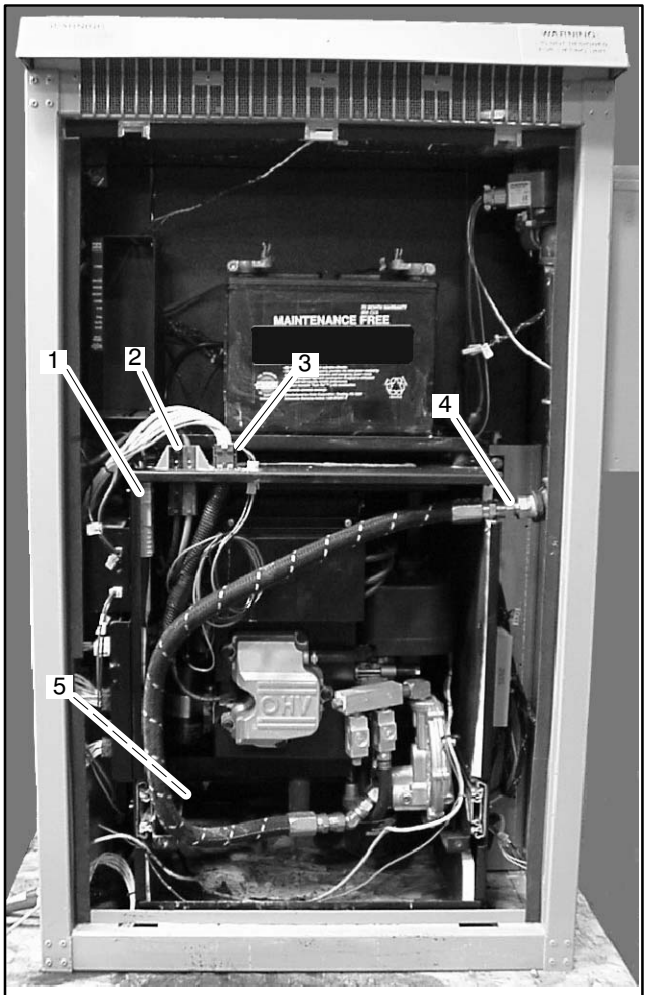
A key is required to open the enclosure. Obtain the enclosure key from the equipment owner. Use the following procedure to gain access to the generator set for maintenance or service. See Figure 2-1.

Refer to the enclosure manufacturer's instruction manual for more information.

Note: Allow the exhaust system to cool before disconnecting the exhaust pipe. Inspect the exhaust gasket and replace if damaged or if it does not seal properly. See the list of maintenance and service parts in this manual for the gasket part number.

Generator Set Service Access

1. Unlock and remove the front door of the enclosure.
2. Place the generator set master switch in the STOP position.
3. Remove the front panel from the generator set compartment.
4. Disconnect the generator set battery harness, engine wiring harness, and load leads at the quick-disconnect plugs.



TP6076

1. Load lead connector
2. Battery harness connector
3. Engine harness connector
4. Fuel connection
5. Exhaust pipe connection (not visible in this photo)

Figure 2-1 Generator Set Installed in the Enclosure (front panel and door removed)

5. Turn off the fuel supply at the upstream valve and disconnect the fuel line on the right side of the enclosure. See Figure 2-1.

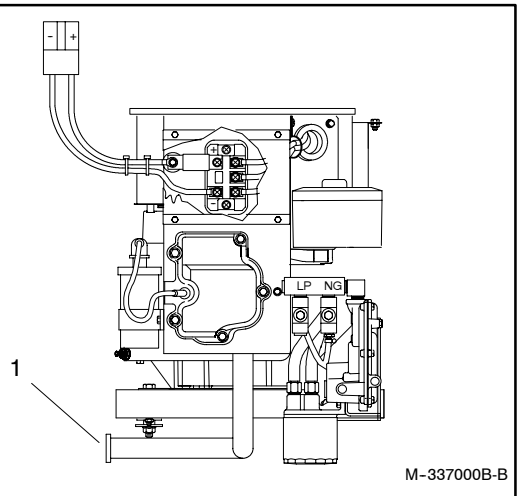
6. Remove the back panel of the enclosure to gain access to the exhaust pipe connection.

7. Disconnect the engine exhaust pipe at the left side below the generator set. See Figure 2-2 and Figure 2-1.

8. Grasp the generator tray at the sides and pull the generator set forward.

9. Remove the four bolts securing the generator set to the enclosure rails. Use appropriate lifting equipment to lift the generator set off the rails. The generator set weighs approximately 68 kg (150 lb.).

Note: Service fixtures are required to run the generator set outside the enclosure. Refer to Section 4.1 for instructions and precautions.



1. Exhaust connection

Figure 2-2 Exhaust Connection

Return to Operation

Slide the generator set back into the enclosure and reconnect the exhaust pipe, fuel system, and wiring harnesses as described below.

1. Verify that the generator set master switch is in the STOP position.

2. Slide the generator set back into the enclosure.

3. Install the exhaust gasket and reconnect the exhaust pipe.

4. Reinstall the enclosure back panel.

5. Reconnect the fuel line and turn on the fuel supply.

6. Check for fuel leaks.

7. Reconnect the engine wiring harness, load leads, and battery harness.

8. Reconnect the generator set engine battery harness.

9. Move the generator set master switch to the center (AUTO) position to return the generator set to standby service.

10. Reinstall the generator set compartment front panel.

11. Reinstall the enclosure door.

2.4 Lubrication System

See the service schedule in Section 2.2 for oil change and oil filter replacement intervals. See the Service Views in Section 1.4 for the oil drain, oil check, oil fill, and oil filter locations. The list of routine service parts in the Introduction of this manual shows the oil filter part number.

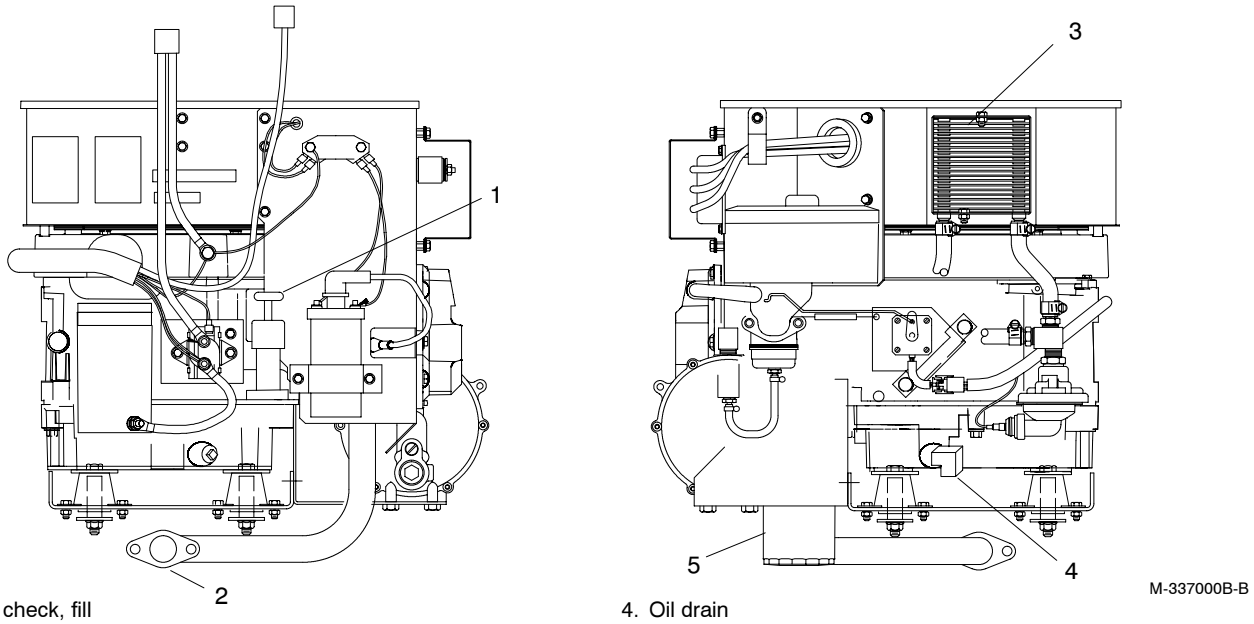
System Component or Procedure	See Section	Procedure					Frequency
		Visually Inspect	Check	Change	Clean	Test	
Fuel							
Inspect flexible lines and connections. Replace cracked or spongy hoses. *	—	X		R			Q
Main LP tank supply level, if used.	—		X				M
Inspect fuel piping for damage or corrosion.	—	X					Y
Lubrication							
Oil level.	2.4.1	X	X				M or before use
Change oil.	2.4.2, 2.4.3			R			Y or 100 hr.
Replace oil filter.*	2.4.3, Intro Figure 1			R			Y or 200 hr.
Cooling							
Check that air ducts and louvers are clean and unobstructed.	2.8		X		X		Q
Exhaust System							
Check for leakage. Carbon or soot residue indicates a leak. Repair leaks.	2.9	X	X	R			Q
Check for fire hazards.	2.9	X	X		X		Q
Check for loose or broken hangers and supports. Tighten or replace as needed.	—	X	X	R			S
Battery Connections							
Check battery charger operation and charge rate (if equipped).	Battery charger manual.	X	X				M
Clean and tighten battery terminals.		X	X		X		Y
Remove corrosion, clean and dry battery and rack.		X			X		Y
Battery electrolyte level and specific gravity.†			X				Q
Electrical System							
Inspect wiring and components for visible wear or damage.	—	X					Q
Check for abrasions where wiring is subject to motion.	—	X	X				S
Engine And Mounting							
Inspect for visible wear or damage.	—	X					Q
Inspect air cleaner element; replace if necessary.*	2.5	X		R			Y or 500
Inspect spark plugs; replace if necessary.*	2.7.2	X		R			Y or 500
Control System							
Check remote control operation.	Controller manufacturer's instructions.					X	M
Generator Set							
Check items listed in the Prestart Checklist.	Operation Manual	X					M
Exercise generator set.	Operation Manual					X	W
General Condition Of Equipment							
Check for signs of vibration, leakage, excessive noise, extreme temperature, or deterioration.	—	X	X		X		Q
Inspect and clean enclosure interior.	—	X			X		Q
* Consult your local distributor/dealer for parts or service. † Not necessary for maintenance-free batteries.		X Action R Replace as necessary					W=Weekly M=Monthly Q=Quarterly S=Six Months Y=Yearly No.=Hours of Running Time

Figure 2-3 Service Schedule

2.4.1 Oil Check

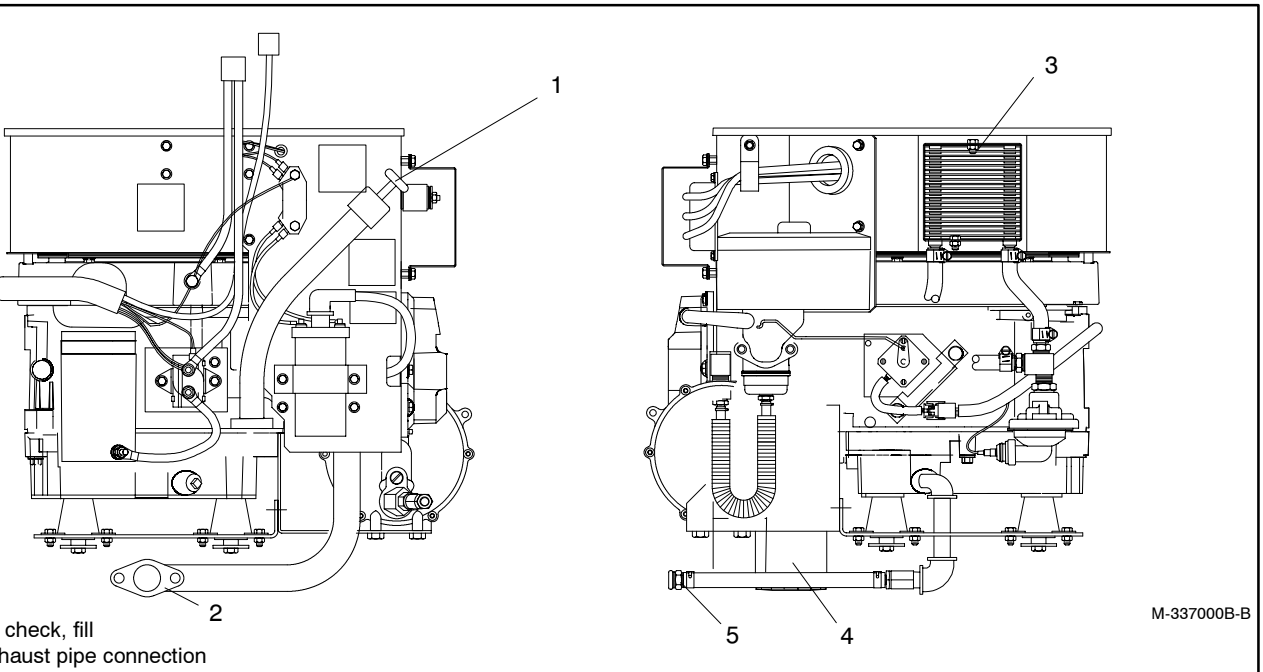
Before operating a new generator set, check the engine oil in the crankcase. See Figure 2-4 or Figure 2-5. Verify that the oil level is at the F mark on the dipstick. Add oil that has a viscosity appropriate for the climate. See Section 2.4.2 for engine oil recommendations.

Do not check the oil level when operating the generator set. To obtain the most accurate oil level reading, shut down the generator set and wait several minutes before checking the oil .



1. Oil check, fill
2. Exhaust pipe connection
3. Oil cooler
4. Oil drain
5. Oil filter

Figure 2-4 Lubrication System, Specification Numbers PA-195023 and PA-195027



1. Oil check, fill
2. Exhaust pipe connection
3. Oil cooler
4. Oil filter
5. Oil drain

Figure 2-5 Lubrication System, Specification Numbers GM14140-GA1 through -GA6

2.4.2 Engine Oil Recommendation

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

2.4.3 Oil Change Procedure

Allow the oil to cool to a safe temperature before changing.

1. Follow the instructions in Section 2.3 to access the generator set oil drain plug, filter, and fill tube. See Figure 2-4.
2. Drain the oil.
   a. Place an oil collection container below the oil drain and remove the oil drain plug.
   b. Allow the engine oil to drain completely.
   c. Replace the oil drain plug.
3. Replace the oil filter.
   a. Place an oil collection container below the oil filter.
   b. Remove the oil filter by rotating it counterclockwise with an oil filter wrench.
   c. Clean the gasket sealing surface of the oil filter adapter.
   d. Apply a light coat of clean oil to the rubber seal of the new oil filter.
   e. Install the new oil filter following the instructions provided with the filter. Hand-tighten the filter.

      Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner.
4. Fill with oil.
   a. Remove the oil fill cap and fill the engine to the F mark on the dipstick. The engine oil capacity is 2.0 L (2.1 qt.). See Section 2.4.2 for oil selection.
   b. Reinstall the dipstick and the oil fill cap.
5. Slide the generator set back into the enclosure and reconnect the fuel line, exhaust pipe, and wiring harnesses as described in Section 2.3. Do not replace the compartment front panel.
6. Check for leaks.
   a. Start and run the generator set to allow the oil pressure to reach the operating range.
   b. Check for oil leaks around the oil filter and oil drain plug.
   c. Stop the generator set and recheck the oil level. Tighten the oil filter to stop any leaks. Add oil to bring the level up to the F mark on the dipstick.
7. Replace the generator set compartment front panel.
8. Move the generator set master switch to the AUTO or center position to return the unit to standby service.
9. Reinstall the enclosure door.

2.4.4 Low Oil Pressure Shutdown

The low oil pressure shutdown feature protects the engine against internal damage if the oil pressure drops below a safe operating value because of oil pump failure or other malfunction. This shutdown feature does not protect against damage caused by operating with the oil level below the safe range—it is not a low oil level shutdown. Check the oil level regularly and add oil as needed.

2.5 Air Cleaner Element and Precleaner

The engine has a replaceable high-density paper air cleaner element with an oiled-foam precleaner. See Figure 2-6. Refer to the service views in Section 1.4 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.

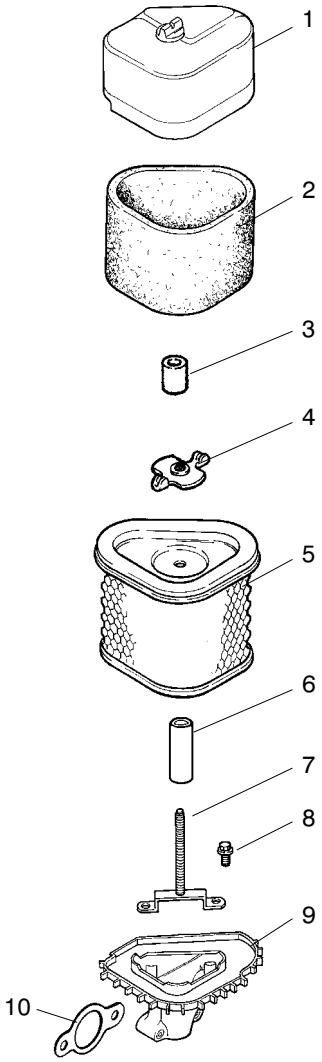
Note: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine, causing premature wear and failure.

⚠ WARNING

Fire.
Can cause severe injury or death.

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

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



1. Cover with knob
2. Foam precleaner
3. Short seal
4. Wing nut
5. Air cleaner element
6. Long seal
7. Stud
8. Screw (2)
9. Air cleaner base
10. Gasket

Figure 2-6 Air Cleaner Components

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 short seal, wing nut, and paper element with precleaner.

   d. Remove the precleaner from the paper element.

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 it is worn or damaged.

   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 they are worn or damaged.

