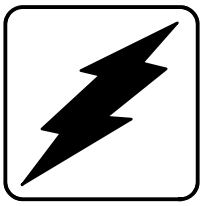
Service

Residential/Commercial Generator Sets



Models:

8.5RES
12RES
12RESL
12RESM1
12RESNT
12TRES

Controllers:
ADC 2100
ADC-RES
DC 2200
DC-RET

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
Power Systems

TP-6196 8/17c

Kohler strongly recommends that only factory-authorized distributors or dealers install and service the generator.

Table of Contents

Table of Contents, continued

Notes

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

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

DANGER

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

WARNING

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

CAUTION

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

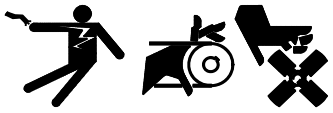
NOTICE

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

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

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

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

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

Battery

WARNING

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

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

WARNING

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

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

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

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

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

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

Engine Backfire/Flash Fire

⚠ WARNING

Risk of fire.
Can cause severe injury or death.

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

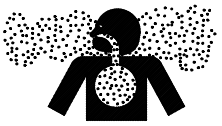
Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

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

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

Exhaust System

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

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

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

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

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

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

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

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

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

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

Hazardous Voltage/ Moving Parts

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

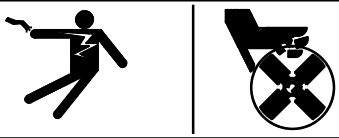
This equipment must be installed and serviced by qualified electrical personnel.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ DANGER



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

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

⚠ WARNING

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

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

⚠ CAUTION

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

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

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

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

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

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

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

Heavy Equipment

⚠ WARNING

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

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

Hot Parts

⚠ WARNING

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

Do not work on the generator set until it cools.

⚠ CAUTION

Hot surfaces.

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

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

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

Notice

NOTICE

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

NOTICE

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

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

Generator set service must be performed only by factory-authorized distributors or dealers.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals.

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.

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

List of Related Materials

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

Operation and installation manual part numbers have changed. Find the build date on the generator set nameplate and see the notes in the table below to identify the manuals for your unit.

Document Description	Part Number
Operation/Installation Manual, 8.5/12RES (before 5/04) *	TP-6195
Operation Manual, 8.5/12RES w/ADC 2100	TP-6331
Installation Manual, 8.5/12RES w/ADC 2100	TP-6328
Operation Manual, 12RESL/RESM1 w/DC 2200	TP-6397
Installation Manual, 12RESL/RESM1 w/DC 2200	TP-6398
Operation Manual, 8.5/12RES/12TRES w/ADC-RES	TP-6515
Installation Manual, 8.5/12RES/12TRES w/ADC-RES (before 10/2011)	TP-6514
Installation Manual, 8.5/12RES/12TRES w/ADC-RES (after 10/2011)	TP-6792
Installation Manual, 12RES w/ADC-RES (after 8/2015)	TP-6967
Operation Manual, 12RESL/RESM1 w/DC RET	TP-6517
Installation Manual, 12RESL/RESM1 w/DC RET (before 10/2011)	TP-6516
Installation Manual, 12RESL/RESM1 w/DC-RET (after 10/2011)	TP-6793
Parts Catalog, 8.5/12RES	TP-5868
Parts Catalog, 12RESL/RESM1	TP-6399
Engine Service Manual	24 690 06
* Replaced by TP-6328 and TP-6331, May, 2004.	

Routine Service Parts

See the Parts Catalog for a list of common replacement 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 KOHLERPower.com.
- Look at the labels and decals on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
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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

1.1 Introduction

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

Check the generator set nameplate for specific generator set ratings.

1.2 Controller Specifications

For a specific description of the controller, see Section 2, Operation, in the operation manual.

Environmental Specifications	
Operating temperature	-20°C to 70°C
Storage temperature	-60°C to 70°C
Humidity	0-95% condensing
Power requirements:	
Voltage	12 or 24 VDC
Current	250 mA @ 12 VDC 125 mA @ 24 VDC

1.3 Engine Features

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

- One-side serviceability of air cleaner, carburetor, oil fill, dipstick, and oil drain.
- Efficient overhead valve design and full pressure lubrication for maximum power, torque, and reliability under all operating conditions.
- Electronic governor to ensure AC power output is maintained at desired frequency.
- Overspeed shutdown to prevent governed frequency from exceeding 70 Hz on 60 Hz models (60 Hz on 50 Hz models).
- Low oil pressure cutout to prevent failure.
- Dependable, maintenance free electronic ignition.
- Digital Spark Advance Ignition (DSAI) optimizes engine timing for natural gas or LP fuel (12 kW models only).
- Parts subject to the most wear and tear made from precision formulated cast iron.
- Hydraulic valve adjusters to eliminate the need for valve adjustments.
- Field-convertible fuel systems that allow fuel changeover from natural gas to LP vapor (and vice-versa) while maintaining CARB certification.

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

1.4 Engine Specifications

Engine Specification	8.5 kW (60 Hz)	12 kW (60 Hz)
Manufacturer	Kohler	
Model	CH20	CH740
Cycle	4	
Number of cylinders	2	
Compression ratio	8.5:1	9.0:1
Displacement, cc (cu. in.)	624 (38.0)	725 (44.0)
Rated power, propane fuel, kw (HP)	11.5 (15.4)	17.6 (23.6)
Rpm	3600	
Bore x stroke, mm (in.)	77 x 67 (3.03 x 2.64)	83 x 67 (3.27 x 2.64)
Valve material	Steel/Stellite®	
Cylinder block material	Aluminum w/cast iron liners	
Cylinder head material	Aluminum	
Piston rings	2 compression/1 oil	
Crankshaft material	Heat-treated ductile iron	
Main bearings: number, type	2, parent material	
Governor	Electronic	
Lubrication system	Full pressure	
Oil capacity (w/filter), L (qt.)	1.9 (2.0)	2 (2.1)
Oil pressure, kPa (psi)	172–241 (25–35)	
Fuel system	LP gas or natural gas	
LP/natural gas minimum supply pressure, in. H_2O (oz./in.^{2})	7–11 (4–6)	
Battery voltage	12 VDC	
Battery ground	Negative	
Spark plug gap, mm (in.)	0.51 (0.020)	0.76 (0.030)
Ignition system	Capacitor Discharge	Smart Spark Capacitor Discharge
Starter motor	Electric, solenoid shift	
Cooling system	Air-cooled	

1.5 Torque Specifications

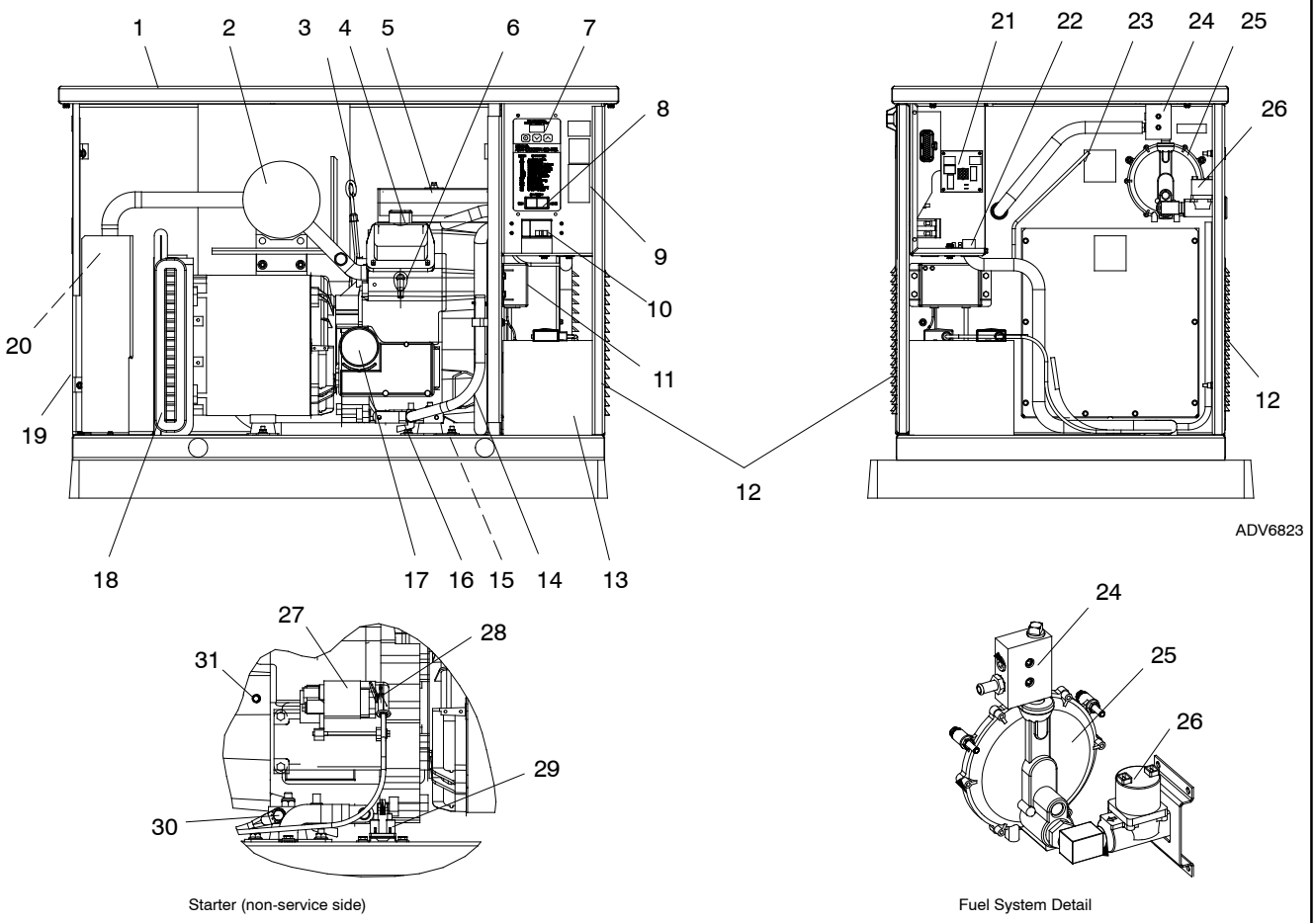
Torque Specifications, Nm (ft. lb.)	8.5/12 kW
Alternator overbolts	7 (5)
Alternator thrubolt	40 (28)
Cylinder head nuts	30 (40.7)
Generator adapter screws	40 (28)
Muffler flange bolts	24 (17.7)
Oil filter	5.7–9.0 (4.2–6.7)
Spark plug	24.4–29.8 (18–22)

1.6 Alternator Specifications

Alternator Specification	8.5/12 kW 1 phase	12TRES 3 phase
Frequency Hz	50/60	50
Phase	Single-Phase	Three
Number of leads	4	12
Excitation method	Static Excited	
Voltage regulator type	Digital	
Coupling type	Direct	
Thrubolt torque, Nm (ft. lb.)	40 (28)	
Overbolt torque, Nm (in. lb.)	7 (60)	
Insulation (rotor and stator)	Epoxy varnish, vacuum impregnated Class 180 (H)	
Winding material	Copper	
Bearing, number and type	1, replaceable ball	
Circuit protection		
Controller	10 amps	
Aux. winding	20 amps	
Generator AC output	Dependent on voltage configuration	
Rotor resistance, ohms, cold	4.0	4.2
Stator resistance, ohms,* cold		
Single-Phase Leads 1-2, 3-4	0.07	N/A
Three-Phase Leads 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	N/A	0.18
Leads 11-44	0.14	N/A
55-66	0.70	0.15
Stator output voltage with separately excited rotor using 12-volt battery, minimum		
Single-Phase Leads 1-2, 3-4	132 V	N/A
Three-Phase Leads 1-4, 2-5, 3-6, 7-10, 8-11, 9-12	N/A	115 V
11-44	264 V	N/A
55-66	145 V	150 V
Rotor field voltage/current readings at rated output voltage, hot		
No load	12 V/2.0 amps	14 V/2.8 amps
Full load	47 V/7.4 amps	78 V/11.5 amps
Brush length, new	19.05 mm (0.75 in.)	

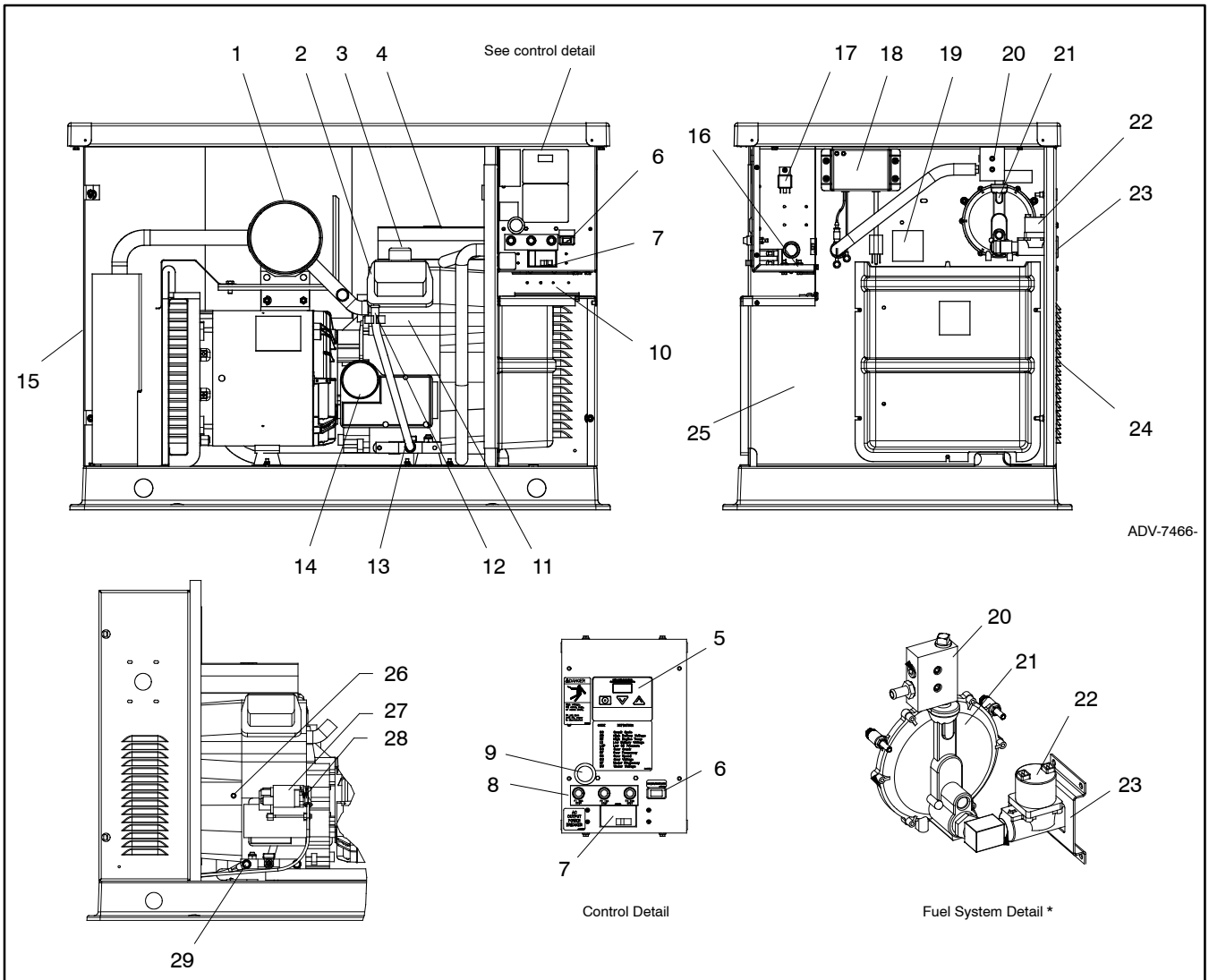
* Most ohmmeters do not give accurate readings when measuring less than 1 ohm. The stator can be considered good if a low resistance reading (continuity) is obtained and there is no evidence of shorted windings (discoloration). Do not confuse a low resistance reading with a reading indicating a shorted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

1.7 Service Views



1. Enclosure
2. Muffler
3. Oil check
4. Oil fill
5. Air cleaner
6. Spark plug locations (both sides)
7. Controller
8. Generator set master switch (RUN\OFF/RESET\AUTO)
9. Nameplate
10. Line circuit breaker
11. Battery charger
12. Air intake
13. Engine starting battery location
14. Oil drain hose
15. High engine temperature (HET) sensor (located on non-service side)
16. Oil drain valve
17. Oil filter
18. Air intake, alternator
19. Exhaust
20. Spark arrestor (not visible in this view)
21. Relay interface board (RIB)
22. SCR module
23. Digital spark advance module leads (DSAM leads, ignition timing)
24. Multi-fuel block
25. Secondary fuel regulator assembly
26. Fuel solenoid valve
27. Starter solenoid
28. Positive battery connection
29. Starter relay
30. Negative battery connection
31. DSAM ground screw

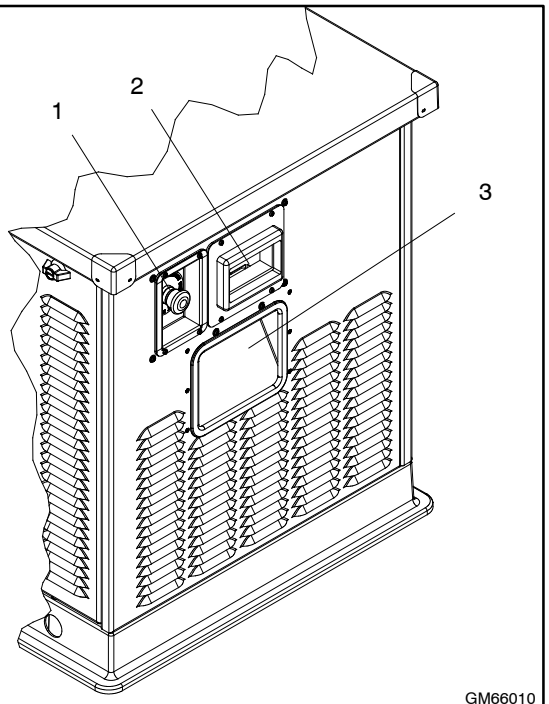
Figure 1-1 Generator Set Service View, 12 kW Model with ADC 2100 Controller



1. Muffler
2. Oil check
3. Oil fill
4. Air cleaner
5. Controller user interface (switch membrane)
6. Generator set master switch (RUN-OFF/RESET-AUTO)
7. Load circuit breaker (1-phase models)
8. Fuses
9. RS-232 connector (for application program updates)
10. Field-connection terminal block location
11. Spark plug locations (both sides)
12. Oil drain hose
13. Oil drain valve
14. Oil filter
15. Exhaust
16. Equipment ground
17. Starter relay
18. Battery charger
19. DSAI lead location
20. Fuel block *
21. Gas regulator assembly
22. Fuel solenoid valve
23. Fuel inlet
24. Air intake
25. Engine starting battery location (battery purchased separately)
26. DSAI ground screw
27. Starter solenoid
28. Positive battery connection
29. Negative battery connection

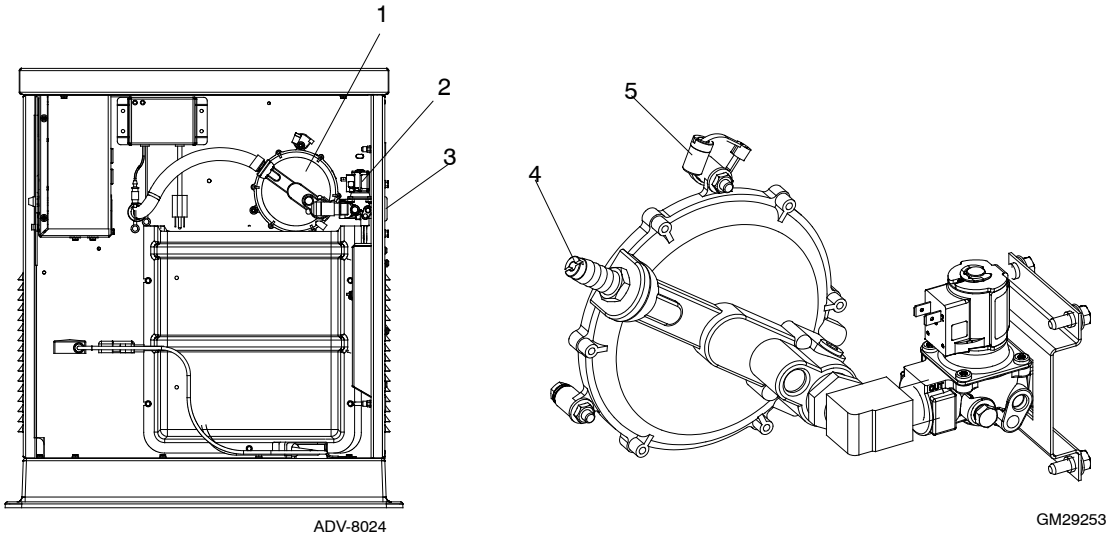
* For 12RES units built after August, 2015, see Figure 1-4.

Figure 1-2 Generator Set Service View, 12 kW Model with ADC-RES Controller



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

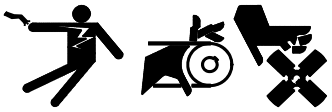
Figure 1-3 Additional Components, 3-Phase TRES Models



1. Fuel regulator
2. Fuel solenoid valve
3. Fuel inlet location
4. Fuel orifice
5. Second fuel orifice (shipping location)

Figure 1-4 Fuel System Views, Model 12RES built after August, 2015

⚠ 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.

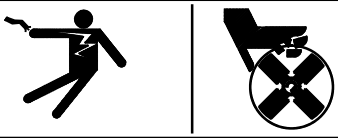
Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger.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

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

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

⚠ DANGER



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

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

⚠ WARNING

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

Do not work on the generator set until it cools.

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

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

⚠ WARNING

Risk of fire.
Can cause severe injury or death.

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

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

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

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

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

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

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

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

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

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

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

2.1 Service Schedule

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

System—Component	Refer to Section	Action					Interval
		Inspect	Check	Change	Clean	Test	
Lubrication	2.2						
Oil level	2.2.2	X	X				8 hr. or before use
Crankcase breather hose	E	E					Yearly or 500 hr.
Change oil	2.2.4			R			Yearly or 100 hr.
Replace filter(s)*	2.2.4			R			Yearly or 200 hr.
Oil cooler*	2.2.5	X		R	X		Yearly or 100 hr.
Fuel	6.12						
Flexible lines and connections †		X		R			Quarterly
Main tank supply level			X				Weekly
Fuel piping		X					Yearly
Cooling	2.5						
Air ducts and louvers in enclosure *			X		X		Yearly
Exhaust System	2.6						
Leakage		X	X				Weekly
Obstructions or combustible materials near exhaust outlet		X			X		Weekly
DC Electrical System	2.7						
Battery charger operation	O/M	X					Monthly
Remove corrosion, clean and dry battery and rack	2.7	X			X		Yearly
Clean and tighten battery terminals	2.7	X	X				Yearly
Inspect battery boots and replace if necessary	2.7	X		R			Yearly
Tighten DC electrical connections	2.7		X				Yearly
AC Electrical System							
General inspection		X					Quarterly
Wire abrasions where subject to motion		X	X				Six Months
Tighten control and power wiring connections			X				Yearly
Wire-cable insulation breakdown		X					3 yr. or 500 hr.
Engine and Mounting							
General inspection	E	E					Weekly
Air cleaner and precleaner service *	2.4		X		X		Yearly or 100 hr.
Spark plugs	2.3	X					Yearly
Replace spark plugs	2.3	E		R	E		500 hr.
Stepper motor coupling and bushing	6.9			R			3 yr. or 500 hr.
Generator							
Compartment condition		X			X		Weekly
Inspect brushes and collector ring	6.6	X					Yearly
Measure and record resistance readings of windings with insulation tester (Megger, with SCR assembly or rectifier and load leads disconnected)	6.3					X	3 yr.
Run/exercise generator set						X	Weekly
Remote control operation						X	Monthly
General Condition Of Equipment							
Any condition of vibration, leakage, excessive noise, high temperature, or deterioration		X	X		X		Weekly
Interior of enclosure		X			X		Quarterly

R Replace
X Action
O/M Generator Set Operation Manual

E Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual. If not indicated, follow this service schedule. Some items may not apply to all generator sets.

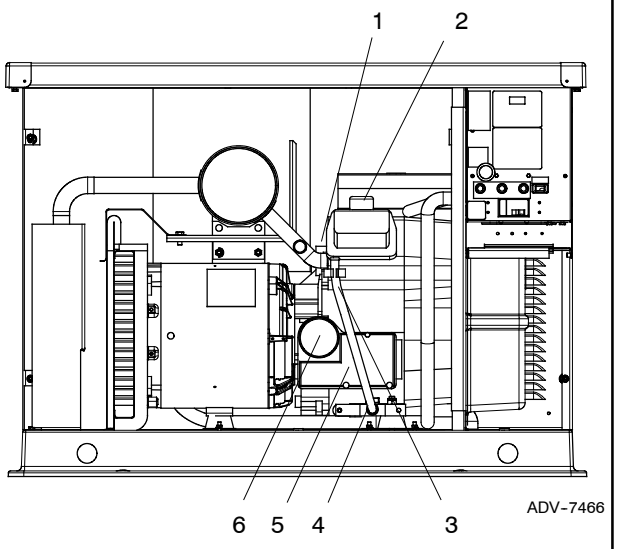
* Service more frequently if operated in dusty areas.
† Replace fuel lines and connections as necessary.

Figure 2-1 Service Schedule

2.2 Lubrication System

See Section 2.1, Service Schedule, for oil change and oil filter replacement intervals. See Figure 2-2 for the oil drain, oil check, oil fill, and oil filter locations.

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



1. Dip stick location
2. Oil fill
3. Oil drain hose
4. Oil drain valve
5. Oil cooler
6. Oil filter

Figure 2-2 Lubrication System (typical)

2.2.1 Low Oil Pressure Shutdown

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

2.2.2 Oil Level Check

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

2.2.3 Engine Oil Recommendation

Use synthetic oil of API (American Petroleum Institute) Service Class SG or higher. Synthetic oil causes fewer deposits on the engine intake valves and pistons because it oxidizes and thickens less than other oils. See Figure 2-3 and Figure 2-4.

Model	L (Qt.)
8.5kW	1.9 (2.0)
12kW	2.0 (2.1)

Figure 2-3 Oil Capacity with Filter

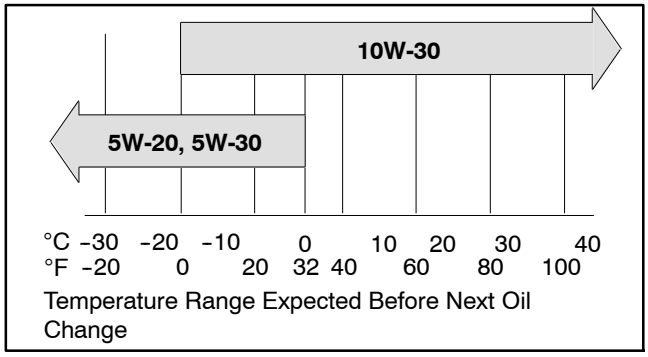
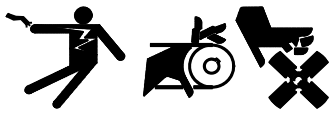


Figure 2-4 Engine Oil Selection

2.2.4 Oil Change Procedure

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Note: Dispose of all waste materials (engine oil, filter, etc.) in an environmentally safe manner and in accordance with all applicable laws.

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

1. **Drain the oil.**

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

b. Disconnect the power to the battery charger.

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

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

e. Open the oil drain valve on the engine. Remove the dipstick and oil fill cap.

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

g. Close the oil drain valve.

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

2. **Replace the oil filter.**

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

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

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

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

3. **Fill with oil.**

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

b. Replace the oil fill cap and dipstick.

4. **Check for leaks.**

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

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

c. Reconnect the power to the battery charger.

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

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

f. Reinstall the housing side panel.

2.2.5 Oil Cooler

Inspect and clean the oil cooler at the intervals shown in the Service Schedule. The oil cooler must be kept free of debris.

See Figure 2-2 and Figure 2-5 for the oil cooler location. Clean the outside of the oil cooler with a brush or compressed air. If it is necessary to clean the back of the oil cooler, remove the two screws holding the oil cooler unit to the blower hosing. Tilt the cooler and clean with a brush or compressed air as shown in Figure 2-6. After cleaning, reinstall the oil cooler and secure with the mounting screws.

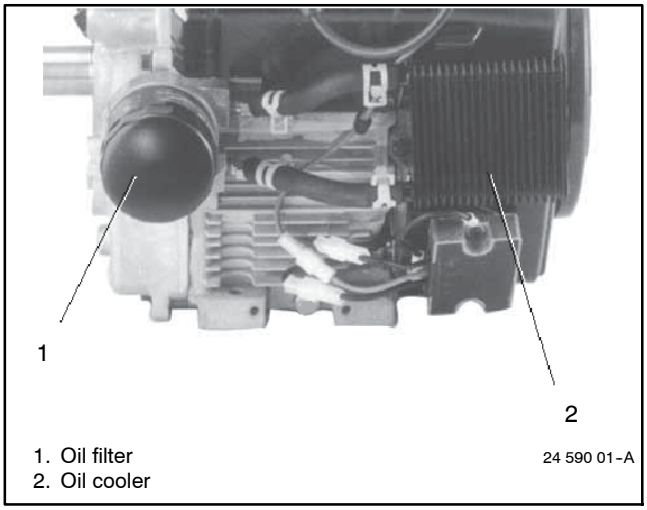


Figure 2-5 Oil Cooler Location

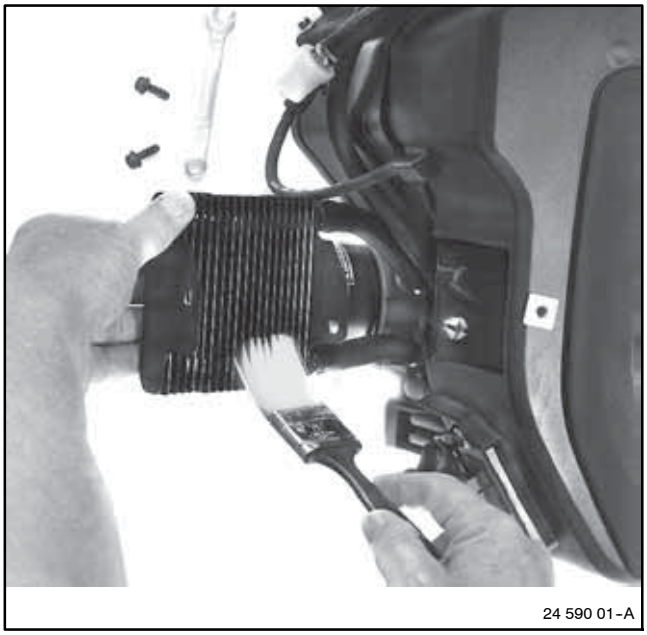
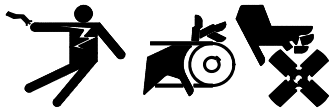


Figure 2-6 Cleaning the Oil Cooler

2.3 Spark Plugs

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

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

Spark Plug Maintenance Procedure

1. Clean the area around the base of the spark plug to keep dirt and debris out of the engine.
2. Remove the spark plug and check its condition. Replace the spark plug if it is worn or if its reuse is questionable.
3. Check the spark plug gap using a wire feeler gauge. See Figure 2-7 for the recommended gap. Adjust the gap by carefully bending the ground electrode. See Figure 2-8 and Figure 2-9.
4. Install the spark plug and tighten it according to the torque specification in Section 1.5.

Model	Spark Plug Gap
8.5 kW	0.51 mm (0.020 in.)
12 kW	0.76 mm (0.030 in.)

Figure 2-7 Spark Plug Gap

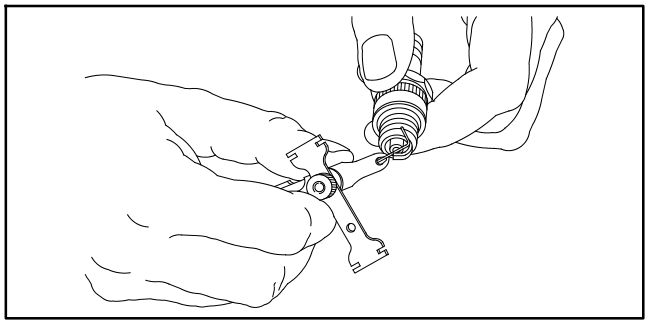


Figure 2-8 Checking the Spark Plug Gap

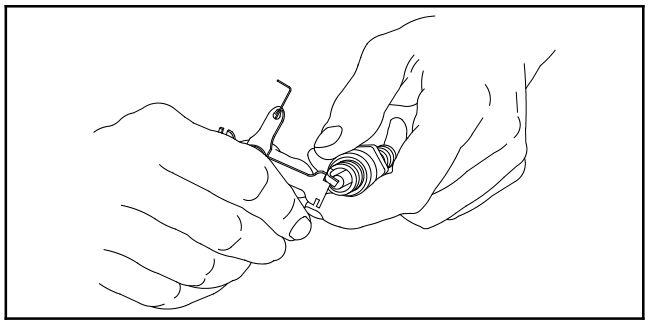
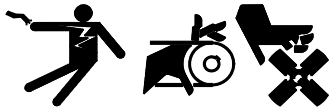


Figure 2-9 Adjusting the Spark Plug Gap

2.4 Air Cleaner Service

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Risk of fire.
Can cause severe injury or death.

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

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

The engine has a replaceable high-density paper air cleaner element with an oiled foam precleaner. See Figure 2-10. Refer to Section 1.7, Service View, for the air cleaner location.

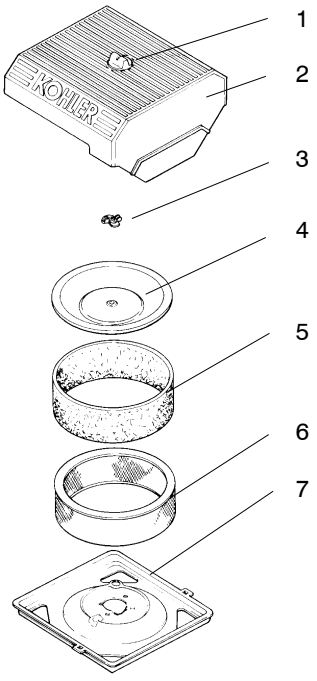
Wash and oil the precleaner and replace the paper element at the intervals shown in the service schedule, Figure 2-1. Service the air cleaner more often if the generator set operates under dusty or dirty conditions. Refer to Maintenance and Service Parts in the Introduction section of this manual for replacement part numbers.

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

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

Air Cleaner Service Procedure

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



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

Figure 2-10 Air Cleaner Components

3. Wash and oil the foam precleaner.
   a. Wash the precleaner in warm soapy water.
   b. Rinse the precleaner with warm water until the water runs clear.
   c. Squeeze out excess water and allow the precleaner to air dry.

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

   d. Saturate the precleaner with new engine oil. Squeeze out the excess oil.
4. Replace the paper element if it is dirty, bent, or damaged.

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

5. Reinstall the air cleaner.
   a. Install the precleaner over the paper element.
   b. Check the air cleaner base. Make sure it is secure and not bent or damaged. Remove any dirt or debris from the air cleaner base. Wipe the base carefully so that no dirt falls into the intake throat.

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

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

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

6. Enable the generator set.

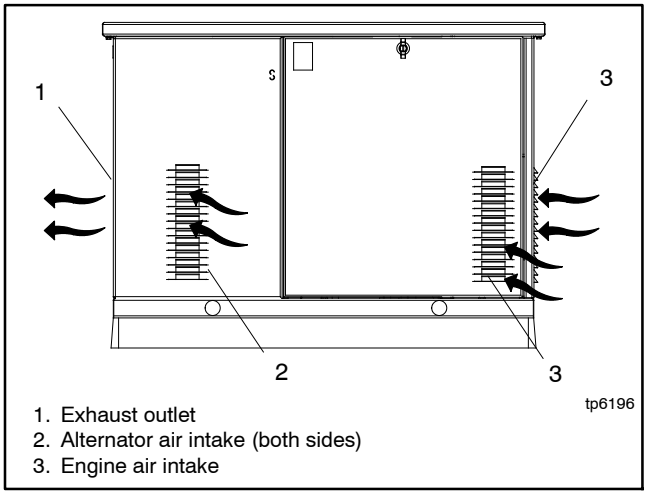
   a. Reconnect the generator set engine starting battery, negative (–) lead last.

   b. Reconnect the power to the battery charger.

2.5 Cooling System

Fans in the engine and generator draw cooling air through the louvered openings in the sides and end of the sound enclosure. The cooling air mixes with the engine exhaust and is discharged through the outlet end. To prevent generator set damage caused by overheating, keep the housing cooling inlets and outlets clean and unobstructed at all times. See Figure 2-11.

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



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

Figure 2-11 Cooling Air Intake and Exhaust

2.6 Exhaust System

⚠ WARNING

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

Do not work on the generator set until it cools.

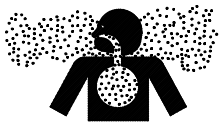
Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

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

⚠ WARNING



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

The exhaust system must be leakproof and routinely inspected.

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

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

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

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

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

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

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

2.7 Battery

⚠ WARNING

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

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

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

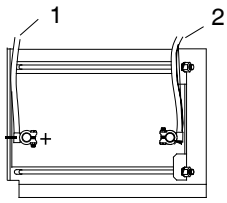
Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled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

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

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

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

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



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

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

Clean the battery and cables and tighten battery terminals using the service schedule recommendations. Clean the battery by wiping it with a damp cloth. Keep the electrical connections dry and tight.

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

2.7.1 Cleaning Battery

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

To prevent corrosion, maintain tight, dry electrical connections at the battery terminals. To remove corrosion from battery terminals, disconnect the cables from the battery and scrub the terminals with a wire brush. Clean the battery and cables with a solution of baking soda and water. Do not allow the cleaning solution to enter the battery's cells. After cleaning, flush the battery and cables with clean water and wipe them with a dry, lint-free cloth.

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

2.7.2 Battery Charger

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

See the generator set operation manual for information about battery charger operation and troubleshooting.

2.8 Storage Procedure

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

2.8.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

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

2.8.2 Fuel System

Prepare the fuel system for storage as follows:

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

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

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

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

If a fogging agent is not available perform the following:

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

2.8.4 Exterior

Prepare the exterior for storage as follows:

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

2.8.5 Battery

Perform battery storage after all other storage procedures.

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

   Maintain a full charge to extend battery life.

Notes

3.1 Introduction

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

Refer to the engine service manual for engine service information. See List of Related Materials for the document part number.

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

3.2 Initial Checks

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

- **Loose connections or damaged wiring.**
- **Dead battery.**
- **Fault shutdown.** Check for a fault code on the controller display. Section 4.4 describes the warning and shutdown fault codes.
- **Blown fuses.** Fuses in the wiring harness protect the controller, SCR module, and relay interface board. A battery charger fuse is located in the positive battery lead. Always check and replace the fuses before replacing other components.
- **Incorrect controller settings.** Always check the controller configuration settings before replacing the controller. Section 4.5 contains the instructions for checking and changing the controller configuration.
- **Inadequate fuel supply.** Check for damaged primary or secondary fuel regulators, loose connections to the fuel solenoid valve, a damaged or closed fuel shutoff valve, an empty LP fuel tank, or other problems with the fuel supply. Check the fuel supply pressure to the generator set. See Section 6.12, Fuel Systems.

3.3 Troubleshooting Chart

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

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank	Weak or dead battery	Recharge or replace battery. If battery is weak or dead, check battery charger fuse, power supply, and operation.	Generator Set O/M
	Battery connections	Check for reversed or poor battery connections.	—
	Open circuit in engine/controller connections	Check for loose connections. Check the wire harness continuity.	Section 6.17 Section 8
	Blown fuse F3, controller	Replace fuse; if fuse blows again, check circuit and components.	Section 6.15 Section 8
	Blown fuse F2, relay interface board (RIB)	Replace fuse.	Section 6.15
		If fuse blows again, disconnect the board leads one at a time to identify the cause of the blown fuse: Lead 70A at the fuel valve Lead IGN at the ignition module Lead 71A at the starter relay Leads FP and FN at the rotor Repair or replace the component causing the blown fuse.	Section 8, ADV-6835
		If fuse continues to blow and the previous step did not identify the cause, check the continuity of leads FP and FN and the leads from the P14 connector. Replace any bad leads. Use a pin pusher to remove leads from the connector, if necessary. If replacing the leads does not solve the problem, replace the RIB.	Section 8, ADV-6835 Section 4.8 or 5.7

Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank, continued	Crank relay on relay interface board (ADC 2100)	Check connections to the RIB. Check for 12VDC to the RIB on lead 71N.	Section 4.8 or 5.7; Section 8
		Check for a good ground connection (lead 16N)	Section 8
		Check crank relay K2 operation (LED3). Replace the RIB if relay does not operate.	Section 4.8 or 5.7
	Crank relay K3 on controller circuit board (ADC-RES)	Check connections to the controller.	Section 5.7 Section 8
		Check for a good ground connection.	Section 8
		Check LED3 to verify 12 VDC to relay K3. If LED3 is not lit, check for 12 VDC to the board. If LED3 is lit but the relay does not operate, replace the controller circuit board.	Section 5.7
	Blown fuse F2 (ADC-RES)	Replace fuse.	Section 6.15
		If fuse blows again, disconnect the leads one at a time to identify the cause of the blown fuse: • Lead 70C at the fuel valve. • Lead IGN at the ignition module • Lead 71A at the starter relay • Leads FP and FN at the rotor • Repair or replace the component causing the blown fuse.	Section 8, ADV-7325
		If fuse continues to blow and the previous step did not identify the cause, check the continuity of leads FP and FN and the leads from the P14 connector. Replace any bad leads. Use a pin pusher to remove leads from the connector, if necessary. If replacing the leads does not solve the problem, replace the controller circuit board.	Section 8, ADV-7325 Section 4.8 or 5.7
	Generator set master switch	Check connections to the master switch.	Section 6.17
		Test function of master switch.	Section 6.17
	Poor ground (–) connection	Clean and retighten.	—
	Starter relay	Check connections to the starter relay.	Section 1.7
		Check continuity of circuit.	Section 6.17 Section 8
		Check that the starter relay picks up when 12VDC is applied at lead 71A connection.	Section 8
	Starter	Check starter connections.	Section 1.7 Section 8
		Rebuild or replace starter.	Engine Service Manual (S/M)
	Controller	Check controller connections and operation. Check for power to the controller. Move generator set master switch to OFF/RESET and then to RUN.	Section 4 or 5 Section 8
Cranks but does not start	No fuel	Open (turn on) manual fuel valve. Check fuel supply tank (LP).	—
	Insufficient fuel pressure	Check fuel pressure to the generator set. Verify adequate fuel pressure and pipe size for the generator set plus all other gas appliances.	Section 6.12.3
	Fuel regulator/valve	Check regulator/valve operation.	Section 6.12
	Spark plugs or spark plug connections	Check spark plug wires and connections. Replace or clean and regap spark plugs.	Section 2.3
	Loose connection or open circuit	Check for loose or open connection at the fuel valve (lead 70A) and at the engine spark control module (leads IGN and 70A). Check controller/engine wiring continuity.	Section 8

Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Cranks but does not start, continued	Air cleaner clogged	Clean or replace.	Section 2.4
	Magnetic pickup	Check for 1.75 volts or higher from the magnetic pickup during cranking. A lower signal will cause the stepper motor to open and close during cranking.	Section 6.9.4
		Measure the resistance across the magnetic pickup according to the procedure in Section 6.9.4. Replace the mag pickup if the resistance is more than 20% higher or lower than the specified value.	Section 6.9.4
	Incorrect controller configuration	Check for correct controller configuration settings.	Section4.5 or 5.5
	Ignition system spark control or ignition coil	Test and/or replace components.	Engine S/M
	Digital spark advance ignition (DSAI) connections (12kW only)	Connect for natural gas. Disconnect for LP. Check for loose connections.	Section 6.13.3
	No engine rotation sensed (check for an overcrank fault shutdown)	Check mag pickup connections, air gap, resistance, and operation.	Section 6.9.4
		Check for locked rotor.	Section 6.4
Starts hard	Low battery voltage	Check battery voltage and battery charger connections, power supply, and operation.	Generator Set O/M
	Air cleaner clogged	Replace element.	Section 2.4
	Fuel mixture adjustment incorrect	Adjust fuel valve.	Section 6.12
	DSAI leads incorrectly connected or disconnected (12kW only)	Connect for natural gas. Disconnect for LP.	Section 6.13.3
	Spark plug(s)	Replace or regap spark plug(s).	Section 2.3
	Spark plug wire(s)	Check spark plug wires and connections. Replace spark plug wires.	Engine S/M
	Ignition components (spark control or ignition module)	Test/replace ignition components.	Engine S/M
	Insufficient fuel pressure	Check fuel pressure.	Section 6.12.3
	Worn piston rings, valves	Check compression.	Engine S/M
Starts but shuts down	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.4 or 5.4 Section 6.11
Stops suddenly	Fault shutdown	Check for a fault shutdown code on the controller's LED display. Correct the fault and then move the generator set master switch to OFF/RESET to reset the controller.	Section 4.4 or 5.4 Section 6.11
	No fuel	Turn on fuel supply.	—
	Fuel line restriction	Inspect fuel lines.	—
	Fuel lines too long	Check fuel line length.	Section 6.12.1
	Air cleaner clogged	Replace element.	Section 2.4
	Blown fuse	Check fuses F1, F2 and F3. Replace any blown fuses. If fuse blows again, test generator components.	Section 6.15
	Spark plug(s)	Replace and regap plug(s).	Engine S/M
	Engine overheated (hot engine only)	Check air intake, fuel adjustment, oil level, air inlet/ outlet.	Section 2.5 Section 2.2 Section 6.12

Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Stops suddenly, continued	Low oil pressure (LOP) switch	Attempt startup. If unit shuts down, remove lead from LOP switch and reset controller. A successful restart attempt indicates a faulty LOP shutdown switch. **Note:** Check engine oil pressure before performing test and/or replacing LOP shutdown switch.	Section 2.2.1 Section 6.11.2
	Fuel valve/fuel regulator	Check regulator/valve operation.	Section 2 Section 7
	Engine overloaded	Reduce electrical load.	—
	Loss of generator output voltage to controller	Check connections at P15 plug. Check continuity of AC sensing leads 11 and 44.	Section 8
	Magnetic pickup connections	Check for loose connections to the mag pickup.	Section 6.9
	Ignition module	Test and/or replace.	Engine S/M
	K3 (flash) relay on RIB. (ADC 2100)	Check for Flash LED illumination. Check fuse F2. Replace relay board.	Section 4.8
	K3 (flash) relay on controller board (ADC-RES)	Check for Flash LED1 illumination. Check fuse F2. If LED1 is lit but relay does not operate, replace controller board.	Section 5.7
Operates erratically	Air cleaner clogged	Replace element.	Section 2.4
	Spark plug(s)	Replace and regap plugs.	Section 2.3
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	DSAI leads incorrectly connected or disconnected (12kW only)	Connect for natural gas. Disconnect for LP.	Section 6.13.3
	Fuel line restriction	Check fuel lines.	Section 6.12.1
	Fuel mixture adjustment incorrect	Check and/or adjust.	Section 6.12
	Magnetic pickup connections	Check for loose connections to the mag pickup.	Section 6.9
	Governor adjustment incorrect	Adjust governor stability.	Section 6.9 or 6.10
	Ignition system	Test and/or replace components.	Engine S/M
	Inadequate cooling (hot engine only)	Inspect air inlet and outlet.	Section 2.5
	Carbon buildup in engine	Clean cylinder head.	Engine S/M
	Engine valves not seating correctly	Check cylinder pressures with leakdown test. Inspect valves and valve seats.	Engine S/M
Lacks power	Air intake restriction, inadequate cooling	Inspect air intakes and exhaust for obstructions. Check air cleaner.	Section 2.5 Section 2.4
	Generator overloaded	Reduce load.	—
	Spark plug(s)	Replace and regap plug(s).	Section 2.3
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	DSAI leads incorrectly connected or disconnected (12kW only)	Connect for natural gas. Disconnect for LP.	Section 6.13.3
	Insufficient fuel pressure	Check fuel pressure at carburetor outlet.	Section 6.12
	Fuel line restriction	Check fuel pipe size.	Section 6.12
	Fuel regulator	Check function of fuel regulator.	Section 6.12

Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
Lacks power, continued	Engine not running at rated rpm	Check controller settings for unit configuration (UC) and engine type (EC). Adjust governor speed.	Section 4.5 or Section 5.5 Section 6.9 or 6.10
	Engine power loss	Refer to the engine service manual for troubleshooting and repair instructions.	Engine S/M
	Governor malfunction or misadjustment	Test/readjust governor.	Section 6.9 or 6.10
	Ignition system	Test and/or replace.	Engine S/M
Overheats	Inadequate cooling	Inspect cooling system for air intake obstructions.	Section 2.5
	Fuel mixture adjustment incorrect	Readjust fuel mixture. **Note:** Adjusting the fuel mixture may void the emission certification.	Section 6.12
Low output or excessive drop in voltage	Generator overloaded	Reduce load.	—
	Incorrect controller configuration	Check and adjust the controller configuration parameters.	Section 4.5 or 5.5
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 4.5.3 or 5.6
	Alternator or control system	Perform separate excitation procedure to isolate problem to the alternator or the control system.	Section 6.2
	SCR module	Check wiring and connections to the SCR module. Check auxiliary winding fuse F1. Replace SCR module and test voltage.	Section 6.15 Section 6.8
	Controller	Check controller settings. Check controller fuse, wiring and connections. Before replacing controller, replace SCR module and test voltage.	Section 4.5 or 5.5 Section 6.8
	Rotor (open, grounded, or shorted windings)	Test and/or replace.	Section 6.4
	Stator (open, grounded, or shorted windings)	Test and/or replace.	Section 6.3
	Brush connection	Check for loose brush connections. Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.	Section 6.6
	Low engine speed causing voltage roll-off	Check system voltage/frequency (Uu) and engine type (Ec) parameters. Adjust engine governor speed. Troubleshoot engine.	Section 4.5 or 5.5 Section 6.9 or 6.10 Engine S/M
Light flicker	Voltage stability (gain) setting	Check and adjust the voltage stability (gain) setting using the controller keypad.	Section 4.5.3
High output voltage	Incorrect controller configuration	Check and adjust the controller configuration parameters.	Section 4.5 or 5.5
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 4.5.3
	Engine speed too high	Check engine speed using tachometer or frequency meter. Adjust governor as necessary.	Section 6.9 or 6.10
	Loose voltage sensing connections	Check connections: stator leads 11 and 44 and P15 controller connection.	Section 8
	SCR module	Check wiring and connections to the SCR module. Check auxiliary winding fuse F1 (lead 55). Replace SCR module and recheck voltage.	Section 6.8 Section 6.15 Section 6.8
	Controller	Check fuses, wiring and connections. Before replacing controller, replace SCR module and test voltage.	Section 4.9

Troubleshooting Chart, continued

Problem	Possible Cause	Corrective Action	Reference
No output voltage	AC output circuit breaker open	Check for AC voltage on the generator side of circuit breaker. If there is AC voltage on the generator side of the breaker, then a problem in the load circuits is causing the line circuit breaker to trip. Check for and correct short circuits or overloading on the load side before resetting the circuit breaker.	—
	Alternator or control system	Perform separate excitation procedure to isolate the problem to the alternator or the control system. Then troubleshoot the alternator or control system components as follows.	Section 6.2
	Aux. winding fuse F1 blown.	Check fuse F1 and replace if blown. If fuse blows again, check stator.	Section 6.3
	SCR module	Check auxiliary winding fuse F1. Replace SCR module and test voltage.	Section 6.15 Section 6.8
	Controller	Check controller settings. Check wiring and connections. Before replacing controller, replace SCR module and check voltage.	Section 4.5 or . Section 6.8
	Open wiring, terminal, or pin in buildup circuit or SCR module circuit	Check continuity.	Sections 6.15 Section 8
	Brushes	Inspect brushes and replace if worn.	Section 6.6
		Check for brushes sticking in brush holder or broken brush spring.	Section 6.6
	Rotor connections	Check for open circuit in rotor connection circuit (leads FN and FP to SCR and RIB).	Section 8
	Rotor slip rings dirty or corroded	Check slip ring condition.	Section 6.4
	Rotor (open, grounded, or shorted windings)	Check voltage and continuity.	Section 6.4
	Stator (open, grounded, or shorted windings)	Check voltage and continuity.	Section 6.3
	Flash relay (K3) on RIB (ADC 2100)	Check flash LED on RIB. Check fuse F2 and troubleshoot RIB.	Section 4.8
	Flash relay (K3) on controller board (ADC-RES)	Check fuse F2. Check flash LED1 on controller board. If LED1 indicates power to K3 but relay does not operate, replace controller circuit board.	Section 5.7
Noisy operation	Exhaust system leaks	Check and replace as necessary.	Section 2.6
	Engine not running smoothly	See *Generator set operates erratically* in this table.	—
	Broken or damaged vibromount(s)	Check and replace as necessary.	Section 7
	Loose or vibrating sheet metal/housing	Retighten screws, replace rivets.	—
	Exhaust piping or air inlets/outlets not securely installed	Inspect for loose parts and secure if necessary.	Section 2.6
	Excessive engine/generator vibration	Check, rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Section 7 Engine S/M

3.4 Controller Troubleshooting

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

Possible Cause	Test	Corrective Action	Reference
Controller	Check controller settings. *	Adjust controller settings as required. *	Section 4.5 or 5.5
	Check for power to the controller at lead PF1.	Check/replace fuse F3. Check battery.	Section 8
	Check controller fuse F3.	Replace controller fuse.	Section 8
	Check controller wiring and connections.	Tighten connections and/or replace wiring.	—
	Replace SCR module and recheck voltage.	Replace the SCR module.	Section 6.8
	Perform all tests listed under high output voltage.	Replace the controller only if previous steps do not solve the problem.	Section 4.9 or 5.9
SCR module	Check wiring and connections to the SCR module.	Tighten connections and/or replace wiring to the SCR module.	Section 6.8
	Test the SCR module using the procedure in Section 6.8.	Replace the SCR module and recheck voltage.	Section 6.8
	Check auxiliary winding fuse F1 (lead 55).	Replace auxiliary winding fuse F1 (lead 55).	Section 8
* ADC 2100 or ADC-RES controllers only.			

Notes

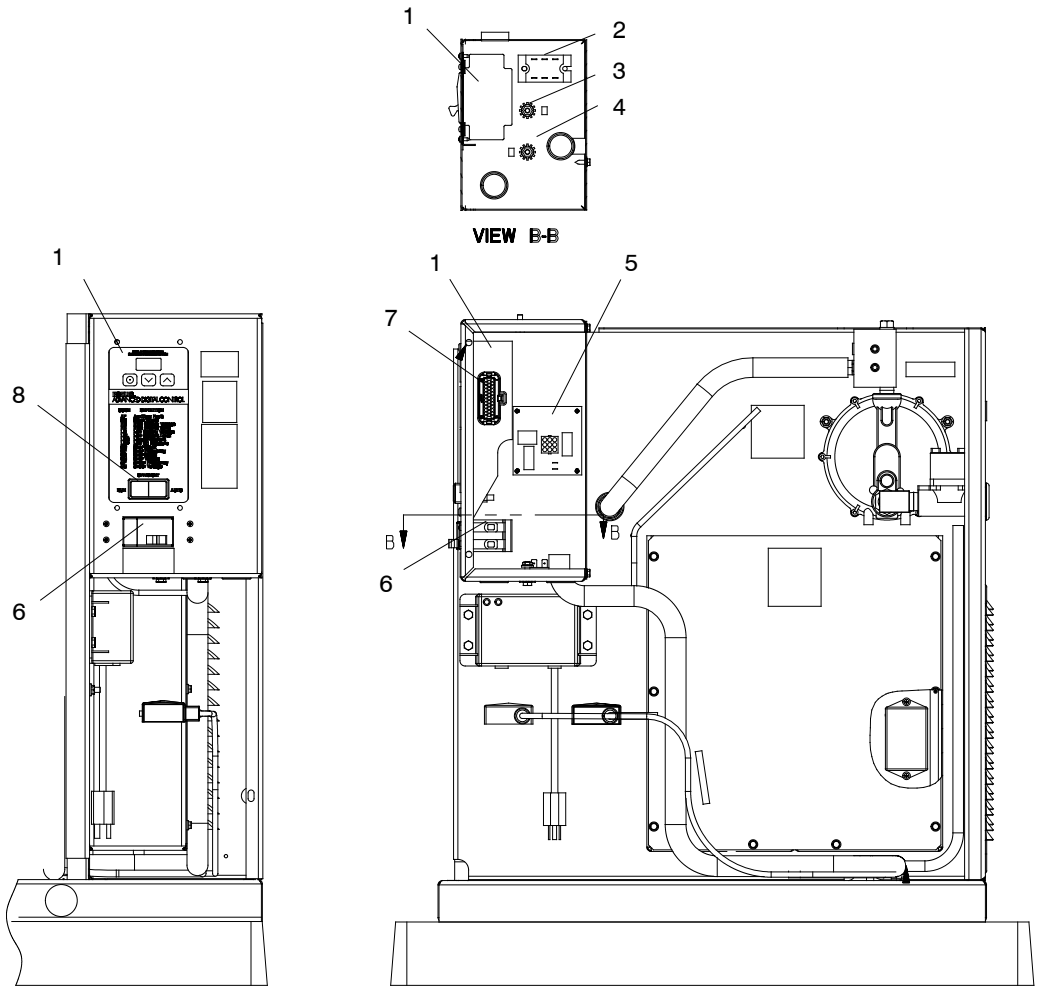
4.1 Introduction

This section covers operation, configuration, adjustment, and replacement of the ADC 2100 and DC 2200 controller. See Section 3 for troubleshooting procedures.

See Figure 4-1 for the locations of the controller and related components. Section 4.2 describes the controller keypad and display. Section 4.3 describes the sequence of operation and faults are described in Section 4.4. Controller configuration and adjustment are covered in Section 4.5.

A silicon controlled rectifier (SCR) module works with the controller to regulate the output voltage. See Section 6.8.

A relay interface board (RIB) is used with the ADC controller. Section 4.8 describes the standard and optional RIBs.

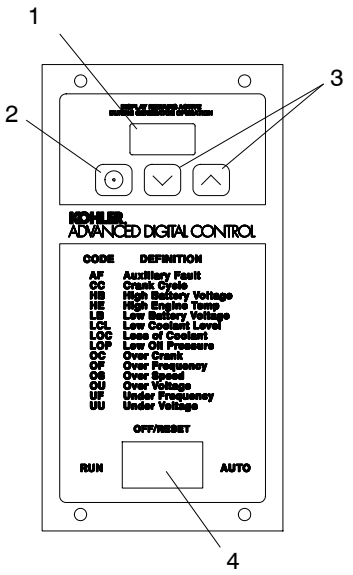


1. Controller
2. SCR module
3. Ground stud
4. L0 stud
5. Relay interface board (RIB)
6. Line circuit breaker (load connection)
7. Engine harness-to-controller connection
8. Generator set master switch

Figure 4-1 Advanced Digital Control (ADC 2100)

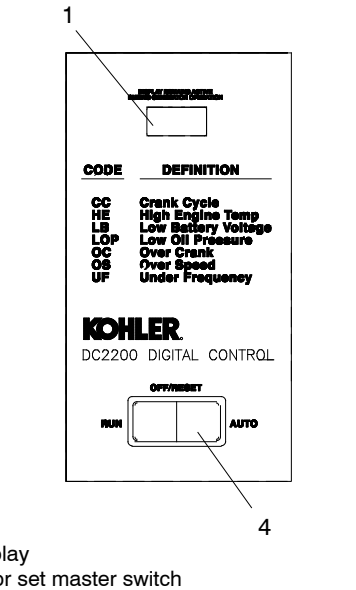
4.2 Controller Display and Keypad

The ADC 2100 controller has an LED display and a three-button keypad. See Figure 4-2. The DC 2200 controller has a display, but no keypad. See Figure 4-3. The LED display shows runtime hours, fault codes, application program version number, or controller parameters during configuration and adjustment. See Figure 4-4.



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

Figure 4-2 ADC 2100 Controller



1. LED display
2. Generator set master switch

Figure 4-3 DC 2200 Controller

Controller Display	
Item	**Description**
Crank indication	Displays CC_1, CC_2, or CC_3 to indicate the first, second or third attempt to start the engine. The last digit flashes during the crank cycle rest periods.
Runtime hours	Displays total generator set runtime hours when no other code is displayed.
Fault codes	Flashes a 2- or 3-letter fault code to indicate various fault conditions. See Section 4.4.
System parameters	Displays 2-letter codes or 4-digit alphanumeric codes during system configuration or adjustment. See Section 4.5.
Application program version number	ADC 2100: Displays the version number of the controller's application program before entering the configuration or adjustment mode. See Section 4.5.4. DC 2200: Application program version number is displayed at controller powerup.

Figure 4-4 Controller LED Display

The ADC 2100 keypad is used to enter the controller's configuration and adjustment menus and to change the controller settings. A password key sequence is required to enter the configuration and adjustment menus. Section 4.5 contains the instructions to enter the configuration and adjustment menus and change the settings using the controller keypad.

4.3 Sequence of Operation

The following sections describe the controller sequence of operation during generator start, run, stop, and fault shutdown modes. Use this as a starting point for controller and relay board fault identification. Refer to the wiring diagrams in Section 8 to assist in the troubleshooting procedure.

4.3.1 Starting Sequence, Master Switch Moved to RUN

When the master switch is moved to the RUN position, there is a delay of about 2 seconds before the controller attempts to start the engine. The electronic governor moves to its start position. The run relay energizes and the run LED (1) turns on. The crank and flash relays energize and the corresponding LEDs (2 and 3) turn on 0.5 seconds later. The controller display indicates the crank cycle 1 code, CC 1.

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

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

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

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

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

4.3.2 Starting Sequence, Remote Start

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

The start sequence proceeds as described in Section 4.3.1, Starting Sequence, Master Switch Moved to RUN.

4.3.3 Running Sequence

When the engine speed reaches 750 rpm, the crank relay de-energizes and the crank LED (3) turns off. When the output voltage on leads 11 and 44 reaches about 30 VAC, the flash relay de-energizes and the flash LED (2) turns off.

4.3.4 Stopping Sequence, Master Switch Moved to OFF/RESET

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

4.3.5 Stopping Sequence, Remote Stop

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

Note: Disconnecting the P7 jumper (if equipped) on the back of the controller will allow the controller to power down 48 hours after generator set shutdown. See Section 4.6, Continuous Power Mode.

4.4 Faults

4.4.1 Warnings

The fault conditions listed in Figure 4-5 will cause the controller to display a fault code but will not shut down the generator set.

4.4.2 Shutdowns

Under the fault conditions listed in Figure 4-6, the controller displays a fault code and the generator set shuts down.

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

Move the generator set master switch to the OFF/RESET position to reset the controller after a fault

shutdown. Then move the switch to the AUTO or RUN position.

Generator sets with serial numbers below 2051415 were built with controllers equipped with the continuous power mode jumper. If the power jumper is removed and the controller powers down after a fault shutdown, move the master switch to OFF/RESET and then to RUN to display the fault code. Then move the switch to OFF/RESET again to clear the fault. See Section 4.6 for more information on the continuous power mode jumper.

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

Figure 4-5 Fault Warning Codes

Code	Fault	Description	Check	Refer to Section
AF	Auxiliary fault	Not used on these models.	—	—
HE	High engine temperature	Shutdown occurs if the engine coolant temperature exceeds the maximum temperature for more than 5 seconds. This protective becomes active after the engine reaches crank disconnect speed.	Check for blocked air inlets and exhaust outlets.	1.7
LCL	Low coolant level	Not used on air-cooled models.	—	—
LOC	Loss of coolant	Not used on air-cooled models.	—	—
LOP	Low oil pressure	Shutdown occurs if a low oil pressure condition exists for more than 5 seconds. This protective becomes active 30 seconds after the engine has reached crank disconnect speed (30 second inhibit). **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low. Check low oil pressure switch connections and operation. Check the oil pump and lubrication system.	2.2 2.2 6.11.2 6.11 Engine S/M
OC	Overcrank	Shutdown occurs after 3 unsuccessful starting attempts. The crank cycle is set for three starting attempts of 15 seconds cranking and 15 seconds rest.	Check the fuel supply valves and pressure. Check spark plug and battery. See Troubleshooting Chart, generator set cranks but does not start.	6.12 2.3 3.3
		The generator set shuts down on an overcrank fault if no engine rotation is sensed. Shuts down after 3 seconds of cranking or 1 second after the fault is detected.	Check mag pickup connections and operation. Check for a locked rotor.	6.9.4 6.4
OF	Overfrequency	Shutdown occurs when the governed frequency exceeds 110% of the system's frequency setpoint for more than 5 seconds. This protective becomes active 10 seconds after engine start (10 second inhibit).	Check system frequency setting (parameter UU) on controller. Measure output frequency and adjust, if necessary. Check governor system condition and operation.	4.5 6.9.5 6.9
OS	Overspeed	Shutdown occurs if the engine speed exceeds 115% of the normal running speed for more than 0.3 seconds.	Check governor settings and operation.	6.9
OU *	Overvoltage	Shutdown occurs if the voltage exceeds 120% of the system nominal voltage for more than 2 seconds.	Check AC voltage. Check wiring and connections.	6.7 8
UF	Underfrequency	Shutdown occurs when the governed frequency falls blow 90% of the nominal system frequency for more than 5 seconds. This protective becomes active 10 seconds after engine start (10 second inhibit).	Reduce the load and restart the generator set.	—
UU *	Undervoltage	Shutdown occurs if the voltage falls below 80% of the nominal system voltage for more than 10 seconds.	Reduce the load and restart the generator set. Check wiring and connections. Check controller configuration, system voltage and frequency (parameter UU). Check AC voltage and adjust, if necessary. Replace the SCR module and test voltage again. Separately excite unit. Check stator continuity.	— 8 4.5 6.7 6.8 6.2 6.3
SCF0	Software Communication Fault 0	Indicates a software or communication problem within the ADC 2100	Replace the controller.	4.9

* Not applicable on DC 2200 controllers with software versions below 1.26. DC 2200 software version number is displayed on controller powerup.

Figure 4-6 Fault Shutdown Codes

4.5 ADC 2100 Controller Configuration and Adjustment

Note: The settings described in this section are not adjustable on the DC 2200 controller.

The first step in troubleshooting the controller is to verify that the controller is correctly configured for the generator set. The controller's configuration modes allow setting of the engine type, generator set configuration (marine, mobile, or standby), data input types, and other parameters.

The controller configuration for each generator model is set at the factory. Changes in the controller configuration may be required after controller replacement or other service. Use the instructions in the following section to check the controller settings and change them, if necessary.

4.5.1 Controller Time Out

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

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

4.5.2 Controller Configuration

The controller configuration is factory-set and should not normally require changes in the field. However, the controller configuration may need to be checked or changed during generator set service or controller replacement.

The controller's configuration mode allows adjustment of the system parameters listed in this section. The system voltage and frequency and unit configuration and engine type are factory-set for each type of generator set and engine and should not require changes unless the controller is replaced.

The controller's advanced configuration mode allows the user to set the data input type for engine senders, toggle the battery voltage between 12 and 24 volts, and change the controller communications setting for optional meters (not offered for standby models). Check these settings after controller replacement and change them, if necessary, to match the settings shown in Figure 4-7.

Follow the instructions in Figure 4-8 to enter the configuration mode while the engine is not running and then step through the following parameters. Use the up (∧) and down (∨) arrow buttons to select the appropriate setting for the application.

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

Voltage/frequency setting (Uu). Select the system voltage and frequency from the table in Figure 4-7.

Note: This parameter sets the nominal system voltage and frequency. To adjust the output (measured) voltage and frequency, see Section 4.5.3, Figure 4-11 and Figure 4-12.

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

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

Parameter	Setting	Definition
Unit's system voltage and frequency.	Uu00	Single phase, 60 Hz, 120 VAC
	Uu01 *	Single phase, 60 Hz, 120/240 VAC
	Uu05	Single phase, 50 Hz, 115 VAC
	Uu06 *	Single phase, 50 Hz, 115/230 VAC
Unit configuration	Uc01 *	Standby
Engine type	Ec00 *	8.5/12RES
Engine data input types	Ed05 *	Digital low coolant level, digital pressure, analog temp, with mag. pickup
	Bt12 *	Battery voltage 12 VDC
Communications	Cn00 *	No CAN communications
* Factory settings. Choose 50 or 60 Hz setting for Uu as required for generator set frequency .		

Figure 4-7 ADC 2100 Controller Configuration Parameters

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

Engine data input types (Ed). This setting defines the type of senders used on the generator set engine.

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

Communications setting (Cn). This setting allows the user to set the controller for communication with optional meters, which are available for marine and mobile units only.

4.5.3 Voltage and Frequency Adjustments

The flowchart in Figure 4-12 outlines the procedures for using the ADC controller to adjust the output voltage and engine speed (frequency). Voltage and/or frequency adjustments may be required after controller replacement or other service procedures.

The generator set must be running during these adjustments. Use a multimeter to measure the generator set output voltage and frequency during adjustments. Refer to Sections 6.7.2, Voltage Adjustment, and 6.9.5, Frequency Adjustment, for instructions to measure the output voltage and frequency.

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

4.5.4 Controller Application Program

The ADC 2100 application program version number is displayed on the LED screen during the key sequence to enter the configuration mode. Hold the Select button and move the generator set master switch to the RUN position. After about 5 seconds, the application program version number will be displayed on the controller display. For example, 01.04 will be displayed for program version 1.04.

The DC 2200 controller application program version number is displayed at controller powerup.

Controller Configuration Mode:

Hold the Select button:

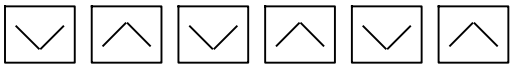
Move the generator set master switch to the RUN position. (The generator set engine will not start.)

Display: * . 0

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

1 0 4

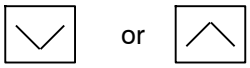
Press the down arrow key and then the up arrow key 3 times to enter the configuration mode. (This is the controller "password.")



U u 0 1

Now release the Select button.

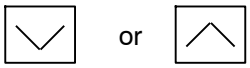
Press:



To set the system voltage and frequency. **See Figure 4-7 for settings.**

U u 0 1

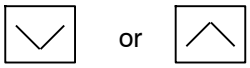
To step to the next parameter, unit configuration Uc.



To set the unit configuration setting to Uc01, if necessary.

U c 0 1

To step to the next parameter, engine type Ec.



To set the engine type to Ec00, if necessary.

E c 0 0

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

A d n c

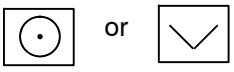
Now either save your settings or enter the Advanced Configuration Mode to set the engine data inputs, battery voltage, and communications.

Press:

or

To enter advanced configuration mode. **Go to Figure 4-9.**

E d 0 5



To proceed to the save mode without entering the advanced configuration mode. **Go to Figure 4-10.**

S A V E

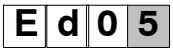
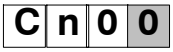
Note: Be sure to save your settings before exiting the configuration mode. The controller reverts to the last *saved* settings when the master switch is moved to the OFF/RESET position.