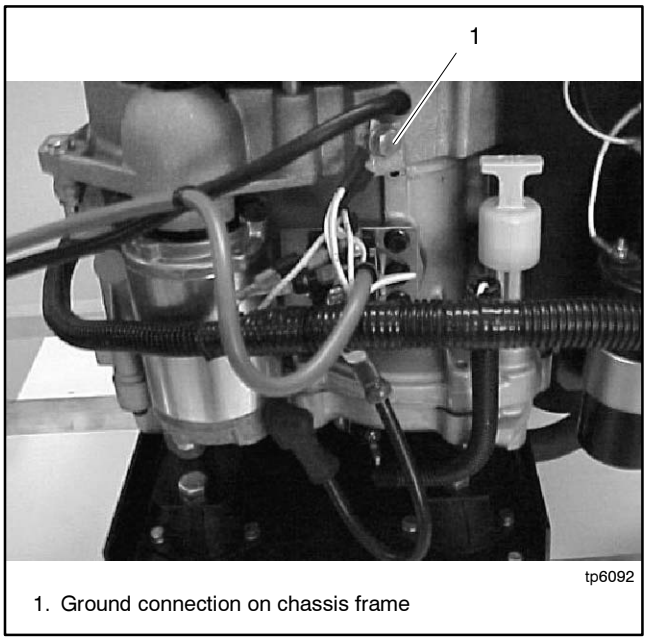
   f. Install the paper element, precleaner, and wing nut. Replace the short seal and the air cleaner cover. Secure the cover with the cover retaining knob (finger-tighten only).

6. Follow the instructions in Section 2.3 to return the generator set to operation.

2.6 Battery

Use a starting battery that meets or exceeds the requirements shown in Section 1.3. Follow the battery manufacturer's instructions for battery maintenance and service.

All generator set models use a negative ground with a 12-volt engine electrical system. See Figure 2-7 for the location of the ground connection.



1. Ground connection on chassis frame

Figure 2-7 Ground Connection

2.7 Ignition System

2.7.1 Ignition System Description

The generator set uses a battery-powered coil ignition system. Ignition system components include the ignition module, ignition coil, trigger coil assembly, wiring, and spark plug. See the service views in Section 1.4 for ignition system component locations.

Maintain the spark plugs using the instructions in Section 2.7.2. The other ignition system components do not require routine maintenance.

2.7.2 Spark Plug

Reset the spark plug gap or replace the plug if necessary. Replace the plug at the intervals shown in the service schedule, Figure 2-3.

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. Verify that the insulator is a light toast or gray color. Replace the spark plug if the insulator is discolored, the plug is coated with deposits, or the electrodes are pitted or worn.

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 2-8 and Figure 2-9.

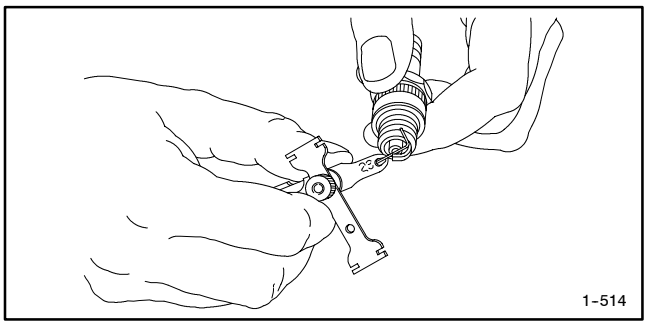


Figure 2-8 Checking the Spark Plug Gap

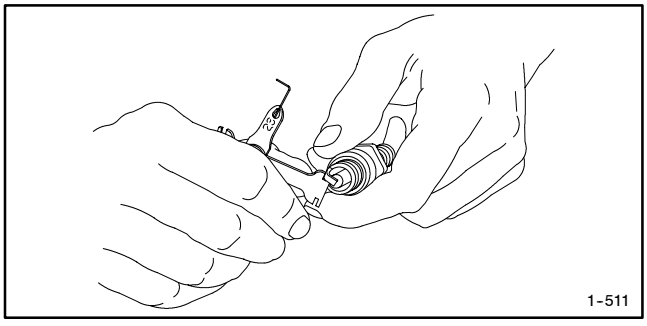


Figure 2-9 Adjusting the Spark Plug Gap

2.8 Cooling System

The air inlet and outlet vents are located near the top of the enclosure. To prevent generator set damage caused by overheating, keep the housing cooling inlets and outlets clean and unobstructed at all times.

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

2.9 Exhaust System

Remove all combustible materials from the exhaust location. Combustible materials include building materials as well as natural surroundings. Keep dry field grass, foliage, and combustible landscaping material a safe distance from the exhaust outlet.

Periodically inspect the 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 as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace clamps and/or hangers as needed.
- Check for and remove loose insulation in the exhaust duct.
- Check that the exhaust outlet is clear.

This section contains generator set troubleshooting and diagnostic information.

Use the following charts to diagnose and correct common problems. First check for simple causes such as a dead engine starting battery or loose connections.

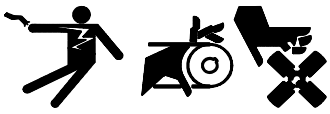
The generator set may be connected to a customer-supplied remote control system. Disconnect the generator system from the remote control system at plug P6 and use the generator set master switch to operate the generator set. If the problem persists after P6 is disconnected, use the troubleshooting procedures in this manual to diagnose the problem. If the generator set operates normally when P6 is disconnected, the remote controller may have sent a remote stop command or there may be a problem with the remote control system. Refer to the instructions for the remote control system.

Note: Use an ohmmeter or continuity tester to check for shorts or open leads in the wiring harnesses before replacing the controller circuit board or other system components.

Follow the instructions in Section 2.3 to remove the generator set from the enclosure, if necessary. Service fixtures are required if it is necessary to run the generator set outside of the enclosure. See Section 4.1.

Maintain a record of repairs and adjustments performed on the equipment.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

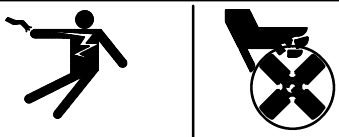
⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ 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 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.

⚠ 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.

3.1 Troubleshooting Chart

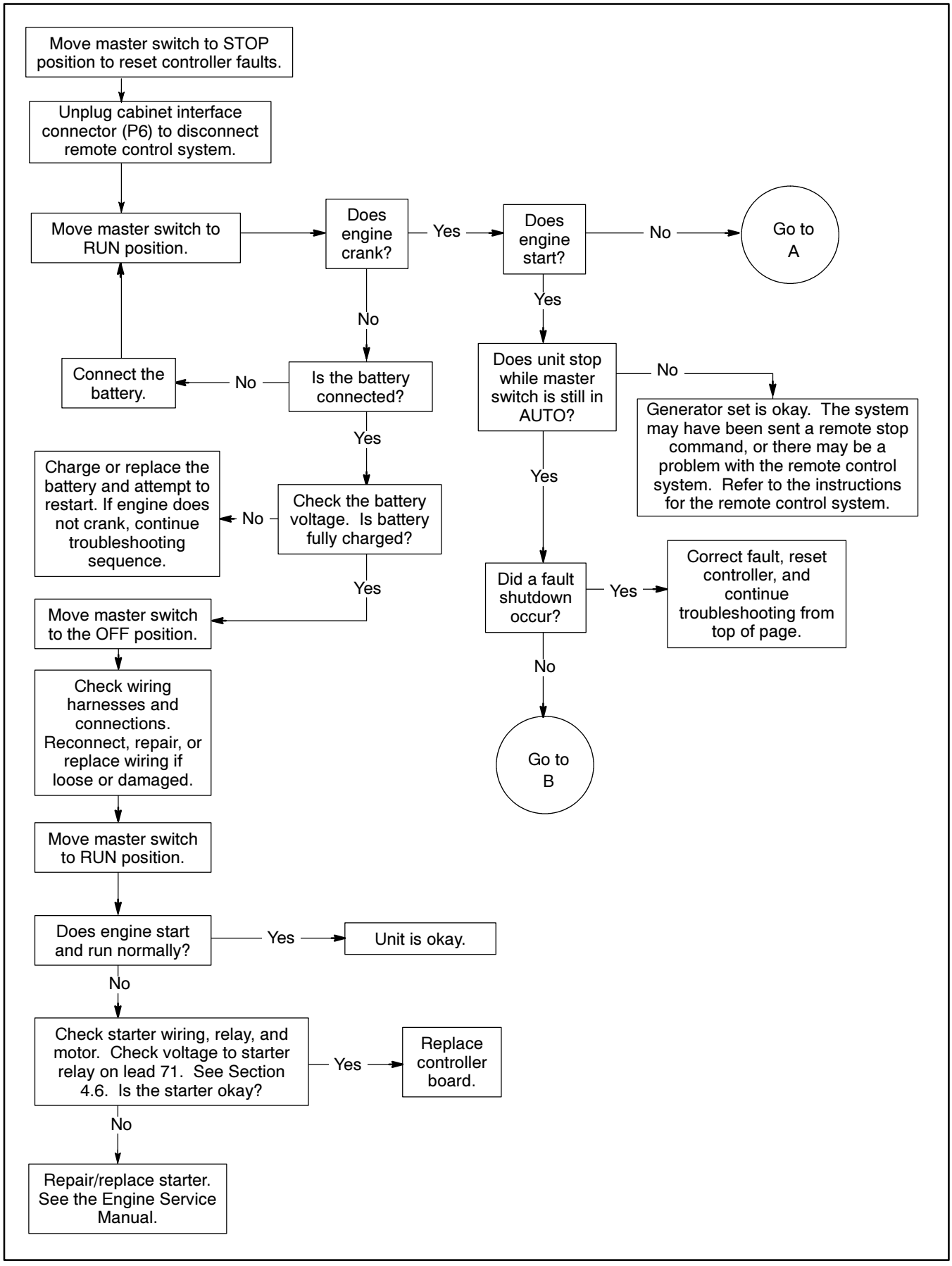
The chart includes a list of common problems, possible causes, and recommended corrective actions.

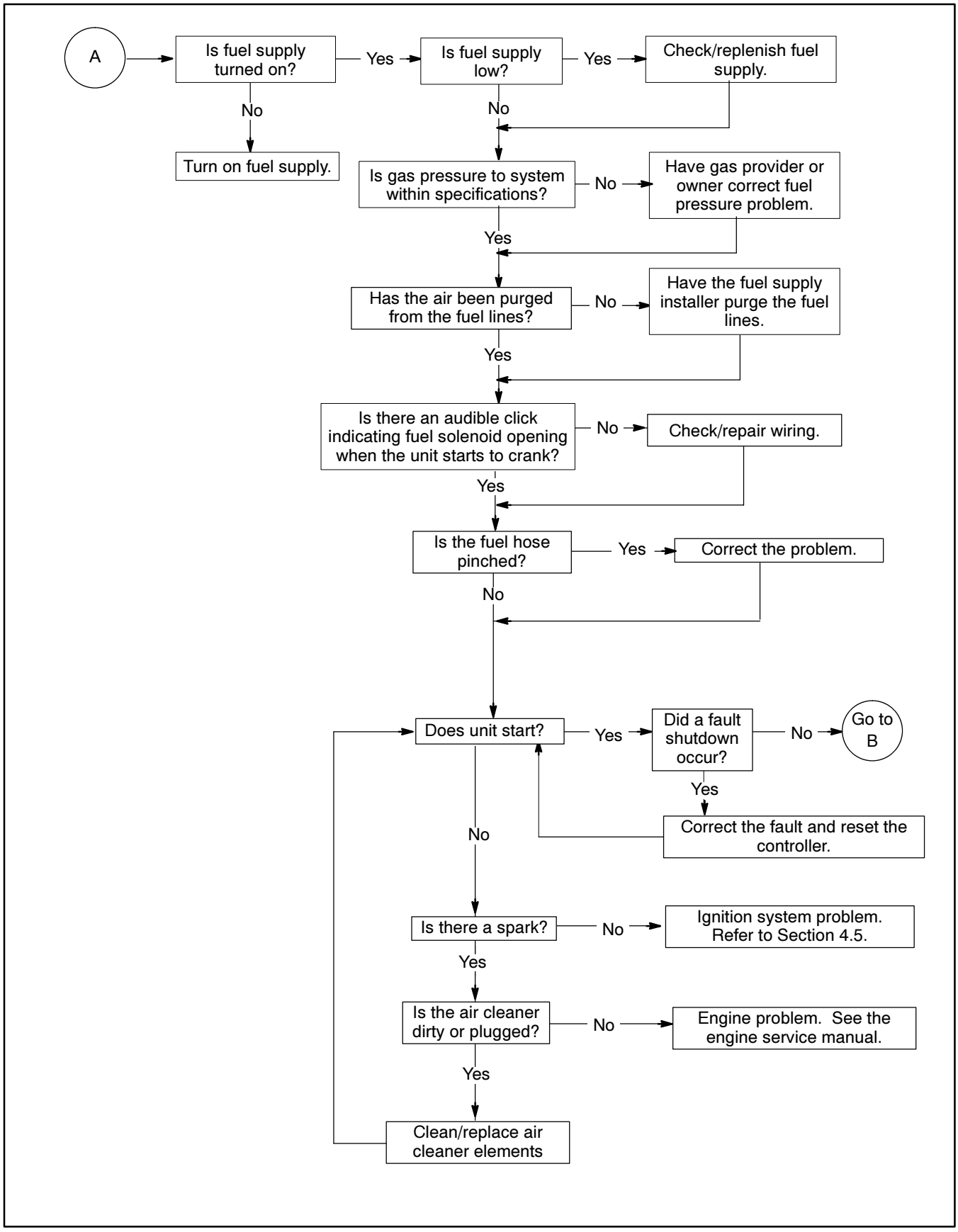
Problem	Possible Cause	Corrective Action	Reference
Unit does not crank	Weak or dead battery	Recharge or replace battery	—
	Engine harness connector not fully locked tight	Disconnect and reconnect	—
	Start switch not in the Auto position.	Move switch to Auto.	—
	Remote start cable disconnected	Reconnect start cable	—
	Generator set controls are not receiving the remote start command.	Check remote start cable connections and continuity. Troubleshoot remote control system.	—
	Starter problem	Test starter	Section 4.6 and the Engine Service Manual, TP-2339-C
	Battery connections loose, dirty or incorrect	Correct, clean, or tighten battery connections	—
	Fault shutdown	Identify and correct the cause of the fault. Reset the controller	Section 5.3
	Controller board problem.	Test the board as described in Section 5.5. Connect a spare control board to verify that the board needs to be replaced.	Sections 5.5 and 4.10.
Unit cranks but does not start	Air cleaner clogged	Clean or replace air cleaner	Section 2.5
	Fuel problem	Check fuel supply and replenish if necessary.	—
		Verify that the fuel valve is open.	—
		Check that the fuel regulator opens.	Section 4.7.1
		Check that the throttle linkage moves freely and opens at start.	Section 4.4
		Check the fuel adjustment (oxygen sensor required for this test).	Section 4.7.4
		Check for the correct fuel and fuel block connection.	Section 4.7
	Choke spring disconnected (if equipped with choke assembly)	Connect the choke spring and check that it holds the choke open. (Many units have no choke and do not require the spring.)	Section 4.7.5
	Faulty spark plug	Replace or regap spark plugs	Section 2.7.2
	Loose spark plug wire connection	Reconnect and/or tighten spark plug wire	—
	Ignition system problem	Test ignition system. Replace ignition module if faulty.	Sections 5.5.4 and 4.5
	Weak or dead battery	Recharge or replace battery	Section 2.6
Unit starts hard	Air cleaner clogged	Clean or replace air cleaner element	Section 2.5
	Faulty spark plug	Replace or regap spark plugs	Section 2.7.2
	Weak or intermittent ignition module(s)	Test the ignition system and replace faulty components.	Section 4.5

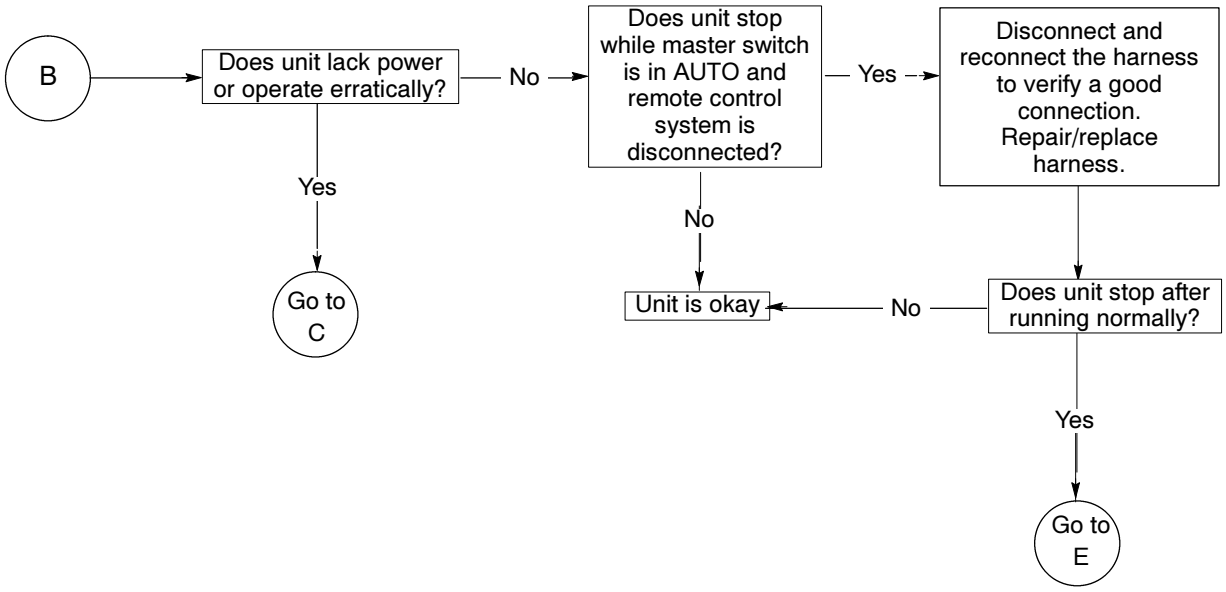
Troubleshooting Chart (continued)