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

Figure 4-8 Configuration Mode (system voltage/frequency, unit configuration, and engine type parameters)

Pressing the up arrow key at the Adnc display (See Figure 4-8) puts you into the Advanced Configuration Mode.

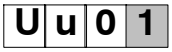
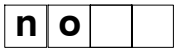
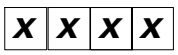
Press:

 or 	To set the engine data input type to Ed05.	
	To enter battery voltage selection mode.	
 or 	To toggle between 12 and 24 VDC. Set this parameter to 12 VDC.	
	To enter communications selection mode.	
 or 	To set the communications parameter to Cn00.	
	To enter SAVE mode. Go to Figure 4-10.	

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

Figure 4-9 Advanced Configuration Mode (engine data input types, battery voltage, and engine communications)

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

	To return to the first parameter, system voltage/frequency Uu, to check or change settings before saving. See Figure 4-8.	
or		
	To save changes.	
or		
	To discard changes without saving.	
	Yes or *no* flashes when the up or down arrow is pressed and then the controller exits the configuration mode. The display returns to the runtime hours. *	

Now move the master switch to OFF/RESET.

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

Figure 4-10 Save Mode (after configuring generator set parameters)

Output Voltage and Frequency Adjustment Mode:

Display :*

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

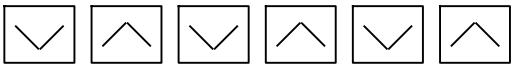
Display: X X X X

Hold:

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

Display: X. X X

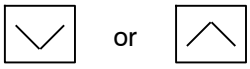
Press the down arrow key and then the up arrow key 3 times to enter the adjustment mode. (This is the controller "password.")



Display: 1 P X X

The controller is now in the voltage coarse adjustment mode.

Press:



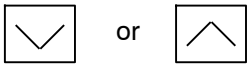
or

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

Display: 1 P X X

To enter fine voltage adjustment mode.

Display: 1 P X X

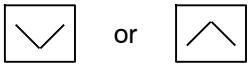


or

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

To enter coarse voltage stability (gain) adjustment mode.

Display: 2 P X X

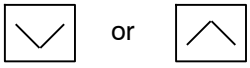


or

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

To enter fine voltage stability (gain) adjustment mode.

Display: 2 P X X

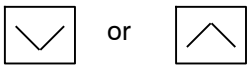


or

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

To enter volts/Hz adjustment mode.

Display: 3 P 0 X



or

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

Continued on Figure 4-12.

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

TP6196

Figure 4-11 Output Voltage and Frequency Adjustments

Continued from Figure 4-11:

Press: | **Display : ***

Press:		Display : *
	To enter engine governor speed coarse adjustment mode.	**4 P *x x***
 or 	To raise or lower the engine speed in large increments.	
	To enter engine governor speed fine adjustment mode.	**4 P *x x***
 or 	To raise or lower the engine speed in smaller increments.	
	To enter engine governor stability (gain) coarse adjustment mode.	**5 P *x x***
 or 	To raise or lower the engine governor stability (gain) in large increments.	
	To enter engine governor stability (gain) fine adjustment mode.	**5 P *x x***
 or 	To raise or lower the engine governor stability (gain) in smaller increments.	
	To enter SAVE mode. Go to Figure 4-13.	**S A V E**

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

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

Figure 4-12 Output Voltage and Frequency Adjustments, Continued

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

SAVE

⊙	To return to the first parameter, coarse voltage adjustment, to check or change settings before saving. See Figure 4-8.	1Px x
or		
∧	To save changes.	YES
or		
∨	To discard changes without saving.	no
	"Yes"or "no" flashes when the up or down arrow is pressed and then the controller exits the configuration mode. The display returns to the runtime hours.	x x x x

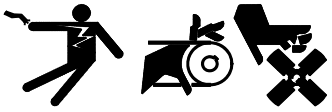
Now move the master switch to OFF/RESET.

Figure 4-13 Save Mode (after generator set and engine adjustments)

4.6 Continuous Power Mode Jumper

Generator sets with serial numbers below 2051415 were built with controllers equipped with the continuous power mode jumper. See TT-1364, ADC 2100 Controller Replacement, for additional information.

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

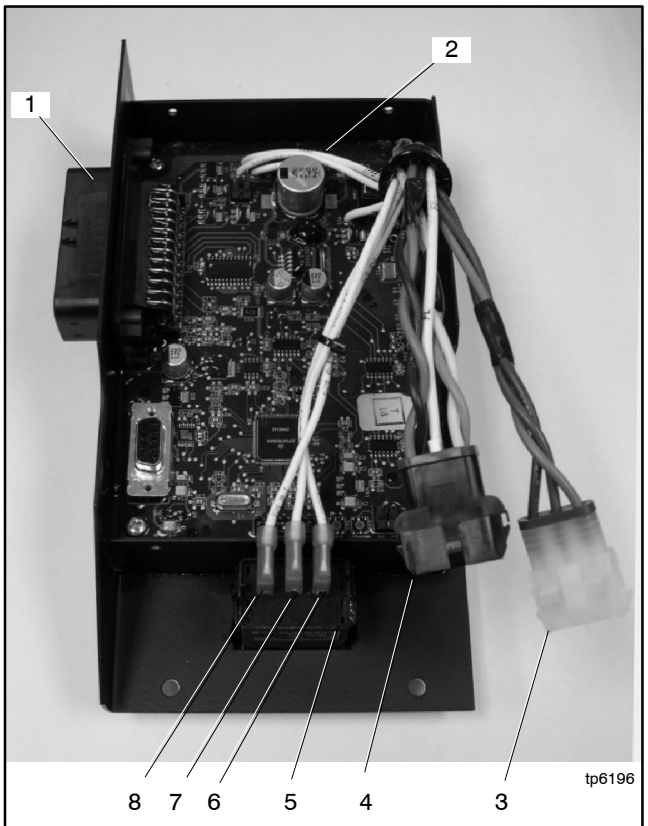
Short circuits. Hazardous voltage/current will cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

A jumper across controller pins P7-1 and P7-2 maintains power to the controller at all times. Controllers are shipped with the jumper connected for continuous power. See Figure 4-14.

Note: The controller is powered by the generator set engine starting battery. The 8.5 and 12 RES generator sets are equipped with factory-installed battery chargers to prevent battery discharge.

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

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



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

Figure 4-14 ADC 2100 (back cover removed)

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

Note: For most applications, it is not necessary to disconnect the continuous power mode jumper.

1. Prevent the generator set from starting.
   a. Move the generator set master switch to the OFF/RESET position.
   b. Disconnect power to the battery charger.
   c. Disconnect the generator set engine starting battery, negative (–) lead first.
2. Remove the controller from the generator set housing.
   a. Disconnect the engine wiring harness connector P1 plug (35-pin) from the controller. Disconnect the J15 and J16 connectors. See Figure 4-14.
   b. Remove the controller from the generator set housing in order to access the back of the controller.
3. Remove the controller's back cover to access the jumper.
   a. Note the labels on the three leads connected to the generator set master switch for reconnection later. Disconnect the leads at the pink connectors. See Figure 4-14.
   b. Remove the cover screws and remove the controller's back cover. See Figure 4-14.
4. Locate the P7 connector near the top of the controller. See Figure 4-14. Remove the jumper from pins 1 and 2 of the P7 connector. If the P7 connector has three pins, connect the jumper across pins 2 and 3 for storage.
5. Replace the controller's back cover and secure the cover screws.
6. Reconnect the three pink connectors to the generator set master switch as shown in Figure 4-14.
7. Reconnect the J15 and J16 connectors.
8. Reconnect the generator set engine starting battery, negative (–) lead last.
9. Reconnect power to the battery charger.
10. Place the generator set master switch in the AUTO position.

4.7 Master Switch

The generator set master switch is a three-position (RUN\OFF/RESET\AUTO) rocker switch. The leads connecting to the master switch are labeled RUN, VBAT, and AUTO. Check that the three pink connectors are connected to the terminals on the back of the switch as shown in Figure 4-14. Be careful not to reverse the RUN and AUTO leads.

4.8 Relay Interface Board (RIB)

The standard relay interface board (RIB) contains the K2 crank, K3 flash, and K5 run relays. Three LEDs indicate relay operation. See Figure 4-15.

Refer to the schematic diagram in Section 8 for the standard relay board connections.

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

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

Repair or replace the component causing the blown fuse.

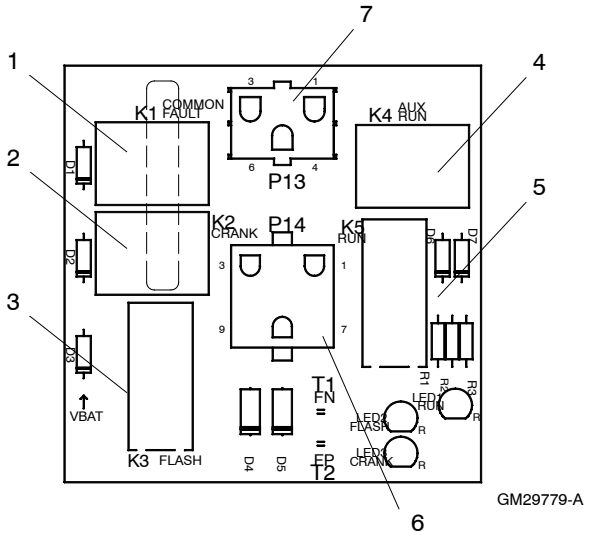
If fuse continues to blow and disconnecting components did not identify the cause, remove the leads from the P14 connector using a pin pusher, part #241918 (large) or 241919 (small). If replacing the leads does not solve the problem, replace the RIB.

The individual relays are not replaceable. If one or more relays are faulty, replace the entire RIB.

To replace the RIB:

1. Disconnect P14 and the brush leads FP and FN.
2. Pull the board straight off the mounting stand-offs.
3. Snap the new board onto the stand-offs and reconnect P14 and the brush leads.

The generator set may be equipped with an optional RIB, which contains the K4 auxiliary run relay and K1 common fault relay in addition to the standard relays. The optional relay board kit includes a wiring harness for connection of customer equipment to the K1 and K4 relays. See Figure 4-16 for optional relay connections.



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

Figure 4-15 Relay Board

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

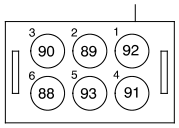


Figure 4-16 Optional Common Fault and Run Relay Board Harness Connections

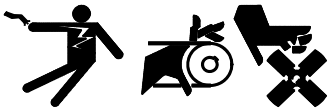
4.9 Controller Replacement

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

After replacing the controller, verify that the new controller's configuration settings match the generator set system voltage and frequency, unit configuration, engine type, engine data input types, battery voltage, and communications settings. Refer to Section 4.5 for instructions to check the controller configuration and to change the settings, if necessary.

After the controller configuration has been checked and set to match the generator set, use a voltmeter to check the generator set output voltage and frequency. If the output voltage or frequency needs adjustment, use the Voltage and Frequency Adjustment Procedure in Section 6.7.2 and the controller voltage and speed adjustment instructions in Section 4.5.3. Also see the Frequency Adjustment Procedure in Section 6.9.5.

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

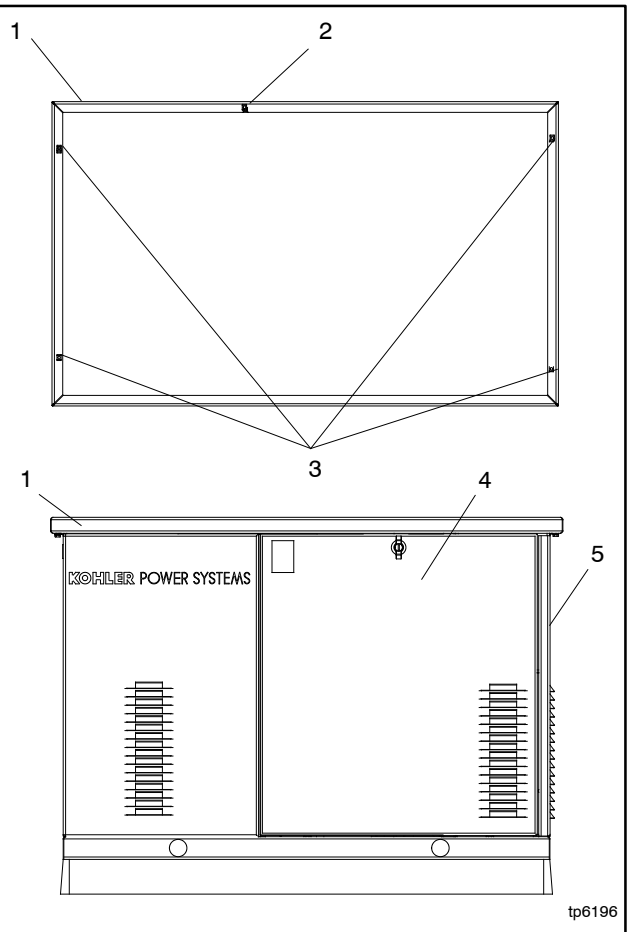
Disconnect all power sources before opening the enclosure.

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

Short circuits. Hazardous voltage/current will 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.

ADC 2100 Controller Replacement Procedure

1. Remove the enclosure service-side door. See Figure 4-17.
2. Place the generator set master switch in the OFF position.
3. Remove 4 roof screws. Lift the roof up and off. See Figure 4-17.
4. Disconnect power to the battery charger.
5. Disconnect the generator set engine starting battery, negative (–) lead first.



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

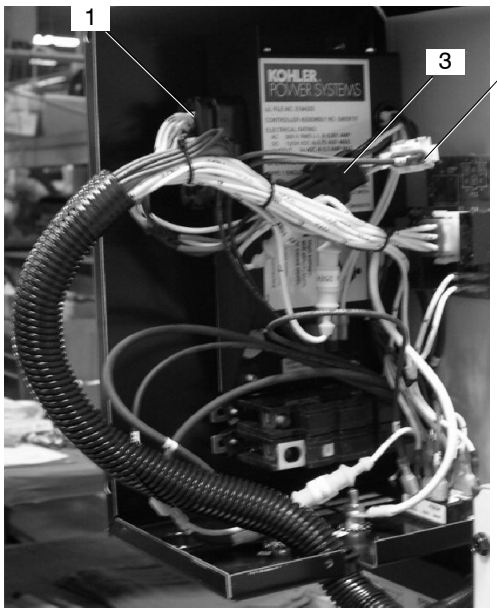
Figure 4-17 Enclosure Roof and Door

Note: Some versions of the controller mount from inside the controller compartment. Others are front-mounted.

6. For **inside-mounted controllers**:
   a. Remove 5 screws to remove the front panel on the air intake end of the enclosure. Remove the plastic caps to access the 2 side screws. See Figure 4-17.
   b. Remove two screws to remove the cover from the controller compartment. See Figure 4-18.
   c. Disconnect wiring harness plugs P1, P15, and P16 from the ADC controller. See Figure 4-19.
   d. Loosen and remove four controller mounting screws at the front of the controller. See Figure 4-20. Remove the controller from the compartment.
   e. Place the new controller into position and install the four mounting screws.
   f. Attach connectors P1, P15, and P16 to the new controller.
   g. Replace the cover on the controller compartment.
   h. Replace the front panel on the air intake end of the enclosure.

1. Cover screws

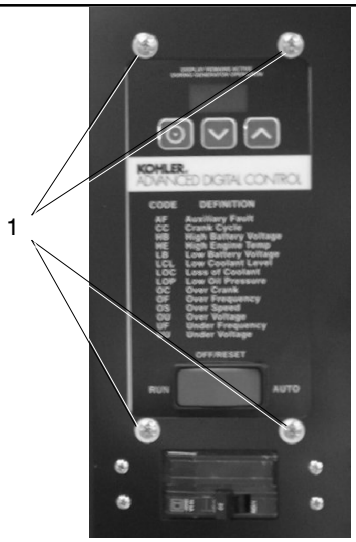
Figure 4-18 Controller Compartment Cover



tp6196

1. P1 35-pin connector
2. P15 3-pin connector
3. P16 6-pin connector

Figure 4-19 Controller Connections



tp6196

1. Controller mounting screws (4 ea.)

Figure 4-20 Controller Mounting Screws (inside-mounted controller shown)

7. For **front-mounted controllers**:

   a. Remove four mounting screws from the front of the controller.

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

   c. Disconnect plugs P1, P15, and P16 from the ADC controller. See Figure 4-19.

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

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

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

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

10. Reconnect power to the battery charger.

11. Replace the roof and tighten the four roof screws.

12. Follow the instructions in Section 4.5.2 to change the new controller's configuration settings to match the generator set system voltage and frequency, unit configuration, engine type, engine data input types, battery voltage, and communications settings.

13. Use a voltmeter to check the output voltage. Follow the instructions in Sections 4.5.3, Voltage and Frequency Adjustments, and 6.7.2, Voltage Adjustment, to adjust the output voltage and stability.

14. Check the output frequency. Follow the instructions in Sections 4.5.3, Voltage and Frequency Adjustments, and 6.9.5, Frequency Adjustment, to adjust the output frequency and stability.

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

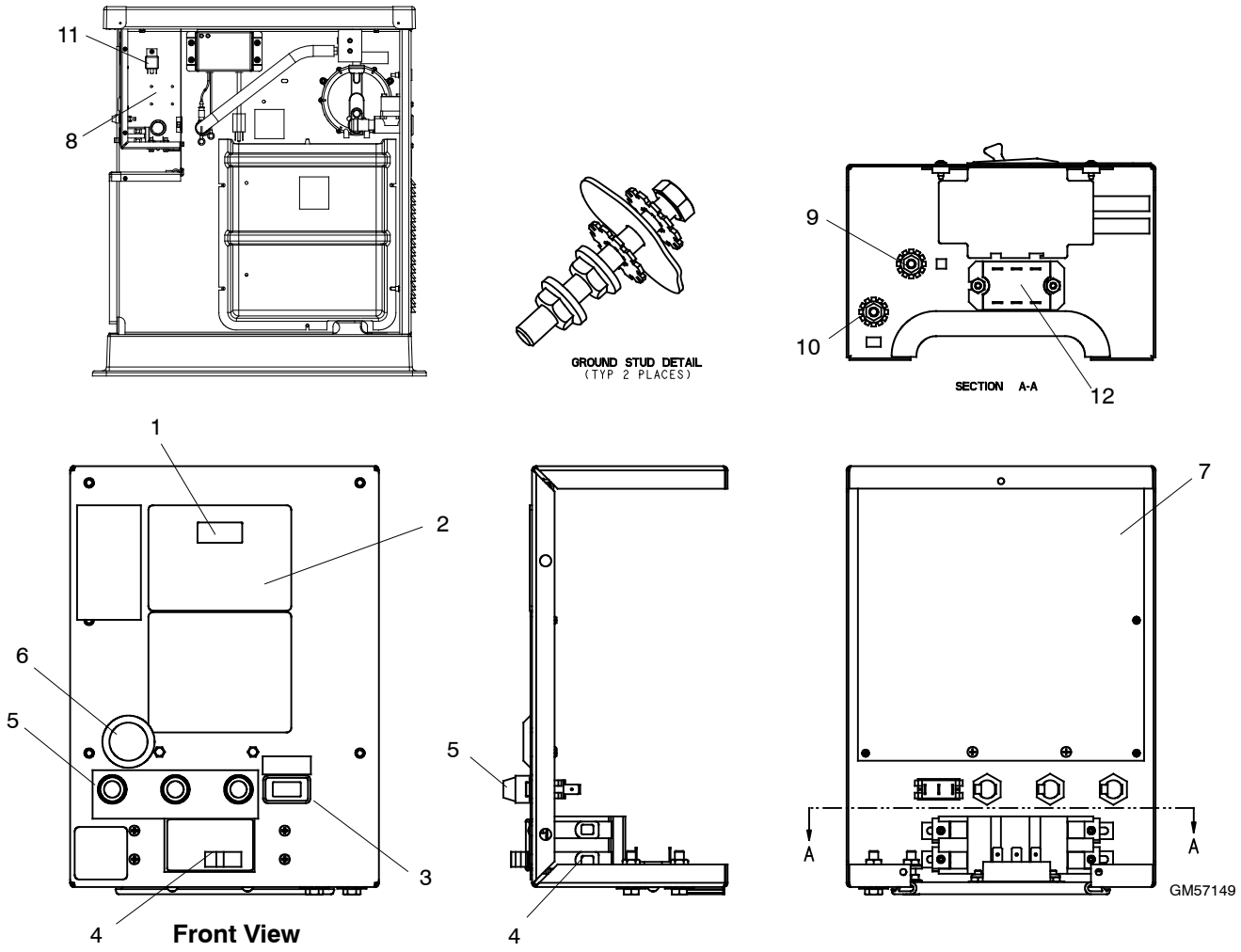
16. Replace the enclosure door.

Notes

5.1 Introduction

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

See Figure 5-1 for the controller location.



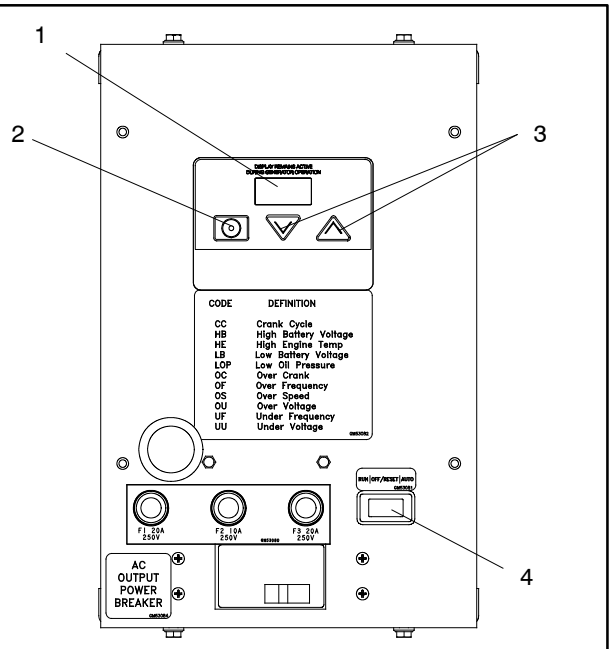
1. Controller display
2. Keypad (ADC-RES only; see Figure 5-2)
3. Generator set master switch (RUN-OFF/RESET-AUTO)
4. Line circuit breaker (load connection)
5. Fuses F1, F2, and F3
6. Serial port for communication connection (remove plug to access)
7. Logic board
8. Optional relay board location
9. L0 stud
10. Ground stud
11. Start relay
12. SCR module

Figure 5-1 Controller Components

5.2 Controls and Display

The ADC-RES controller has an LED display and a three-button keypad. See Figure 5-2. The DC-RET controller has an LED display. See Figure 5-3.

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



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

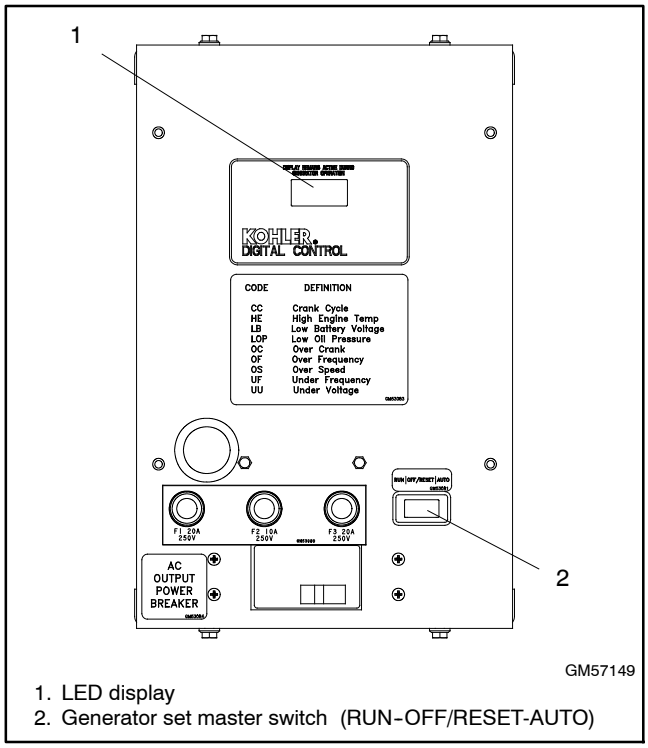
Figure 5-2 ADC-RES Controller

5.2.1 Master Switch

The generator set master switch is a three-position (RUN\OFF/RESET\AUTO) rocker switch. See Figure 5-2 or Figure 5-3 for the master switch location. See Section 6.17 for master switch connections.

5.2.2 LED Display

The LED display shows runtime hours, fault codes, application program version number, or controller parameters during configuration and adjustment. See Figure 5-4.



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

Figure 5-3 DC-RET Controller

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

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

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

When the generator set is running, the arrow keys on the ADC-RES can be used to step through the other displays as described in Section 5.2.3.

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

Control or Indicator	Item	Description
LED display	Runtime hours	Displays total generator set runtime hours while the generator set is running and when no other codes are displayed.
	Metering display (ADC-RES only)	Displays AC voltage (output), frequency, and battery voltage. Press the up or down arrow when runtime hours are displayed to step through these displays.
	Crank indication	Displays CC_1, CC_2, or CC_3 to indicate the first, second, or third attempt to start the engine. The last digit flashes during the crank cycle rest periods.
	Software version number	ADC-RES: The software version number (v#.##) is displayed when entering configuration mode. See the installation manual. DC-RET: The software version number (v#.##) is displayed during the first 2 seconds of the crank cycle.
	Fault codes	Flashes a 2- or 3-letter fault code to indicate various fault conditions. See Section 4.4.
Keypad (ADC-RES only)	Select and arrow buttons	Use the arrow buttons to step through the data displays. See Section 5.2.3. The keypad is also used for controller setup and adjustment. The setup and adjustment functions are password-protected. Have setup and adjustments performed only by an authorized distributor/dealer.
Generator set master switch	Three-position switch	Switch functions as the generator set operation and controller reset switch.

Figure 5-4 Controls and Indicators

5.2.3 Keypad

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

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

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

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

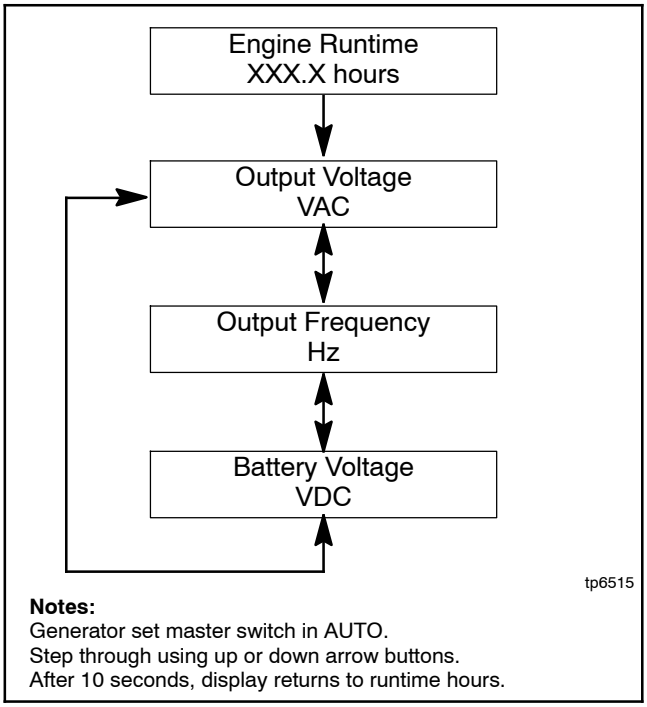


Figure 5-5 Generator Set Status Displays (ADC-RES only)

5.3 Sequence of Operation

The following sections describe the controller sequence of operation during generator start, run, stop, and fault shutdown modes. Use this as a starting point for controller and relay board fault identification. Refer to the wiring diagrams in Section 8 to assist in the troubleshooting procedure.

5.3.1 Starting Sequence, Master Switch Moved to RUN

When the master switch is moved to the RUN position, there is a delay of about 2 seconds before the controller attempts to start the engine. The electronic governor moves to its start position. The fuel (run) relay energizes and the corresponding LED on the control board turns on. (See Section 4.8 for relay information.) Then the crank and flash relays energize and the corresponding LEDs turn on. The controller display indicates the crank cycle 1 code, CC 1.

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

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

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

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

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

5.3.2 Starting Sequence, Remote Start

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

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

5.3.3 Running Sequence

When the engine speed reaches 750 rpm, the crank relay deenergizes and the crank LED turns off. When the output voltage on leads 11 and 44 reaches about 30 VAC, the flash relay deenergizes and the flash LED turns off.

5.3.4 Stopping Sequence, Master Switch Moved to OFF/RESET

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

5.3.5 Stopping Sequence, Remote Stop

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

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

5.3.6 Standby Mode

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

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

5.3.7 Sleep Mode

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

5.4 Faults

5.4.1 Warnings

The fault conditions listed in Figure 5-6 will cause the controller to display a fault code but will not shut down the generator set.

5.4.2 Shutdowns

Under the fault conditions listed in Figure 5-7, the controller displays a fault code and the generator set shuts down.

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

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

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

Figure 5-6 Fault Codes, Warnings

Code	Fault	Description	Check	Refer to Section
AF	Auxiliary fault	Indicates a shutdown initiated by the emergency stop switch or a tripped circuit breaker. (TRES models only)	Check the position of the emergency stop button. (TRES models only)	O/M
HE	High engine temperature	Shutdown occurs if the engine coolant temperature exceeds the maximum temperature for more than 5 seconds. This protective becomes active after the engine reaches the crank disconnect speed.	Check for blocked air inlets and exhaust outlets.	1.7
LOP	Low oil pressure	Shutdown occurs if a low oil pressure condition exists for more than 5 seconds. This protective becomes active 30 seconds after the engine has reached crank disconnect speed (30 second inhibit). **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low. Check low oil pressure switch connections and operation. Check the oil pump and lubrication system.	— 2.2 6.11 Engine S/M
OC	Overcrank	Shutdown occurs after 3 unsuccessful starting attempts. The crank cycle is set for three starting attempts of 15 seconds cranking and 15 seconds rest.	Check the fuel supply valves and pressure. Check spark plug and battery. See Troubleshooting Chart, generator set cranks but does not start.	6.12 O/M 3.3
	Locked rotor	The generator set shuts down on an overcrank fault if no engine rotation is sensed. Shuts down 3 seconds after the fault is detected.	Check mag pickup connections and operation. Check for a locked rotor.	6.9.4 —
OF	Overfrequency	Shutdown occurs when the governed frequency exceeds 110% of the system's frequency setpoint for more than 5 seconds. This protective becomes active 10 seconds after engine start (10 second inhibit).	Check system frequency setting (parameter UU) on controller.	4.5
			Measure output frequency and adjust, if necessary.	6.9.5
			Check governor system condition and operation.	6.9
OS	Overspeed	Shutdown occurs if the engine speed exceeds 110% of the normal running speed for more than 0.3 seconds.	Check governor settings and operation.	6.9.5 6.9
OU *	Overvoltage	Shutdown occurs if the voltage exceeds 120% of the system nominal voltage for more than 2 seconds.	Check AC voltage. Check wiring and connections.	6.7 8W/D
UF	Underfrequency	Shutdown occurs when the governed frequency falls below 54 Hz for more than 5 seconds. This protective becomes active 10 seconds after engine start. (10 second inhibit).	Reduce the load and restart the generator set.	—
UU	Undervoltage	Shutdown occurs if the voltage falls below 80% of the nominal system voltage for more than 10 seconds.	Reduce the load and restart the generator set.	—
			Check wiring and connections.	8W/D
			Check controller configuration, system voltage and frequency (parameter UU).	4.5
			Check AC voltage and adjust, if necessary.	6.7
			Check the SCR module. Replace if necessary and test voltage again.	6.8
			Separately excite unit.	6.2
			Check stator continuity.	6.3
SCF0	Software Communication Fault 0	Indicates a software or communication problem within the ADC-RES.	Replace the controller.	4.9

Engine S/M = Engine Service Manual; O/M = Generator Set Operation Manual

* ADC-RES only

Figure 5-7 Fault Codes, Shutdowns

5.5 Controller Configuration and Adjustment, ADC-RES

Note: The settings described in this section are not adjustable on the DC-RET controller.

The first step in troubleshooting the controller is to verify that the controller is correctly configured for the generator set. The ADC-RES controller's configuration modes allow setting of the engine type, generator set configuration (marine, mobile, or standby), data input types, and other parameters.

The controller configuration for each generator model is set at the factory. Changes in the controller configuration may be required after controller replacement or other service. Use the instructions in Section 5.5.4 to check the controller settings and change them, if necessary.

5.5.1 Controller Time Out

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

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

5.5.2 Voltage and Frequency Adjustments

Voltage and/or frequency adjustments may be required after controller replacement or other service procedures. See the instructions in Section 5.6 to adjust the generator set output voltage and frequency using the ADC-RES.

5.5.3 Controller Application Program Version Number

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

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

5.5.4 System Parameters

The controller configuration for each generator model is set at the factory and should not normally require changes. The controller's configuration mode allows adjustment of the system parameters listed in this section. Use the instructions in this section to check the configuration after installation and change them to match the settings shown in Figure 5-8, if necessary.

Parameter	Setting	Definition
Unit's system voltage and frequency	Uu01	Single phase, 60 Hz, 120/240 VAC
	Uu03	Three-phase, 50 Hz, 230/400 VAC (TRES)
	Uu06	Single phase, 50 Hz, 115/230 VAC
Controller type	Uc01	ADC-RES (distributor) (Use for 8.5/12RES)
	Uc05 ‡	DC-RET (retail) (use for RESL models) ‡
Engine type	Ec00	8.5/12 kW
Communication setting *	Cn00	No J1939 communication. Sleep mode enabled (48-hour power down in AUTO).
	Cn01 †	J1939 communication enabled. Sleep mode disabled (no power down in AUTO).

* Controller application code version 1.13 or higher.

† Default setting for application code version 1.13 or higher.

‡ Default setting for service replacement controllers is Uc05. Change to Uc01 for the 8.5RES and 12RES.

Figure 5-8 Controller Configuration Parameters

Follow the instructions in Figure 5-10 to enter the configuration mode while the engine is not running and then step through the following parameters. Use the up (∧) and down (∨) arrow buttons to select the appropriate setting for the application. See Figure 5-9.

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

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

Voltage/frequency setting (Uu). Select the system voltage and frequency from the table in Figure 5-8.

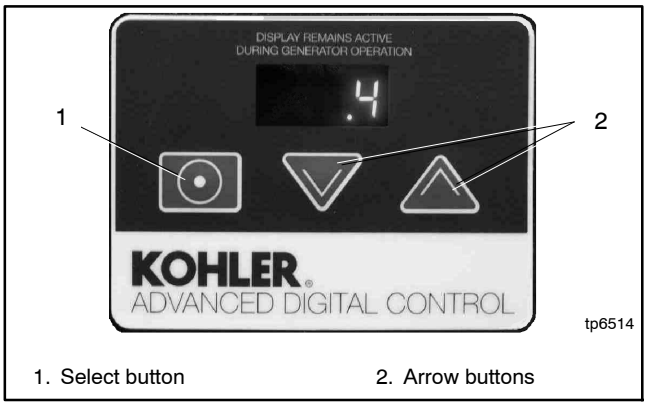
Note: The Uu parameter sets the system's *rated* voltage and frequency. To adjust the output (measured) voltage and frequency, see Section 5.6, Voltage and Frequency Adjustments.

Controller type (Uc). The Uc setting is used during initial controller installation in the factory or controller replacement in the field. **The Uc setting can be changed only once.** The default setting for service replacement controllers is Uc05, controller type DC-RET. Changing it to UC01 sets the controller type to ADC-RES. Uc01 is the correct setting for the Model 12RES.