Problem	Possible Cause	Corrective Action	Reference
Unit stops suddenly	Air cleaner clogged	Clean or replace air cleaner element	Section 2.5
	Faulty spark plug	Replace or regap spark plugs	Section 2.7.2
	Fuel starvation	Replenish fuel	—
	Engine harness connector not fully locked tight	Disconnect and reconnect	—
	Fault shutdown	Check controller LEDs. Correct fault and reset controller. Test shutdown operation.	Sections 5.2.3, 5.3 and 5.4
	Faulty shutdown switch	Test switches and replace if necessary.	Section 4.9
Unit lacks power or operates erratically	Engine harness connector not fully locked tight	Disconnect and reconnect	—
	Air cleaner clogged	Clean or replace air cleaner element	Section 2.5
	Insufficient cooling	Inspect and clean cooling system	Section 2.8
	Engine overload	Reduce load on generator set	—
	Faulty spark plug	Replace or regap spark plugs	Section 2.7.2
	Fuel supply problem	Check valves and fuel pressure	Section 4.7
	Governor system problem	Check governor and trhottle linkage.	Section 4.4
Unit does not supply load	Fuel supply problem	Check for the correct fuel and fuel block connection.	Section 4.7
	Excessive load	Check that load does not exceed rating, 3.5 or 5 kW.	—
	Throttle linkage binding	Check that throttle linkage is free to move and open while engine is running.	Section 4.4
	Undervoltage	Check that voltage with no load is 52 volts (48 V models), 39 volts (36 V models), or 104 volts (96 V models).	Section 4.3
Engine noise	Hydraulic lifter leakdown.	Run unit 5–10 minutes under load	—
Unit overheats	Air openings clogged	Clean intake and outlet openings	Section 2.8
	Air cleaner clogged	Clean or replace air cleaner element	Section 2.5
	Overload	Verify that load is within the specified range. Reduce load.	Section 1.3.1

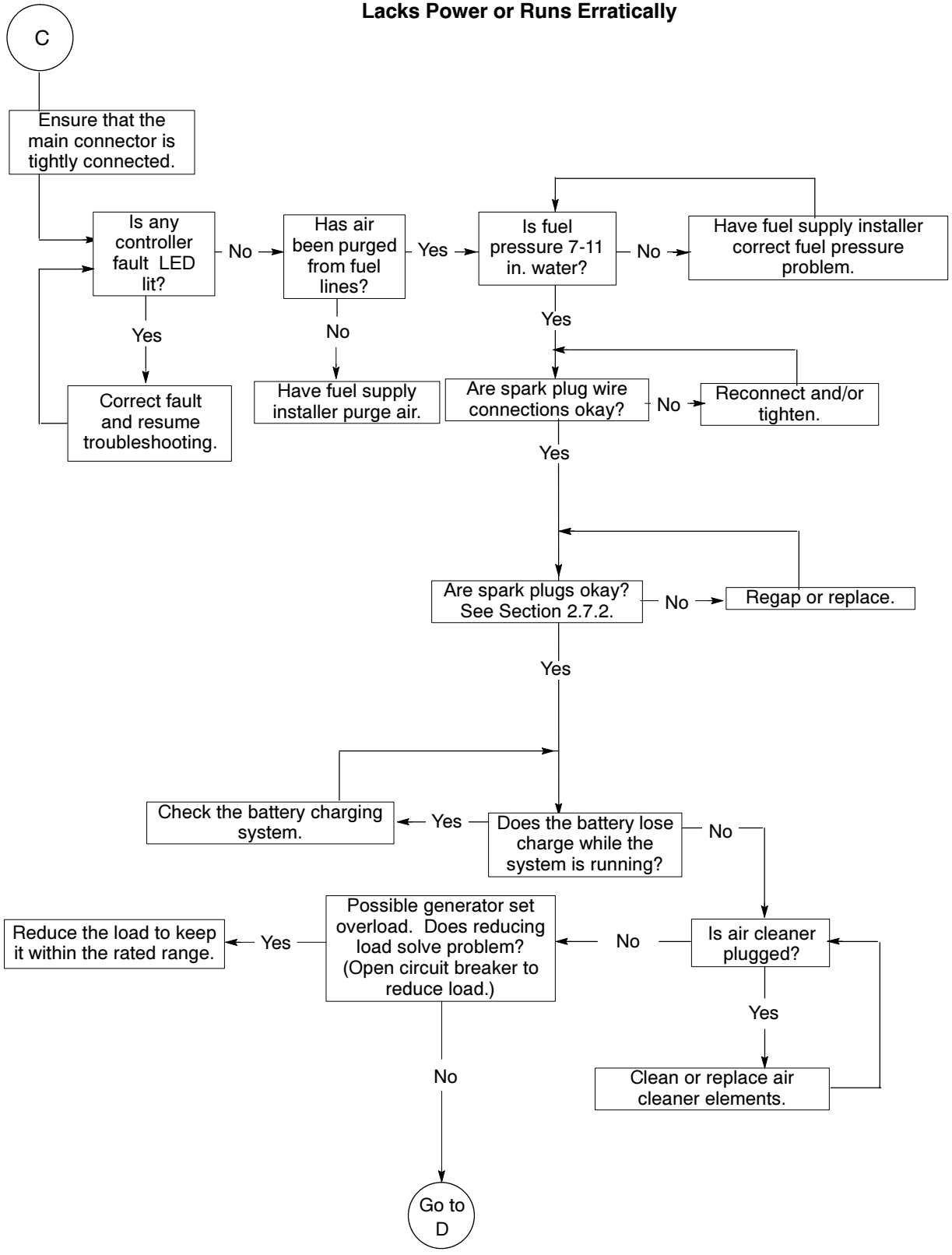
3.2 Generator Set/Controller System Troubleshooting Flowcharts



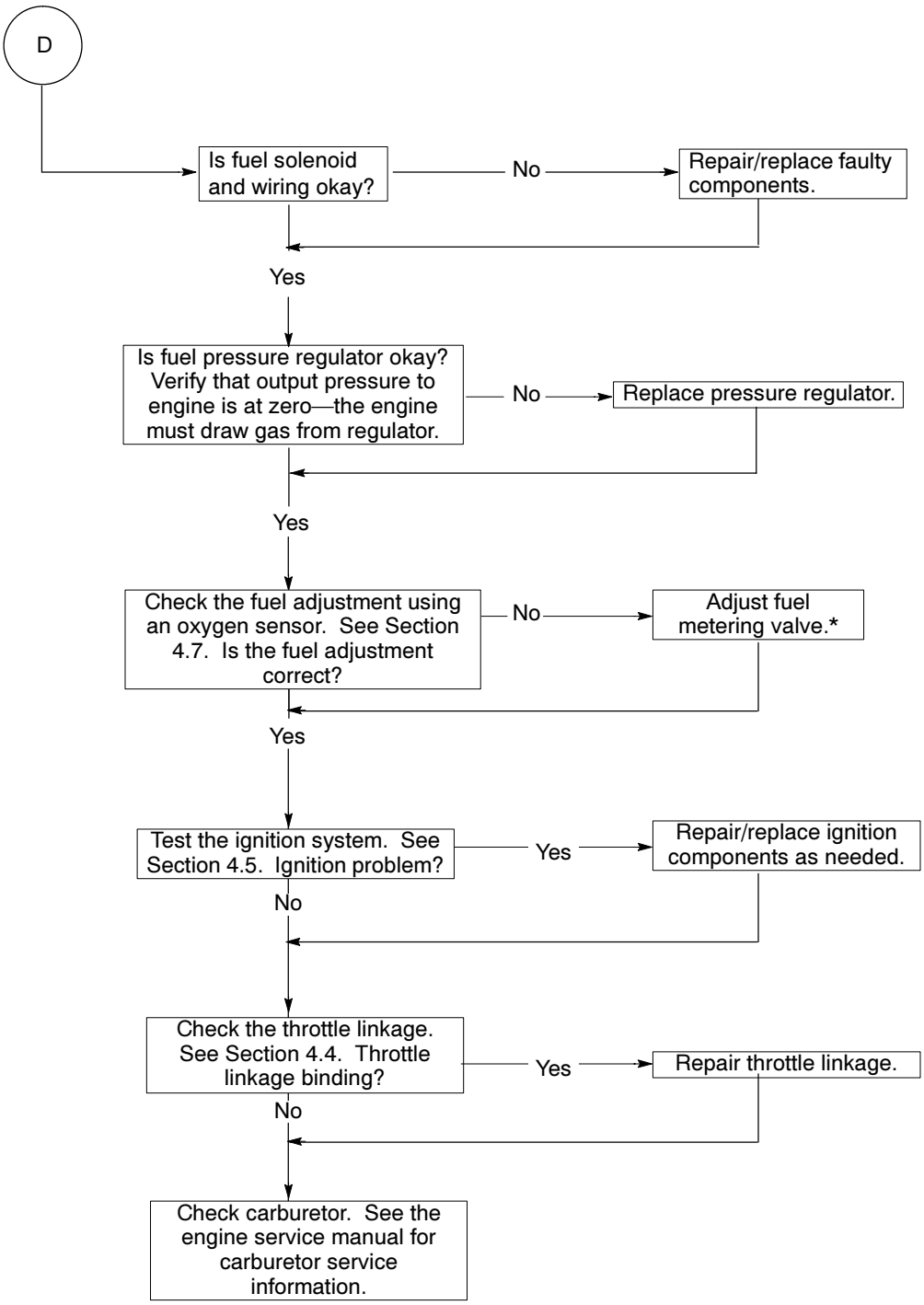

A
Is fuel supply turned on?
Yes
Is fuel supply low?
Yes
Check/replenish fuel supply.
No
No
Turn on fuel supply.
Is gas pressure to system within specifications?
No
Have gas provider or owner correct fuel pressure problem.
Yes
Has the air been purged from the fuel lines?
No
Have the fuel supply installer purge the fuel lines.
Yes
Is there an audible click indicating fuel solenoid opening when the unit starts to crank?
No
Check/repair wiring.
Yes
Is the fuel hose pinched?
Yes
Correct the problem.
No
Does unit start?
Yes
Did a fault shutdown occur?
No
Go to B
Yes
Correct the fault and reset the controller.
No
Is there a spark?
No
Ignition system problem. Refer to Section 4.5.
Yes
Is the air cleaner dirty or plugged?
No
Engine problem. See the engine service manual.
Yes
Clean/replace air cleaner elements


B
Does unit lack power or operate erratically?
No
Does unit stop while master switch is in AUTO and remote control system is disconnected?
Yes
Disconnect and reconnect the harness to verify a good connection. Repair/replace harness.
Yes
Go to C
No
Unit is okay
No
Does unit stop after running normally?
Yes
Go to E

Lacks Power or Runs Erratically

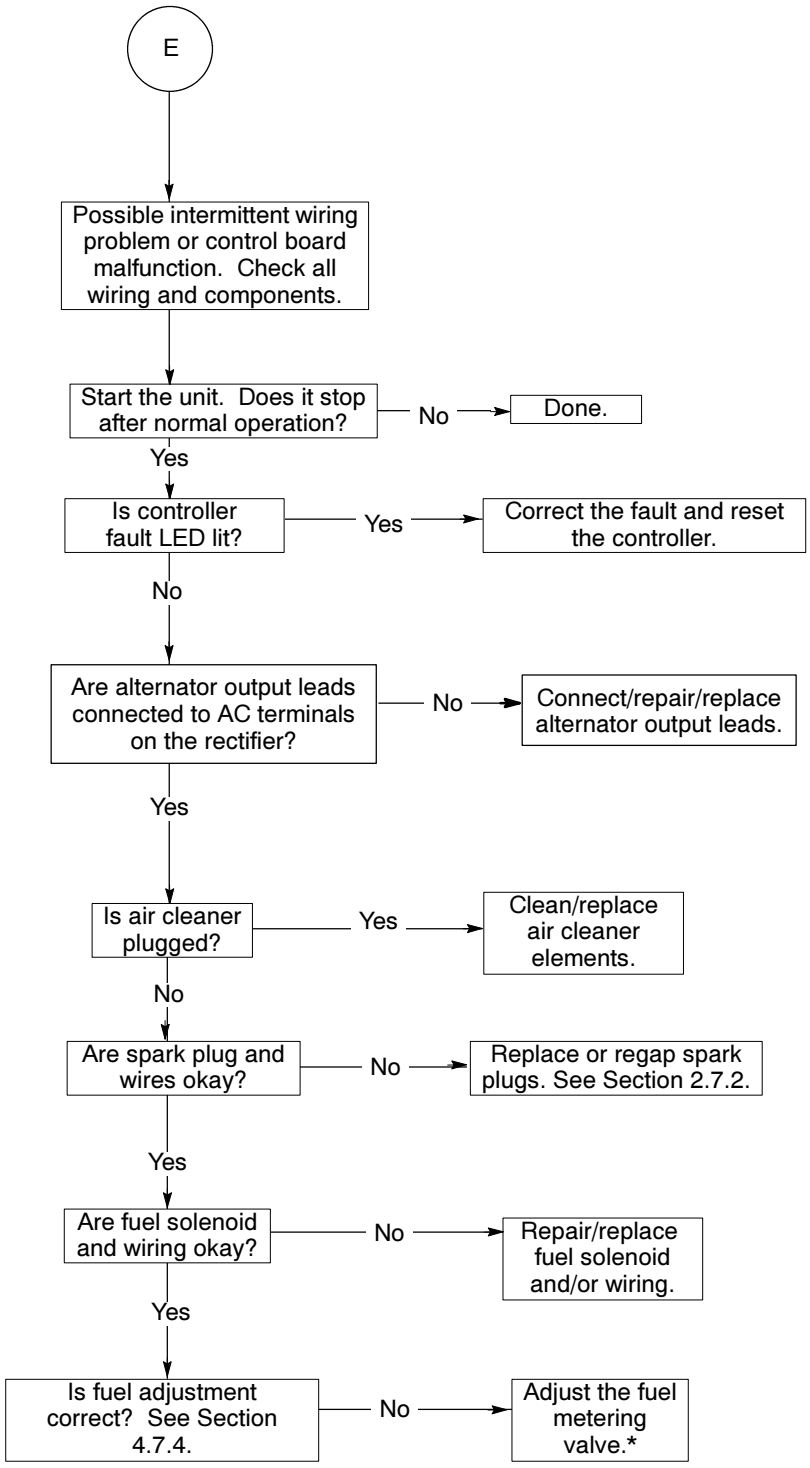


Lacks Power or Runs Erratically, continued



* Adjusting the fuel system may void the emissions certification. Only trained and authorized service technicians should adjust the fuel system. Use the test equipment specified in the test procedure in Section 4.7.

Unit Stops After Normal Operation



* Adjusting the fuel system may void the emissions certification. Only trained and authorized service technicians should adjust the fuel system. Use the test equipment specified in the test procedure in Section 4.7.4..

Use the troubleshooting procedures in Section 3 and the wiring diagrams in Section 7 to diagnose problems with the generator set operation. For controller operation and test, refer to Section 5 of this manual and to the remote control manual. Use the procedures in this section to check generator components for proper operation and adjust components when necessary. See the service views in Section 1.4 for component locations.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

4.1 Operating the Generator Set Outside the Enclosure

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

⚠ 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

Fire.
Can cause severe injury or death.

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

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

The generator set is mounted on rails inside the enclosure. Follow the instructions in Section 2.3 to open the enclosure, disconnect the generator set, and slide it out for removal or service.

4.1.1 Test Equipment

The following test equipment, available from Kohler Co., is required to run the generator set outside the enclosure:

- Generator set fixture
- Cover plate
- Exhaust pipe extension with test port
- Oxygen sensor (for testing the fuel system)
- Silencer
- Control board
- Extended wiring harness

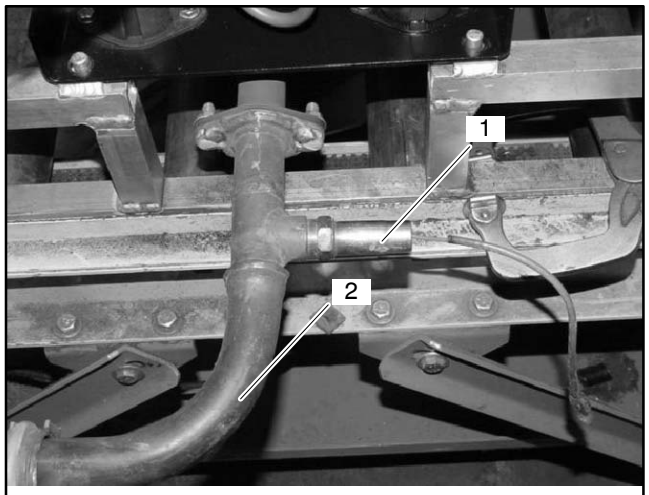
See Maintenance and Service Parts in this manual for the part numbers for the test equipment.

Before running the generator set outside the enclosure:

- Set the generator set on the fixture, aligning the generator set mounting holes with the four pins on the fixture.
- Place the cover over the top of the generator to prevent contact with rotating parts. Tie the cover to the generator set's lifting eye and one of the bolts that secure the rectifier cover.
- Attach the exhaust pipe extension to the silencer. Verify that the test port is plugged or install the oxygen

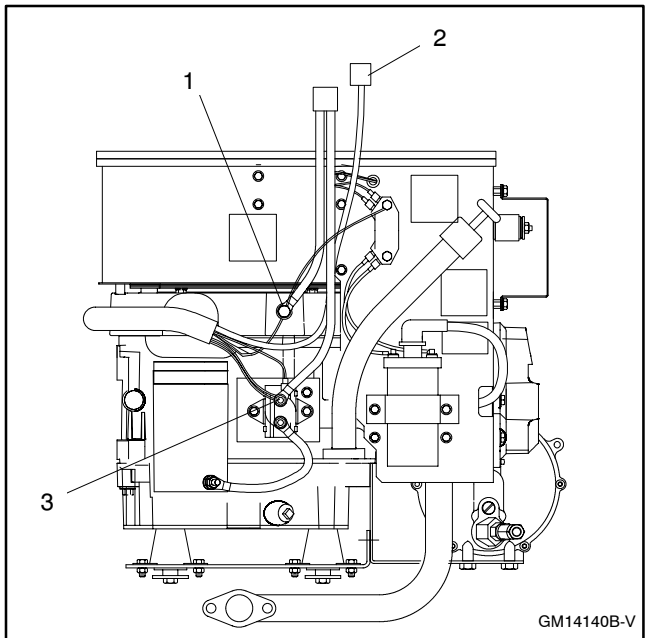
sensor in the port if needed for fuel adjustments. See Figure 4-1.

- Connect a silencer to the output end of the exhaust pipe extension.
- Connect the engine/controls interface connector P4 to the control board. Use the extension harness if the extra length is needed. See Figure 4-2.
- Connect a starting battery to the terminals shown in Figure 4-2. Connect the negative lead last.