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

Communication/Sleep Mode Setting (Cn). (Available on controllers with application code version 1.13 or higher.) The communication setting enables or disables J1939 communication, and also disables or enables the sleep mode. When J1939 communication is enabled, the sleep mode is turned off to allow uninterrupted communication with a personal computer running remote monitoring software. If remote monitoring is not used, the communication can be turned off, enabling the sleep mode which causes the controller to power down after 48 hours of inactivity. The generator set master switch must be in AUTO for the sleep mode to function.

The default setting for controllers with application code version 1.13 or higher is Cn01, communication on/sleep mode off. Controllers with earlier application code versions have communication disabled and the sleep mode enabled. The Cn setting is not adjustable on these earlier versions.



1. Select button 2. Arrow buttons

Figure 5-9 ADC-RES Controller Interface

Controller Configuration Mode:

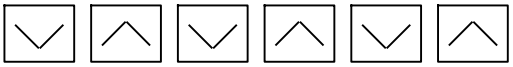
Display:

Hold the Select button:

Move the generator set master switch to the RUN position. (The generator set engine will not start.) — Display: ` . 0`

Wait about 5 seconds until the display shows the program version number. (The number may be different than the one shown here.) — Display: `v113`

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



Display: `Uu01`

Now release the Select button.

Press:

or

To change the voltage/frequency setting, if necessary. See Figure 4-7. — Display: `Uu0x`

To enter setting and step to the next parameter, controller type Uc.

or

To change the controller type, only if necessary. This setting is used during controller replacement and can be changed only once.

ADC-RES Display: `Uc01`

DC-R-ET Display: `Uc05`

To enter setting and step to the next parameter, engine type Ec.

or

To change the engine type, if necessary. — Display: `Ec00`

To enter setting and step to the next parameter, communication setting Cn.

or

To change the communication setting, if necessary. See Figure 4-7. — Display: `Cn0x`

To enter setting and step to SAVE. — Display: `SAVE`

Press:

To **SAVE CHANGES**. — Display: `YES`

OR

To **DISCARD CHANGES** without saving. — Display: `no`

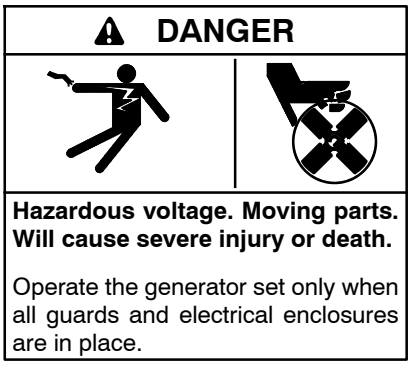
"Yes" or "no" flashes when the up or down arrow is pressed and then the controller exits the configuration mode. The display returns to the runtime hours. — Display: `xxxx`

Now move the master switch to OFF/RESET.

Note: Shaded boxes show which number in the controller display changes when the up or down arrow key is pressed. *X* in the runtime hours display above denotes any number from 0 to 9.

Figure 5-10 Configuration Mode

5.6 Voltage and Frequency Adjustments



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

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

Note: The settings described in this section are not adjustable on the DC-RET controller.

The controller's adjustment mode allows adjustment of the output voltage and frequency, if necessary. Have adjustments performed by an authorized distributor/ dealer or service technician. A digital multimeter that measures voltage and frequency is required for these adjustments.

The generator set must be running during voltage and frequency adjustments. Use a digital multimeter to check the output voltage and frequency. Refer to Sections 6.7.2, Voltage Adjustment, and 6.9.5, Frequency Adjustment, for instructions to measure the output voltage and frequency. Use the ADC controller to adjust the output voltage and engine speed (frequency), if necessary, while the generator set is running. See Figure 5-9. The flowcharts in Figure 5-13 through Figure 5-15 outline the adjustment procedures.

Note: Be sure to save your changes as instructed in Figure 5-15 before exiting configuration mode.

Changes in voltage and frequency are lost if not saved before the generator set shuts down. The generator set continues to run with the new settings until it shuts down but then reverts to the previous settings at the next startup if the changes have not been saved.

5.6.1 Voltage Adjustment

Note: Refer to the flowcharts in Figure 5-13 through Figure 5-15 during the following procedure.

Voltage Adjustment Procedure

1. With the generator set off, connect a digital multimeter to the output leads or an electrical outlet on the load side of the generator set. Set the meter to measure AC voltage.
2. Start the generator set by moving the generator set master switch to the RUN position.
3. Use the ADC controller to adjust the voltage (parameter 1P) until the output voltage reaches the desired value. Refer to the flowcharts in Figure 5-13 through Figure 5-15 for instructions to adjust the output voltage. See Figure 5-11 for the approximate change in voltage per step.

Measured Voltage, VAC	ADC Display	Voltage Change per Step, VAC	
		Coarse	Fine
85–132	1P00–99	5	0.5
180–251	1P00–99	7	0.7

Figure 5-11 Voltage Adjustment (approximate)

4. Adjust the voltage stability (gain, parameter 2P) to minimize light flicker.
5. Readjust the voltage, if necessary.
6. Set the multimeter to measure frequency.
7. Adjust the engine speed to the cut-in frequency shown in Figure 5-12 by adjusting the engine governor speed (parameter 4P).

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

Figure 5-12 Cut-In Frequencies

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

   Note: See Section 6.7.3 for more information about the volts/Hz (droop) adjustment.

9. Reset the engine speed to the operating frequency (50 or 60 Hz) by adjusting engine the governor speed (parameter 4P).

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

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

12. Save settings. See Figure 5-15.

13. Stop the generator set.

5.6.2 Frequency Adjustment

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

Note: Refer to the flowcharts in Figure 5-13 through Figure 5-15 during the following procedure.

Frequency Adjustment Procedure

Note: Refer to the flowcharts in Figure 5-13 through Figure 5-15 during the following procedure.

1. Attach a frequency meter to the AC output leads or an electrical outlet on the load side of the generator set.

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

3. Adjust electronic governor speed (parameter 4P) to obtain a frequency reading of 60 Hz (or 50 Hz if appropriate). Each step changes the engine speed about 3.6 rpm, which changes the output frequency about 0.06 Hz.

4. Check stability with the generator set running and with no load applied. If the generator set speed is unstable, hunts, or surges, adjust the governor stability (gain, parameter 5P) until the generator set becomes stable with no hunting or surging. (Increasing the gain slows the governor response.)

5. Check the frequency reading. Repeat steps 3 and 4 if necessary to obtain the rated frequency and stable operation.

6. Save settings. See Figure 5-15.

Output Voltage and Frequency Adjustment Mode:

Display :*

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

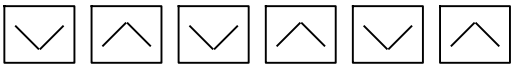
Display: X X X X

Hold:

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

Display: X. X X

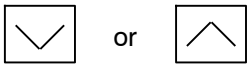
Press the down arrow key and then the up arrow key 3 times to enter the adjustment mode. (This is the controller "password.")



Display: 1 P X X

The controller is now in the voltage coarse adjustment mode.

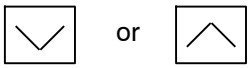
Press:



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

Display: 1 P X X

To enter fine voltage adjustment mode.

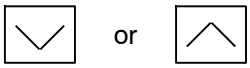


To raise or lower the voltage in smaller increments (approximately 0.5–0.7 volts per step). (Parameter 1P)

Display: 1 P X X

To enter coarse voltage stability (gain) adjustment mode.

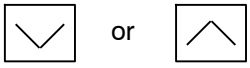
Display: 2 P X X



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

To enter fine voltage stability (gain) adjustment mode.

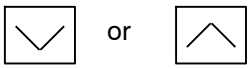
Display: 2 P X X



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

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

Display: 3 P X X



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

Continued on Figure 5-14.

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

TP6196

Figure 5-13 Output Voltage and Frequency Adjustments

Continued from Figure 5-13:

Press:			Display : *
		To enter engine governor speed coarse adjustment mode. (Parameter 4P)	4 P *x* *x*
	or 	To raise or lower the engine speed in large increments.	
		To enter engine governor speed fine adjustment mode. (Parameter 4P)	4 P *x* *x*
	or 	To raise or lower the engine speed in smaller increments.	
		To enter engine governor stability (gain) coarse adjustment mode. (Parameter 5P)	5 P *x* *x*
	or 	To raise or lower the engine governor stability (gain) in large increments.	
		To enter engine governor stability (gain) fine adjustment mode. (Parameter 5P)	5 P *x* *x*
	or 	To raise or lower the engine governor stability (gain) in smaller increments.	
		To enter SAVE mode. Go to Figure 5-15.	S A V E

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

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

Figure 5-14 Output Voltage and Frequency Adjustments, Continued

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

		S A V E
⊙	To return to the first parameter, coarse voltage adjustment, to check or change settings before saving. See Figure 5-13.	1 P *x* *x*
or		
^	To save changes.	Y E S
or		
v	To discard changes without saving.	n o

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

Now move the master switch to OFF/RESET.

Figure 5-15 Save Mode

5.7 Controller Relays

The K1 flash, K2 fuel (run), and K3 crank relays are located on the controller's logic board. An LED is associated with each relay. See Figure 5-16.

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

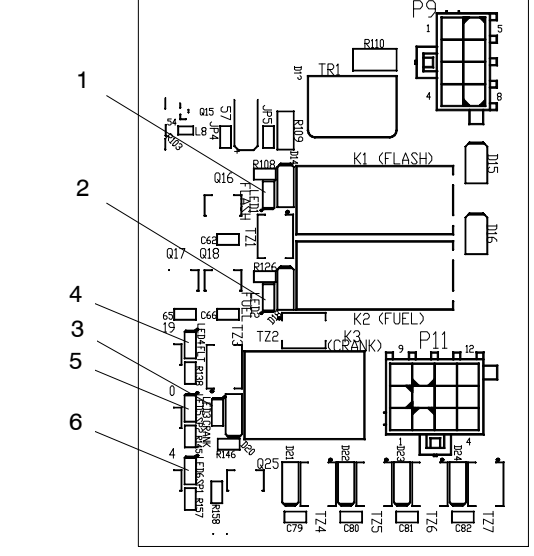
The individual relays are not replaceable. If one or more relays are faulty, replace the logic board. LED 4 lights to indicate a fault condition. See Section 4.4, Faults.

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

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

Repair or replace the component causing the blown fuse.

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

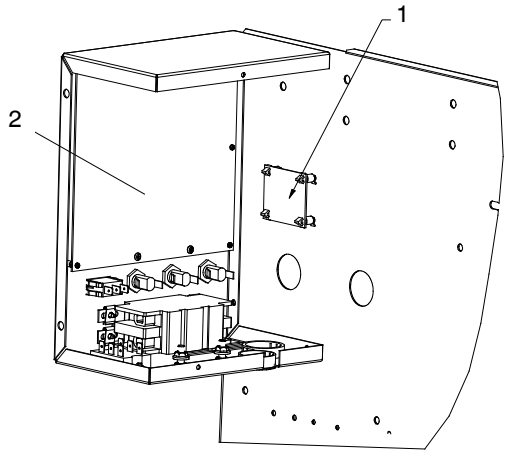


1. LED1 Flash (K1)
2. LED2 Fuel (K2)
3. LED3 Crank (K3)
4. LED4 Fault
5. LED5 SP2
6. LED6 SP1

Figure 5-16 Relays and LEDs on Controller Logic Board

5.8 Optional Relay Board

The generator set may be equipped with an optional relay board, which contains the K1 common fault relay and K4 auxiliary run relay. See Figure 5-17 for the relay board location inside the controller junction box.



1. Relay board
2. Controller circuit board location

Figure 5-17 Relay Board Location (inside controller junction box)

5.8.1 Relay Board Troubleshooting

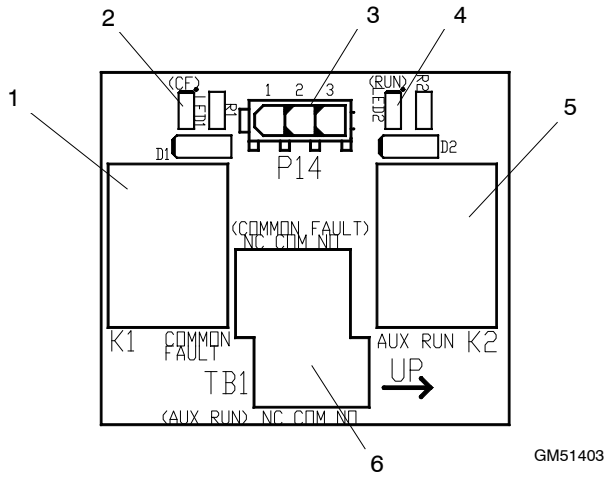
First check for loose connections. Check the relay board harness connections to the relay board, control board, and engine harness. See Figure 5-18, Figure 5-19, and Figure 5-20.

Check for loose customer connections to terminal strip TB1 on the relay board. See Figure 5-18 and Figure 5-21.

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

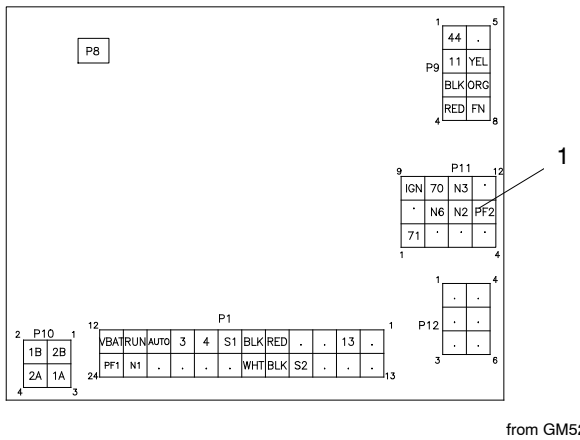
Check that the ratings of the customer's connected equipment do not exceed the relay contact specifications shown in Figure 5-22.

An LED is associated with each relay. See Figure 5-18. The LED indicates power to the corresponding relay. If the LED is illuminated but the relay is not activated, the relay is faulty. The individual relays are not replaceable. If one or more relays are faulty, replace the entire RIB. See Section 5.8.2, Relay Board Replacement Procedure.



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

Figure 5-18 Optional Relay Board



1. P11, Relay board harness connection to the controller board.

Figure 5-19 Relay Board Harness Connection to Controller Circuit Board

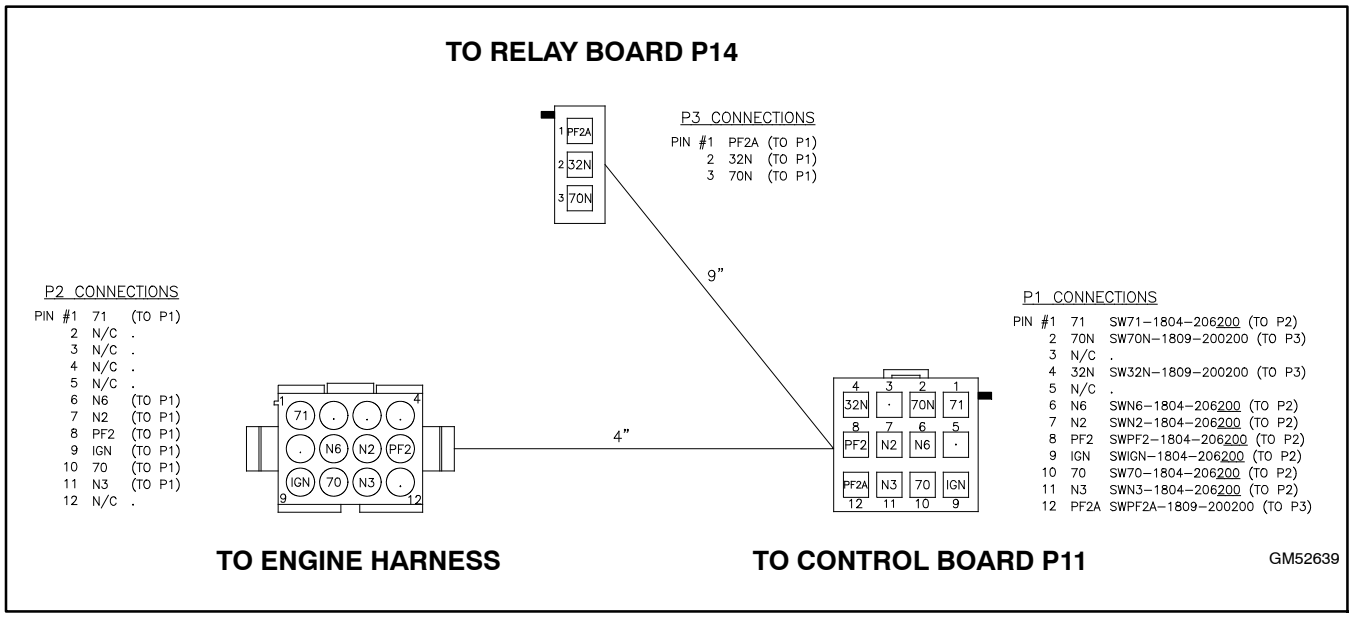


Figure 5-20 Relay Board Connection Harness GM52639

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

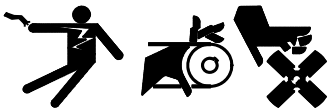
Figure 5-21 TB1 Customer Connections

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

Figure 5-22 Relay Contact Ratings

5.8.2 Relay Board Replacement Procedure

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

1. Access the controller junction box to locate the relay board. See Figure 5-17.
2. Disconnect relay board harness connector P3 from connector P14 on the relay board.
3. Pull the faulty relay board off the four mounting standoffs inside the junction box.
4. Press the new relay board onto the four standoffs.
5. Connect three-pin connector of the relay board harness GM52639 to P14 on relay board GM51403. See Figure 5-18 and Figure 5-20.
6. Verify that the relay board harness is securely connected to P11 on the control board. See Figure 5-19 and Figure 5-20.
7. Verify that the relay board harness is securely connected to the engine harness. See Figure 5-20.

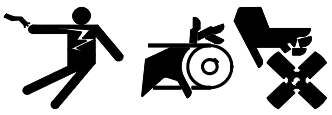
5.9 Controller Replacement

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

After replacing the controller, verify that the new controller's configuration settings match the generator set system voltage/frequency and unit configuration. Refer to Section 4.5 for instructions to check the controller configuration and to change the settings, if necessary.

After the controller configuration has been checked and set to match the generator set, use a voltmeter to check the generator set output voltage and frequency. If the output voltage or frequency needs adjustment, use the voltage and frequency adjustment procedure in Section 6.7.2 and the controller voltage and speed adjustment instructions in Section 5.6. Also see the frequency adjustment procedure in Section 6.9.5.

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

Short circuits. Hazardous voltage/current will 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.

Controller Replacement Procedure

1. Remove the service door and the front panel to access the controller junction box. See Figure 5-23.
2. Place the generator set master switch in the OFF position.
3. Disconnect power to the battery charger.
4. Disconnect the generator set engine starting battery, negative (–) lead first.

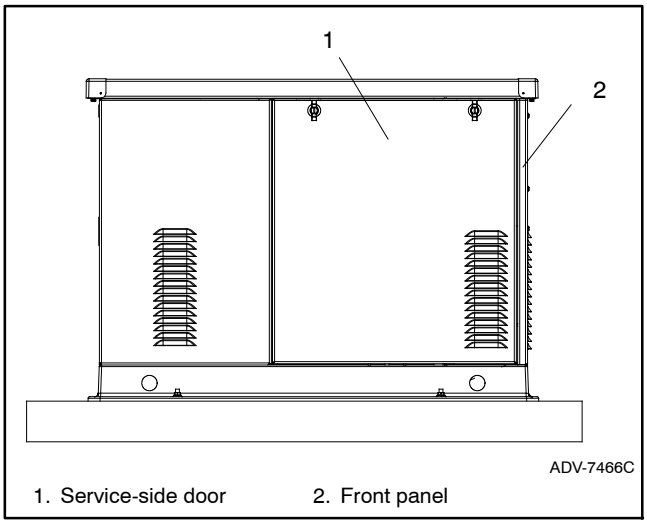
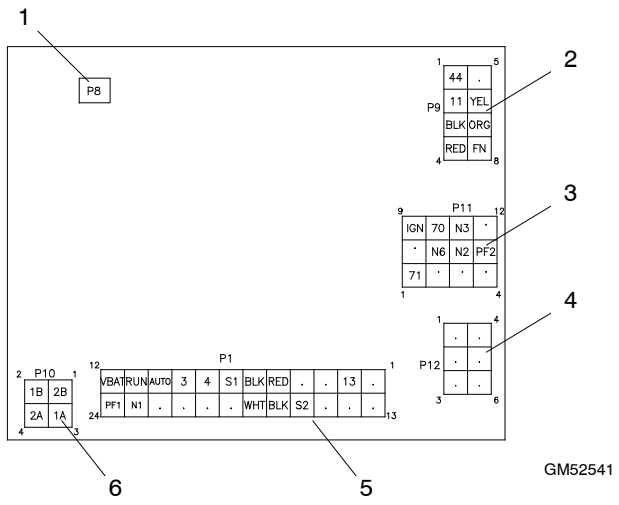


Figure 5-23 Enclosure Roof and Door

Logic Board Replacement

5. Note the connections on the logic board, and then disconnect. See Figure 5-24.

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



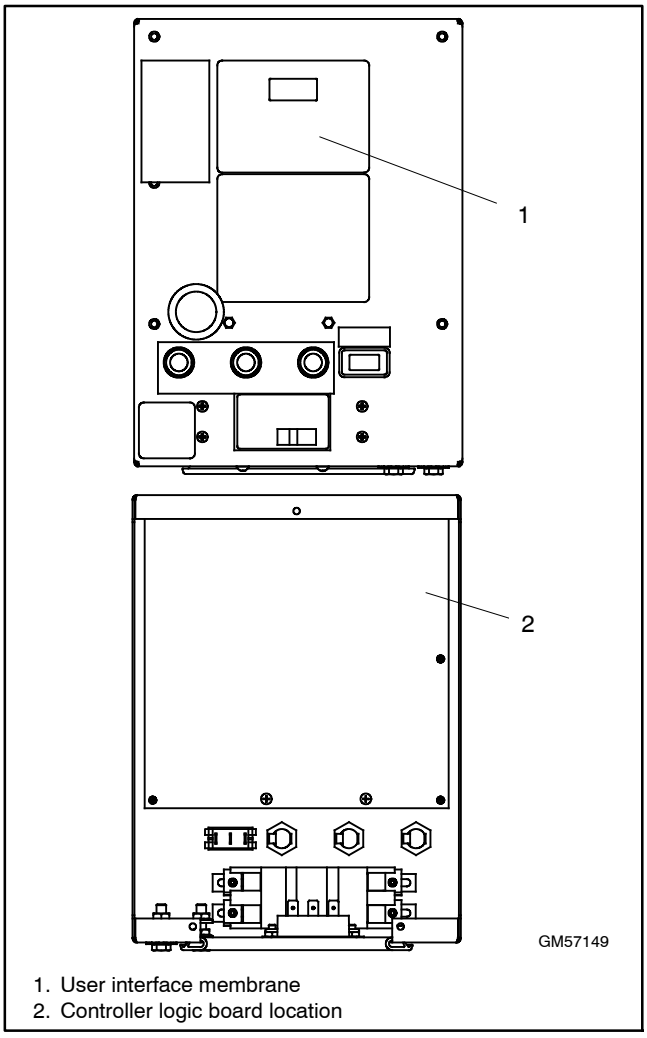
1. P8 switch membrane connection
2. P9
3. P11 to engine harness and optional relay board, if equipped
4. P12 not used at this time
5. P1
6. P10

Figure 5-24 Controller Logic Board Connections

7. Check that the replacement board is positioned so that the display shows through the opening in the cover plate and then press the board onto the standoffs. Check that all corners are securely mounted. See Figure 5-25.

8. Reconnect all cables and harnesses to the board. See the wiring diagram in Section 8 for connections.

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



1. User interface membrane
2. Controller logic board location

Figure 5-25 Controller

User Interface Membrane Replacement

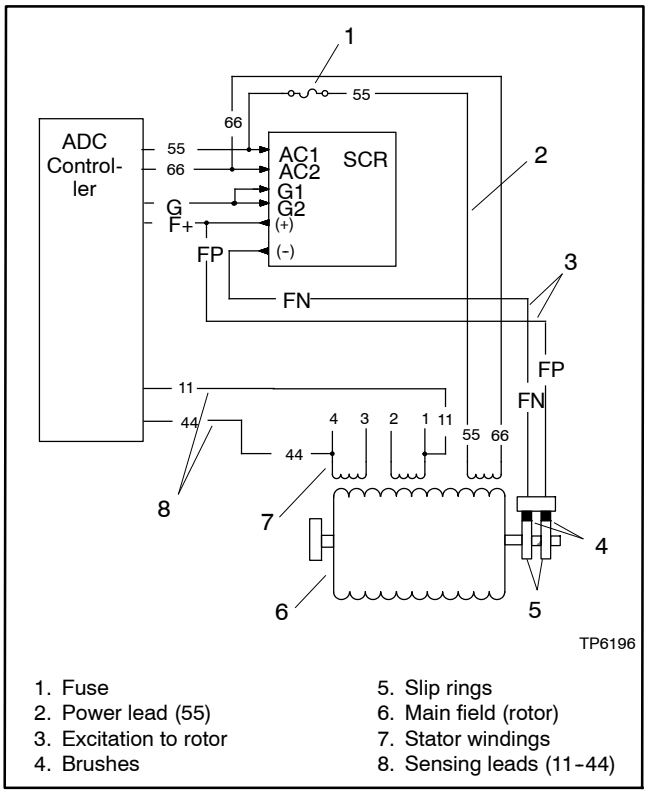
9. Disconnect the membrane ribbon cable from connector P8 on the logic board.
10. Carefully remove the membrane from the junction box cover.
11. Remove the protective backing to expose the adhesive on the new membrane.
12. Thread the new membrane's ribbon cable through the small rectangular opening in the cover. Line up the membrane window with the larger rectangular opening.
13. Press the membrane firmly into place.
14. Connect the ribbon cable to the P8 connector on the logic board.
15. Verify that the generator set master switch is in the OFF position.
16. Reconnect the engine starting battery, negative (–) lead last.
17. Reconnect power to the battery charger.
18. Replace the front panel.

Controller Setup

19. Check settings and adjustments for the ADC-RES controller only:
    a. Follow the instructions in Section 5.5.4 to change the new controller's configuration settings to match the generator set system voltage/frequency and unit configuration.
    b. Use a voltmeter to check the output voltage. Follow the instructions in Sections 4.5.3, Voltage and Frequency Adjustments, and 6.7.2, Voltage Adjustment, to adjust the output voltage and stability.
    c. Check the output frequency. Follow the instructions in Sections 4.5.3, Voltage and Frequency Adjustments, and 6.9.5, Frequency Adjustment, to adjust the output frequency and stability.
20. Place the generator set master switch in the AUTO position if an ATS or remote start/stop switch is used.
21. Replace the service door.

6.1 Theory of Operation

These generator sets utilize a rotating-field alternator to produce AC voltage. Upon activation of the generator master switch, DC current from the battery magnetizes the rotor (field). When the magnetized rotor rotates within the stator windings, an electrical voltage develops within the stator. As engine speed and generator output increase, the SCR module feeds rectified stator output current to the rotor through the brushes/slip rings to increase the strength of the rotor field. As the rotor field increases in strength, generator output also increases. The ADC controller monitors the generator output voltage through leads 11 and 44 (single-phase) or leads V7, V8, and V9 (three-phase) and adjusts the DC current from the SCR module to the rotor to meet load requirements. See Figure 6-1.



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

Figure 6-1 Single-Phase Generator Schematic

6.2 Separate Excitation

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

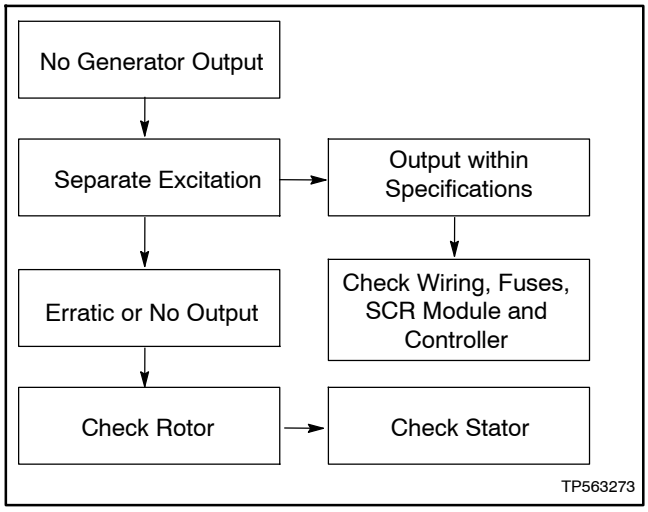


Figure 6-2 Generator Troubleshooting

Check the condition of the alternator fuse before performing the separate excitation procedure. The inline fuse is located in lead 55 of the wiring harness or on the junction box panel near the controller. See Figure 6-1. If the fuse is not blown, use the following procedure to separately excite the generator using an external voltage source (a 12-volt automotive battery).

Separately exciting the generator can identify faulty voltage regulation by the ADC controller or reveal a running fault in the rotor and/or stator. An external power source duplicates the role of the voltage regulator and excites the generator field (rotor). A generator component that appears to be in good condition while stationary may exhibit a running open or short circuit while moving. Centrifugal forces acting on the windings during rotation cause a broken circuit to open, or increasing temperatures cause the insulation to break down, resulting in a running fault. If this test shows that the rotor and stator are in good condition, test the voltage regulation using the tests in Section 6.15.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

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

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

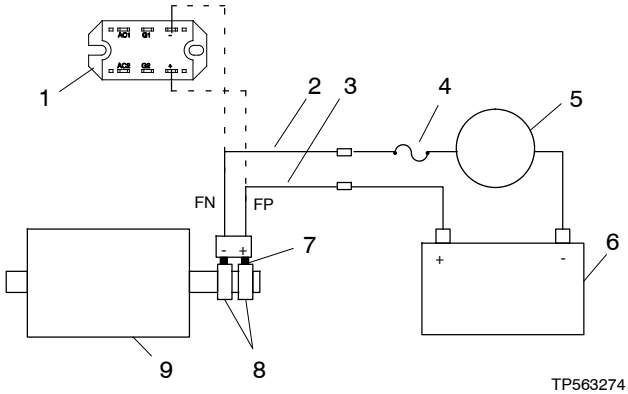
Short circuits. Hazardous voltage/current will cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Separate Excitation Procedure

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

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

2. Connect a DC ammeter, 20-amp fuse, and a 12-volt automotive battery to the positive (FP) and negative (FN) brush leads as shown in Figure 6-3. Note and record the ammeter reading.



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

Figure 6-3 Separate Excitation Connections

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

Example:

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

3. Start the engine and check that the ammeter reading remains stable. An increasing meter reading indicates a shorted rotor. A meter reading decreasing to zero or an unstable reading suggests a running open. Refer to Section 6.5, Main Field (Rotor), to test the rotor. If the ammeter reading is stable, proceed to step 4.

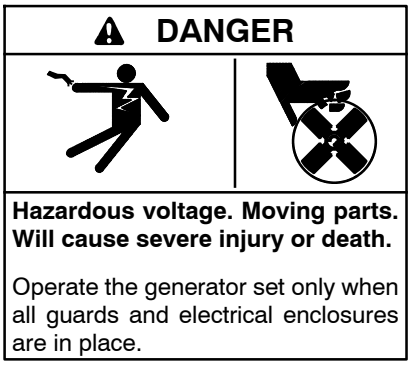
4. Check for AC output across the stator leads; see Section 6.3, Stator. Compare the readings to the AC output values shown in Section 1, Specifications. If the readings vary considerably, a faulty stator is likely. Refer to Section 6.3, Stator, for further information.

5. If this test shows that the rotor and stator are in good condition, check the wiring and fuses. Check SCR module. See Section 6.8, Silicon Controlled Rectifier Module. Check the controller settings and connections. See Section 4, Controller Configuration and Adjustment.

6.3 Stator

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

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



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

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

Stator Continuity and Resistance Tests

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Disconnect all stator leads before performing all stator tests.
5. To check for stator continuity, set the ohmmeter on R x 1 scale. First set the ohmmeter zero by holding the red and black meter leads together and setting the ohmmeter reading to zero. Then check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 6-4.

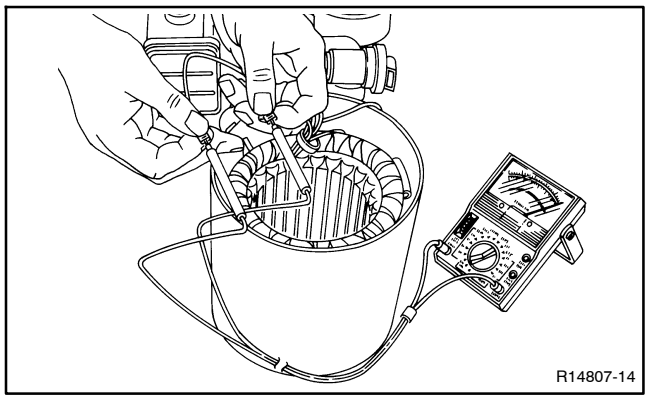


Figure 6-4 Testing Stator Windings

Note: For single-phase models. leads 1, 2, 3, and 4 are the generator output leads. Leads 11, 44, 55, and 66 are the controller and SCR module sensing and supply leads. Refer to the schematic in Figure 6-5 when performing the following steps.

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

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

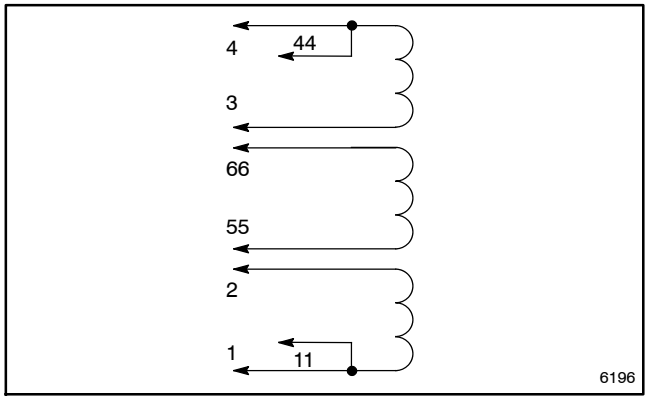


Figure 6-5 Single-Phase Alternator Stator Leads

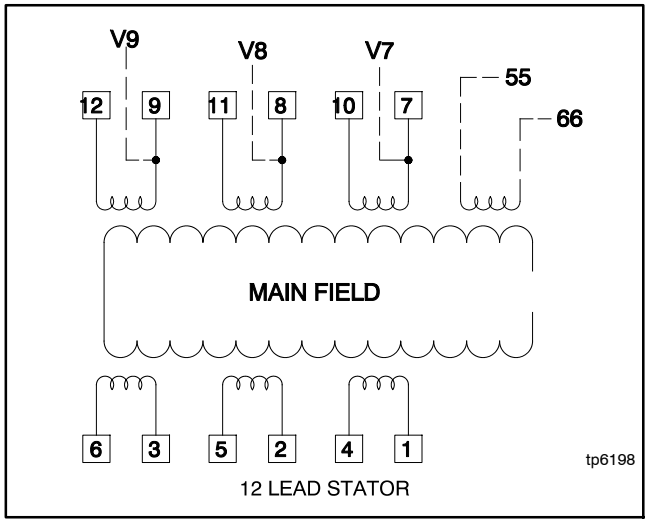


Figure 6-6 Three-Phase Alternator Stator Leads

7. Check the cold resistance of the stator windings by connecting the meter leads to stator leads 1-2, 3-4, and 55-66. See Section 1.6, Alternator Specifications, for stator winding resistances. Most ohmmeters do not provide accurate readings below 1 ohm. Low resistance readings (continuity) and no evidence of shorted windings (heat

discoloration) indicate a stator in good condition. See Figure 6-7.