1. Oxygen sensor
2. Exhaust tube GM23580

Figure 4-1 Exhaust Tube and Oxygen Sensor



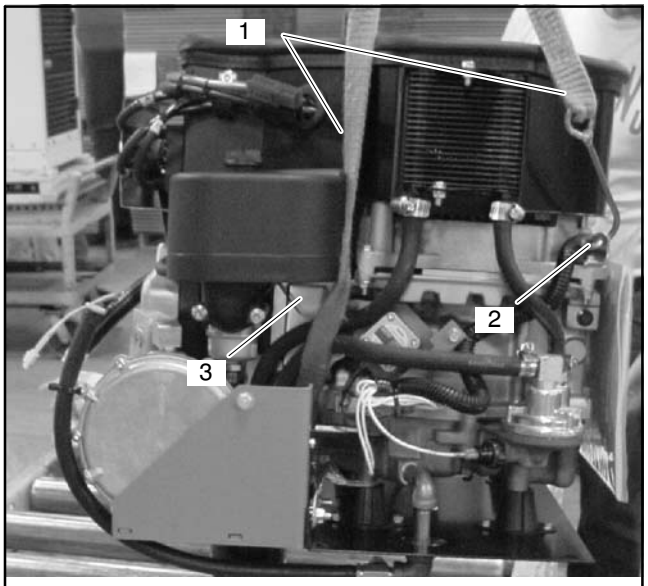
1. Battery negative (-) connection to ground
2. Engine/controls interface connector P4
3. Battery positive (+) connection to starter relay

Figure 4-2 Connections

4.1.2 Lifting the Generator Set

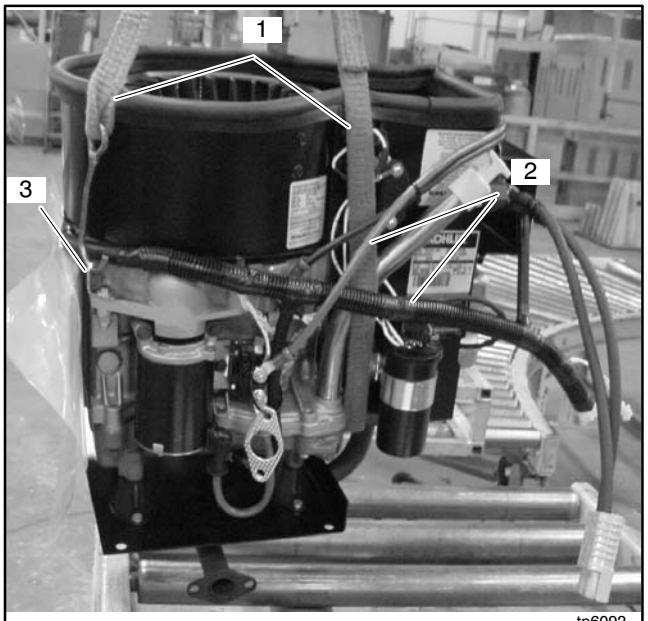
The generator set weighs approximately 68 kg (150 lbs.). Use adequately rated equipment to lift the generator set.

The generator set has two lifting eyes. Connect lifting hooks to the two lifting eyes *and* use a strap to support the other end of the generator set. Thread the strap under the wiring harnesses and over the hoses as shown in Figure 4-3 and Figure 4-4, taking care not to damage the throttle linkage.



1. Straps
2. Lifting eye
3. Throttle linkage location

Figure 4-3 Lifting the Generator Set, Air Cleaner Side

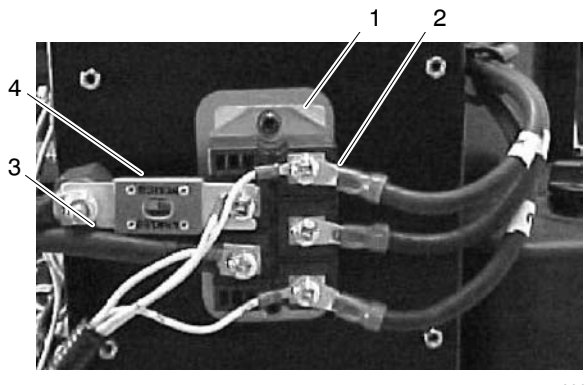


1. Lifting straps
2. Wiring harnesses
3. Lifting eye

Figure 4-4 Lifting the Generator Set, Starter Side

4.2 Circuit Protection

A fuse on the output (DC) side of the voltage rectifier interrupts the generator output in the event of a 50% overload or a short circuit in the wiring between the generator and the load. See Figure 4-5. Replace the fuse if it blows. See Maintenance and Service Parts in the Introduction of this manual for the fuse part number.



1. Voltage rectifier
2. AC input side (stator leads)
3. DC output side (output leads)
4. Output fuse

Figure 4-5 Voltage Rectifier and Fuse

4.3 Voltage Rectifier

The voltage rectifier converts AC voltage from the alternator into DC voltage. Figure 4-6 shows the rectifier schematic.

If there is no DC voltage at the output connector, check the fuse (see Figure 4-5). Test for output at the rectifier to check the output leads. Check for AC voltage into the rectifier. If there is AC voltage coming into the rectifier, but no DC output, replace the rectifier. The voltage rectifier has no adjustments.

The microprocessor controller monitors the DC output voltage. To verify accurate voltage control, increase and decrease loads while measuring DC output voltage at the output connector. The output voltage should remain fairly steady at the rated voltage as the engine speed increases or decreases in response to load changes.

If voltage falls below the rated value as load increases or decreases, check for the following problems:

- Inadequate fuel supply
- Fuel solenoid malfunction
- Fuel metering valve malfunction
- Stepper motor/throttle linkage binding

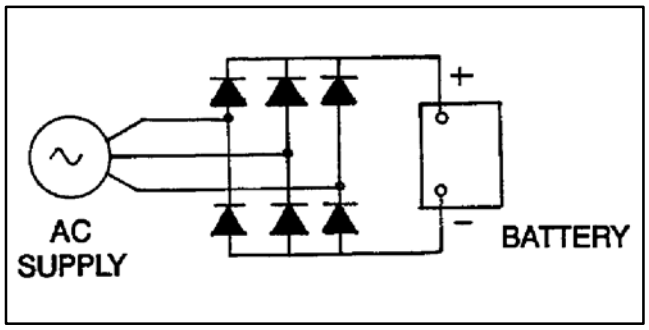


Figure 4-6 Rectifier Schematic

4.4 Electronic Governor

The system uses a variable-speed generator to maintain the rated output voltage with varying loads. The governor system regulates the engine speed with changing loads.

The governor system consists of an electronic governor control and an electromechanical actuator. Leads AC1 and AC2 provide a speed (frequency) signal from the AC side of the voltage rectifier (terminals E and C) to the control board. The control board signals the actuator, which controls the throttle and hence the engine speed, to maintain the generator nominal output voltage.

4.4.1 Governor Checks

The factory-set electronic governor does not normally require adjustment. If the engine operates erratically, check the following connections and conditions *before* adjusting the governor:

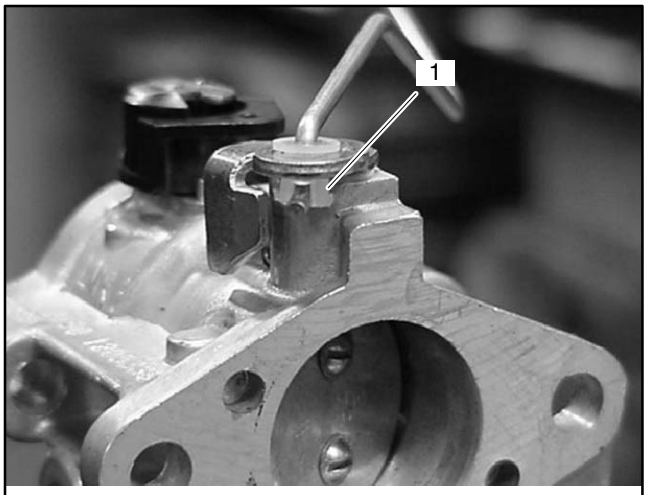
- Check the electrical connections and wire harnesses for clean, tight connections.
- Check the speed-sensing connections at rectifier terminals C and E. Poor connections may cause an erratic signal, which could cause the unit to shut down.
- Check the electrical ground connections.
- Check the battery connections. Verify that the connections are clean and tight.
- Check for a good positive 12-volt DC supply. Also check if the positive voltage supply is unstable or below 8 volts DC making the control unit function erratically.
- Check for stepper motor/throttle shaft linkage binding or wear. The linkage arm and lever arms must not bind or rub against other components while moving.
- Verify that the governor stepper motor operates with steady and smooth movement. If the movement of the stepper motor is erratic or large changes in movement occur, check for shaft misalignment, linkage binding, or loose or broken wiring or plug connections.
- If the throttle linkage binds or otherwise does not operate smoothly, check the bushing shown in Figure 4-7 and Figure 4-8. The bushing has a longer slot on one side that must be oriented as shown in Figure 4-7.
- Check the carburetor for dirt, grime, or misadjustment. Also, check the idle-adjustment screw. The screw should not prevent the throttle plate from completely closing. Also, check the throttle linkage for any binding, dirt, damage, etc.

Note: Often hunting/surging problems thought to be caused by the governor are actually linked to carburetor adjustment. Check the carburetor adjustment before adjusting the governor.

The fuel shutoff solenoid deenergizes and the generator set shuts down with the following electronic governor faults:

- Loss of pickup while running (throttle moves to closed position)
- Engine overspeed
- Break of fuel shutoff solenoid lead
- Loss of DC power to governor assembly
- Break of stepper motor leads (erratic performance)
- Actuator linkage failure (erratic performance)

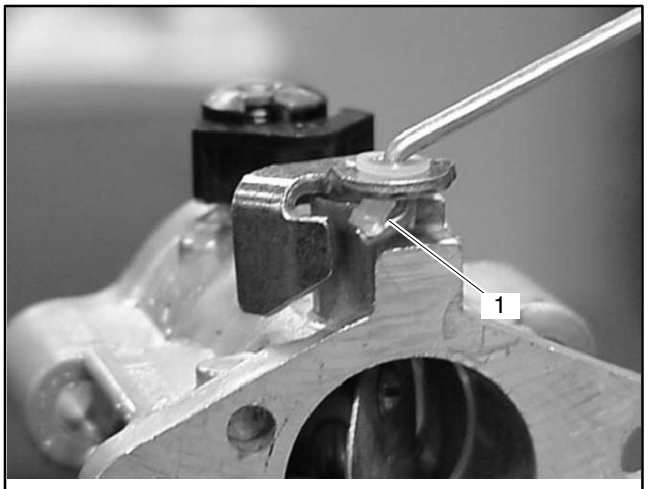
If none of the above conditions exist, proceed to Section 4.4.2, Stepper Motor Check.



tp6092

1. Bushing in the correct orientation, with long slot facing the viewer

Figure 4-7 Correct Bushing Rotation



tp6092

1. Bushing in the wrong orientation

Figure 4-8 Incorrect Bushing Rotation

4.4.2 Stepper Motor Check

Use the following procedure to test the operation of the governor stepper motor.

Stepper Motor Test Procedure

1. Stop the generator set and disconnect the battery.
2. Manually move the governor linkage fully counterclockwise (open throttle). See Figure 4-10.
3. Reconnect the battery. The stepper motor should move clockwise to the closed-throttle position with a noticeable clicking sound. If the stepper motor does not stay in the closed-throttle position, replace the stepper motor.

Only two stepper motor leads of each coil group are utilized (BLACK-YELLOW and RED-WHITE). The resistance per phase is 38.5 ohms. See Figure 4-9.

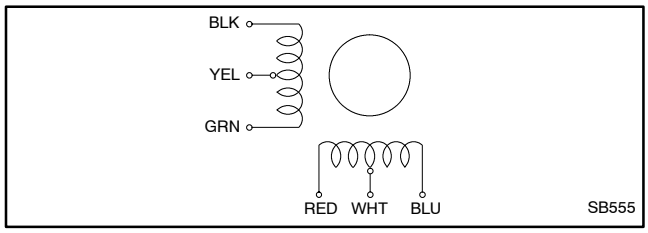
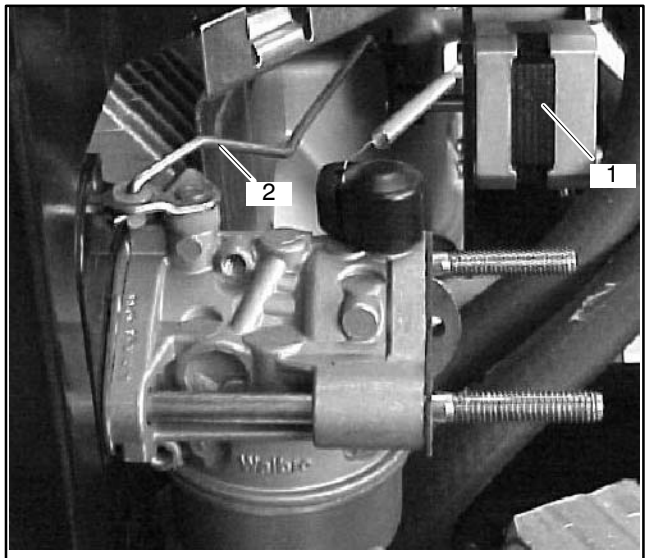


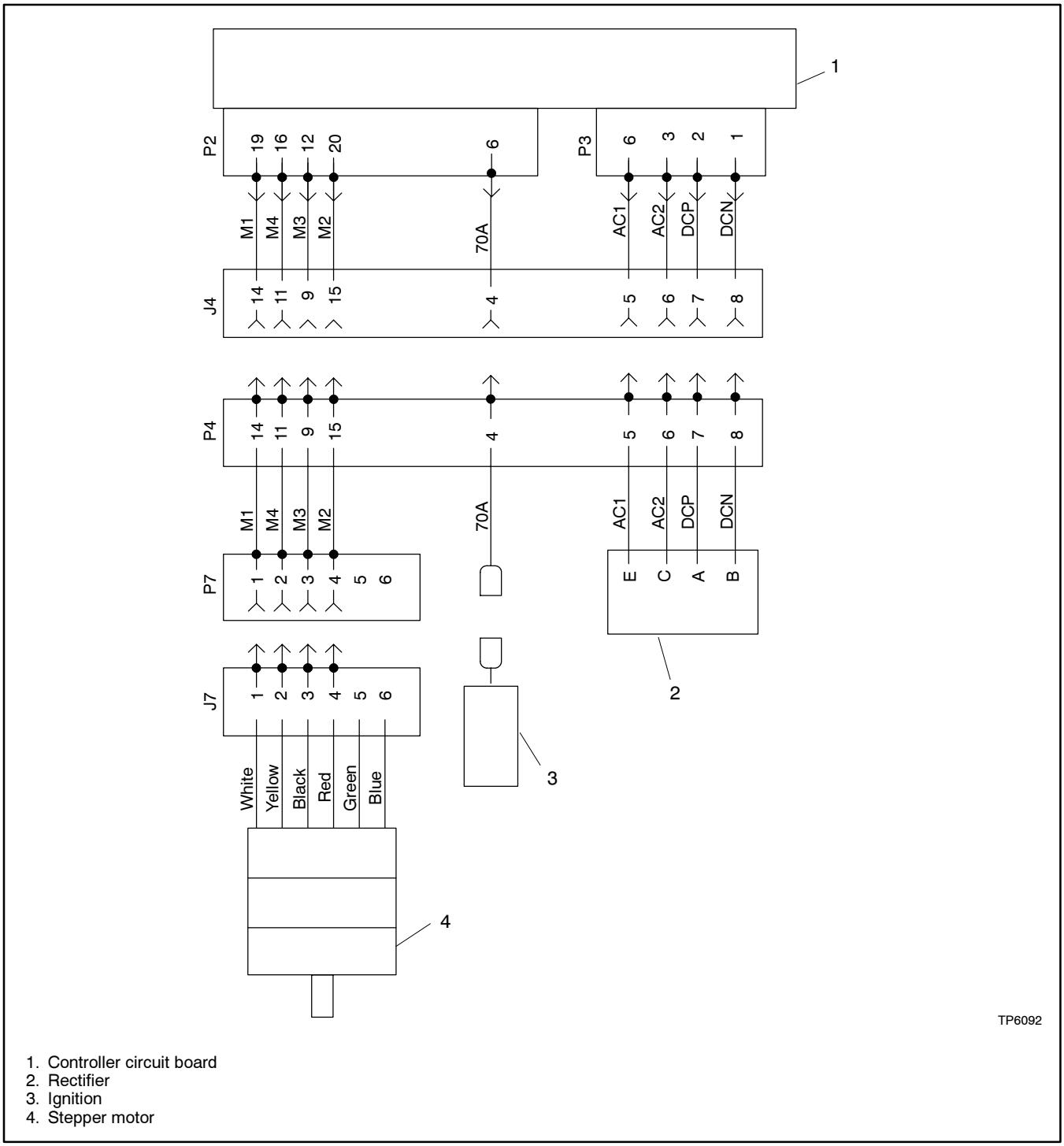
Figure 4-9 Actuator Coil Group



1. Electronic governor stepper motor
2. Carburetor throttle linkage

TP5632721

Figure 4-10 Stepper Motor Throttle Linkage



1. Controller circuit board
2. Rectifier
3. Ignition
4. Stepper motor

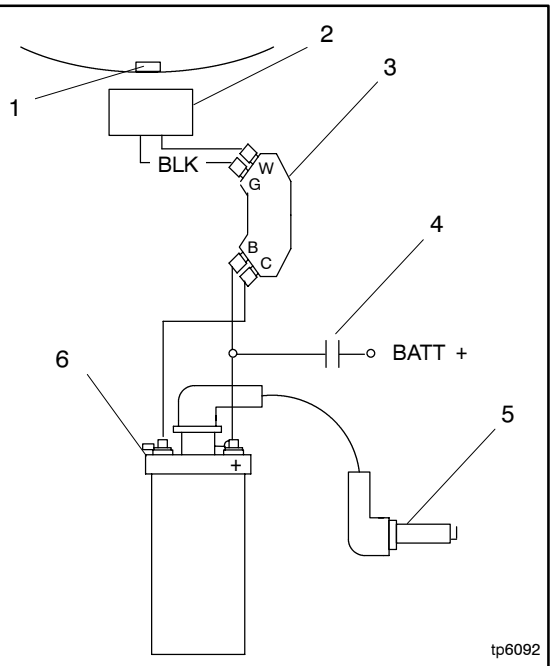
Figure 4-11 Electronic Governor Wiring

4.5 Ignition System

The breakerless ignition system includes a battery ignition coil, electronic ignition module, and an ignition trigger coil. See Figure 4-12. The ignition module electronically interrupts battery voltage to the primary coil winding, inducing high voltage in the secondary winding and producing the spark at the spark plug.