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

Figure 6-7 Continuity Test Results on a Good Stator (single-phase)

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

Figure 6-8 Continuity Test Results on a Good Stator (3-phase)

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

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

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

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

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

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

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

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

6.4 Main Field (Rotor)

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

Rotor Continuity and Resistance Tests

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

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

High voltage test. Hazardous voltage will 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.

Testing live electrical circuits. Hazardous voltage or current will 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)

Rotor Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Remove the brush cover from the alternator end bracket.
5. Check the rotor for continuity and resistance. Raise the brushes from the slip rings while performing ohmmeter tests. Measure the rotor resistance (ohms) between the two slip rings; see Figure 6-9. See Section 1.6, Alternator Specifications, for rotor resistance readings. If the resistance readings are low, perform a megohmmeter test on rotor as described in the next step.

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

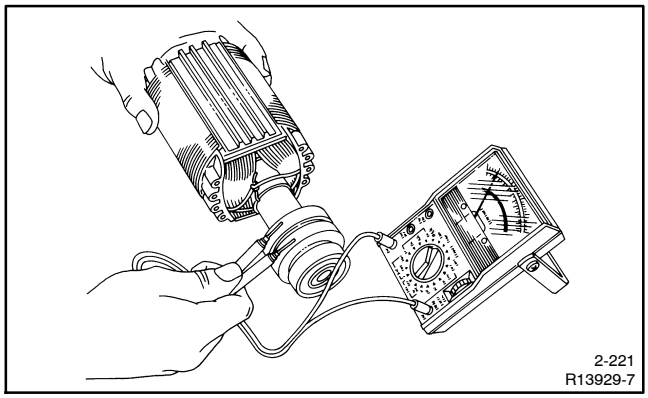


Figure 6-9 Rotor Resistance Check

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

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

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

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

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

d. Following the test, remove the retainer wire from the brush holder and check the brush positions on the slip rings. See Section 6.6, Brushes.

e. Reinstall the brush cover on the end bracket.

6.5 Slip Rings

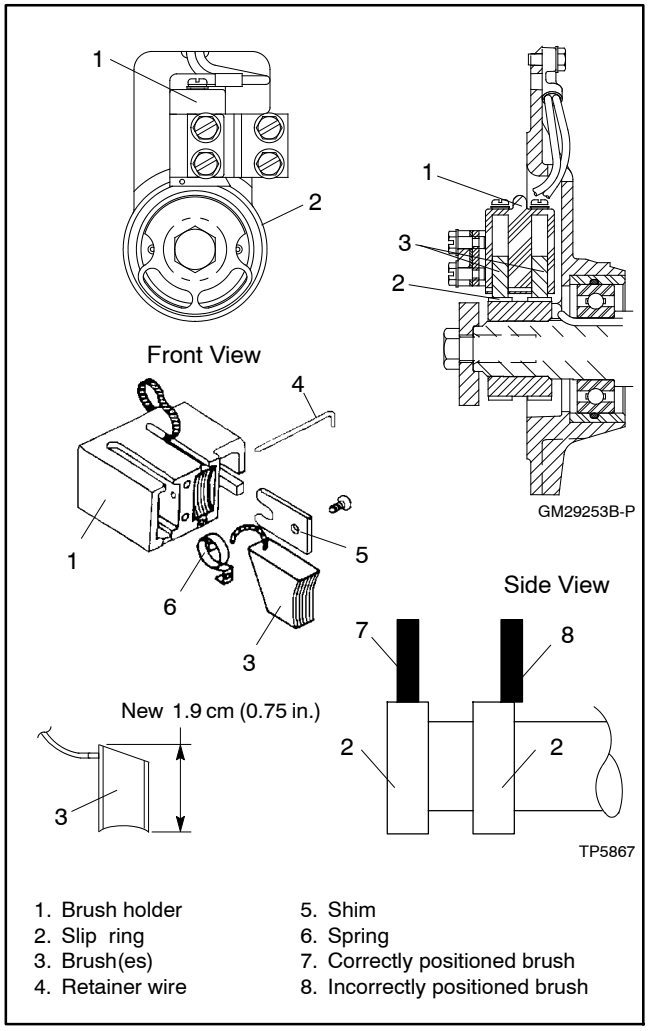
Slip rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly-machined appearance on the slip rings. Cleaning with a dry, lint-free cloth is usually sufficient. Use very fine sandpaper (#00) and apply light pressure to remove roughness. Do not use emery or carborundum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

6.6 Brushes

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

The brushes must be free to move within the holder and be held in contact with the slip rings by the springs. When correctly positioned, spring pressure on the brush surface causes the brush to wear evenly. The entire brush must ride on the ring or arcing occurs and causes burned rings or voltage regulator failure. Figure 6-10 shows the correct positioning of the brushes. Add or remove shims as necessary to center the brushes on the slip rings. Replace the brushes if they show uneven wear or are worn to one half their original length.

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



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

Figure 6-10 Brush Assembly

6.7 Voltage

6.7.1 Voltage Regulation

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

6.7.2 Voltage Adjustment

The factory sets the voltage for correct generator operation under a variety of load conditions. Usually, the voltage needs no further adjustment. Adjust the voltage when necessary according to the following procedure.

The adjustment procedure requires a meter that can measure voltage and frequency.

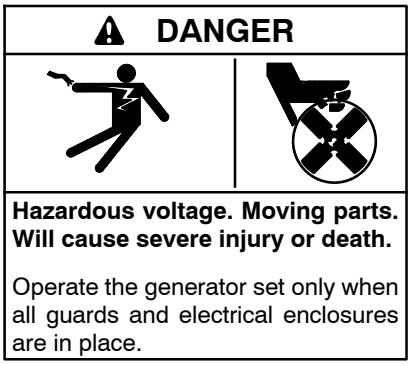
Use the ADC controller to adjust the voltage, gain, and volts/Hz. Refer to Section4.5 for instructions to adjust each setting and save the changes using the controller keypad.

Note: Be sure to save your settings as instructed. The ADC controller will time out and exit the adjustment mode after approximately 1 minute if no buttons are pressed. Any unsaved changes are discarded if the controller times out before the settings are saved.

Voltage Adjustment. Adjusts generator output voltage.

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

Volts/Hz Adjustment. Determines frequency (Hz) at which generator output voltage begins to drop. The controller maintains generator output at the specified voltage under load until the generator engine speed drops to a preset level (factory setting 57.5 Hz on 60 Hz models and 47.5 Hz on 50 Hz models). Then the controller allows the generator voltage and current to drop. The voltage/current drop enables the engine to pick up the load. When the generator speed returns to normal (60 Hz or 50 Hz) as load is accepted, the generator output also returns to normal. See Section for more information about the volts/Hz (droop) adjustment.



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

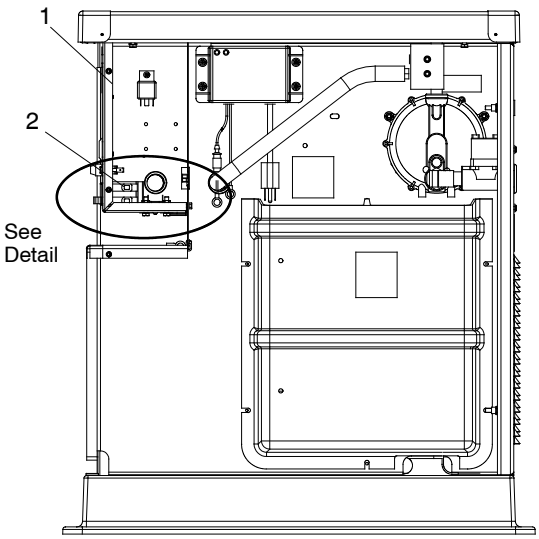
Short circuits. Hazardous voltage/current will cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

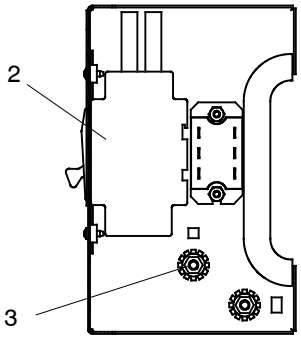
Voltage Adjustment Procedure

1. Connect a digital voltmeter from one side of the circuit breaker to the L0 terminal inside the controller assembly. See Figure 6-12. For 3-phase models. connect the voltmeter from L0 to L1, L2, or L3 on the circuit breaker. See Figure 6-14. Set the meter to measure voltage.
2. Start the generator set.
3. Follow the controller instructions in Section 4.5 to enter the adjustment mode and increase voltage or decrease voltage (parameter 1P) until the output reaches the desired voltage. See Figure 6-11.

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

Figure 6-11 Voltage Measurement





Controller Box Detail

GM57149

1. Controller box location
2. Line circuit breaker
3. Load connection terminal L0

Figure 6-12 Circuit Breaker and L0 Terminal Location

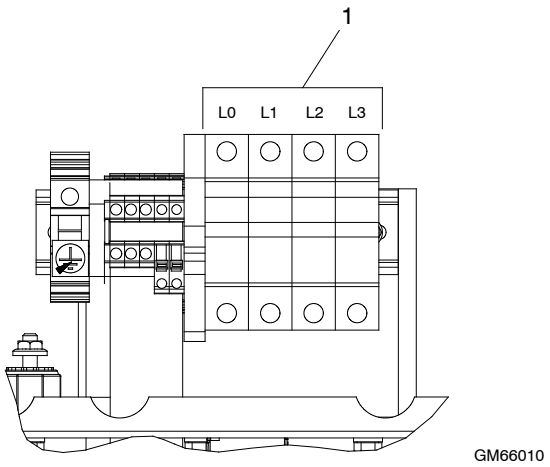
4. Follow the controller instructions to step to the voltage gain adjustment menu. Adjust the voltage gain (parameter 2P) until the light flicker minimizes. Save the settings.

5. Check and readjust the voltage if necessary.

6. Set the voltmeter to measure frequency. Adjust the engine speed to the cut-in frequency shown in Figure 6-13 by adjusting the engine governor speed (parameter 4P) through the ADC controller. See Section 4.5.3 for the ADC 2100 controller or Section 5.6 for the ADC-RES controller.

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

Figure 6-13 Cut-In Frequencies



GM66010

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

Figure 6-14 Voltage Measurement, Three-Phase Models

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

   Note: See Section 6.7.3 for more information on the volts/Hz (droop) adjustment.

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

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

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

11. Save the settings.

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

12. Stop the generator set.

6.7.3 Volts per Hertz (Hz) Adjustments (Droop)

When the frequency falls below the cut-in frequency (see Figure 6-13), output voltage is reduced to relieve the engine. The magnitude of the voltage reduction is set by the 3P parameter. Monitor engine speed and output voltage as loads are applied.

- If there is excessive droop in engine speed and little droop in voltage, increase the 3P value.
- If there is little engine speed droop but excessive voltage droop, decrease the 3P value.
- Readjust the voltage stability (2P) and voltage (1P) parameters after adjusting the 3P setting, if necessary. See Section 4.5.3 for the ADC 2100 controller or Section 5.6 for the ADC-RES controller.
- Remember to save your settings.

Each step of 3P changes the amount of voltage droop approximately 0.5% of system voltage for each cycle (Hz) below the cut-in frequency. See Figure 6-15.

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

Figure 6-15 Voltage Droop Adjustments

6.7.4 Voltage Connections, Single-Phase

Single-phase generator sets are available from the factory connected for 110/220 volt 50 Hz or 120/240 volt 60 Hz. See Figure 6-16 for the factory connections. These generator sets are not reconnectable.

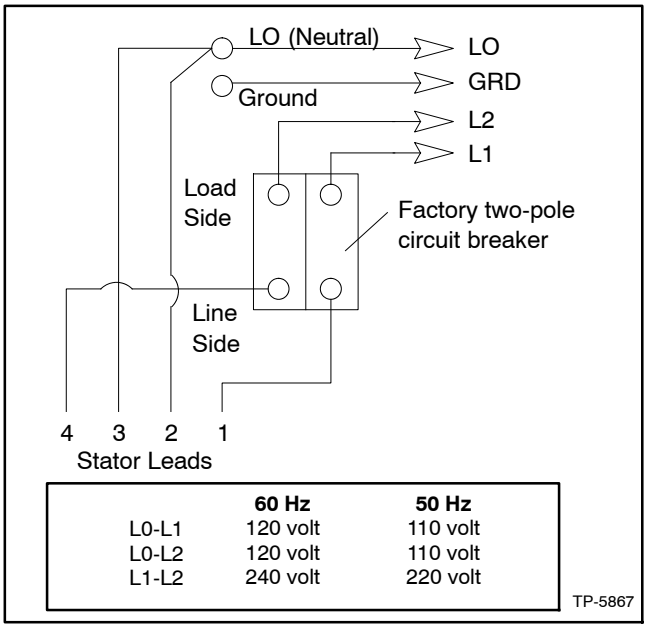


Figure 6-16 110/220 and 120/240 Volt, 3-Wire Configurations

6.7.5 Voltage Connections, 3-Phase

Three-phase generator sets are connected for 230/400 Volts, 50 Hz. See Figure 6-17 for the factory connections. The generator sets are not reconnectable.

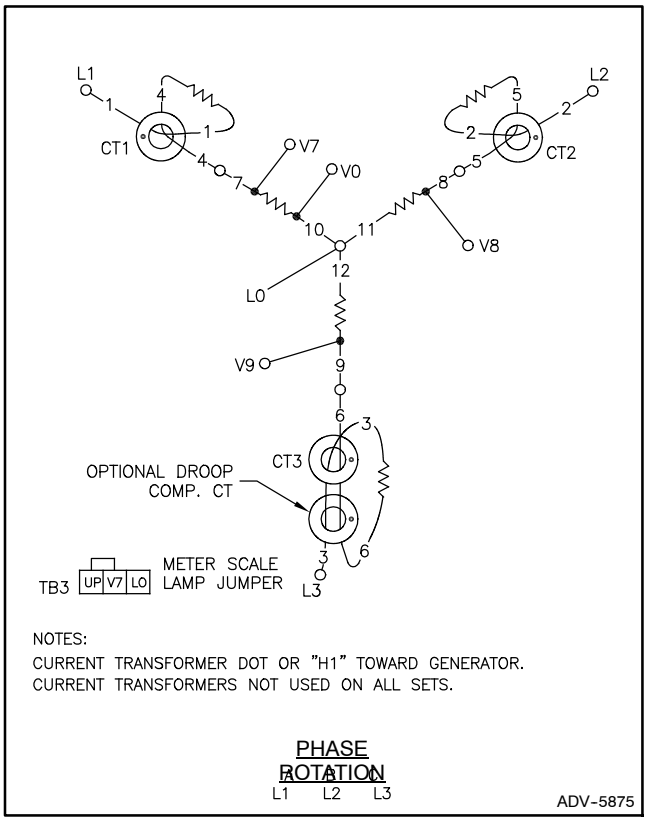


Figure 6-17 3-Phase Configuration

6.8 Silicon Controlled Rectifier Module

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

The SCR module is powered through stator leads 55 and 66 connected to SCR terminals AC1 and AC2. Leads G connected to terminals G1 and G2 provide the controller signal. Leads FP and FN connected to the positive (+) and negative (–) SCR terminals provide excitation current to the rotor. See Figure 6-18 and the wiring diagrams in Section 8.

The SCR module is protected by a 20-amp fuse (F1) in lead 55 on the controller. Check the fuse and replace it, if blown.

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

Note: If it is necessary to replace the SCR module, be sure to apply thermal compound to the back of the module to prevent overheating. Thermal compound is provided with the SCR module replacement kit.

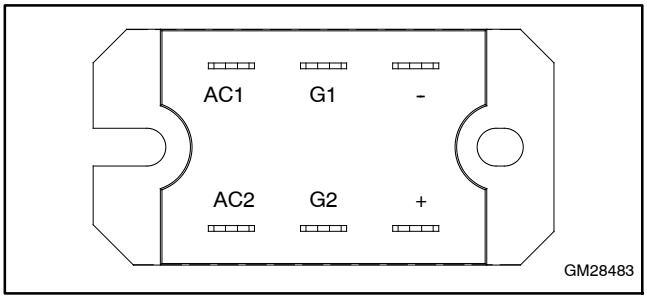


Figure 6-18 Silicon Controlled Rectifier (SCR) Module

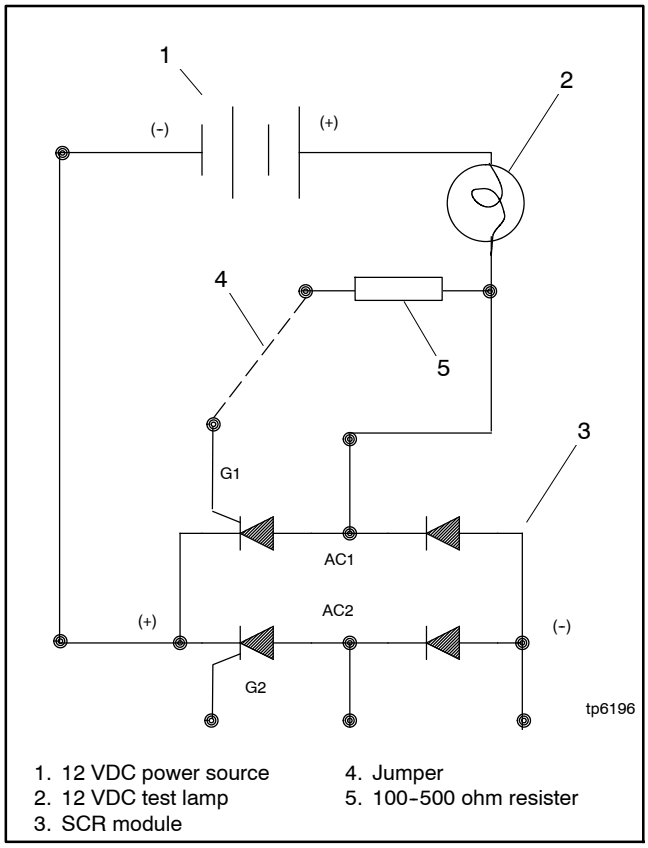
SCR Module Test Procedure

Required equipment:

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

1. Set the ohmmeter to the R x 1 scale.
2. Connect the ohmmeter from (+) to (–) on the SCR module. You should read high resistance in one direction and low resistance in the other (reverse the leads).
3. Connect the ohmmeter from AC1 to (+) on the SCR module. You should read high resistance in both directions.
4. Connect the ohmmeter from AC1 to (–) on the SCR module. You should read high resistance in one direction and low resistance in the other.
5. Repeat steps 3 and 4 for AC2.
6. Connect the ohmmeter from G1 to (+) on the SCR module. You should read low resistance in both directions.
7. Repeat step 6 for G2. You should read low resistance in both directions.
8. See Figure 6-19. Connect the *negative* (–) lead from the DC power source to the *positive* (+) terminal on the SCR module.

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



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

Figure 6-19 SCR Test

9. Connect the positive (+) lead from the DC power source, with the lamp in series, to terminal AC1 on the SCR module. The lamp should not glow.
10. Connect the jumper, with the resistor in series, from the positive lead of the DC power source to terminal G1 on the SCR module. The lamp should glow.
11. Repeat steps 9 and 10, with the positive (+) lead and lamp connected to terminal AC2 on the SCR module, and connecting the jumper with resister to terminal G2.
12. If any of the above checks indicates a bad SCR module, replace the module. Be sure to apply the thermal compound supplied with the module replacement kit to the back of the new module.

6.9 Electromechanical Governor System

Electromechanical governor systems are used on models 8.5/12RES and 12TRES.

The governor system consists an electromechanical stepper motor (actuator) and a magnetic pickup. The ADC controller controls the governor system operation. See Section 8, Wiring Diagrams, for governor connections.

6.9.1 Operation

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

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

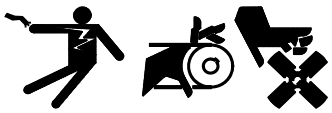
At cranking speed a properly adjusted pick-up should produce a minimum of 1.75 VAC. The magnetic pick-up air gap is factory-set to 0.5 mm (0.020 in.). Failure or loss of the input speed signal from the magnetic pick-up will result in erratic speed.

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

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

6.9.2 Initial Checks and Operation Test

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

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

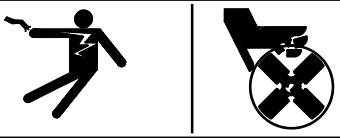
- Verify that the electrical connections are clean and tight.
- Verify that the battery connections are clean and tight.
- Check the magnetic pickup connections. Poor connections may cause an erratic signal or an overspeed condition. An erratic signal causes the generator set to govern poorly but not shut down.
- Check the resistance across the magnetic pickup. See Section 6.9.4.
- Check for dirt buildup on the magnetic pickup. Metal filings or caked-on dirt or grease decreases the output signal of the magnetic pickup.
- Check for a loose or worn stepper motor/throttle shaft coupling. Replace the shaft and bushing every 500 hours of engine operation.
- Check the carburetor for dirt, grime, or misadjustment. Check for a loose mixer assembly.

- Check the idle-adjustment screw. The screw should not prevent the throttle plate from closing completely.
- Check the throttle linkage for any binding, dirt, damage, or other visible problems.
- Check for electronic governor faults. The fuel shutoff solenoid deenergizes and the generator set shuts down under the following conditions:
  - Closed throttle
  - Engine overspeed
  - Broken fuel shutoff solenoid lead
  - Broken stepper motor leads (erratic performance)
  - Failed actuator linkage (erratic performance)

6.9.3 Hunting/Surging

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

⚠ DANGER



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

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

⚠ WARNING

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

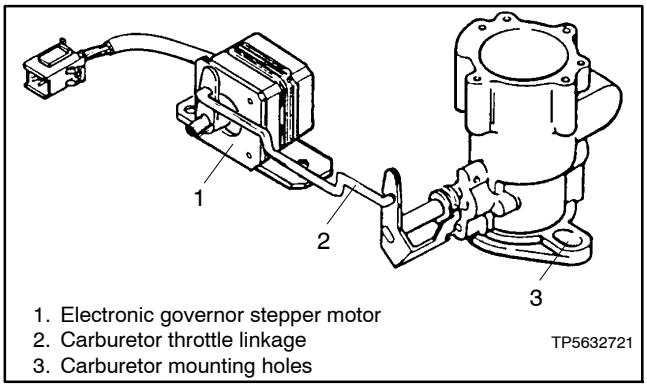
Do not work on the generator set until it cools.

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

1. Open the generator set line circuit breaker.
2. Start the generator set.
3. Hold the throttle linkage steady while the engine is running. See Figure 6-20. If the engine runs at a steady speed with no hunting or surging when the throttle is held steady, then the hunting/surging problems during operation are probably caused by the governor. Proceed to Section 6.9.4.
4. If the engine speed hunts or surges while the throttle is held steady, check the carburetor position and engine operation.

   a. Check carburetor position. Slotted mounting holes in the base of the carburetor determine the carburetor position, which affects the throttle operation. Verify that the carburetor is mounted as close to the governor actuator (stepper motor) as the mounting holes allow.

   b. Refer to the engine service manual for other engine diagnostic and service information.



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

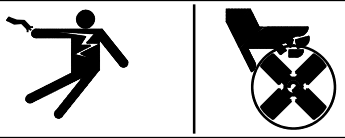
TP5632721

Figure 6-20 Stepper Motor and Carburetor

6.9.4 Governor System/Magnetic Pickup Operation Test

If the engine continues to operate erratically after the previous checks, test the governor system operation using the following procedure. The procedure is summarized in the flowchart in Figure 6-21.

⚠ DANGER



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

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

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

⚠ WARNING

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

Do not work on the generator set until it cools.

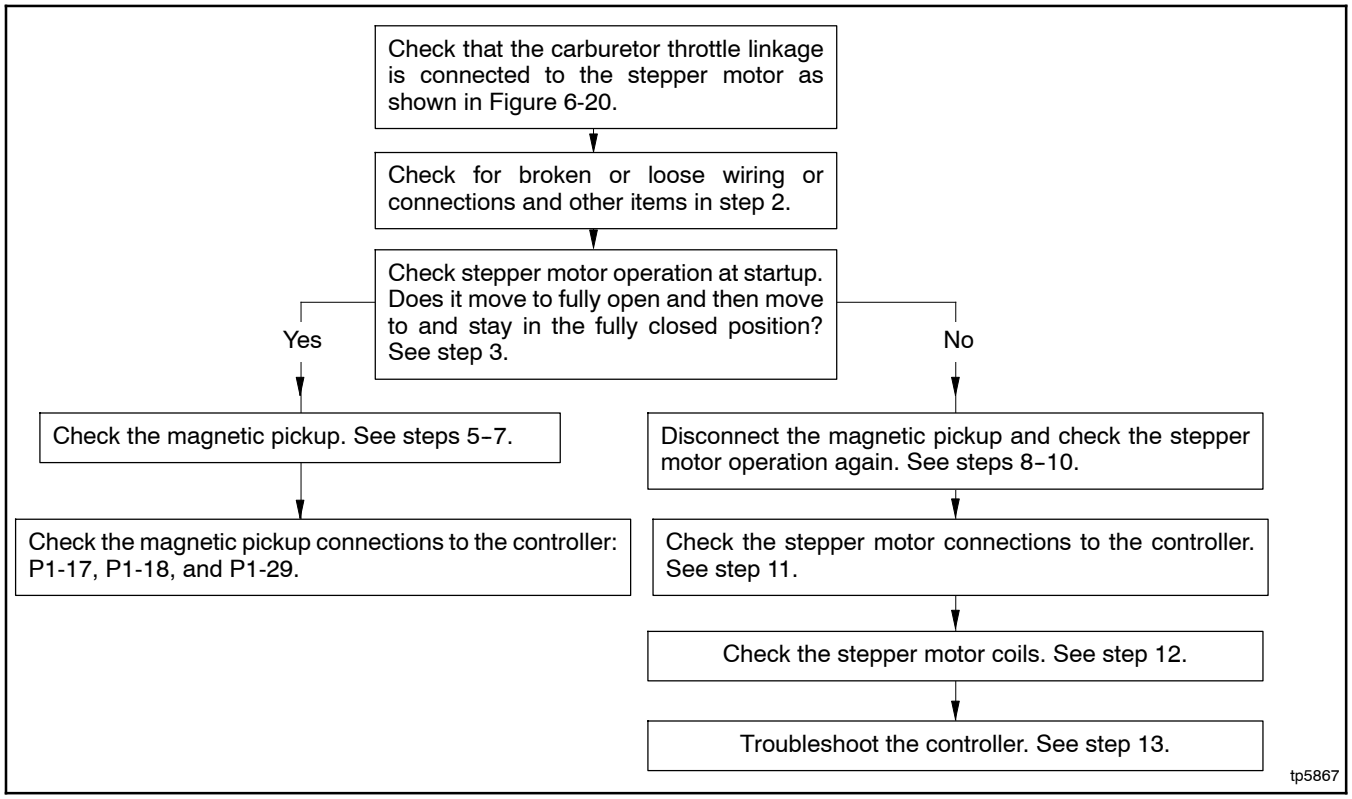


Figure 6-21 Governor System Operation Test Procedure Summary (Section 6.9.4)

Governor System Operation Test Procedure

1. Verify that the carburetor throttle linkage is connected to the stepper motor as shown in Figure 6-20.

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

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

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

   b. If the throttle linkage moves erratically or not at all at startup, proceed to step 8 to check the stepper motor.

4. Stop the generator set and check the resistance of the magnetic pickup.

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

   b. Disconnect the magnetic pickup at QCON1 and QCON2. The magnetic pickup must be isolated from the generator controller to allow an accurate resistance measurement.

   c. Measure the electrical resistance through the magnetic pickup at QCON1 and QCON2. See Figure 6-23.

   d. Compare the resistance measurement to the value shown in Figure 6-22. If the resistance measurement is outside of the specified range, replace the magnetic pickup.

   e. Reconnect QCON1 and QCON2.

Magnetic Pickup Resistance	
Resistance across QCON1 and QCON2	1.3 –1.9 kΩ

Figure 6-22 Magnetic Pickup Resistance

5. Verify the operation of the magnetic pickup by connecting a voltmeter to the magnetic pickup leads. See Figure 6-23. If the air gap is correct, the voltage should be 1.75 volts AC minimum during engine cranking.

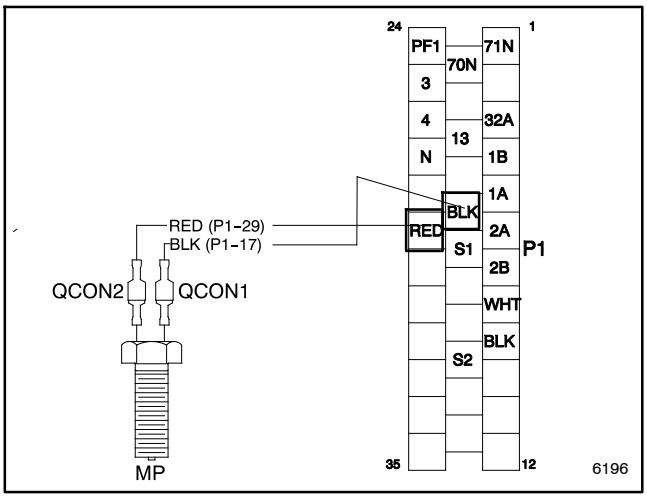


Figure 6-23 Magnetic Pickup Leads

6. If the voltmeter displays less than 1.75 volts AC, check the air gap as described in the following steps before replacing the sensor. Verify that the magnetic pickup air gap is 0.5 mm (0.020 in.). Measure the air gap at 3 or 4 places to get an accurate reading. See Figure 6-24.

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

   b. Remove the engine blower housing.

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

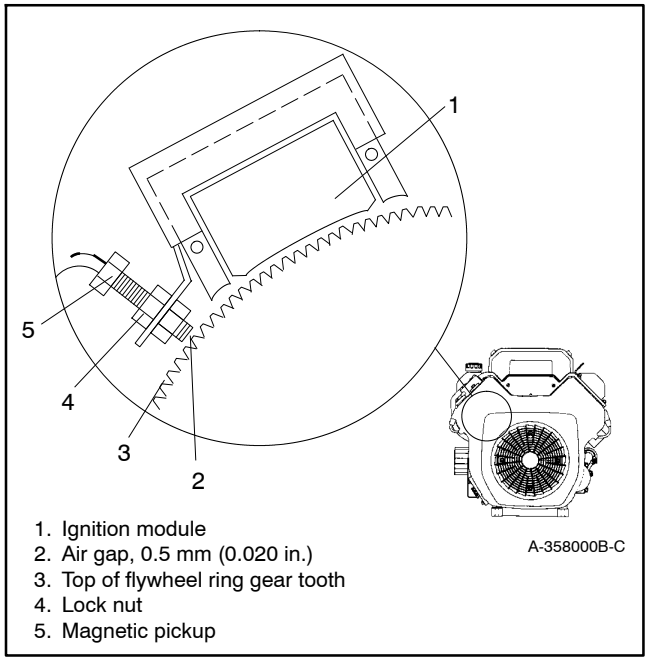
   d. Adjust the air gap, if necessary, by loosening the locknut and turning the pickup. See Figure 6-24.

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

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

   g. Reinstall the engine blower housing.

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



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

Figure 6-24 Magnetic Pickup Air Gap

7. After adjusting the air gap, check the voltage again as described in step 5. If the voltage does not measure 1.75 VAC minimum, replace the magnetic pickup.

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

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

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

11. Place the generator set master switch in the STOP position. Check the stepper motor connections to the controller: Leads 1A, 1B, 2A, and 2B to pins P1-4, P1-5, P1-6 and P1-7. Check the pins and connections at plugs J6 and P6. See the wiring diagrams in Section 8.

12. Check the stepper motor coil resistance across pins 2 and 3 and across pins 1 and 4. Only two stepper motor leads of each coil group are used (BLK-YEL and RED-WHT). See Figure 6-25. The resistance per half coil is 38.5 ohms. If one of the coils has a significantly higher resistance or is shorted, replace the stepper motor.

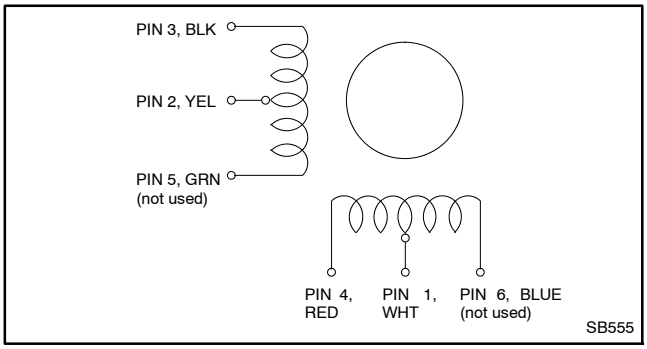


Figure 6-25 Actuator Coil Group

13. If there is power and a good ground connection to the ADC controller and the stepper motor coil resistances are good, but the stepper motor does not operate as described in step 10, the problem is with the ADC controller. Check controller connections, fuses, wiring, and settings. Refer to the troubleshooting procedures in Section 3.

6.9.5 Frequency Adjustment

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

Note: Engine governor speed (frequency) and gain adjustments are made using the ADC controller. See Section 4.5.3 for the ADC 2100 controller or 5.6 for the ADC-RES controller.

Frequency Adjustment Procedure

1. Open the generator set line circuit breaker.
2. Attach a frequency meter to the AC output leads.
3. Start and run the generator set until it reaches normal operating temperature (at least 10 minutes).
4. Use the ADC controller to adjust the electronic governor speed (parameter 4P) to obtain a frequency reading of 60 Hz (or 50 Hz on 50 Hz models). See Section 4.5.3.

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

5. Check stability with the generator set running and with no load applied. If the generator set speed is unstable, hunts, or surges, use the ADC controller to decrease the gain (parameter 5P) until the generator set becomes stable with no hunting or surging. Observe the frequency reading.
6. Repeat steps 4 and 5 to obtain the rated frequency and stable operation.
7. Save the settings as instructed in Section 4.5.

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

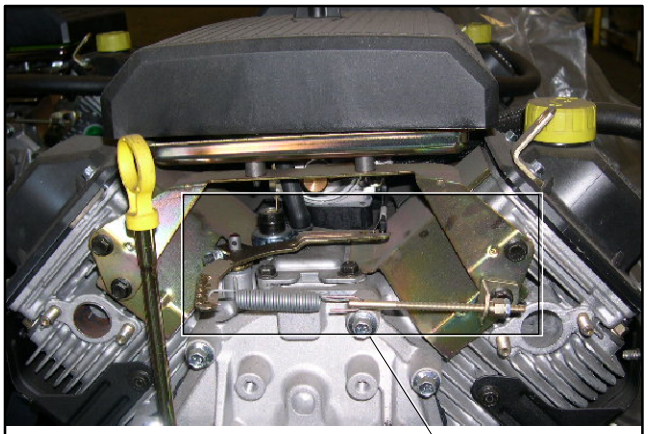
8. Apply rated load to the generator set and observe the frequency reading. The no load and full load frequencies should be within 0.4 Hz of the rated generator frequency; if not, check that the carburetor throttle plate opens completely without sticking and check the carburetor adjustment. If these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

    Note: Speed adjustments have no effect on gain adjustments. It is not necessary to repeat the gain adjustments after adjusting the engine speed.

Check the overspeed shutdown operation when investigating a shutdown problem. See Section 6.11.1 for the overspeed shutdown test procedure.

6.10 Mechanical Governor

Mechanical governors are used on model 12RESL, 12RESM1, and 12RESNT generator sets. See Figure 6-26. This section includes governor adjustment procedures. See the engine service manual for a description of mechanical governor design and operation, if desired.