Check the continuity of the spark plug lead. Check the condition of the lead insulation and spark plug boot. Refer to Section 2.7.2 for additional spark plug information.

Figure 4-13 shows some ignition specifications.



1. Flywheel magnet
2. Ignition trigger
3. Ignition module
4. Run relay (not replaceable)
5. Spark plug
6. Ignition coil

Figure 4-12 Ignition System

Item	Specification
Trigger gap	1.02 mm (0.040 in.)
Trigger coil resistance: Part no. GM17721 Part no. GM23592	 190–205 ohms 320–360 ohms
Timing	28° BTDC
Spark plug gap	0.76 mm (0.030 in.)

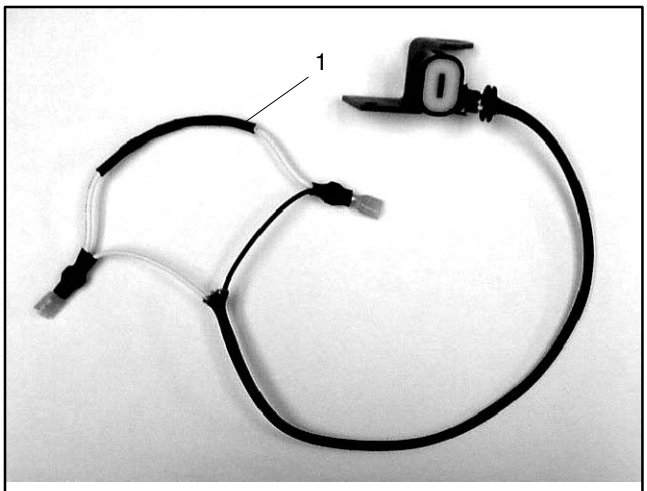
Figure 4-13 Ignition System Specifications

4.5.1 Ignition Trigger

Two types of trigger coils are used. One type, part number GM17721, has a resistor connected to the trigger coil cable. See Figure 4-14. Use trigger coil GM17721 only with ignition module 278903. The other coil, GM23592, has no resistor in the wiring. Use coil GM23592 only with ignition module GM23591, which has an internal resistor. The ignition module part number is stamped on the back of the module. See Section 4.5.2 for more information on ignition modules.

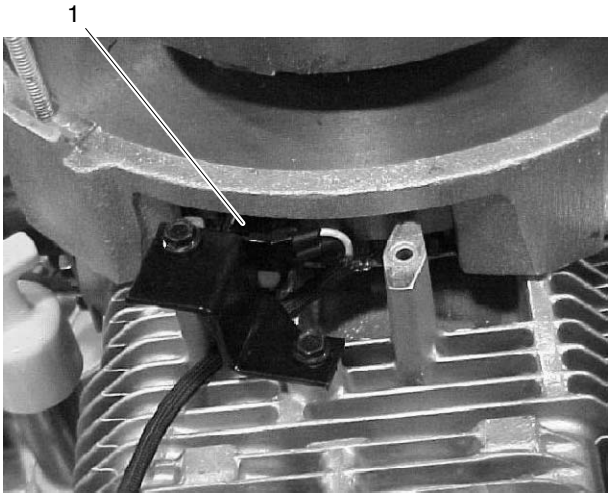
Use an ohmmeter to check the trigger coil resistance and compare the measured value to the resistances shown in Figure 4-13. An open coil will produce a reading of 470 ohms. If the trigger coil is open or shorted, replace it.

Use a feeler gauge to check the gap between the ignition trigger coil and the flywheel. See Figure 4-15 and Figure 4-16. Verify that the gap is set to 1.02 mm (0.040 in.).



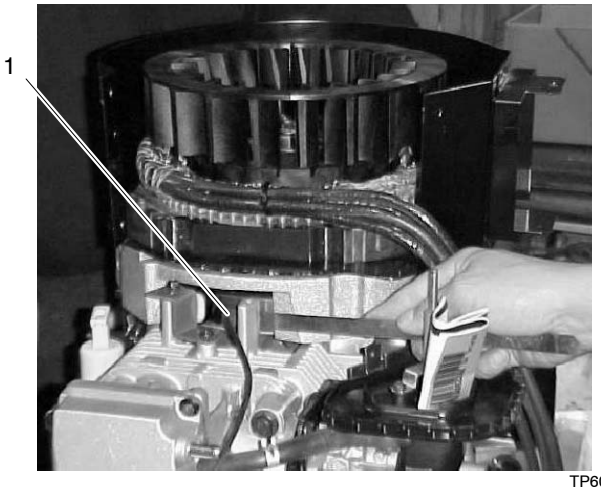
1. Resistor, used on GM17721 only.

Figure 4-14 Trigger Coil GM17721. (Use with ignition module 278903.)



1. Ignition trigger

Figure 4-15 Ignition Trigger



1. Ignition trigger

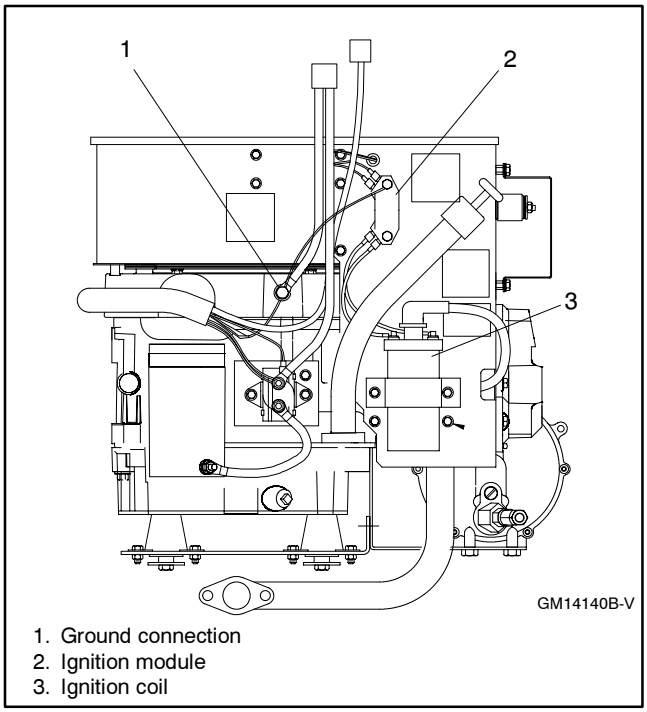
Figure 4-16 Ignition Trigger Adjustment

4.5.2 Ignition Module

Use an ohmmeter to measure the resistances across the ignition module terminals. See Figure 4-17 and Figure 4-18. The ignition module part number is stamped on the back of the module. If the measured resistances do not match those shown in Figure 4-18, replace the module.

Note: The ignition module must be matched with the appropriate trigger coil. See Section 4.5.1 for information.

Apply a thin coating of thermal compound between the mounting pad and the module to ensure good heat transfer. Connect the ground wire to the system ground.



1. Ground connection
2. Ignition module
3. Ignition coil

Figure 4-17 Ignition Components

Terminals	Ohmmeter Indication
Part Number 278903	
W-G	10 kOhms
B-Ground	850 ohms
C-Ground	Diode check: Open circuit in one direction, approximately 2.7 MOhms with the test leads reversed.
Part Number GM23591	
W-G	450 Ohms
B-Ground	850 ohms
C-Ground	Diode check: Open circuit in one direction, approximately 2.7 Mohms with the test leads reversed.

Figure 4-18 Ignition Module Resistances

4.5.3 Ignition Coil

Use an ohmmeter or a test lamp to check the ignition coil primary winding. Measure the resistance across the positive (+) and negative (-) terminals and from one terminal to ground. If the test shows that the winding is open or grounded, replace the ignition coil.

Disconnect the high tension lead from the engine spark plug and connect it to a test spark plug. Disconnect lead C from the ignition module. Move the generator set master switch to START. Ground lead C and watch the test plug for sparks. If no sparks are produced the ignition coil secondary winding is faulty. Replace the ignition coil.

4.6 Starter

Check the starter if the generator set engine does not crank.

Check the battery voltage and connections before proceeding. Check for a locked rotor or other fault condition that may have shut down the unit. Correct the fault condition and reset the controller to clear a fault shutdown.

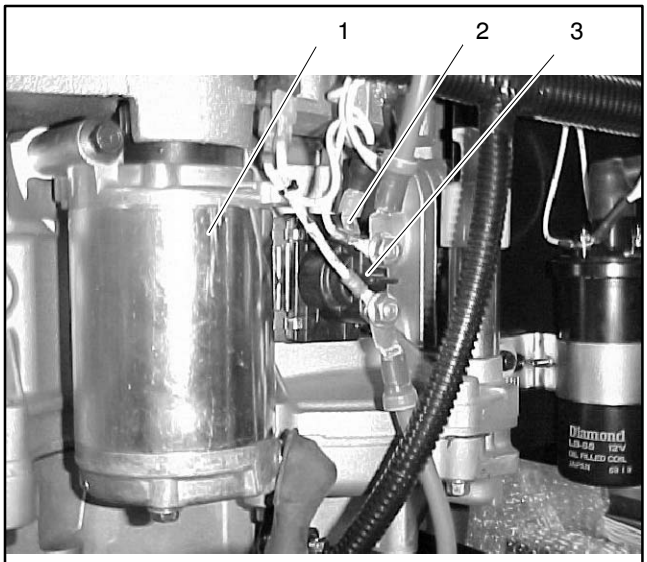
Note: Always check the wiring and connections before replacing components.

The crank cycle attempts to start three times, cranking for 20 seconds and then resting for 5 seconds between attempts. LED 7 on the control board lights to indicate that cranking is energized. LED 5 indicates an overcrank shutdown; reset the controller if LED 5 lights during these tests. See Section 5.2.3.

Move the generator set master switch to Start and check for 12 VDC to the starter relay on lead 71 during the crank attempt. See Figure 4-19. If there is no voltage to the starter during the crank cycle, check the connections. Then check for voltage from the controller at J4-1 and P2-1 (see the wiring diagram, Section 7). If there is no voltage at P2-1 during cranking, replace the control board.

To test the starter relay, check for 12 VDC to the starter motor during the crank attempt. If there is voltage to the relay but not to the starter motor, check the connection between the relay and the starter motor. If the connection is good, replace the relay.

If there is voltage to the starter motor but the starter motor does not crank the engine, refer to the Engine Service Manual for starter service information. The generator set engine uses an inertia-drive electric starter.



1. Starter motor
2. Lead 71 (energized during cranking)
3. Starter relay (crank relay)

Figure 4-19 Starter Components

4.7 Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

⚠ WARNING

Fire.
Can cause severe injury or death.

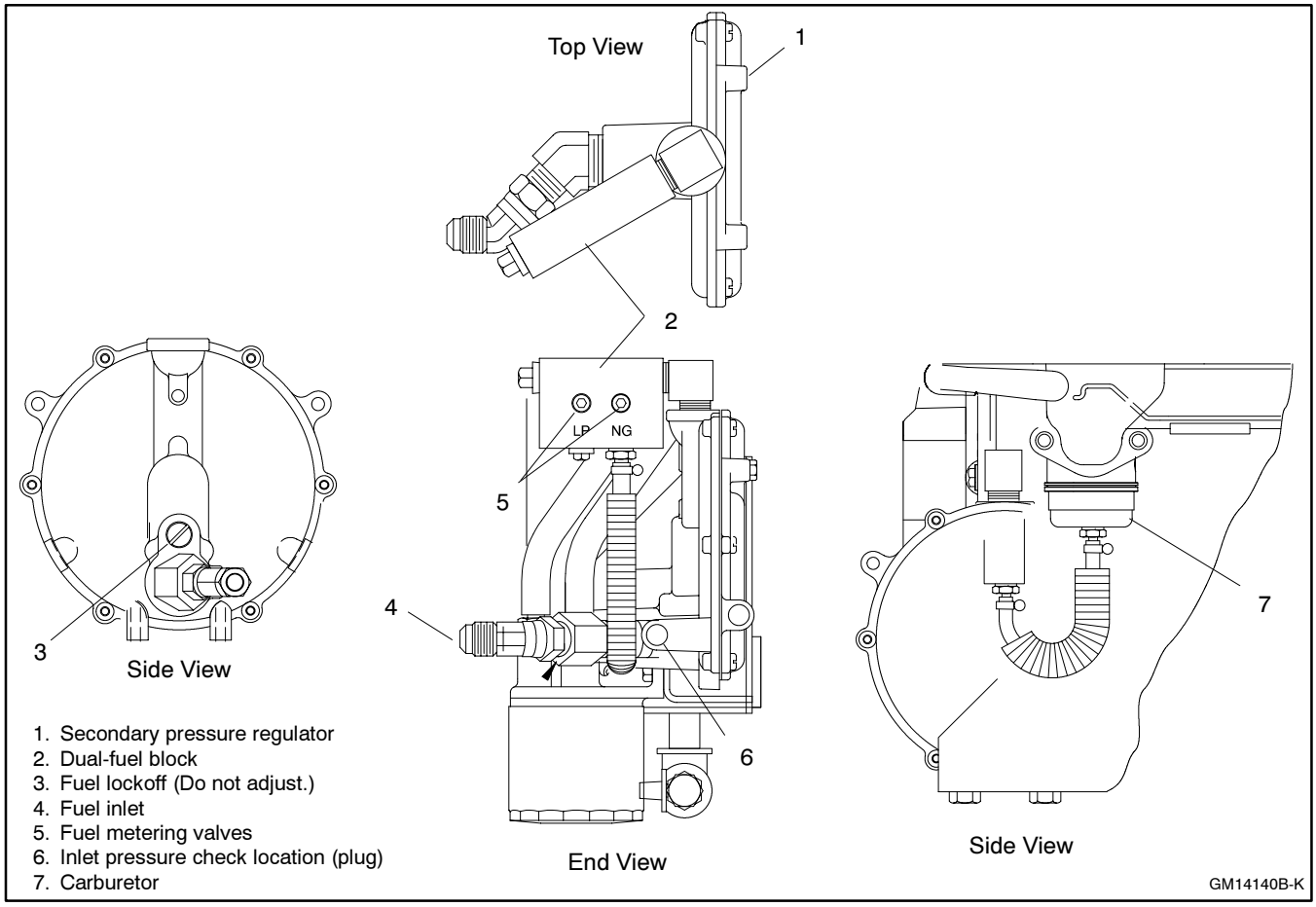
Do not smoke or permit flames or sparks near fuels or the fuel system.

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

4.7.1 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).

Do not try to adjust the fuel pressure, fuel mixture, or engine speed using the fuel lock-off. See Figure 4-20 for the location of the fuel lockoff. The fuel lock-off prevents fuel flow when the engine is not operating.



1. Secondary pressure regulator
2. Dual-fuel block
3. Fuel lockoff (Do not adjust.)
4. Fuel inlet
5. Fuel metering valves
6. Inlet pressure check location (plug)
7. Carburetor

Figure 4-20 Fuel System

Checking the Fuel Pressure

Use a gauge or manometer to check the fuel pressure at the secondary regulator inlet. See Figure 4-20. 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.

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

4.7.2 Fuel Solenoid Valve

The fuel solenoid valve is located on the outside of the enclosure. It is a 12 VDC valve energized by lead 70 when the generator set controller is in the crank or the run mode. The fuel solenoid valve is supplied with the enclosure.

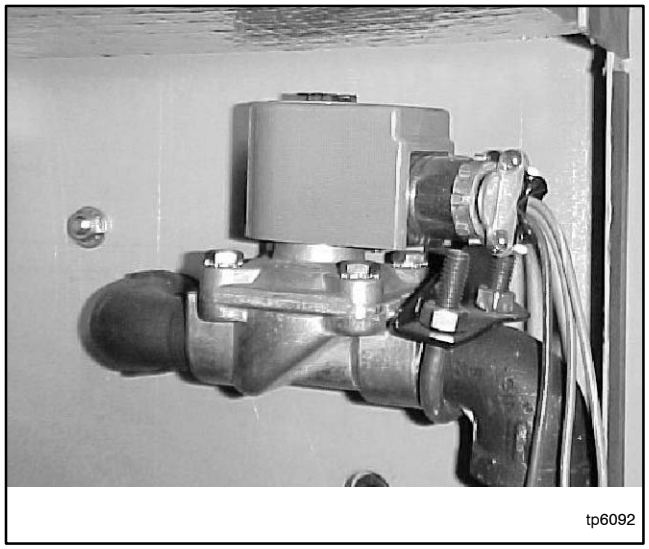


Figure 4-21 Fuel Solenoid Valve

4.7.3 Fuel Conversion

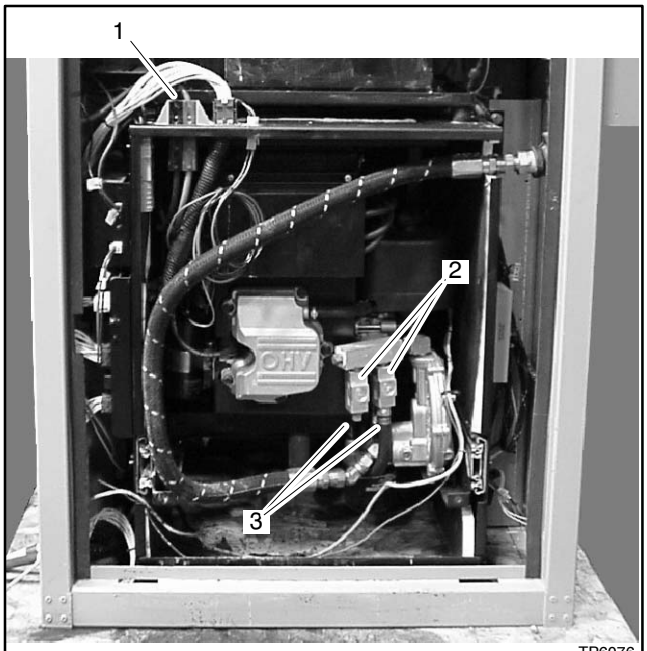
Two fuel metering valves allow field-conversion between natural gas and LP vapor. Have the fuel conversion procedure performed by trained and qualified personnel.

Note: Do not adjust the fuel metering valves. The fuel metering valves are factory-sealed to comply with applicable emission standards and to provide the best possible hot and cold starting.