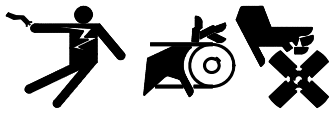


1. Mechanical governor assembly

photo4991

Figure 6-26 Mechanical Governor Assembly Location

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Mechanical Governor Arm Adjustment Procedure

Make this adjustment whenever the governor arm is loosened or removed from the cross shaft. See Figure 6-27 and adjust as follows:

1. Make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor.
2. Loosen the hex nut holding the governor lever to the cross shaft.
3. Move the governor lever toward the carburetor as far as it will move (wide open throttle) and hold in this position.
4. Insert a nail into the hole in the cross shaft and rotate the shaft counterclockwise as far as it will turn. Tighten the hex nut securely and then remove the nail.

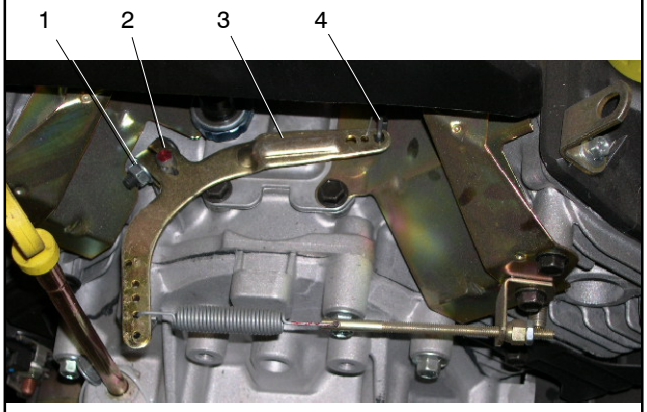


photo5005

1. Hex nut
2. Cross shaft
3. Governor lever
4. Throttle linkage (passes under air cleaner)

Figure 6-27 Governor Arm Adjustment

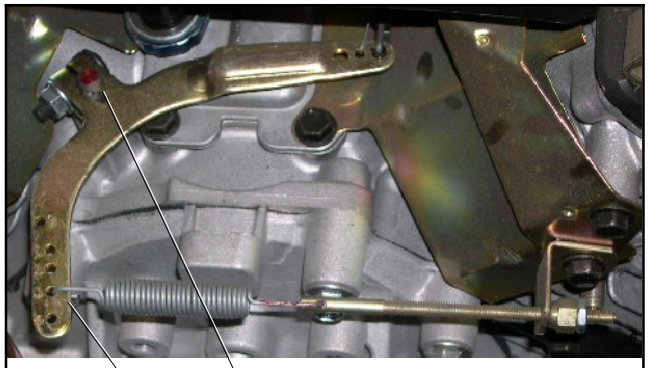
Mechanical Governor Sensitivity Adjustment

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

Governor sensitivity is adjusted by repositioning the governor spring in the holes of the governor lever. If speed surging occurs with a change in engine load, decrease the governor sensitivity. If a drop in speed occurs when normal load is applied, increase the governor sensitivity. See Figure 6-28 and adjust as follows:

1. To increase the sensitivity, move the spring closer to the governor cross shaft.

2. To decrease the sensitivity, move the spring away from the governor cross shaft.

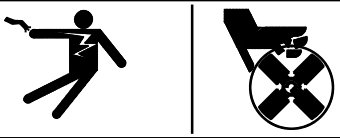


1. Governor lever
2. Cross shaft

Figure 6-28 Governor Sensitivity Adjustment

Engine Speed (Frequency) Adjustment, Mechanical Governor

⚠ DANGER



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

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

⚠ CAUTION

Hot surfaces.

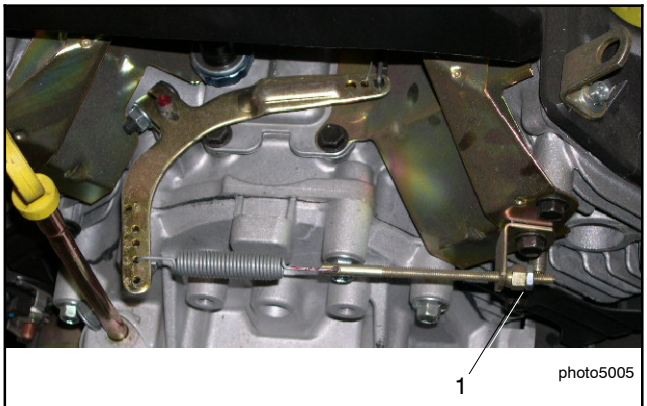
Use the adjusting nut shown in Figure 6-29 to adjust the engine speed, if necessary. Recommended engine speeds with no load and full load are shown in Figure 6-30.

1. With the engine running, loosen the lock nut.

2. If the engine is running too slow (frequency is low), turn the adjusting nut clockwise to increase the speed.

3. If the engine is running too fast, turn the adjusting nut counterclockwise, backing the nut out and decreasing the speed.

4. Verify that the engine speed is correct and tighten the locknut.



1. Speed adjusting nut and lock nut

Figure 6-29 Engine Speed Adjustment

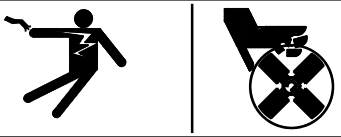
Generator Set Load	Engine Speed
No Load	3780 RPM (63 Hz)
Full Load	3600 RPM (60 Hz)

Figure 6-30 Recommended Engine Speed

6.11 Fault Shutdown Tests

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

⚠ DANGER



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

6.11.1 Controller Fault Shutdown Functions

Check the operation of the fault functions programmed in the ADC controller by performing the following tests. If the ADC controller does not operate as described, check the controller configuration settings; see Section 4.5.2. Also check the controller wiring and connections.

Overspeed Shutdown

The overspeed setting is programmed into the ADC controller and is not adjustable. Verify that the following controller configuration parameters are set correctly for your unit. See Section 4.5 and Figure 4-7 for the settings.

- System voltage/frequency parameter (UU)
- Unit configuration parameter (UC)
- Engine type parameter (EC)
- Engine data input type parameter (ED)

⚠ WARNING

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

Do not work on the generator set until it cools.

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

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

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

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

Increase the engine speed (parameter 4P) to at least 115% of the rated engine speed, 69 Hz on 60 Hz models or 58 Hz on 50 Hz models. Verify that the generator set shuts down on an overspeed fault (OS). If the overspeed shutdown does not operate, the generator set should shut down on an overfrequency fault (OF) after approximately 5 seconds.

If the controller does not indicate an overspeed fault (OS), check the wiring to the magnetic pickup (red and black leads, P1-17 and P1-29). Check the magnetic pickup resistance, air gap and voltage output; see Section 6.9.4.

Low Oil Pressure (LOP) Shutdown

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

Overcrank Shutdown

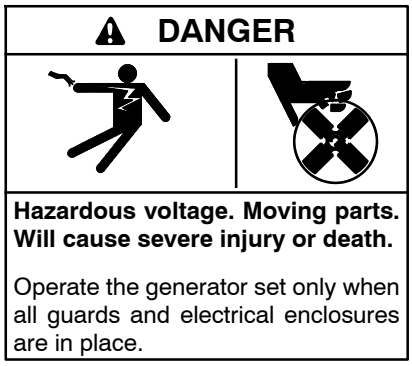
Disconnect the starter motor lead at the starter solenoid (K20) terminal. Move the controller master switch to the RUN position. Observe that the generator set simulates cranking for 15 seconds and then rests for 15 seconds. Check that the generator set shuts down after the third crank/rest cycle.

High Engine Temperature Shutdown

Connect a jumper wire across coolant temperature sensor (CTS) connections P1-8 and P1-9. Start the generator set. Verify that the generator set shuts down approximately 5 seconds after the generator set comes up to speed. Remove the jumper wire. Start the generator set and run it for at least 30 seconds to verify that the generator set does not shut down.

6.11.2 Fault Shutdown Switches

Check the low oil pressure and high engine temperature shutdown switches on the engine by performing the following tests. If the sensor does not function as described, replace it.



Servicing the generator set when it is operating. Exposed moving parts will 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 will cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Temperature Sensor (CTS)

The coolant temperature sensor (CTS) is used to monitor engine temperature for the high engine temperature fault shutdown (HE). See Section 1.7, Service View, for the coolant temperature sensor location. Set the generator set master switch to the OFF position and allow the generator set to cool. Disconnect the CTS and use an ohmmeter to measure the resistance across the sensor. The sensor resistance varies with temperature and should be within the values shown in Figure 6-31. If the resistance is very low (indicated a short circuit) or very high (indicating an open circuit) replace the CTS.

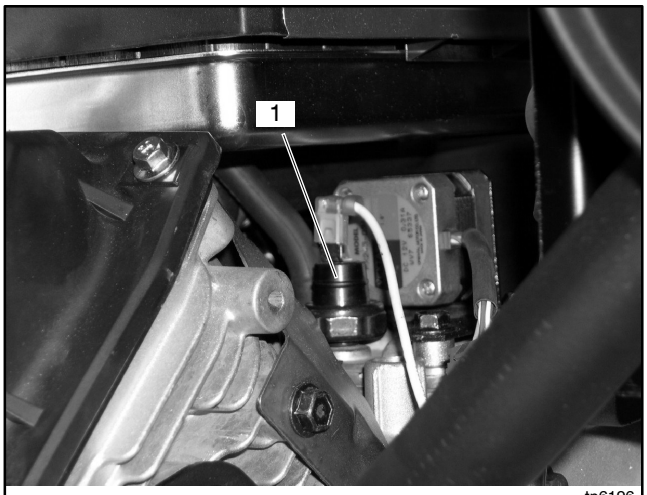
Note: The HET switch is located in the engine oil pan. Drain the engine oil before removing the switch.

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

Figure 6-31 Coolant Temperature Sensor Resistance Readings

Low Oil Pressure (LOP) Switch

The low oil pressure (LOP) switch is located under the engine air cleaner. See Figure 6-32.



1. Oil pressure switch

Figure 6-32 Oil Pressure Switch Location (under air cleaner)

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

6.12 Fuel Systems

⚠ WARNING

Risk of fire.
Can cause severe injury or death.

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

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

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

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

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

Use a universal exhaust gas oxygen (UEGO) sensor to check the fuel mixture after replacing the fuel regulator, fuel mixer, or silencer. The engine should be warm when the fuel mixture is checked. See Section 6.14 for instructions to check the fuel mixture.

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

6.12.1 Gas Piping

Verify that the gas pipe size meets the size specifications in Figure 6-33. Measure the pipe length from the gas utility pressure regulator to the end of the pipe where it connects to the fuel inlet of the generator set. Add 2.4 m (8 ft.) for each bend in the pipe. Compare the total length with the chart in Figure 6-33. If the piping is longer than the maximum length shown in the chart, replace it with a larger pipe size. Bleed the air from the gas lines after installation.

Figure 6-34 lists the maximum gas flow rates for each model.

Pipe Length, m (ft.)	8.5RES		12RES	
	Natural Gas	LP	Natural Gas	LP
8 (25)	3/4	1/2	3/4	3/4
15 (50)	3/4	3/4	1	1
30 (100)	1	1	1	1
46 (150)	1	1	1 1/4	1
61 (200)	1	1	1 1/4	1 1/4

Figure 6-33 Maximum Gas Pipe Length

Generator Set Model	Gas Flow Rate, Btu/hr.	
	Natural Gas	LP
8.5kW	132000	180000
12kW	202000	270000

Figure 6-34 Maximum Natural Gas Flow Rate

6.12.2 Fuel Solenoid Valve

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

Gas Valve Operation Test Procedure

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

6.12.3 Fuel Regulators

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

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

The fuel lock-off prevents fuel flow when the engine is not operating. See Figure 6-36. Do not try to adjust the fuel pressure, fuel mixture, or engine speed using the fuel lock-off.

Checking the Fuel Pressure

Use a gauge or manometer to check the fuel pressure at the secondary regulator inlet. See Figure 6-36. Measure the fuel pressure with the generator set running at rated load. Verify that the fuel pressure is within the range shown in Figure 6-35. Contact the fuel supplier if the inlet pressure is not within the specified range.

Fuel Type	Supply Pressure kPa (in. water column)
Natural Gas	1.2–2.7 (5–11)
LP	1.7–2.7 (7–11)

Figure 6-35 Fuel Supply Pressure

6.13 Fuel Conversion

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

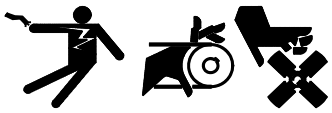
Rating Change

Converting the fuel will change the generator set rating. See the generator set specification sheet for ratings with natural gas and LP. Order a new nameplate with the updated rating and fuel information from a Kohler authorized distributor/dealer, if necessary. Provide the following information from the original nameplate:

- Model Number
- Spec Number
- Serial Number
- Fuel (original and new)
- kW
- kVA
- Amps
- Volts
- Hz

Attach the new nameplate over the old one. Do NOT cover the UL listing information on the old nameplate.

⚠ WARNING

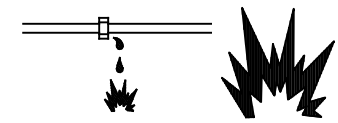


Accidental starting.
Can cause severe injury or death.

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

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

⚠ WARNING

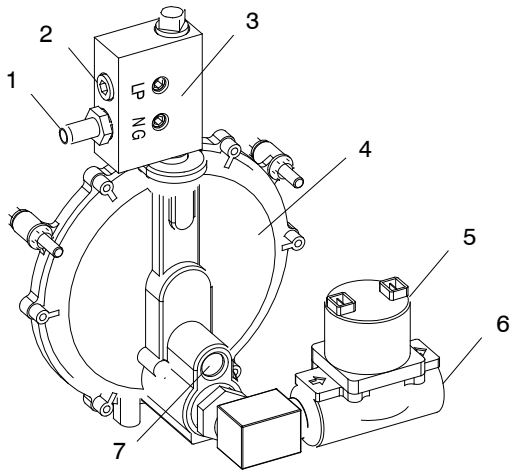


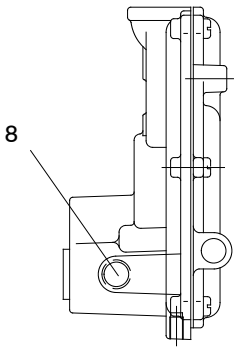
Explosive fuel vapors.
Can cause severe injury or death.

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

6.13.1 Fuel Conversion, Models Equipped with Fuel Block

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





Regulator, Side View

TP-6196

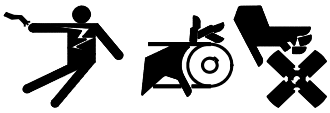
1. Hose fitting
2. Plug
3. Fuel metering valve *(factory-sealed, do not adjust)*
4. Secondary regulator
5. Fuel solenoid valve
6. Fuel inlet, 1/2 in. NPT
7. Fuel lockoff *(do not adjust)*
8. Inlet pressure check location

Figure 6-36 Fuel Regulator, Fuel Metering Valve, and Fuel Solenoid Valve

Fuel Conversion Procedure

Use the following procedure to convert from natural gas to LP vapor. See Figure 6-37 for the fuel system component locations.

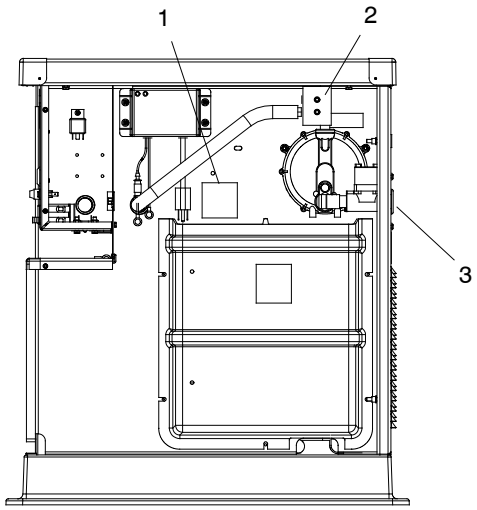
⚠ WARNING



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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



1. DSAI connector location
2. Fuel metering valve
3. Fuel inlet, 1/2 in. NPT female

GM29253

Figure 6-37 Generator Set Fuel System Location, Air Inlet Side

1. Place the generator set master switch in the OFF position.
2. Disconnect the power to the battery charger.

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

4. Turn off the fuel supply.

5. Remove the hose clamp and fuel hose from the hose fitting in the fuel metering valve. See Figure 6-36.

6. Remove the hose fitting from the natural gas outlet port in the fuel metering valve. See Figure 6-36.

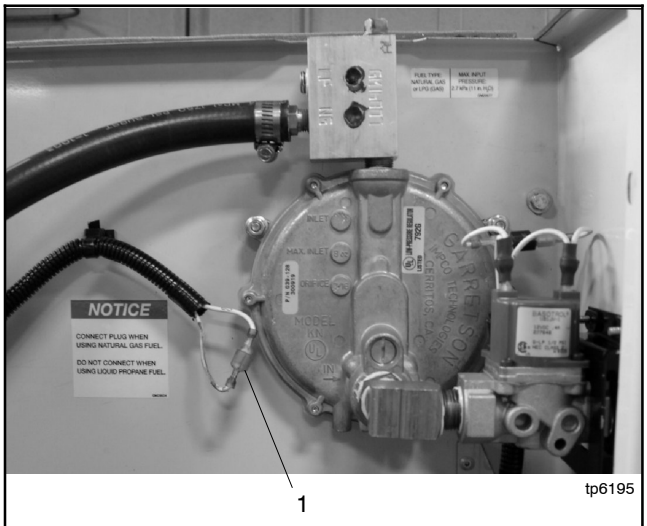
7. Remove the plug from the LP port in the fuel metering valve. See Figure 6-36. Clean the plug with a dry cloth or brush, apply fresh pipe sealant, and install the plug into the natural gas outlet port.

8. Clean the hose fitting with a dry cloth or brush, apply fresh pipe sealant to the threads, and install the fitting into the LP port.

   Note: Do not adjust the fuel metering valves.

9. Slide the hose onto the hose fitting and secure it with the clamp.

10. For 12 kW models only: Connect the digital spark-advance ignition (DSAI) leads together for natural gas. (Disconnect the leads for LP.) See Figure 6-38.



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

Figure 6-38 Digital Spark Advance Ignition Leads (12kW only) (located in generator set air intake area)

11. Connect and turn on the new fuel supply.

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

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

14. Reconnect power to the battery charger.

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

16. Check for leaks using a gas leak detector.

17. Move the generator set master switch to the AUTO position.

To convert from LP vapor to natural gas, follow the same fuel conversion procedure, moving the hose fitting to the natural gas port and plugging the LP port. For the 12kW model, disconnect the DSAI leads for LP vapor. See Figure 6-38.

6.13.2 Fuel Conversion, 12RES Models Equipped with Fuel Orifice

For natural gas and LPG fuel, orifice fittings are used in the fuel line. See Figure 6-39. The natural gas orifice fitting is silver in color and stamped NG. The LPG fitting is gold in color and stamped LPG. The fittings are threaded. A straight-blade screwdriver is required to remove and replace the fittings.

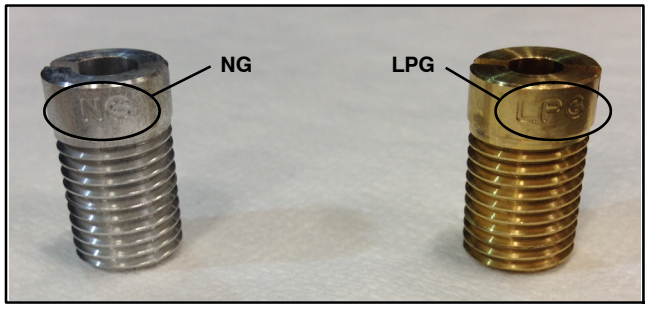


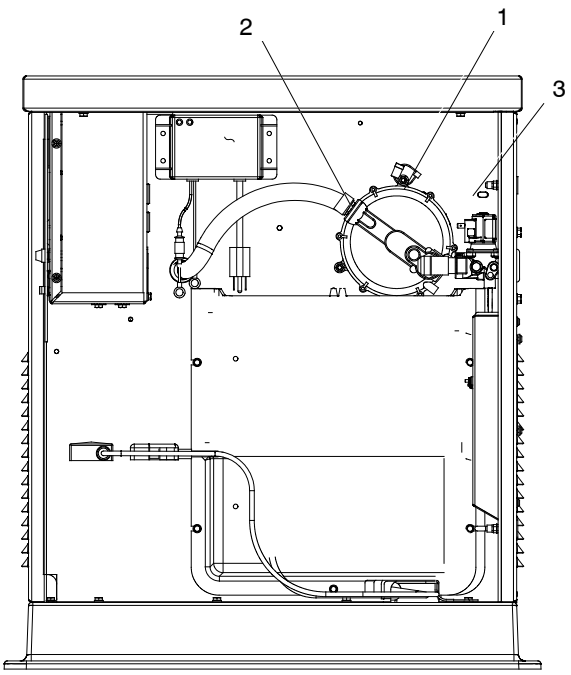
Figure 6-39 NG and LPG Fuel Orifice Fittings

The unit is typically shipped set up for natural gas, with the LPG fitting tied to the fuel regulator. To convert to LPG, remove the NG fitting and install the LPG fitting as described below. See Figure 6-40 for the fuel system component locations.

Procedure to Convert from NG to LPG

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the utility power to the generator.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Turn off and disconnect the fuel supply.
5. Remove the hose clamp and fuel hose from the hose fitting. See Figure 6-40.
6. Use a straight-blade screwdriver to remove the NG orifice from the hose fitting. See Figure 6-41.
7. Insert the LPG orifice into the hose fitting. Use a straight-blade screwdriver to tighten the fitting until it is snug.
8. Slide the hose onto the hose fitting and secure it with the clamp.
9. Disconnect ignition timing leads 65 and N5 for LPG. The ignition timing leads are located near the fuel solenoid valve. See Figure 6-40.

   Note: Do not disconnect the leads to the fuel solenoid valve.



Ignition Timing Lead Connection

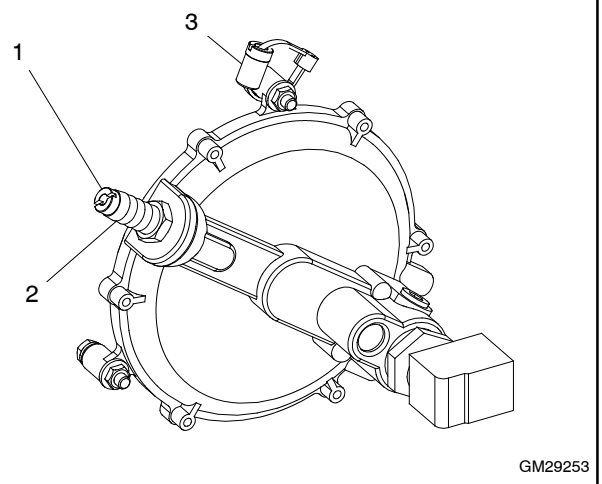
1. LPG fitting tied to regulator for shipping
2. Fuel hose and clamp
3. Ignition timing lead location (leads not shown)

Figure 6-40 Fuel System, As Shipped

10. Connect and turn on the new fuel supply.
11. Reconnect the generator set engine starting battery leads, negative (–) lead last.
12. Reconnect the utility power to the generator.
13. Start the generator set by moving the master switch to the RUN position.
14. Check for leaks using a gas leak detector.
15. Run the generator set and check the operation.
16. Move the generator set master switch to the OFF/RESET position to shut down the generator set.

Conversion from LPG to Natural Gas

To convert from LPG to natural gas, repeat the steps above, removing the LPG fuel orifice and installing the NG fitting. Connect ignition timing leads 65 and N5 together for natural gas.



1. Fuel orifice fitting
2. Hose fitting
3. Orifice tied to regulator for shipping

Figure 6-41 Fuel Orifice Fitting Installation

6.13.3 Digital Spark Advance Ignition

The digital spark advance ignition (DSAI) on 12 kW models optimizes the engine timing for the selected fuel, natural gas or LP. The location of the DSAI leads is shown in Figure 6-37. Connect the DSAI leads in the air intake compartment together for natural gas fuel. Disconnect the leads if LP is used. See Figure 6-38.

See the engine service manual for DSAI service information.

6.14 Fuel Metering Valve Adjustment

Note: This section applies to models equipped with the fuel block.

The fuel system is factory-adjusted to comply with applicable emission standards and to provide the best possible hot and cold starting.

Note: Adjusting the fuel metering valves on emissions-certified generator sets may void the emission certification.

Use a universal exhaust gas oxygen (UEGO) sensor to check the fuel mixture after replacing the fuel regulator, carburetor, or silencer. Use the following procedure to check the fuel mixture after the engine has reached normal operating temperature.

The fuel metering valves are sealed to prevent field adjustments. If the fuel metering valve requires adjustment, do not break the seals on the fuel metering valve. Obtain a new fuel metering valve from the manufacturer and replace the sealed valve with the new part. See Figure 6-37 for the fuel metering valve location. Refer to the generator set Parts Catalog for the fuel metering valve part number.

Only trained, authorized service technicians may adjust the new fuel metering valve. The adjustment procedure requires a digital volt meter (DVM), UEGO oxygen sensor service kit GM29385, and a load bank capable of the rated kW for the fuel being used. Always use an oxygen sensor when adjusting the fuel metering valves.

Observe the following safety precautions while performing the procedure.

⚠ WARNING

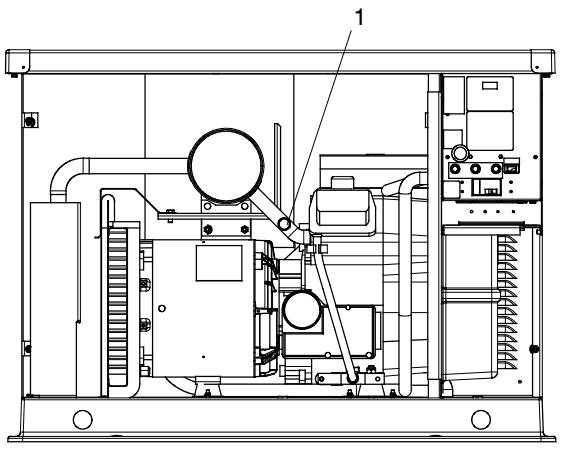
Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

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

Fuel Mixture Check/Fuel Metering Valve Adjustment Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger.
3. Remove the oxygen sensor plug from the exhaust manifold and install the oxygen sensor. See Figure 6-42 for location.



1. Oxygen sensor mounting location

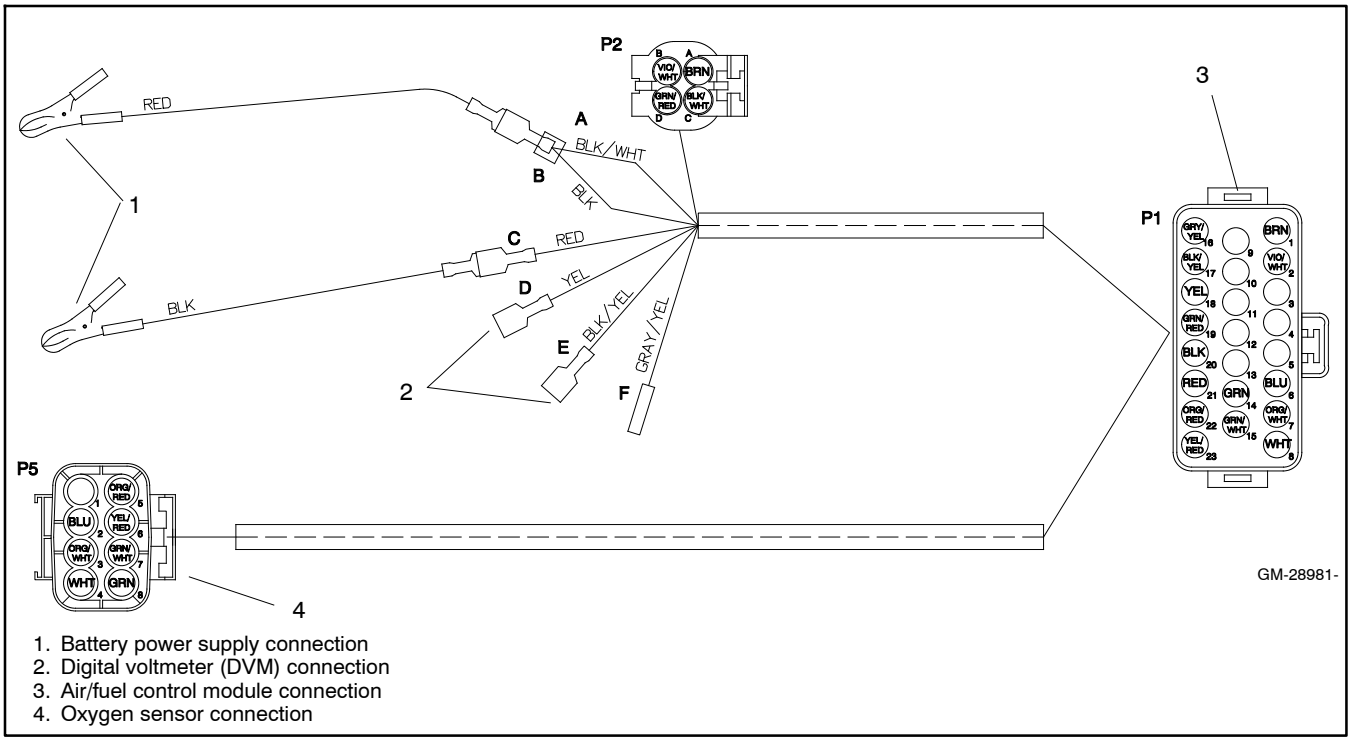
Figure 6-42 Oxygen Sensor Mounting Location

4. Connect the oxygen sensor to the engine starting battery, control module, and voltmeter as shown in Figure 6-44.
5. Reconnect power to the battery charger.
6. Place the controller master switch in the RUN position to start the generator set.
7. Allow the generator set to run until the engine reaches normal operating temperature.
8. With the generator set at normal operating temperature, apply rated load.
9. Connect one of the DVM leads to the oxygen sensor lead. Connect the other DVM lead to ground and measure the output voltage of the oxygen sensor (potential to ground).
10. Adjust the fuel metering valve as required to obtain the output from the oxygen sensor specified in Figure 6-43. The output of the oxygen sensor reads high when the mixture is fuel-rich and close to zero volts when the mixture is lean.

	Oxygen Sensor Reading, VDC	
Model	**Natural Gas**	**LP**
8.5kW	2.40 ± 0.05	2.25 ± 0.05
12kW	2.60 ± 0.05	2.60 ± 0.05

Figure 6-43 Acceptable Oxygen Sensor Readings

11. When the fuel mixture is correct, use thread sealant to seal the metering valve adjustment screws.
12. Remove the load and allow the generator set to run unloaded to cool for at least 5–10 minutes.
13. Place the generator set master switch in the OFF position.
14. Disconnect the generator set engine starting battery, negative (–) lead first.
15. Allow the generator set exhaust system to cool.
16. Disconnect the DVM leads from the oxygen sensor.
17. Remove the oxygen sensor from exhaust manifold.
18. Apply a small amount of antiseize compound to exhaust plug and reinstall the plug into the exhaust manifold.
19. Check that the generator set master switch is in the OFF position.
20. Reconnect the generator set engine starting battery, negative (–) lead last.
21. Reconnect power to the battery charger.



1. Battery power supply connection
2. Digital voltmeter (DVM) connection
3. Air/fuel control module connection
4. Oxygen sensor connection

Figure 6-44 UEGO Sensor Interface Harness GM28981 Electrical Connections

6.15 Fuses

Three fuses are located on the junction box next to the controller display/keypad. (Early models may have the fuses located in the wiring harness.) See Figure 6-45. Another 10-amp fuse protects the battery charger.

Fuse	Label	Part Number
Auxiliary Winding, 20 amps	F1	292937
Relay Interface Board, 10 amps	F2	223316
Controller, 10 amps	F3	223316
Battery Charger, 10 amps	—	223316

Figure 6-45 Fuses

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

6.16 Starter Relay

The starter relay contains an internal diode across the relay coil. See Figure 6-46. Continuity checks across the coil terminals will show continuity (low resistance) in one direction and an open circuit in the other.

Figure 6-47 shows the starter relay connections.

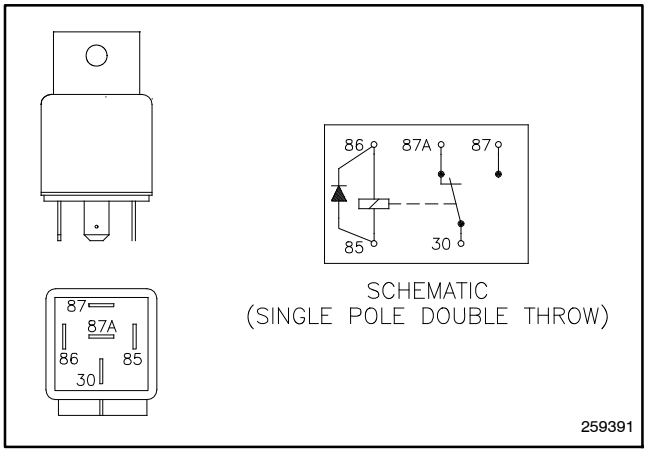


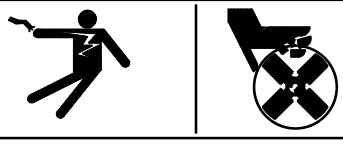
Figure 6-46 Starter Relay

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

Figure 6-47 Starter Relay Connections

6.17 Continuity Checks

⚠ DANGER



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

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

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

To further check generator set components, disconnect the battery and remove wiring harness plugs from the controller circuit board. Use an ohmmeter to check the continuity of the components listed in Figure 6-49. Also see Section 8, Wiring Diagrams.

Figure 6-49 gives resistance readings for functional components. A zero reading on the ohmmeter indicates continuity. No ohmmeter reading indicates very high resistance or an open circuit. A measurement that varies significantly from the value shown in the table indicates a faulty component; replace faulty components.

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

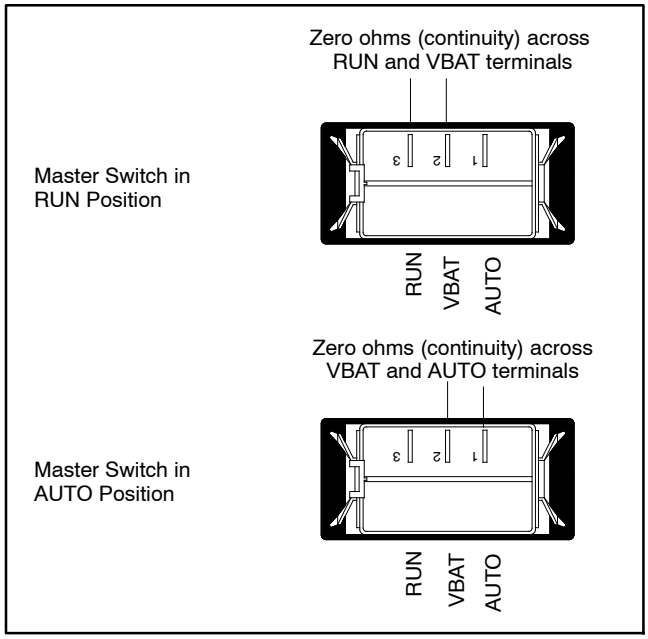


Figure 6-48 Generator Set Master Switch Continuity Checks

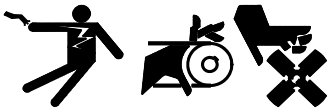
Component	Ohmmeter Connections	Ohmmeter Scale	Generator Set Master Switch Position	Ohmmeter Readings for Operative Components*
Generator set master switch	RUN and VBAT (see Figure 6-48)	R x 100	RUN	Zero ohms (continuity). Any other reading indicates a bad switch.
			OFF/RESET	No reading (open circuit). Any other reading indicates a bad switch.
	AUTO and VBAT (see Figure 6-48)	R x 100	AUTO	Zero ohms (continuity). Any other reading indicates a bad switch.
			OFF/RESET	No reading (open circuit). Any other reading indicates a bad switch.
P1 wiring harness	P1-27 and ground	R x 1	OFF/RESET	Zero ohms (continuity). Any other reading indicates a poor ground connection.
	P15-1 and P15-3 (stator leads 11 and 44)	R x 1	OFF/RESET	Zero ohms (continuity). If no continuity, check wiring.
	P16-3 and P16-6 (stator leads 55 and 66)	R x 1	OFF/RESET	Zero ohms (continuity). If no continuity, check fuse F1 and wiring.
Controller fuse and wiring	P1-24 and battery positive (+)	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check fuse F3 and wiring.
Auxiliary winding fuse 20 amp fuse	P16-3 and stator lead 55	R x 100	OFF/RESET	Zero ohms (continuity). If no continuity is found, check for an open circuit and/or a blown fuse.
Low oil pressure (LOP) switch *	Lead 13 and ground (engine block)	R x 100	OFF/RESET	Zero ohms (continuity). No continuity indicates a bad switch and/or wiring.
Temperature sensor (CTS) *	P1-8 and P1-9	R x 1000	OFF/RESET	180–2500 ohms, depending on engine temperature. Zero ohms or an open circuit indicates bad wiring or a bad switch.
Magnetic pickup	QCON1 and QCON2	R x 1000	OFF	1.3–1.9 kOhms. Resistance values outside of this range indicate a faulty pickup; replace the magnetic pickup.
* See Section 6.11.2, Fault Shutdown Switches				

Figure 6-49 Continuity Checks

Notes

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

⚠ 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) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING

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

Do not work on the generator set until it cools.

⚠ WARNING

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

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

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

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

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

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.

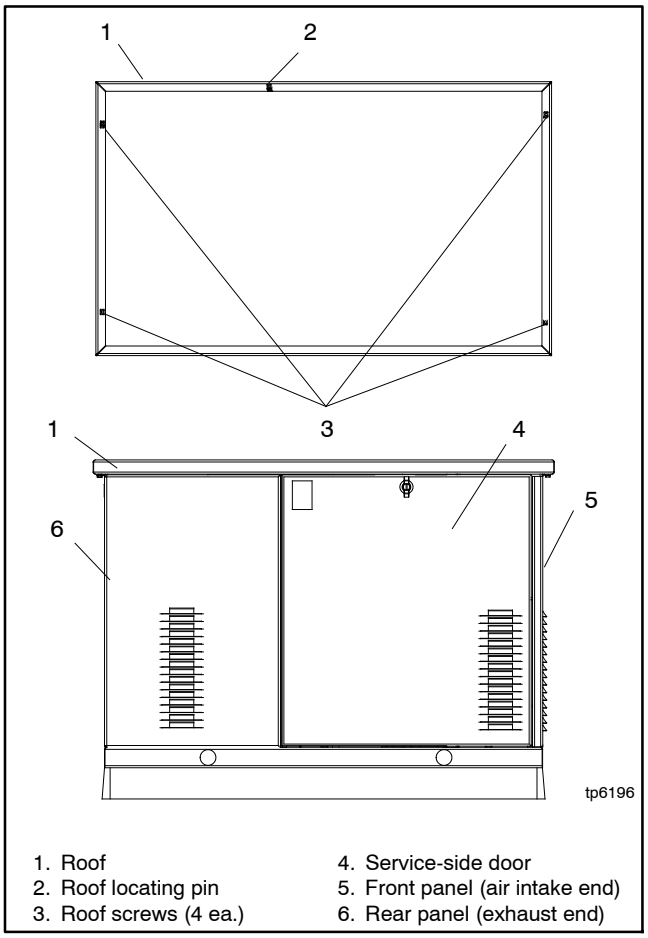
7.1 Disassembly

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

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

1. Remove the generator set from service and remove the generator set enclosure.

   a. Remove the enclosure service-side door. See Figure 7-1.



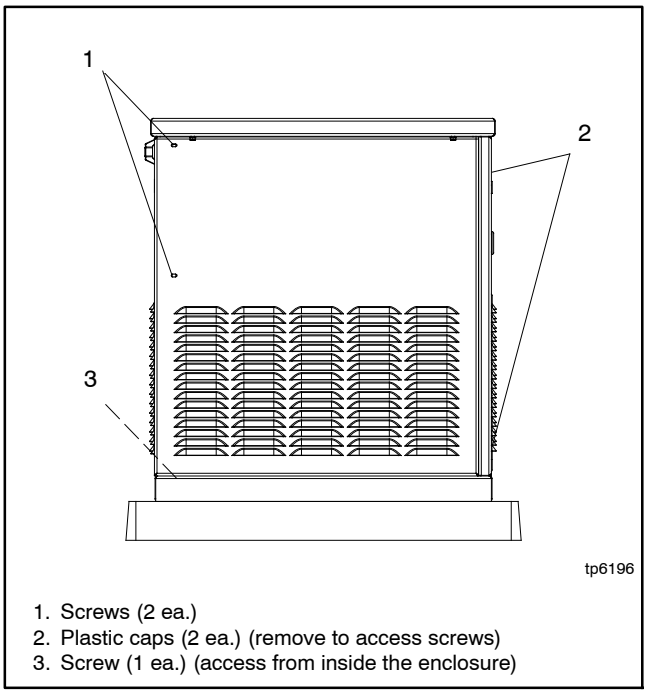
1. Roof
2. Roof locating pin
3. Roof screws (4 ea.)
4. Service-side door
5. Front panel (air intake end)
6. Rear panel (exhaust end)

Figure 7-1 Generator Set Weather Housing

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

   c. Remove 4 roof screws. Lift the roof up and off. See Figure 7-1.

   d. Remove 5 screws to remove the front panel. Remove the plastic caps to access the 2 side screws. See Figure 7-2.



1. Screws (2 ea.)
2. Plastic caps (2 ea.) (remove to access screws)
3. Screw (1 ea.) (access from inside the enclosure)

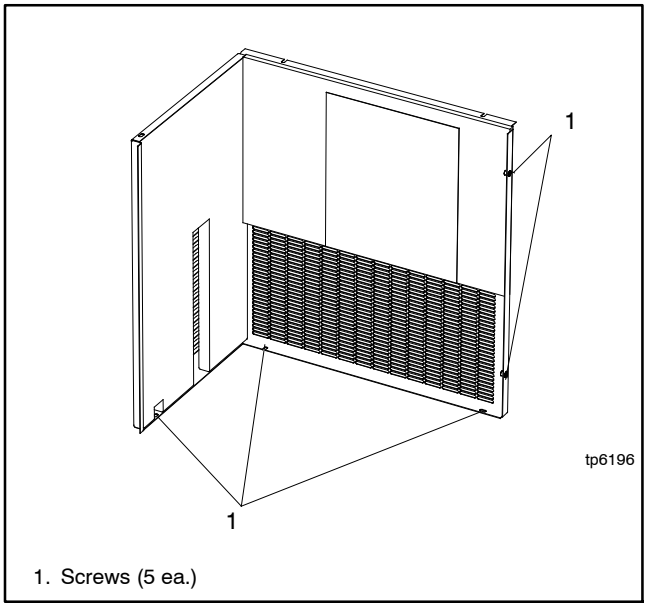
Figure 7-2 Front Panel Mounting Screw Locations

   e. Disconnect power to the battery charger.

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

   g. Turn off the fuel supply to the generator set.

h. From the inside of the enclosure, remove 5 screws to remove the rear (exhaust end) panel. See Figure 7-3.



1. Screws (5 ea.)

Figure 7-3 Rear Panel Mounting Screw Locations (viewed from inside the enclosure)

i. From the inside of the enclosure, remove the remaining screws to remove the non-service side housing panel.

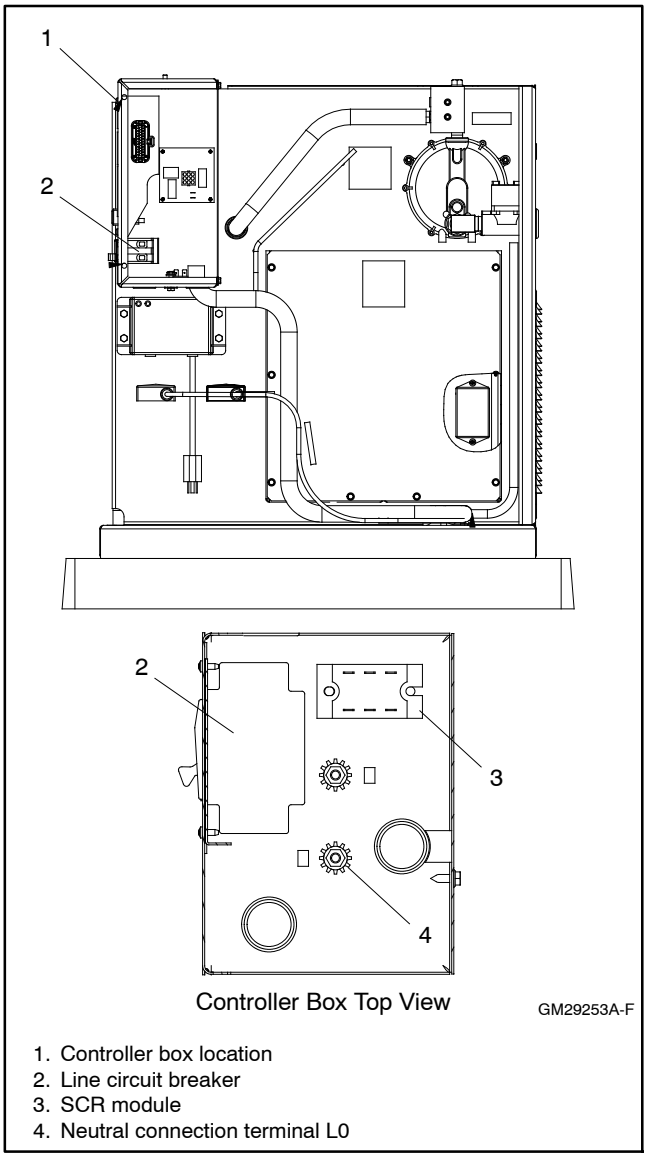
2. Note the alternator connections inside the controller box for reconnection later. Disconnect the alternator leads inside the controller box. See Figure 7-4 or Figure 7-5 and the wiring diagrams in Section 8.

3. Remove the engine exhaust muffler and alternator heat shield. See Figure 7-6.

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

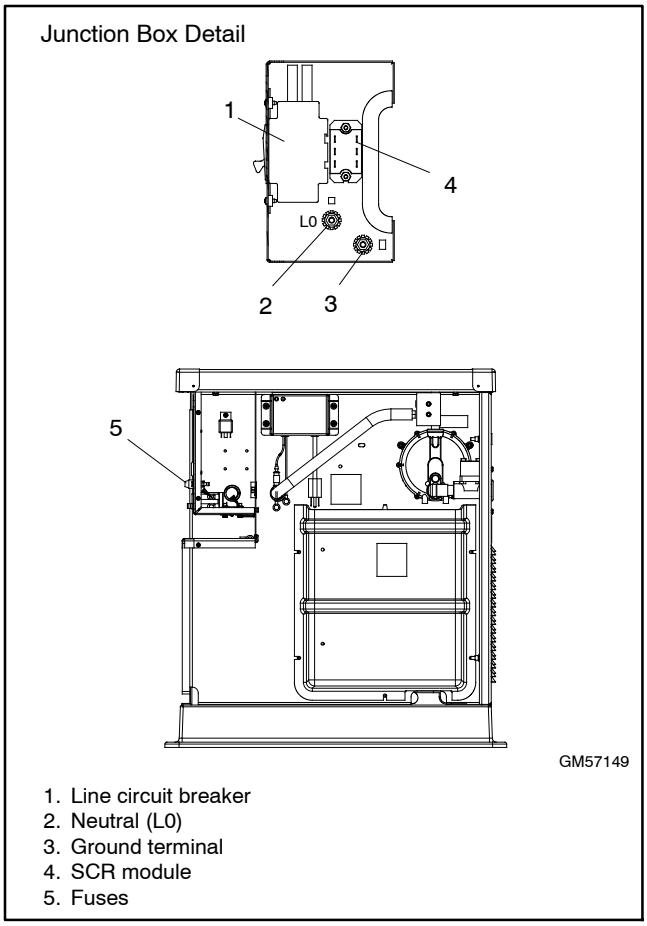
   b. Remove the bolts holding the muffler to the alternator heat shield and remove the muffler.

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



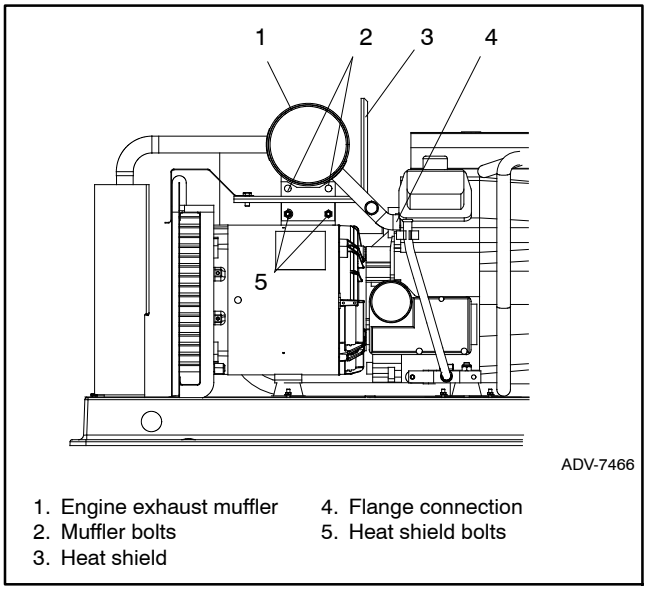
1. Controller box location
2. Line circuit breaker
3. SCR module
4. Neutral connection terminal L0

Figure 7-4 Alternator Connections inside Controller Box, ADC 2100



1. Line circuit breaker
2. Neutral (L0)
3. Ground terminal
4. SCR module
5. Fuses

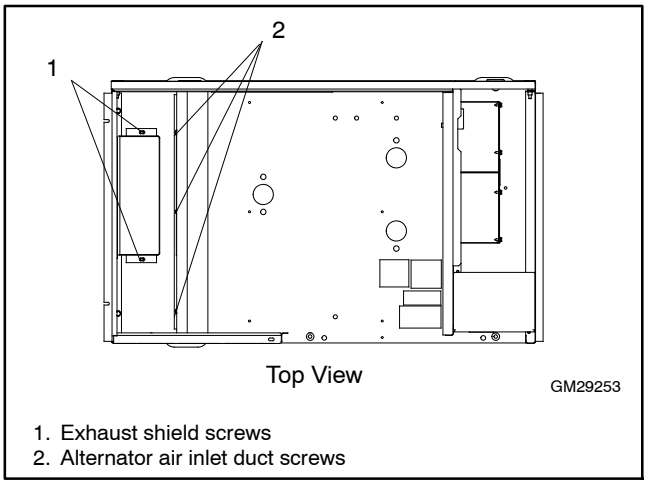
Figure 7-5 Alternator Connections inside Controller Box, ADC-RES



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

Figure 7-6 Muffler and Heat Shield

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



1. Exhaust shield screws
2. Alternator air inlet duct screws

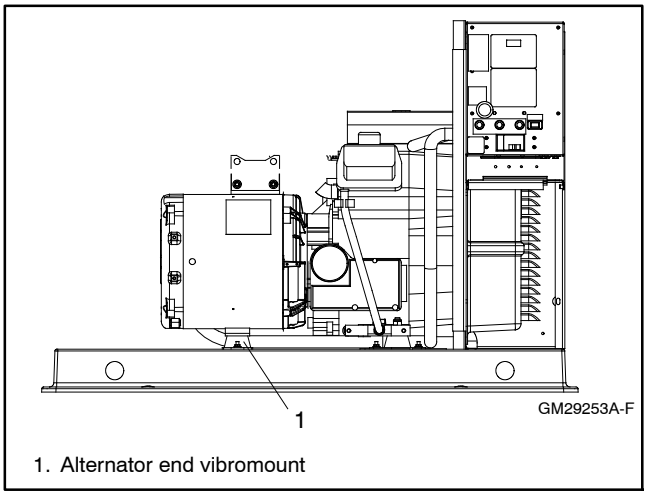
Figure 7-7 Shield and Alternator Air Inlet Duct, Top View

a. Remove two bolts securing the exhaust shield at the exhaust end and remove the shield.

b. Remove three bolts securing the alternator air inlet duct to the base and remove the duct.

5. Remove the alternator end bracket.

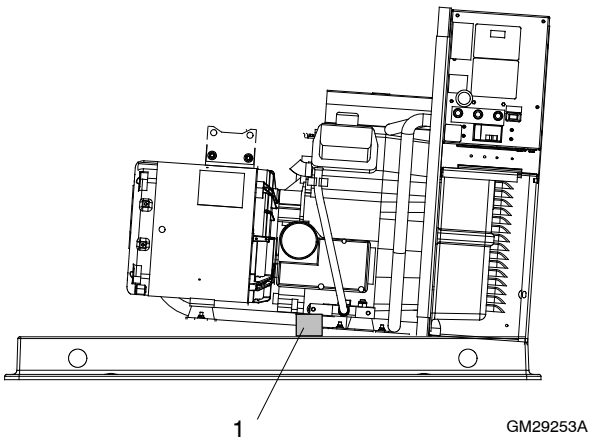
a. Remove the nuts securing the alternator end vibromount mounting plate to the skid. See Figure 7-8.



1. Alternator end vibromount

Figure 7-8 Generator Set, Right Side (typical)

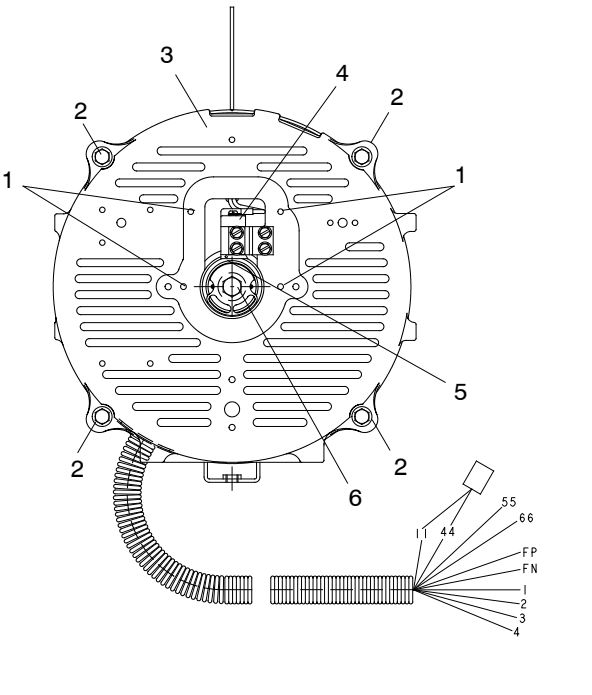
b. Raise the alternator end of the generator set enough to place a thin block of wood beneath the rear of the engine. See Figure 7-9.



1. Engine support block

Figure 7-9 Generator Set, Right Side

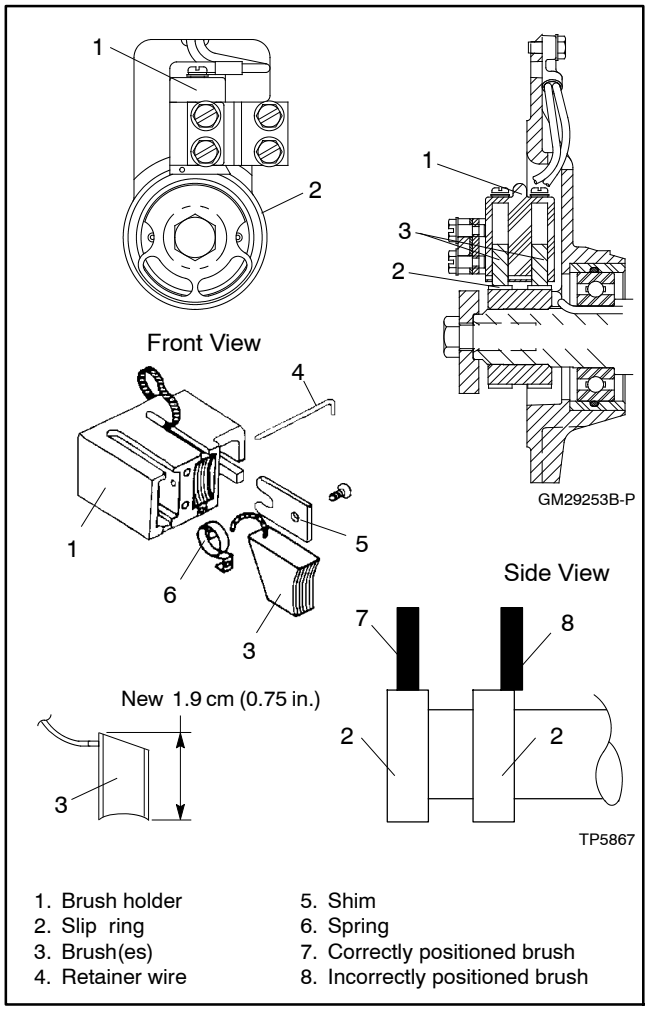
c. Remove 4 screws securing the brush cover to the alternator end bracket. See Figure 7-10.



1. Brush cover screws
2. Overbolt and centering washer
3. Alternator end bracket
4. Brush holder
5. Brush retainer wire hole
6. Thrubolt

Figure 7-10 Alternator End Bracket

d. Raise the brushes in the brush holder and insert a small piece of wire into the brush holder retainer wire hole. See Figure 7-10 and Figure 7-11.



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

Figure 7-11 Brush Details

e. Remove the alternator overbolts and centering washers. See Figure 7-10.

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

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

6. Check the brushes.

a. Remove the brush holder from the end bracket. See Figure 7-10.

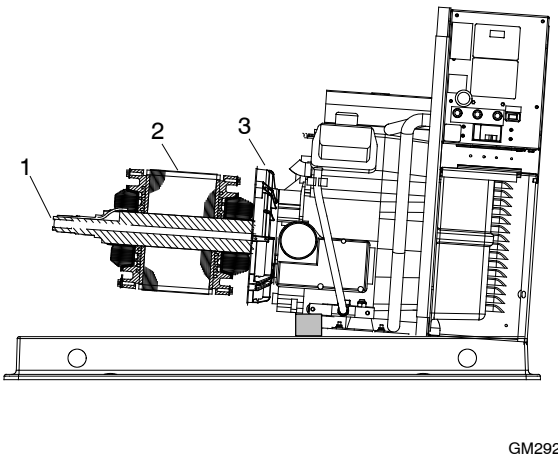
b. Inspect the brushes. Replace brushes when they are worn to half of their original size. See Figure 7-11 and Section 6.6, Brushes.

7. Remove the stator and rotor.

   a. Remove the stator from the rotor.

   b. Loosen and remove the thrubolt. Use a strap wrench on the rotor to keep the rotor from turning during loosening, if necessary. See Figure 7-12.

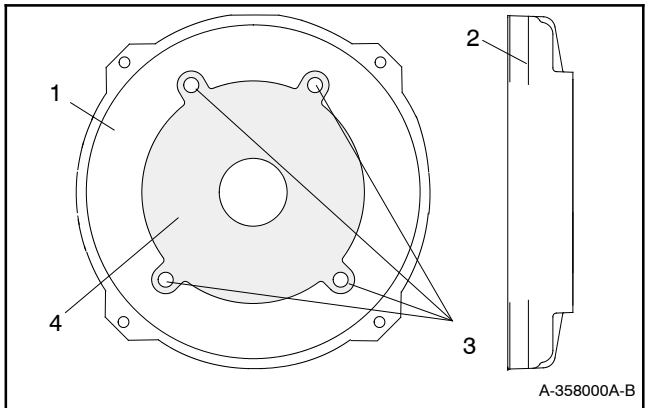
   c. Remove the rotor assembly by striking the side of the rotor repeatedly with a soft-faced hammer to loosen it from the tapered crankshaft fitting. See Figure 7-12. Rotate the rotor and strike it on alternate sides. Set the rotor assembly aside.



1. Thrubolt and magnetic actuator
2. Rotor strike surface
3. Generator adaptor

Figure 7-12 Rotor and Thrubolt

8. Remove the four engine adapter mounting bolts. See Figure 7-13. Remove the generator adapter.



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

Figure 7-13 Generator Adapter

7.2 Reassembly

1. Reinstall the generator adapter onto the engine.

   a. Attach the generator adapter and alternator adapter guard to the engine using four 7/16-14 x 1.0 hex cap bolts and washers. See Figure 7-13.

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

2. Install the rotor. See Figure 7-12.

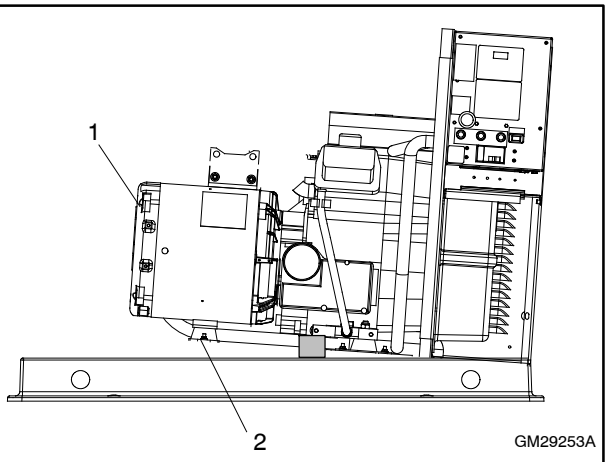
   a. Clean the crankshaft stub and mating surface on the fan hub. Do not use antisieze compound when reassembling the rotor.

   b. Install the rotor onto the engine crankshaft.

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

3. Install the stator and end bracket.

   a. Align the stator so that the alternator frame vibromount points down toward the generator base. See Figure 7-14. Install the stator assembly around the rotor.



1. End bracket
2. Alternator frame vibromount

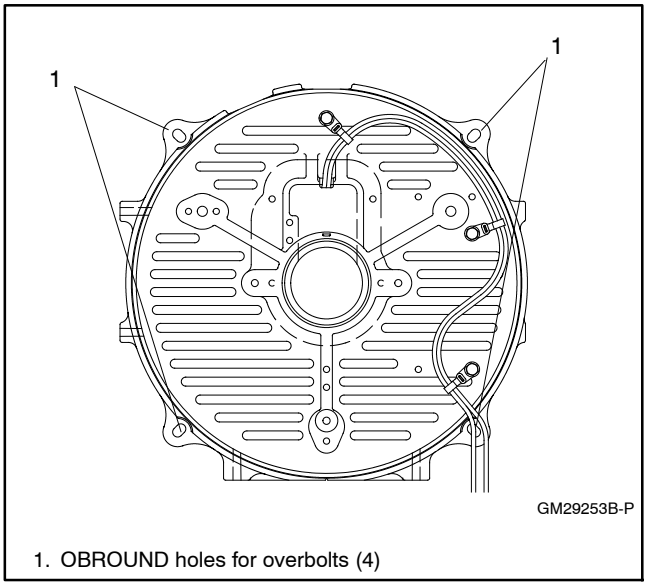
Figure 7-14 Generator Set, Right Side (typical)

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

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

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

   e. Thread the four overbolts with locating washers through the end bracket and into the generator adapter. Position the locating tab of each washer to the outer edge of the oblong (OBROUND) hole on the end bracket. See Figure 7-15. The overbolts should be parallel to the outside of the alternator. If the overbolts are slanted, rotate the locating washer 1/2 turn. Do not final tighten the overbolts.



1. OBROUND holes for overbolts (4)

Figure 7-15 End Bracket

4. Secure the generator set to the skid.

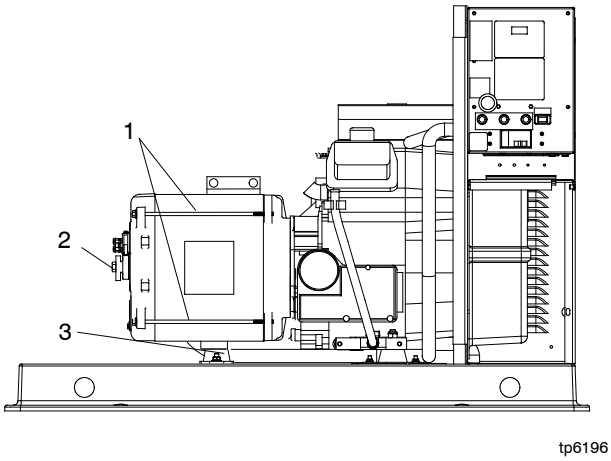
   a. Raise the alternator end of the generator set and remove the block of wood from beneath the rear of the engine.

   b. Lower the end of the generator set and reinstall the screws and washers that secure the vibromount mounting plate to the generator set skid. See Figure 7-16.

5. Tighten the hardware to the following torques. See Figure 7-16.

   a. Tighten the rotor thrubolt to 40 Nm (28 ft. lb.). It may be necessary to keep the engine flywheel from turning while torquing the rotor thrubolt.

   b. Tighten the four alternator assembly overbolts to 7 Nm (60 in. lb.).



1. Alternator assembly overbolts
2. Rotor thrubolt
3. Vibromount plate

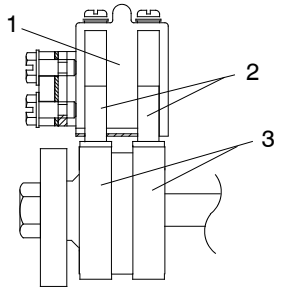
Figure 7-16 Generator Set, Right Side (typical)

6. Reinstall the end bracket components.

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

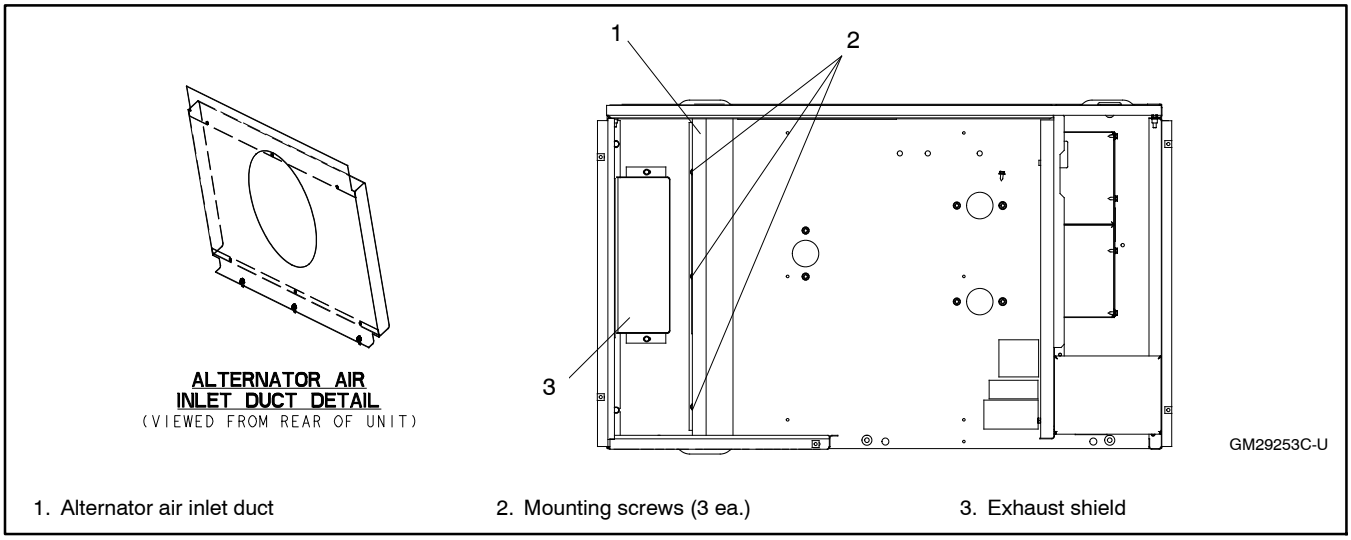
   b. Verify that the brushes are centered on the slip rings. If required, insert spacers between the mounting surface and brush holder to center the brushes on the slip rings. See Figure 7-17. See Section 6.6, Brushes, for more information.

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



1. Brush holder
2. Brushes
3. Slip rings

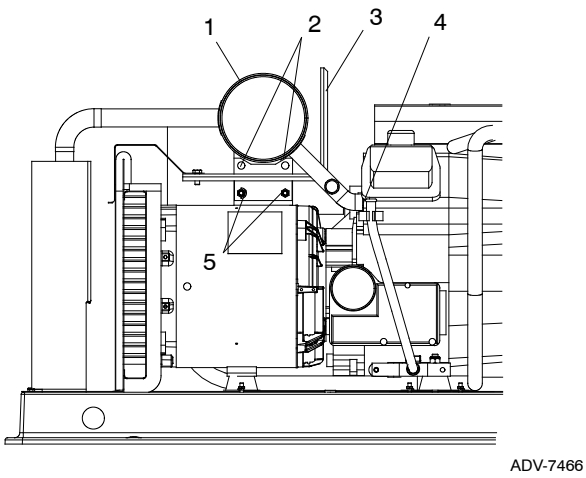
Figure 7-17 Brush Positioning



1. Alternator air inlet duct
2. Mounting screws (3 ea.)
3. Exhaust shield

Figure 7-18 Alternator Air Inlet Duct

7. Reinstall the alternator air inlet duct. Orient the duct as shown in Figure 7-18.
8. Install the exhaust shield. See Figure 7-18.
9. Install the exhaust system. See Figure 7-19.
   a. Install the heat shield onto the alternator exhaust support using M8 hardware.
   b. Using new gaskets, connect the engine exhaust muffler to the engine at the flanges. Do not final tighten the mounting hardware.
   c. Secure the muffler mounting tab to the heat shield with M8 hardware.
   d. Torque the nuts securing the engine muffler flange to the engine to 24 Nm (216 in. lb.).



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

Figure 7-19 Exhaust System

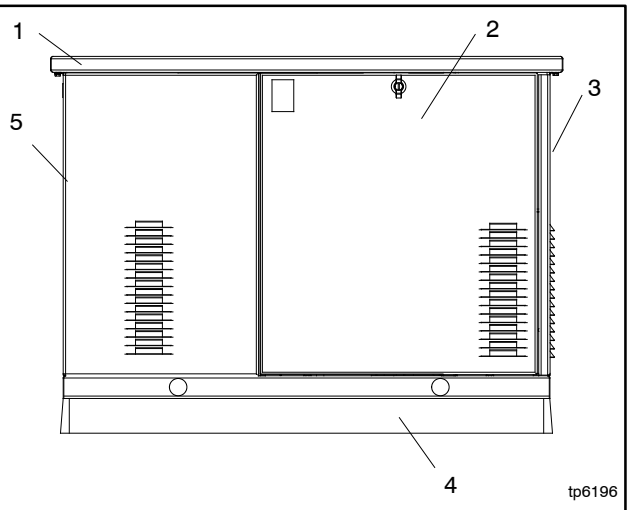
10. Reconnect the alternator leads inside the controller box. See the wiring diagrams in Section 8 for connections.

11. Reinstall the enclosure panels in reverse order of removal. See Figure 7-20 and refer to Step 1 of the disassembly instructions.

    a. Install the non-service side housing panel.

    b. Install the alternator end housing panel.

    c. Install the generator set housing roof.



1. Roof
2. Service-side door
3. Front panel (air intake end)
4. Mounting pad
5. Rear panel (alternator end)

Figure 7-20 Generator Set Enclosure

12. Return the generator set to operation.

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

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

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

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

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

15. Reinstall the generator set housing service side door.

Section 8 Wiring Diagrams

At the time of print, this manual applied to the models with controllers shown in Figure 8-1. The schematics and wiring diagram drawing numbers and page numbers are listed in the table below. The drawings are arranged in alphanumeric order on the following pages.