The manufacturer ships the generator set with the fuel system set for natural gas. To convert to LP gas, use the following procedure to move the fuel line from the natural gas inlet port to the inlet port in the LP fuel metering valve (or from the LP inlet to the natural gas inlet to convert from LP to natural gas). See Figure 4-22 for the LP and natural gas fuel connection and fuel block locations. Also see the service views in Section 1.4.

Fuel Conversion Procedure

1. Remove the enclosure front door and the generator compartment front panel to access the fuel system.
2. Move the generator set master switch to the STOP position.
3. Disconnect the battery at the quick-disconnect plug.
4. Turn off the fuel supply by closing the upstream valve outside of the enclosure.
5. Remove the hose clamp and fuel line hose from the fitting in the fuel metering valve.
6. Remove the hose fitting from the natural gas (or LP) inlet in the fuel metering valve.
7. Remove the plug from the LP (or natural gas) inlet. Clean the plug with a dry cloth or brush, apply fresh pipe sealant, and install it into the natural gas (or LP) inlet.
8. Clean the hose fitting with a dry cloth or brush, apply fresh pipe sealant, and install it into the LP (or natural gas) inlet.
9. Slide the hose onto the hose fitting and secure it with the clamp.
10. Turn on the fuel supply and check for leaks using a gas leak detector.
11. Reconnect the battery harness.
12. Install the generator compartment front panel. Set the generator set master switch to the AUTO or center position to return the generator set to standby service.
13. Replace the enclosure door.



1. Battery harness connector
2. Fuel metering valves
3. LP and natural gas inlet ports

Figure 4-22 Fuel System Conversion

4.7.4 Fuel System Recalibration

The fuel metering valves are factory-set to meet emissions requirements and sealed to discourage field adjustments. If the fuel system requires recalibration, only trained, authorized service technicians may adjust the fuel metering valves. Always use an oxygen sensor and an exhaust tube with an oxygen sensor port, available from the generator set manufacturer, when adjusting the fuel metering valves.

Note: Changing the fuel system adjustments may void the emissions certification.

Fuel system recalibration requires the following equipment, which is available from Kohler Co.:

- Oxygen sensor
- Test exhaust pipe with oxygen sensor port

See Maintenance and Service Parts in this manual for the equipment part numbers.

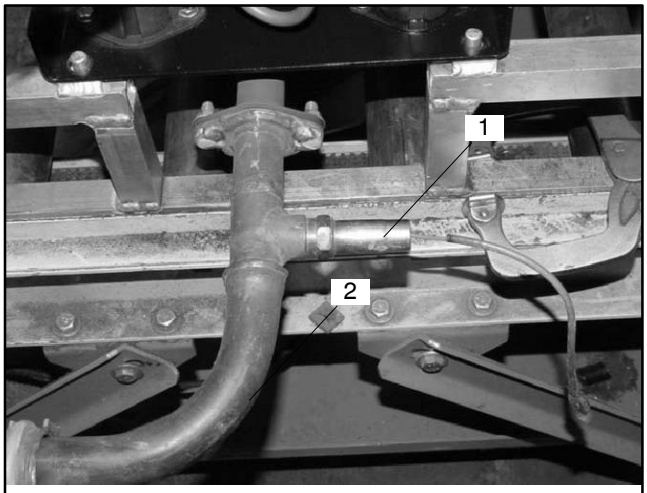
Follow the instructions in Section 4.1 to remove the generator set and operate outside the enclosure.

Fuel System Recalibration Procedure

1. Run the generator set at full load and check the oxygen sensor reading. At full load, the oxygen sensor output voltage should be between 0.75 and 0.85 VDC.

2. If adjustment is required, remove the seal on the fuel metering valve and adjust the valve to obtain an oxygen sensor reading between 0.75 and 0.85 VDC. See Figure 4-20 for the fuel metering valve location.

3. Reseal the valve after adjustment.



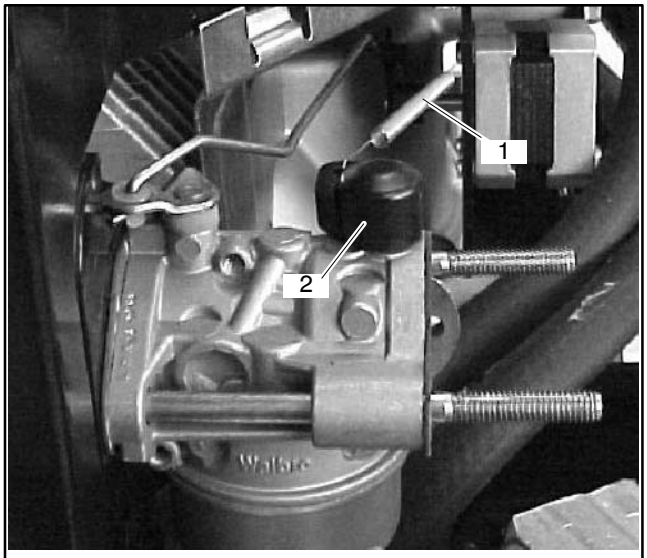
1. Oxygen sensor
2. Exhaust tube GM23580

Figure 4-23 Exhaust Tube and Oxygen Sensor

4.7.5 Choke

Some engines are equipped with a choke, which is held open at all times by the choke spring shown in Figure 4-24. If the engine is equipped with a choke, identified by the knob shown in Figure 4-24, check that the spring is attached and holding the choke open.

Generator sets built after June, 2001, do not have a choke assembly and, therefore, do not require the spring.



1. Choke spring
2. Choke knob

Figure 4-24 Choke Assembly (not included on all engines)

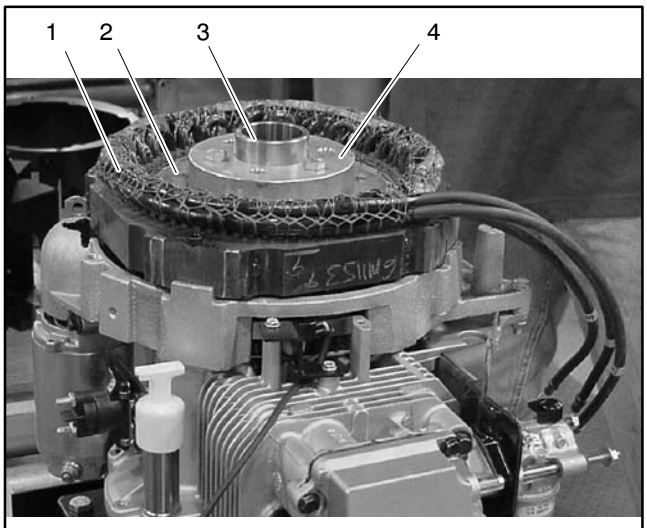
4.8 Alternator

The alternator is connected directly to the engine. The alternator uses a permanent magnet rotor and a 3-lead 3-phase stator. See Figure 4-25.

4.8.1 Stator

The stator contains coils of wire laid in a laminated steel frame. The three stator leads are connected together in a wye configuration. See Figure 4-26.

The stator leads supply voltage to the voltage rectifier and the speed-sensing circuit. Before testing, inspect the stator for heat discoloration, visible damage to housing lead wires, exposed coil windings, or exposed areas of frame laminations. Use an ohmmeter to check the continuity of the stator windings using the following procedure.



1. Stator
2. Rotor
3. Flywheel taper
4. Spacer

Figure 4-25 Alternator (shroud and fan removed to show components)

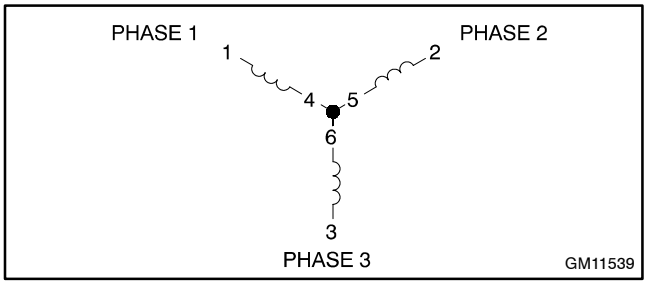


Figure 4-26 Stator Windings

Stator Test Procedure

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

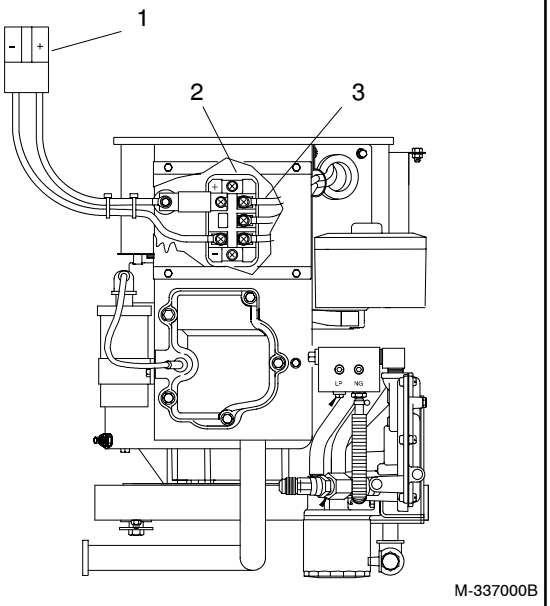
2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Disconnect output connector P8 from the load. See Figure 4-27.

4. Disconnect the stator leads from the voltage rectifier. See Figure 4-27.

   Note: Disconnect all stator leads from the voltage rectifier before performing the test.

5. Set the ohmmeter on R x 1 scale. Touch the red meter lead to the black lead and adjust the ohmmeter to show zero ohms.



1. Output connector P8
2. Voltage rectifier
3. Stator leads (AC Side)

Figure 4-27 Stator Lead Connections to Rectifier

6. Check the cold resistance of the stator windings by connecting the meter leads to stator leads 1 and 2, 1 and 3, and 2 and 3. See Figure 4-28 for stator winding resistance values. Replace the stator if any of the resistance checks reveal an open winding. If the resistance test is not conclusive, perform a megohmmeter test on the stator as described in step 7.

   Note: Most ohmmeters do not measure very small resistance values accurately. Check for continuity of the windings with no shorts to ground. The stator is functional if the resistance reading (continuity) is low and there is no evidence (heat discoloration) of shorted windings.

Generator Set Voltage Rating, VDC	Stator Resistance, Ohms
36	0.014
48	0.024
96	0.054

Figure 4-28 Stator Resistance

7. If the resistance test in the previous step is not conclusive, perform a megohmmeter test to determine whether the stator is shorted to ground.

   a. Use a megohmmeter to apply 500 volts DC to any stator lead and the stator's frame. Follow the instructions of the megohmmeter's manufacturer when performing this test. A reading of approximately 500 kOhms (1/2 MOhm) or higher indicates that the stator is in good condition. A reading of less than approximately 500 kOhms (1/2 MOhm) indicates deterioration of the winding insulation and possible current flow to ground.

   b. If the megohmmeter reading is less than 500 kOhms, replace the stator.

4.8.2 Rotor

The rotor uses permanent magnets. There are no tests or field adjustments for the rotor.

4.9 Fault Shutdown Switches

Check the continuity of the high engine temperature (HET) and low oil pressure (LOP) switches. Check for loose connections and open or short circuits in the connecting wires before replacing the switches.

High Engine Temperature (HET) Switch

The HET switch is normally open. Shut down the generator set and allow the engine to cool. Use an ohmmeter to measure the resistance from pin P4-12 to ground. The ohmmeter should indicate an open circuit. Any other reading indicates a short; replace the HET switch.

Low Oil Pressure (LOP) Switch

The normally closed LOP switch opens when the engine oil pressure reaches the normal operating level and closes if the oil pressure drops below a preset minimum. Use an ohmmeter to check the continuity between pin P4-13 and ground. Verify that the switch is closed while the engine is stopped. Start the generator set and check that the switch opens approximately 5 seconds later. If the switch does not open after the engine reaches normal operating speed, check the oil level and test for leaks in the lubrication system before replacing the LOP switch.

4.10 Control Board Replacement

NOTICE

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

If the controller tests in Section 5 or the troubleshooting procedures in Section 3 indicate that the control board needs to be replaced, follow these guidelines:

- Keep the new board in its protective wrapping until installation.
- Wear a grounding strap while handling the circuit board to prevent damage to the circuit board components.
- Check that all plug connections are secure.

The new circuit board must be calibrated after installation. Use the following procedure to calibrate the board.

Calibration Procedure

1. Connect a voltmeter to the output terminals of the voltage rectifier.
2. Turn R37 on the circuit board fully clockwise.
3. Start the generator set with no load.
4. Adjust R37 to obtain the voltage output shown in Figure 4-29.

Generator Set Model	Measured Output Voltage, VDC
36 Volt	39
48 Volt	52
96 Volt	104

Figure 4-29 Output Voltages, VDC

Notes

This section describes troubleshooting procedures for the generator set control board, shown in Figure 5-1. Refer to the operation manual for operating instructions. Refer to the remote controller manufacturer's instructions for troubleshooting and servicing remote controllers connected to the generator set.

Control circuit boards GM11783 and GM14243 are not interchangeable. However, control circuit board GM17820 can be used to replace either GM11783 or GM14243.

5.1 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 7 to assist in the troubleshooting procedure.

5.1.1 Starting Sequence

Placing the generator set master switch in the RUN position starts the generator set locally. With the generator set master switch in the AUTO position, momentarily closing contacts P6-5 and P6-6 starts the generator set remotely.

The crank relay energizes, activating the starter motor, SM. The hourmeter, ignition module, coil, and gas valve receive power.

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

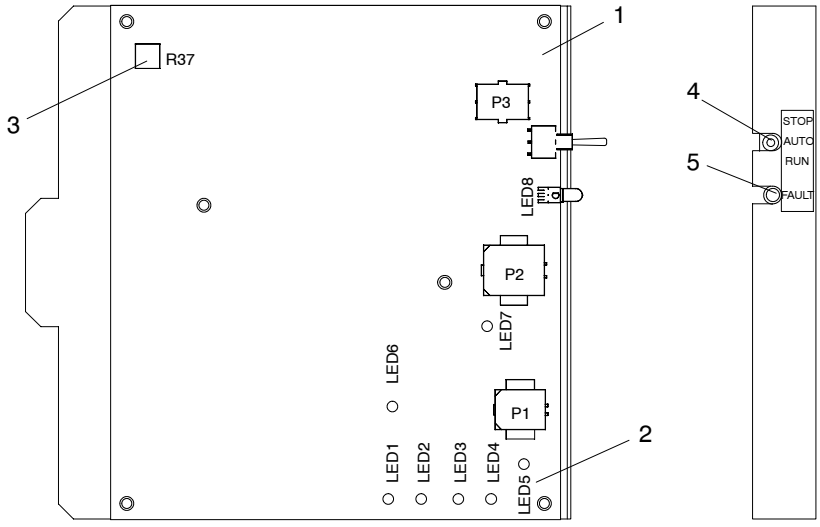
5.1.2 Running Sequence

Leads AC1 and AC2 from the AC side of the voltage rectifier provide speed sensing signals to the control board.

Note: The generator set shuts down if the controller does not obtain AC output within 1 second after engine start (locked rotor shutdown).

5.1.3 Stopping Sequence

Moving the generator set master switch to the stop position or closing a remote contact between pins P6-6 and P6-7 (and opening P6-5 and P6-6) deenergizes the run relay and stops the generator set.



1. Control circuit board
2. LED locations
3. Voltage adjustment pot
4. Generator set master switch, 3-position
5. Common fault indicator, LED8

Figure 5-1 Controller Board

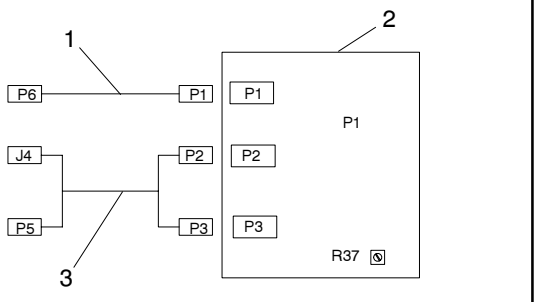
5.2 Control Connections

Wiring harnesses connect the generator set control board to the system remote controls and the engine. Figure 5-2 shows the wiring harness connections to the control board. See the wiring diagrams in Section 7 for pinouts and connection details. Figure 5-3 defines the abbreviations used in the wiring diagrams.

5.2.1 Generator Set Master Switch

Some models use a 3-position generator set master switch. Set the switch to the AUTO position for remote operation. Set both the generator set master switch and the remote switch to the STOP or OFF position and disconnect the engine starting battery before servicing the generator set.

Other models use a momentary start/stop generator set switch that returns to the center position when released. Be sure to set the remote switch to the OFF position before servicing the generator set. Hold the generator set master switch in the STOP position while disconnecting the starting battery.



1. Generator set to remote control system interface harness, GM14245
2. Generator set control circuit board
3. Engine interface harness, GM14244

Figure 5-2 Generator Set Control Connections

Abbreviation	Definition
N	Ground
OVC	Overcrank
N/C	Not connected
STT	Start
LOP	Low oil pressure
STP	Stop
OVT	Overtemperature
OVS	Overspeed
DCP	DC output sensing
DCN	DC output sensing
AC1	AC speed sensing
AC2	AC speed sensing
M1	Throttle control
M2	Throttle control
M3	Throttle control
M4	Throttle control
P	Battery
70	Run
71	Crank

Figure 5-3 Pin Abbreviations

5.2.2 Remote Start/Stop Connections

For remote operation, connect a three-wire remote start/stop switch to P6 of the interface harness. To start, open a contact between pins 6 and 7 and close a contact between pins 5 and 6 of connector P6 (see the wiring diagrams). To stop, close the contact between pins 6 and 7 and open the contact between pins 5 and 6.

5.2.3 Status Indicators

Eight LEDs on the generator set control board indicate the system status conditions and fault shutdowns listed in Figure 5-4. Figure 5-1 shows the LED locations.

LED	Indicates	Remote Annunciation
1	Overspeed shutdown	Yes
2	Overtemperature shutdown	Yes
3	Engine running status indicator	Yes
4	Low oil pressure fault shutdown	Yes
5	Overcrank shutdown	Yes
6	Fuel valve energized	No
7	Cranking energized	No
8	Common fault indicator	No

Figure 5-4 Control Board LEDs

5.3 Fault Shutdowns

The generator set shuts down automatically under the fault conditions listed in Figure 5-5 and cannot be restarted until the controls are reset. Correct the fault condition and then reset the controller by placing either the remote control switch or the generator set master switch in the STOP position. The high engine temperature fault automatically resets when the generator set cools.

Refer to the troubleshooting charts in Sections 3 to further diagnose the cause of a fault shutdown.

5.3.1 Control Resetting Procedure (Following Fault Shutdown)

Use the following procedure to restart the generator set after a fault shutdown.

1. Move either the generator set master switch or the remote switch to the STOP position.
2. Correct the cause of the fault shutdown. See the safety precautions at the beginning of this section before proceeding.
3. Start the generator set locally by moving the generator set master switch to the RUN position, or move the master switch to the AUTO position and start the generator set using the remote start switch. Run the generator set to verify that the cause of the shutdown has been corrected.
4. Move the generator set master switch to the STOP position to stop the generator set.
5. Move the generator set master switch to the AUTO position to return to standby operation.

Fault	Description	Fault Condition/Possible Cause
High engine temperature	Shuts down 5 seconds after the fault. When the engine cools, the fault clears and allows the generator set to be started without resetting the controller. The high engine temperature shutdown is inhibited (does not function) during the first 30 seconds after startup.	• Engine reaches shutdown temperature • Very low oil level • Air inlet or outlets blocked • Cooling system malfunction
Low oil pressure	Shuts down 5 seconds after the fault. The low oil pressure shutdown does not function during the first 30 seconds after startup. **Note:** The low oil pressure shutdown does not protect against low oil level.	• Engine oil pressure drops below low oil pressure limit • Very low oil level
Overcrank	Shuts down after 70 seconds of cyclic cranking. The factory sets the circuit board for three starting attempts: crank 20 sec., rest 5 sec., crank 20 sec., rest 5 sec., crank 20 sec., overcrank fault. Overcrank shutdown also occurs in the case of a locked rotor.	• Starting problem • Locked rotor (two seconds without rotation or no AC speed sensor input)
Overspeed	Shuts down immediately if the engine speed exceeds 3750 RPM.	• Engine RPM exceeds 3750 • Loss of speed (AC) sensing

Figure 5-5 Fault Shutdowns

5.4 Fault Shutdown Tests

Verify operation of the controller overspeed, overcrank, low coolant level, low oil pressure, and high engine temperature shutdowns by performing the following tests with the generator set running. Observe the LEDs on the controller circuit board during the tests. Refer to the service views in Section 1.4 for component locations.

Remove the generator set from the enclosure to gain access to the components in the following tests. See Section 4.1 for instructions to remove the generator set and run it using the service fixtures.

Note: If you run the generator set outside the enclosure, place the cover over the top of the generator to prevent contact with rotating parts. The cover has an opening in the center to allow cooling air flow.

Check the continuity of the wiring harness leads before replacing the control board. Refer to the wiring diagrams in Section 7 for the lead codes and connecting terminals.

If these tests are inconclusive, test the individual shutdown circuit components as described in Section 5.5.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ 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.

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.

5.4.1 Low Oil Pressure (LOP) Shutdown

The low oil pressure (LOP) switch closes 5 seconds after the oil pressure drops below 5 psi, shutting down the generator set and lighting LED4. The low oil pressure shutdown does not function during the first 30 seconds after startup.

To test the operation of the LOP shutdown, connect a jumper wire from pin J4-13 of the controller-to-engine wiring harness to the generator set ground. Start the generator set. After approximately 35 seconds the generator set shuts down and the fault lamp lights. If the generator set does not shut down, replace the control board.

5.4.2 High Engine Temperature (HET) Shutdown

The high engine temperature (HET) switch closes 5 seconds after the generator set temperature reaches 305°F, shutting down the generator set and lighting LED2 on the control board. The high engine temperature shutdown does not function during the first 30 seconds after startup.

To test the HET shutdown, connect a jumper from the HET switch (lead) to the generator set ground. Start the generator set. After approximately 35 seconds the generator set shuts down and the fault lamp lights. Five seconds after the jumper is removed, the fault lamp goes out and the generator set restarts. If the generator set does not shut down and restart as described, replace the control board.

5.4.3 Overcrank Shutdown

The generator set shuts down and LED5 lights after approximately 70 seconds of cyclic cranking (three attempts to start). The manufacturer sets the circuit board for three cranking attempts: crank 20 seconds, rest 5 seconds, crank 20 seconds, rest 5 seconds, crank 20 seconds, shutdown. Use the following procedure to test the overcrank shutdown operation.

Overcrank Shutdown Test Procedure

1. Turn off the fuel supply to prevent flooding and remove the coil wire from the ignition module.

2. Move the generator set master switch to the RUN position.

3. Verify that the generator set shuts down and the fault lamp lights after the third crank/rest cycle.

5.4.4 Overspeed Shutdown

The generator set shuts down and LED1 lights when the engine speed exceeds 3750 rpm.

Use the following procedure to test the operation of the overspeed shutdown.

Overspeed Shutdown Test Procedure

Note: Do not increase the engine speed above 3950 rpm. Increasing the engine speed above 3950 rpm can raise the output voltage high enough to damage the generator and connected equipment.

1. Disconnect the load from the generator set.

2. Connect a tachometer to the engine spark plug lead to measure the engine speed during the test.

   Note: If a tachometer is not available, connect a frequency meter across terminals C and E on the AC side of the voltage rectifier. Increase the engine speed as instructed in step 3. The generator set should shut down when the output frequency reaches 750 Hz. Do not exceed 790 Hz.

3. With the generator set running, carefully move the throttle linkage to increase the engine speed. Watch the tachometer and note the speed when the generator set shuts down.

4. Reset the controller by moving the master switch to the OFF position and then back to AUTO.

If the generator set does not shut down when the engine speed exceeds 3750 rpm, replace the control board.

5.5 Control Board Tests

Use the troubleshooting procedures in Section 3 to diagnose generator set and engine problems. If the troubleshooting procedures indicate a problem with the controller circuit board, use the tests in this section to check the board.

Refer to the wiring diagrams in Section 7 when troubleshooting the generator set control circuit board. Circuit board components cannot be repaired or replaced; if the troubleshooting process reveals a faulty component on the circuit board, replace the board.

Note: Use an ohmmeter or continuity tester to check for shorts or open leads in the wiring harnesses before replacing the controller circuit board or other system components.

Disconnect the generator system from the remote control system at plug P6 and use the generator set master switch to operate the generator set. If the generator set operates normally when P6 is disconnected, then the problem is with the remote control system. Refer to the manufacturer's instructions for the remote control system to troubleshoot the problem. If the problem persists after P6 is disconnected, use the troubleshooting procedures in this manual to diagnose the problem.

⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ 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.

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.

5.5.1 Fuel Control Circuit

Move the generator set master switch to the START position and check for 12 VDC on pin P5-1 (lead 70) of the fuel valve connector. If the valve receives voltage but does not open, replace the valve.

If there is no voltage to the valve, check the battery voltage, battery connections, and ignition system (see Section 4.5). If the battery and ignition system function correctly but the fuel valve does not receive voltage, replace the controller circuit board.

5.5.2 Speed Sensing and Governor (Throttle Control) Circuits

The controller monitors the AC voltage produced by the stator to sense and control the engine speed. If the engine speed varies erratically, test the governor operation as described in Section 4.4. If the tests show that the erratic operation is not caused by a faulty governor, replace the controller circuit board.

5.5.3 Start Circuits

Move the generator set master switch to the START or RUN position. If the engine does not crank, check the following components.

1. Check the battery voltage. Recharge or replace a weak or dead battery.
2. Check for 12 VDC to the starter motor. Also verify that the starter motor is grounded. See Section 7, Wiring Diagrams. If the starter motor is receiving voltage but not functioning, replace it. If there is no voltage to the starter motor, check the harness and connections and then proceed to step 3 to check the starter (crank) relay.
3. Check for 12 VDC to the crank relay. See Section 7, Wiring Diagrams. If the crank relay is receiving voltage but not functioning, replace it. If there is no voltage to the crank relay, check the harness and connections.
4. Check for 12 VDC from the control board at P2-1. If there is no voltage, replace the controller circuit board.

5.5.4 Ignition Circuits

Move the generator set master switch to the START position. If the engine cranks but does not start, check for voltage from lead 70 to ground at terminal B on the ignition module and at the positive terminal of the ignition coil. If no voltage is present during cranking, replace the controller circuit board. If the ignition system is receiving 12 VDC, check the spark plug and test the other ignition system components.

Before disassembly, remove the generator set from any enclosure. Refer to Section 2.3 for instructions. Disconnect the battery (negative [-] lead first), fuel line, exhaust system, remote start switch, load leads, and other wiring harnesses. In addition to the precautions included in the text, observe all safety precautions listed at the beginning of this manual during the disassembly/reassembly procedure.

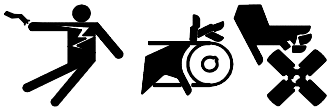
⚠ WARNING

Hazardous voltage.
Can cause severe injury or death.

Only authorized personnel should open the enclosure.

(600 volts and under)

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

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

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Place the generator set start/stop switch in the STOP position. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

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.

6.1 Disassembly Procedure

1. Follow the instructions in Section 2.3 to open the cabinet, disconnect the generator set, and remove it from the cabinet. See Figure 6-1

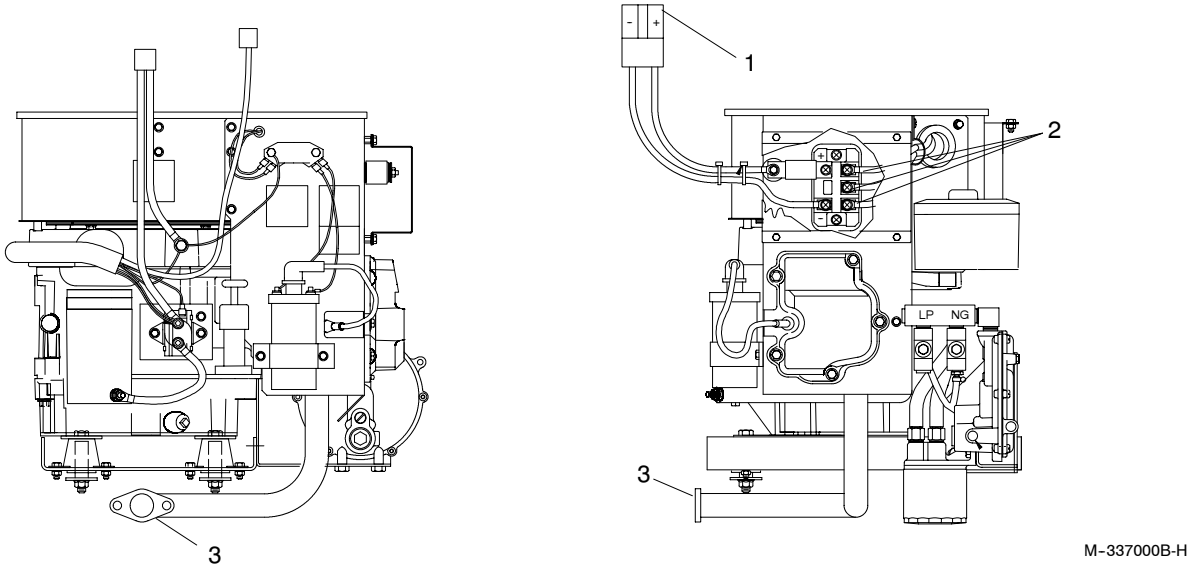
2. Set the generator set on the service fixture, aligning the generator set's mounting holes with the pins in the fixture.

3. Note the 3 stator lead connections to the voltage rectifier for reconnection later. Disconnect the stator leads from the voltage rectifier. See Figure 6-2.

1. Load lead connector
2. Wiring harness connectors
3. Fuel connection
4. Exhaust pipe connection (not visible in this photo)

TP6076

Figure 6-1 Generator Set Installed in the cabinet



1. Output connector
2. Stator leads
3. Exhaust connection

Figure 6-2 Generator Set

4. Disassemble the fan and alternator. See Figure 6-3 and Figure 6-4.

   a. Remove 3 fan screws and remove the fan.

   b. Remove the 4 socket head cap screws securing the stator to the engine adaptor.

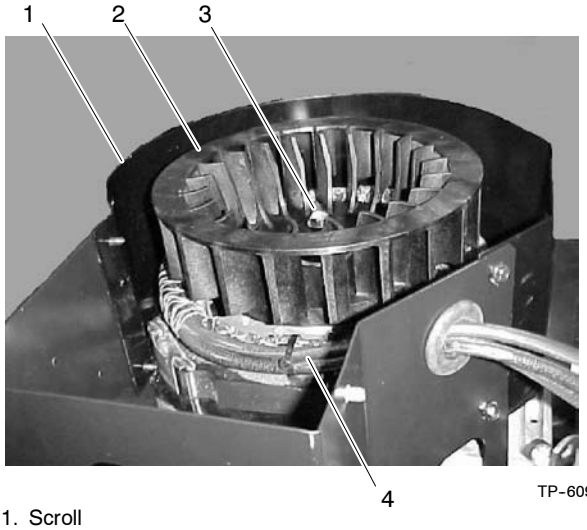
   c. Remove the stator, guiding the 3 stator leads through the opening in the shroud.

   d. Remove the 3 screws securing the spacer and rotor to the flywheel. Remove the spacer and the rotor. See Figure 6-5.

5. Remove the flywheel, if necessary.

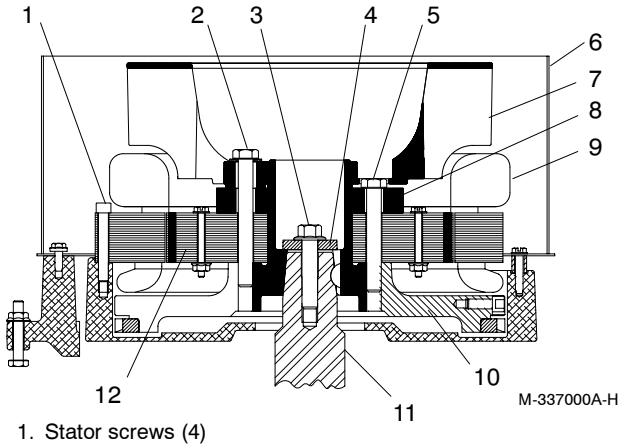
   a. Remove the thrubolt and convex washer at the center of the flywheel taper. See Figure 6-4.

   b. Pull the flywheel off the engine crankshaft.



1. Scroll
2. Fan
3. Fan screw (3 ea.)
4. Stator

Figure 6-3 Alternator with Fan



1. Stator screws (4)
2. Fan screws (3)
3. Flywheel bolt
4. Convex washer
5. Spacer/rotor screws (3)
6. Alternator scroll
7. Fan
8. Spacer
9. Stator
10. Flywheel
11. Engine crankshaft
12. Rotor

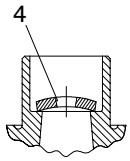
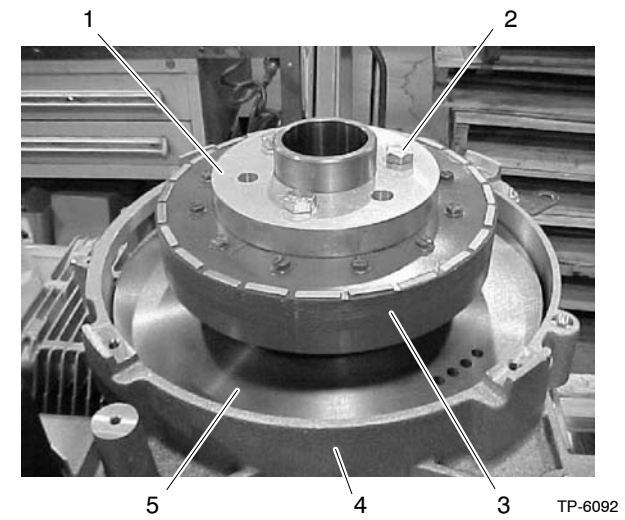


Figure 6-4 Alternator Assembly



1. Spacer
2. Rotor/spacer screws (3)
3. Rotor
4. Engine adaptor
5. Flywheel

Figure 6-5 Rotor and Spacer (shroud and stator removed)

6.2 Reassembly Procedure

1. Install the flywheel, if it was removed.

   a. Clean the engine crankshaft and flywheel taper with a dry cloth.

   b. Slide the flywheel onto the engine crankshaft.

   c. Install the M10-1.50 x 45 mm (1.772 in.) thrubolt and convex washer. Install the washer with the convex side up, as shown in Figure 6-4.

   d. Use a torque wrench to tighten the thrubolt to 67 Nm (49.4 ft. lb.).

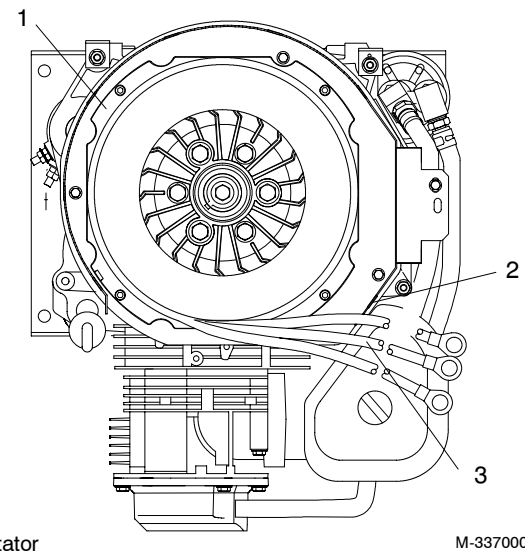
2. Reassemble the alternator. See Figure 6-4.

   a. Slide the rotor over the flywheel taper, aligning the bolt holes in the rotor and the flywheel.

   b. Place the spacer on the rotor, aligning the bolt holes.

   c. Use three 63.5 mm (3/8-16 x 2.5 in.) hex head screws to secure the spacer and rotor to the flywheel. See Figure 6-5. Do not tighten the screws.

   d. Place the stator in position as shown in Figure 6-6. Feed the stator leads through the opening in the alternator scroll.



1. Stator
2. Scroll
3. Stator leads

Figure 6-6 Generator Set Top View

e. Use four 44.5 mm (1/4-20 x 1.75 in.) socket head cap screws to secure the stator to the alternator adaptor. Do not tighten the screws.

f. Use a 0.25 mm (0.010 in.) feeler gauge to check the gap between the rotor and stator at several places. Adjust the stator position so that the gap is even all around. Use a torque wrench to tighten the rotor screws to 38 Nm (28.0 ft. lb.). Tighten the stator screws to 11 Nm (8.1 ft. lb.) and verify that the gap is 0.25 mm (0.010 in.) all around.

3. Install the fan.

   a. Place the fan on the spacer, aligning the bolt holes with the 3 unused holes in the spacer, rotor, and flywheel.

   b. Use three 82.5 mm (3/8-16 x 3.25 in.) hex head screws and washers to secure the fan. Use a torque wrench to tighten the screws to 25 Nm (18.4 ft. lb.).

4. Connect the stator leads to the voltage rectifier. Tighten the voltage rectifier terminal screws to 5 Nm (44 in. lb.).

5. Follow the instructions in Section 2.3 to install the generator set in the cabinet.

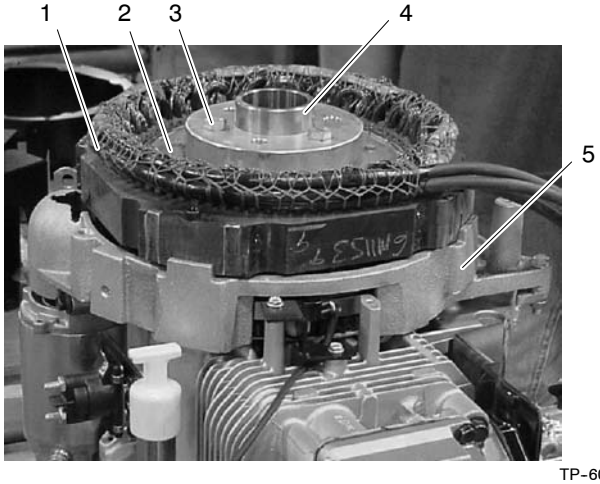
6. Reconnect the generator set components.

   a. Reconnect the exhaust pipes at the lower left side of the generator set.

   b. Reconnect the fuel line.

   c. Reconnect the wiring harnesses.

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



1. Stator
2. Rotor
3. Spacer
4. Flywheel taper
5. Engine adapter

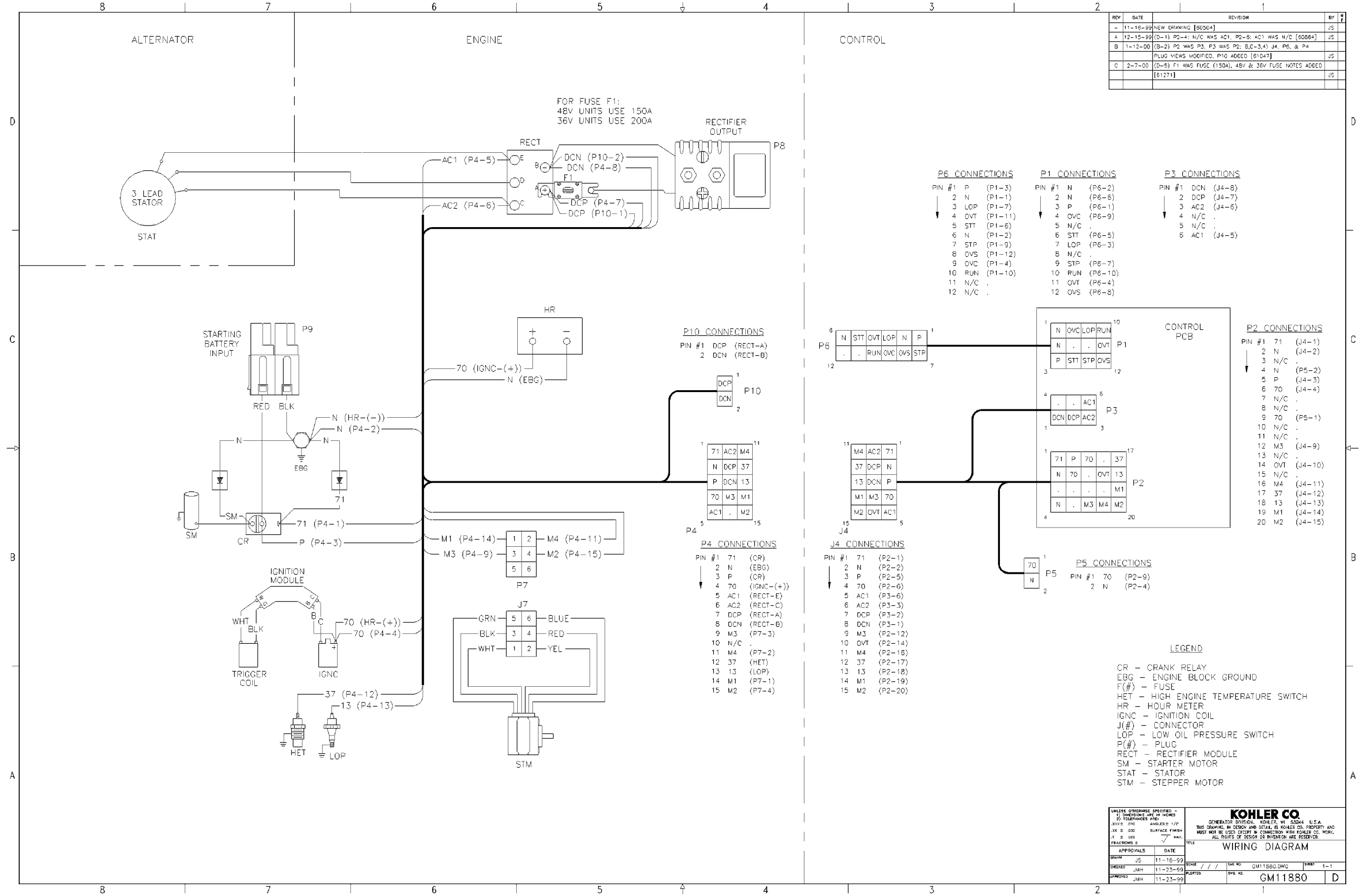
Figure 6-7 Alternator (shroud removed to show components)

Section 7 Wiring Diagrams

Specification Numbers	Drawing Description	Drawing Number	Page
PA-195023, PA-195027	Wiring Diagram	GM11880-C	53
	Schematic	ADV-6536-B	54
GM14140-GA1, GM14140-GA2, GM14140-GA3, GM14140-GA4, GM14140-GA5, GM14140-GA6	Wiring Diagram	GM14258	55

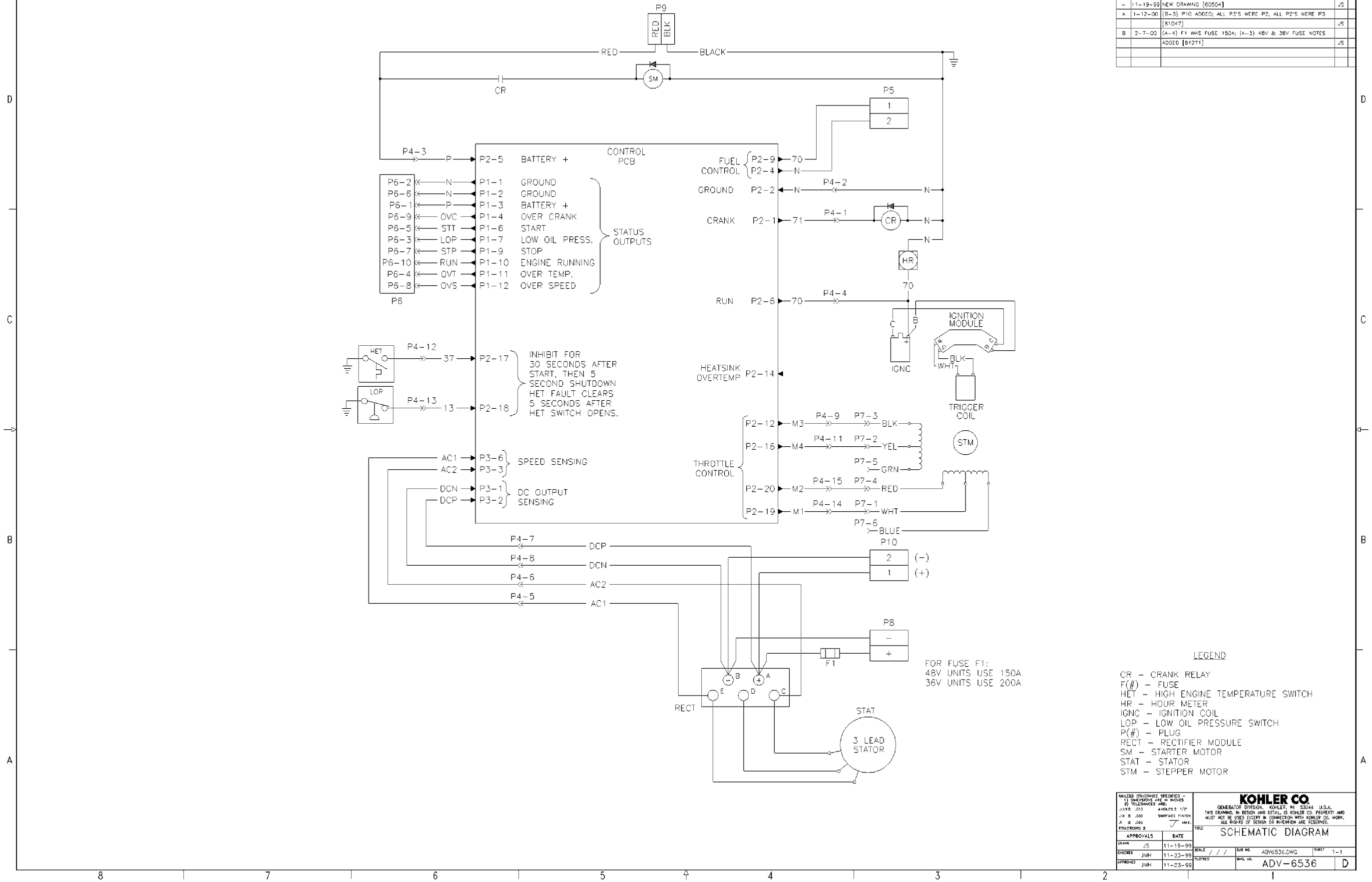
Notes

REV	DATE	REVISION	BY	M F
-	11-16-99	NEW DRAWING [60504]	JS	
A	12-15-99	(D-1) P2-4: N/C WAS AC1, P2-8: AC1 WAS N/C [60864]	JS	
B	1-12-00	(B-2) P2 WAS P3, P3 WAS P2; B,C-3,4) J4, P6, & P4 PLUG VIEWS MODIFIED, P10 ADDED [61047]	JS	
C	2-7-00	(D-5) F1 WAS FUSE (150A), 48V & 36V FUSE NOTES ADDED [61271]	JS	

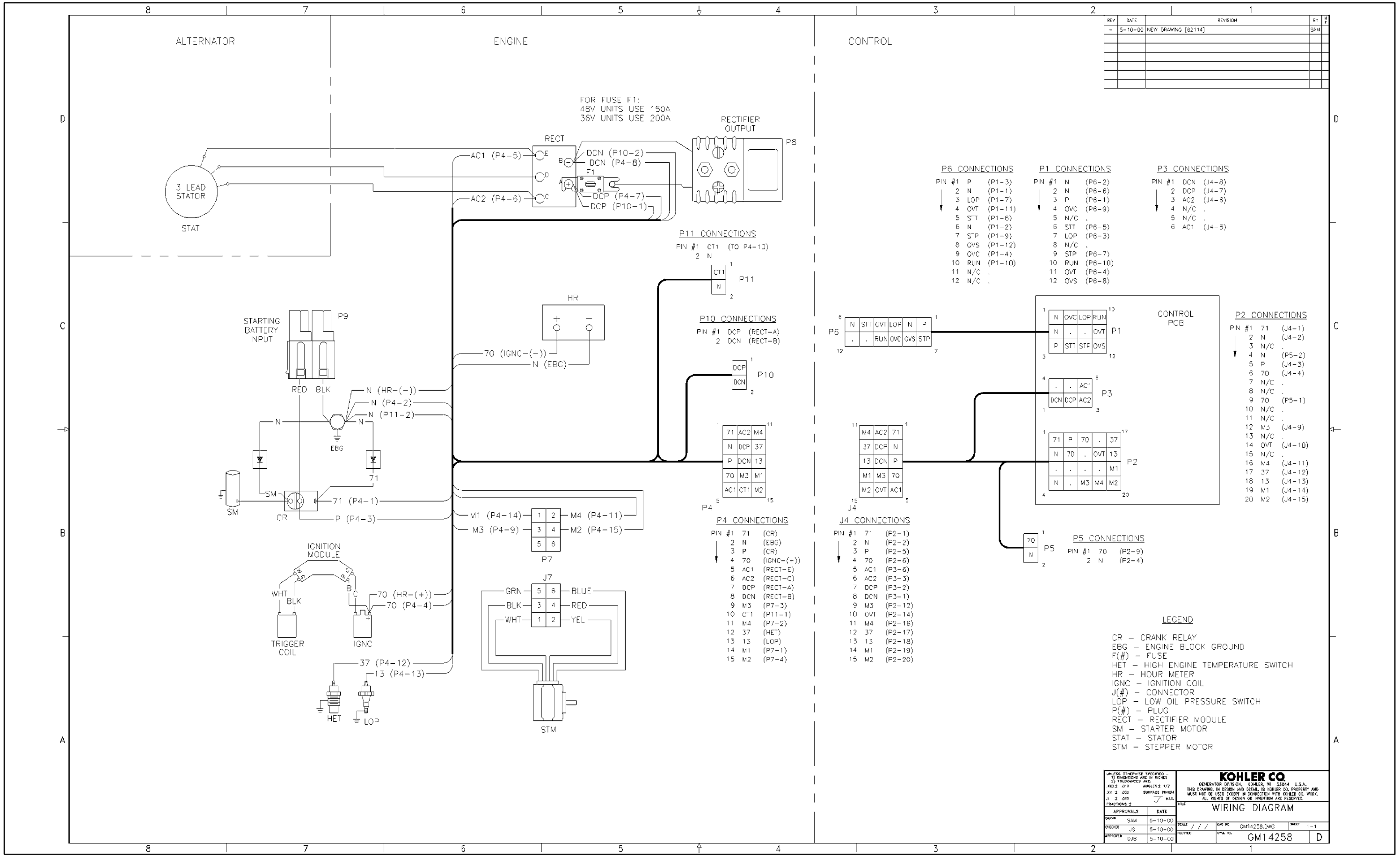


Wiring Diagram, GM11880-C

REV	DATE	REVISION	BY	APP'D
–	11-19-99	NEW DRAWING [60504]	JS	
A	1-12-00	(B-3) P10 ADDED; ALL P3'S WERE P2, ALL P2'S WERE P3		
		[61047]	JS	
B	2-7-00	(A-4) F1 WAS FUSE 150A; (A-3) 48V & 36V FUSE NOTES		
		ADDED [61271]	JS	



Schematic Diagram, ADV-6536-B



Wiring Diagram, GM14258

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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.

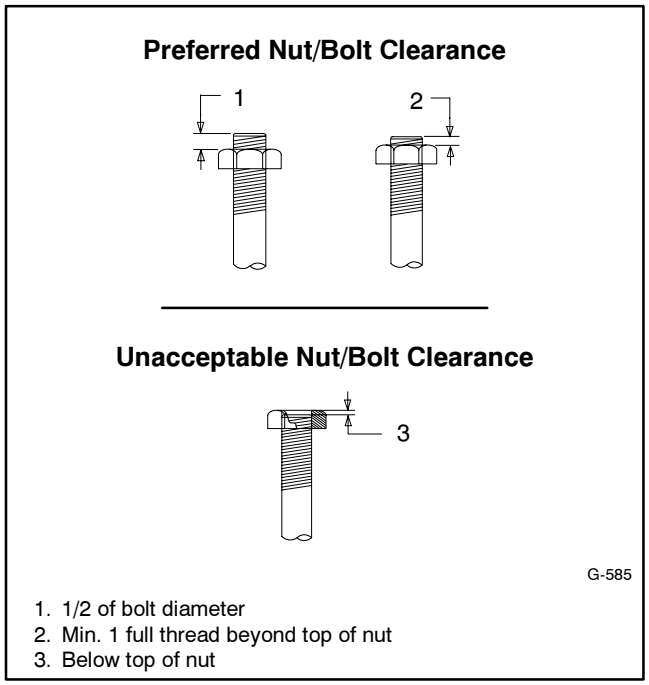


Figure 1 Acceptable Bolt Lengths

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.

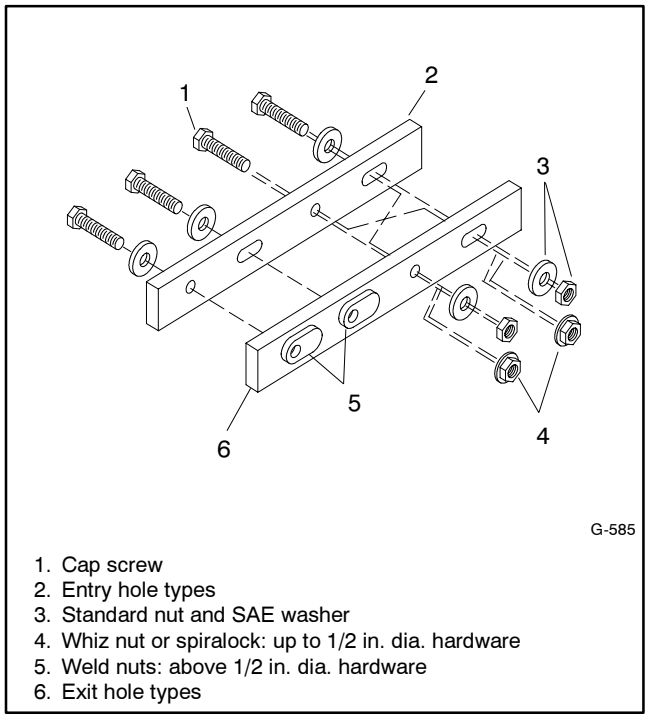


Figure 2 Acceptable Hardware Combinations

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%.

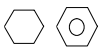
American Standard Fasteners Torque Specifications					
		Assembled into Cast Iron or Steel			Assembled into Aluminum
Size	Torque Measurement	Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	1.8 (16)
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
10-32	Nm (in. lb.)	2.9 (26)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