Model No.	Controller	Schematic		Point-to-Point Wiring Diagram	
		Drawing Number	Page	Drawing Number	Page
8.5RES 12RES	ADC 2100	ADV-6835 Sheet 1	120	GM29358	129
		ADV-6835 Sheet 2	121		
12RESL 12RESM1	DC 2200	ADV-7296 Sheet 1	122	GM49761	130
		ADV-7296 Sheet 2	123		
8.5RES 12RES	ADC-RES	ADV-7325	124	GM51414	131
12RESL 12RESM1 12RESNT	DC-RET	ADV-7351	125	GM52471	132
12TRES (3-phase 50 Hz)	ADC-RES	ADV-7623 Sheet 3	127	GM63546 Sheet 3	134
		ADV-7623 Sheet 4	128		
RGEN12	ADC-RES	ADV-7592	126	GM62285	133

Figure 8-1 Wiring Diagrams and Schematics

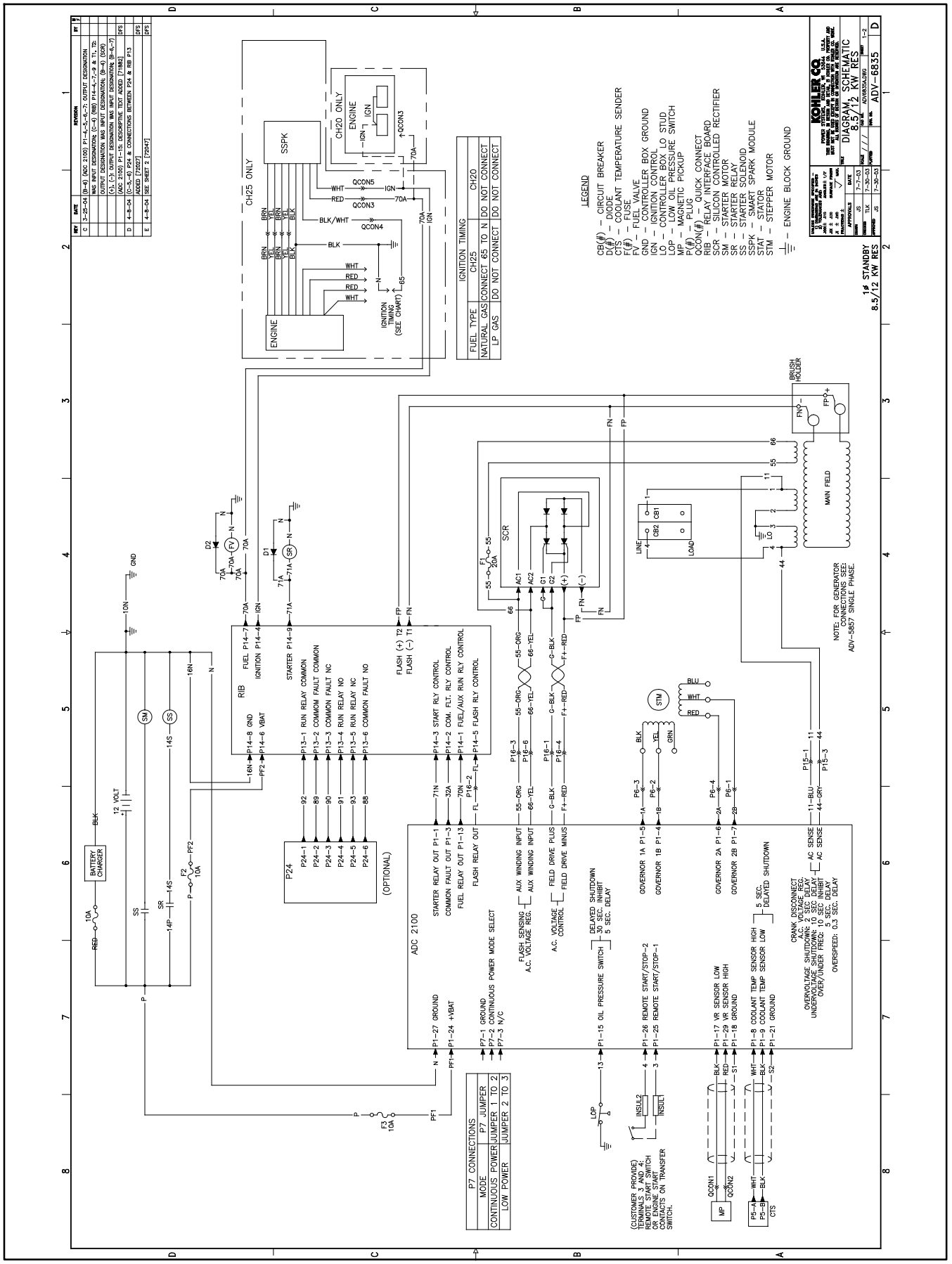


Figure 8-2 Schematic Diagram, Single-Phase, 8.5/12RES w/ADC 2100 Controller, ADV-6835, Sheet 1

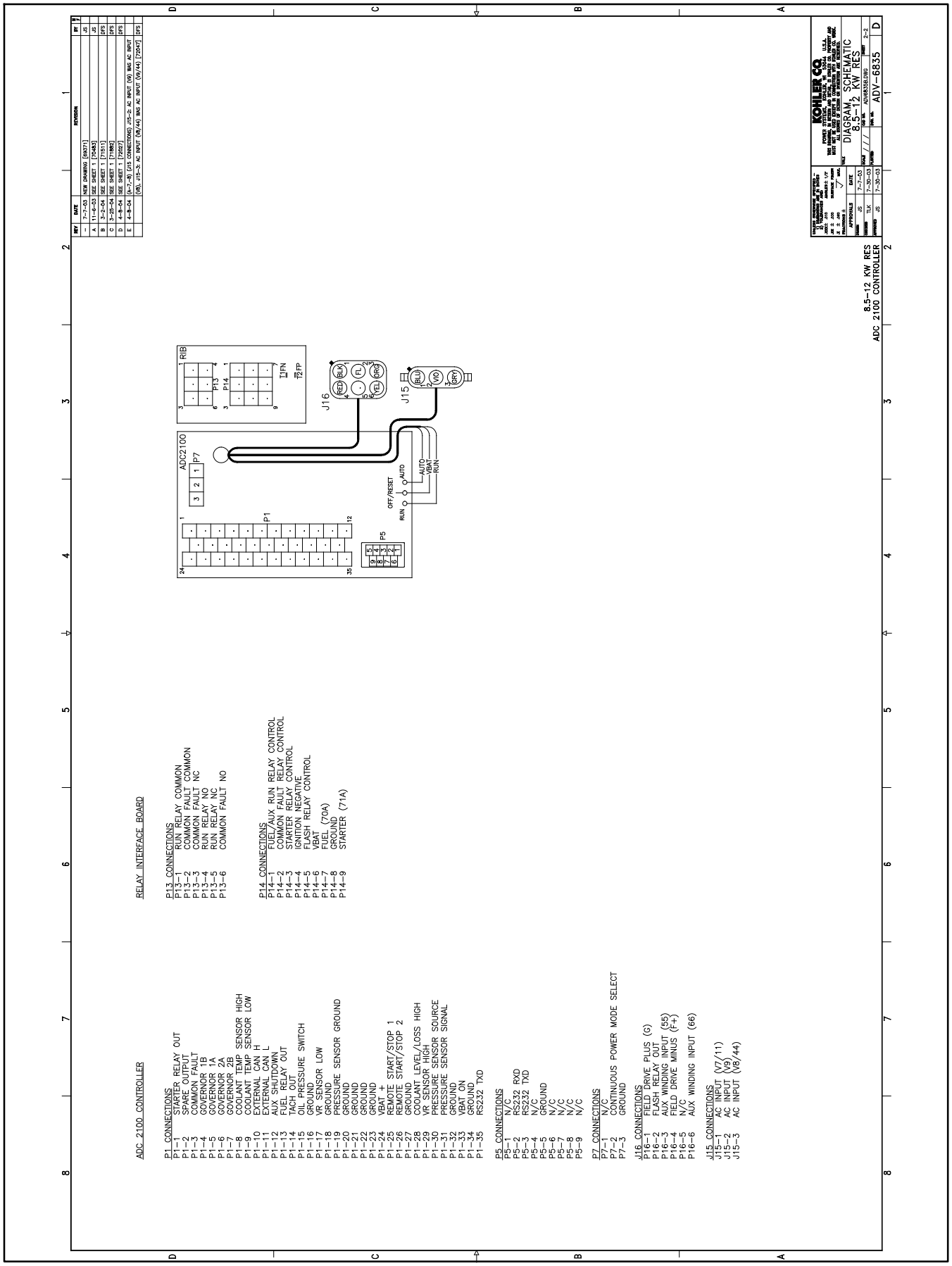


Figure 8-3 Schematic Diagram, Single-Phase, 8.5/12RES w/ADC 2100 Controller, ADV-6835, Sheet 2

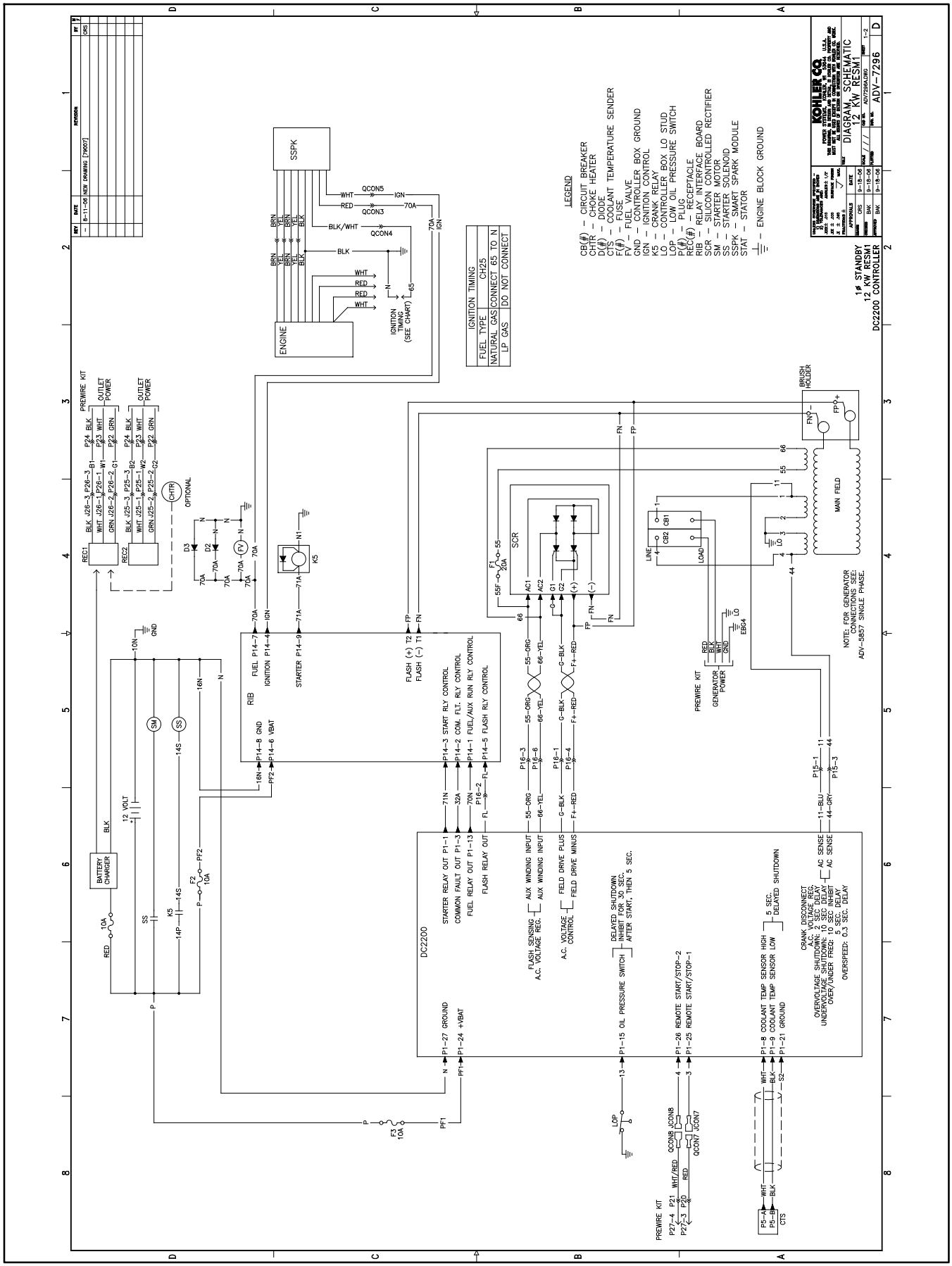


Figure 8-4 Schematic Diagram, Single-Phase, 12RESL/RESM1 w/DC 2200 Controller, ADV-7296, Sheet 1

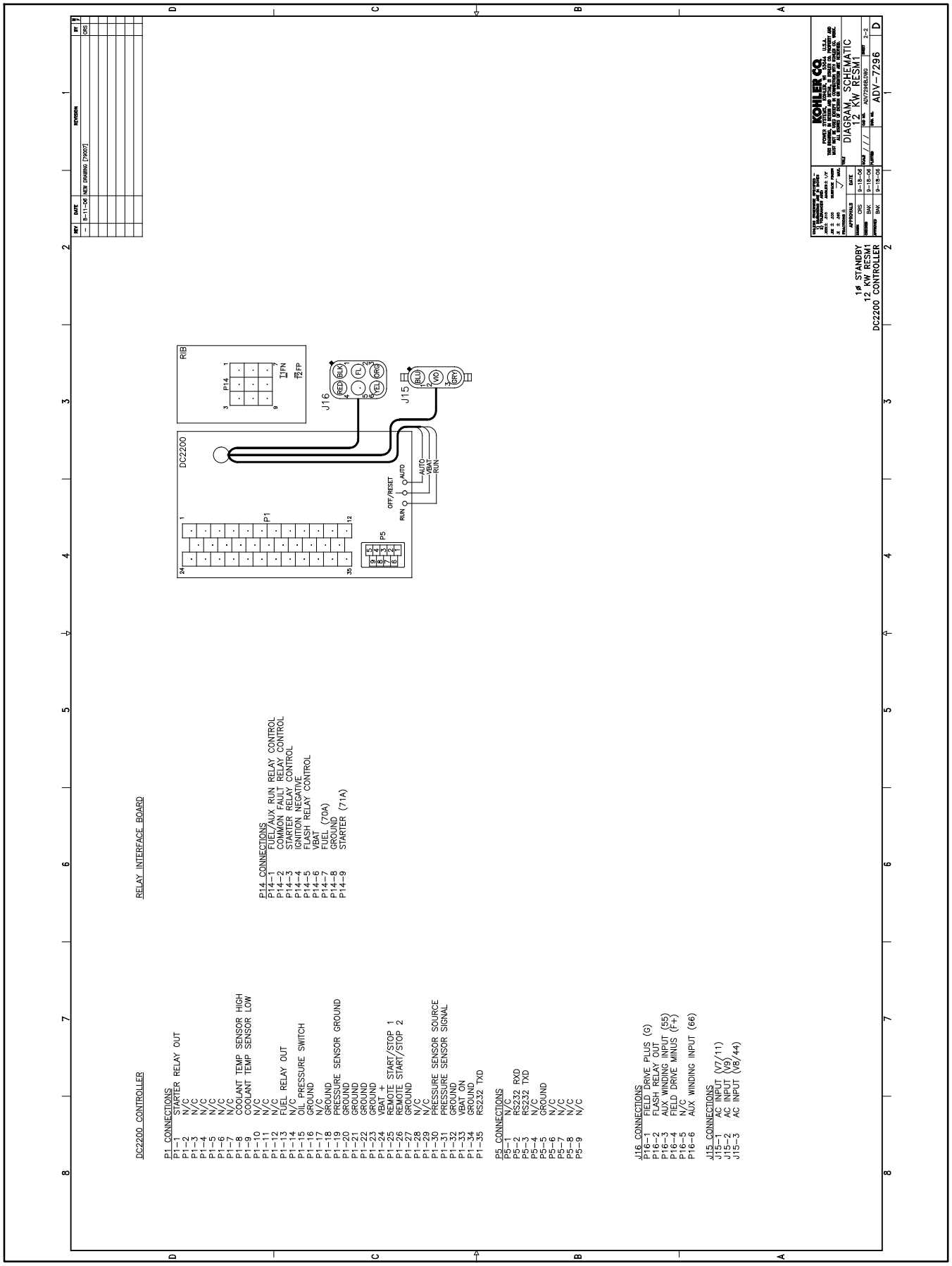


Figure 8-5 Schematic Diagram, Single-Phase, 12RESL/RESM1 w/DC 2200 Controller, ADV-7296, Sheet 2

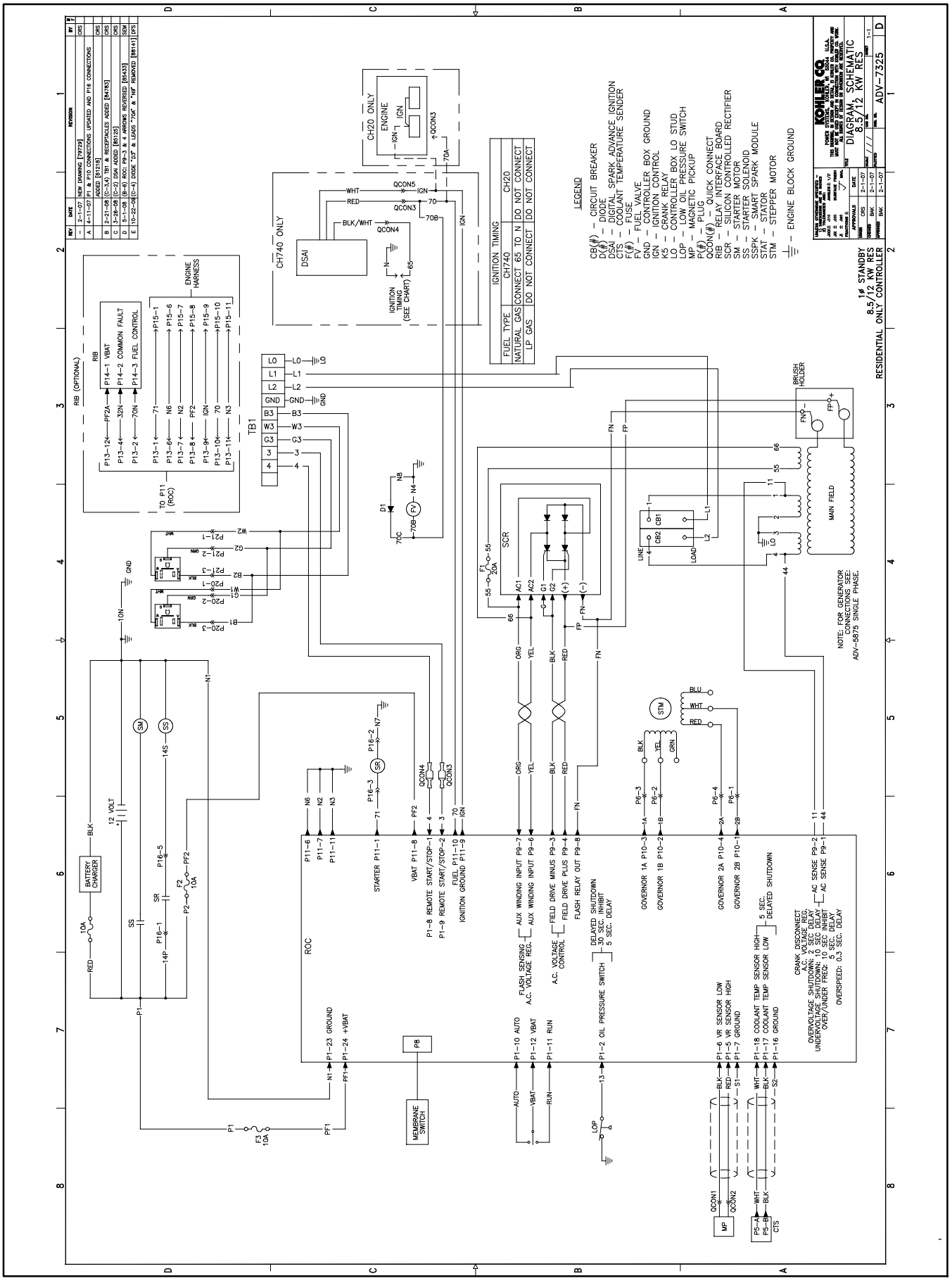


Figure 8-6 Schematic Diagram, 8.5/12RES w/ADC-RES Controller, ADV-7325

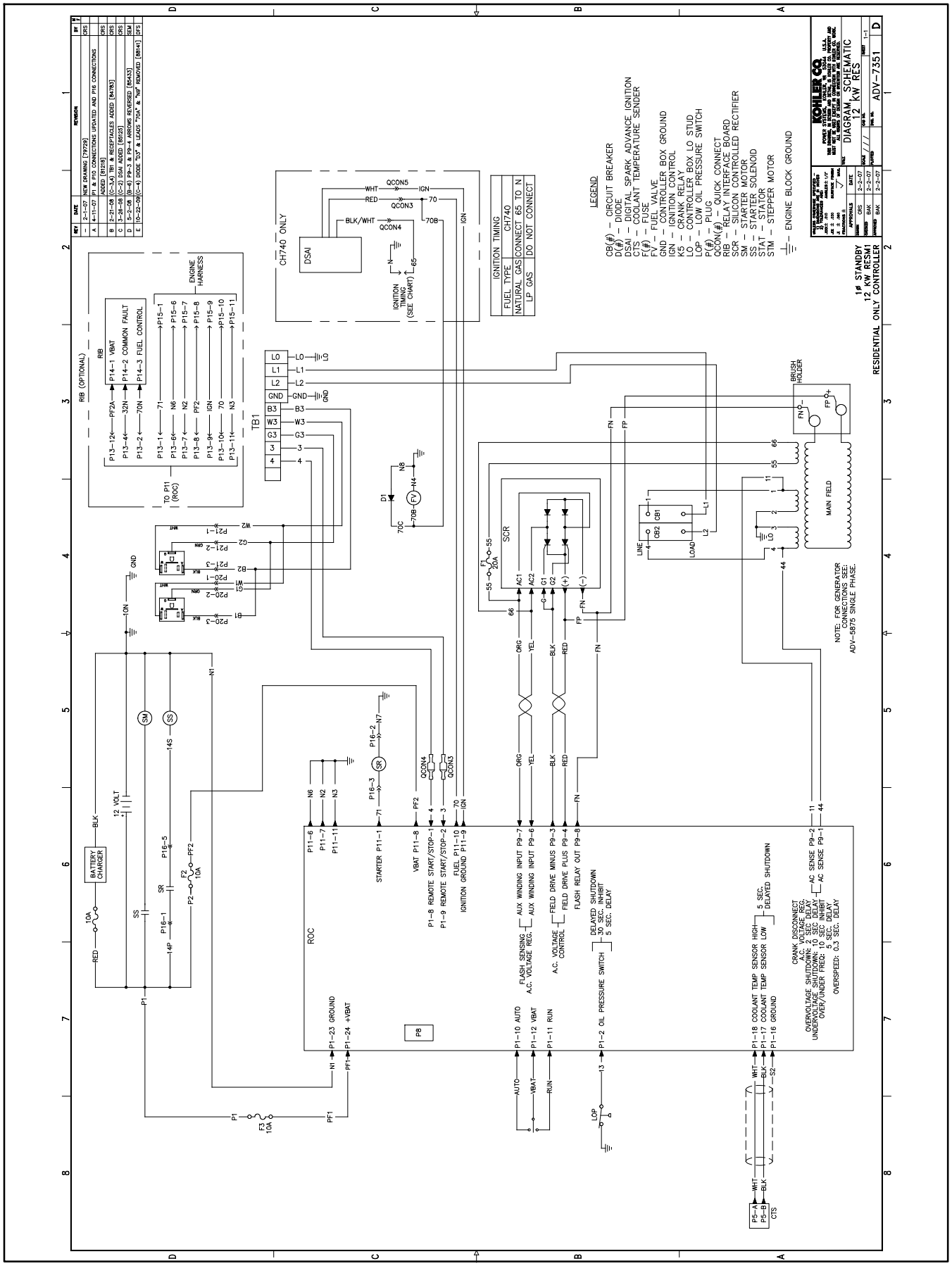


Figure 8-7 Schematic Diagram, Single-Phase, 12RESL/RESM1/RESNT w/DC-RET Controller, ADV-7351

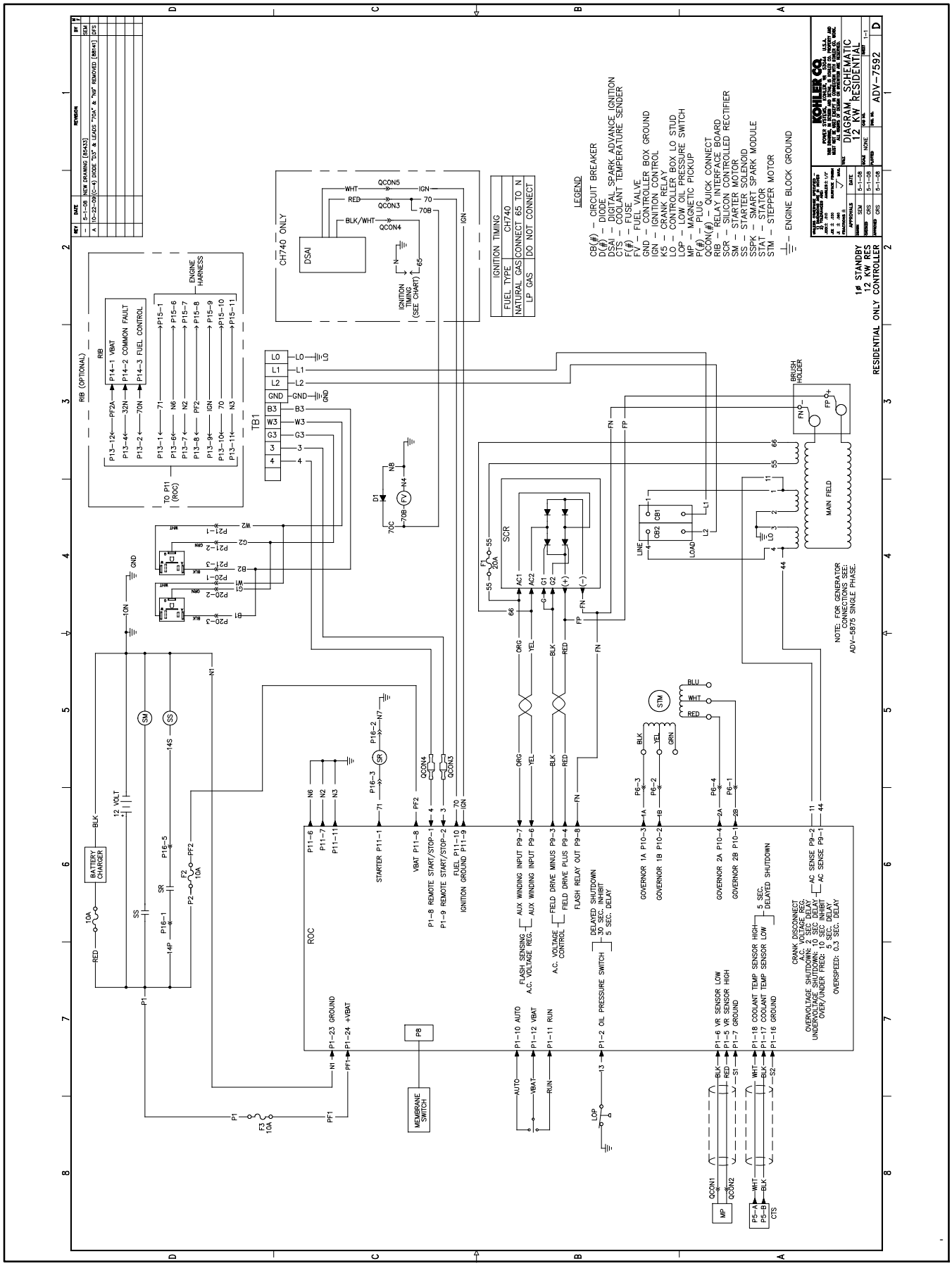


Figure 8-8 Schematic Diagram, Single-Phase, RGEN12 w/ADC-RES Controller, ADV-7592

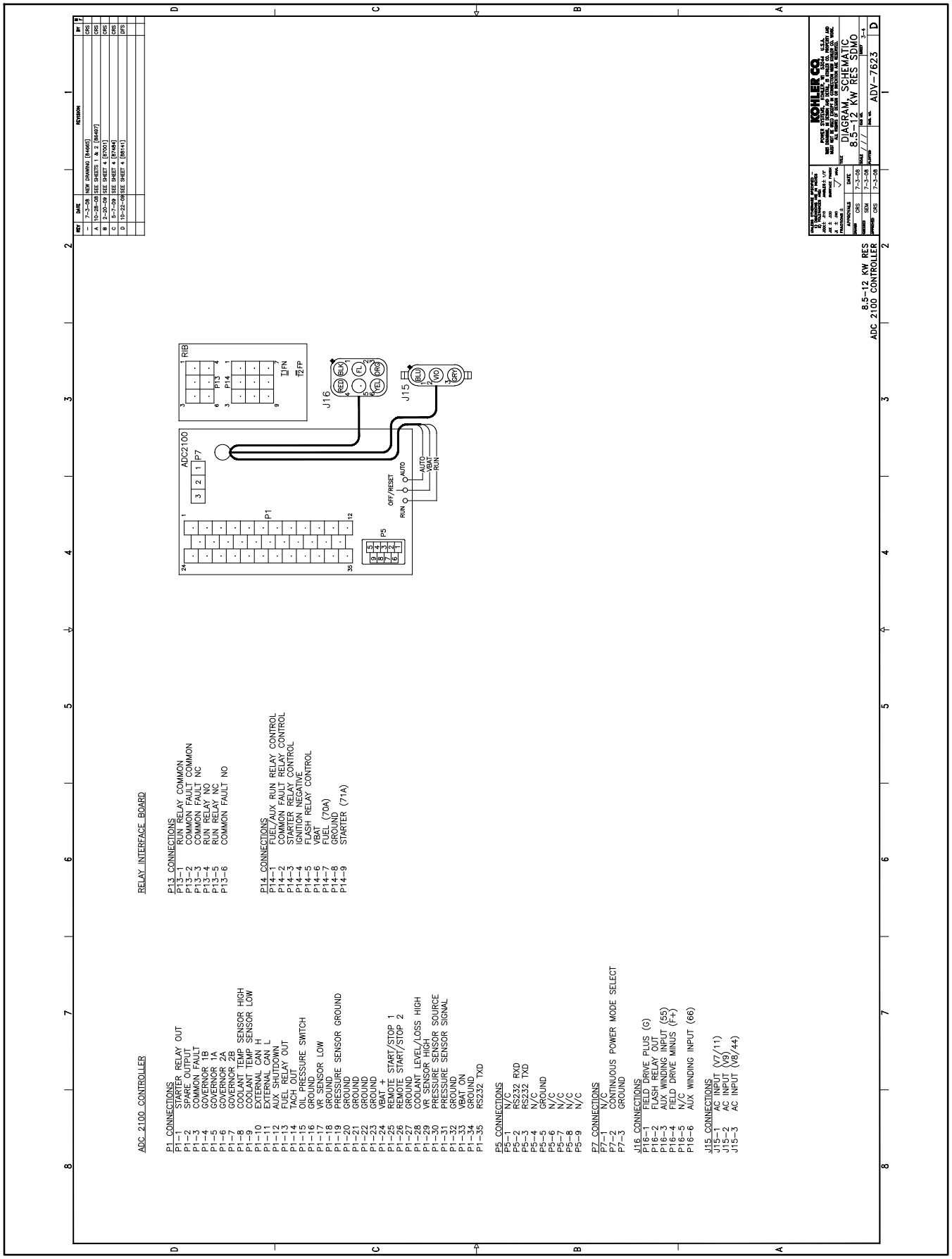


Figure 8-9 Schematic Diagram, Three-Phase, 12TRES w/ADC-RES Controller, ADV-7623, Sheet 3

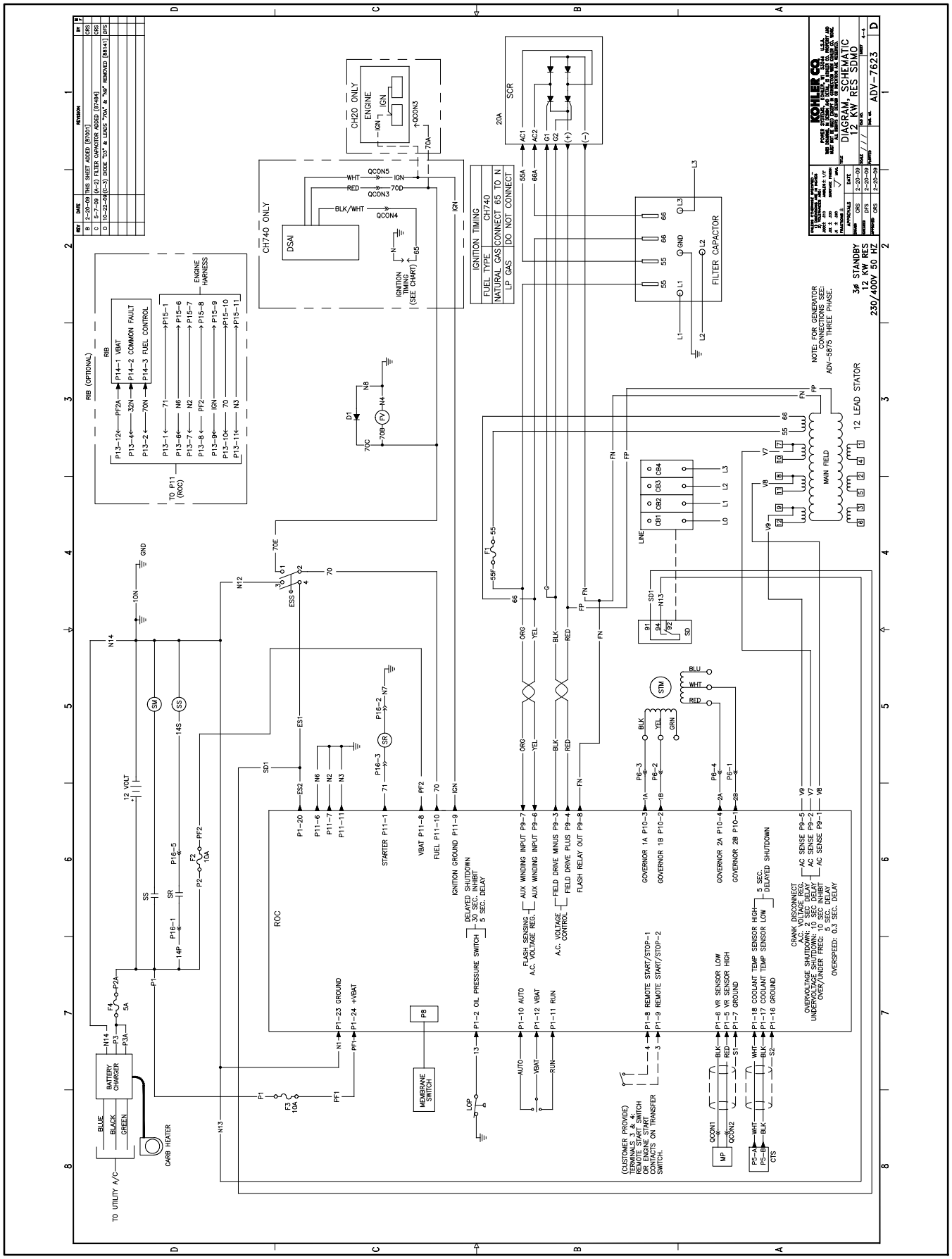


Figure 8-10 Schematic Diagram, Three-Phase, 12TRES w/ADC-RES Controller, ADV-7623, Sheet 4

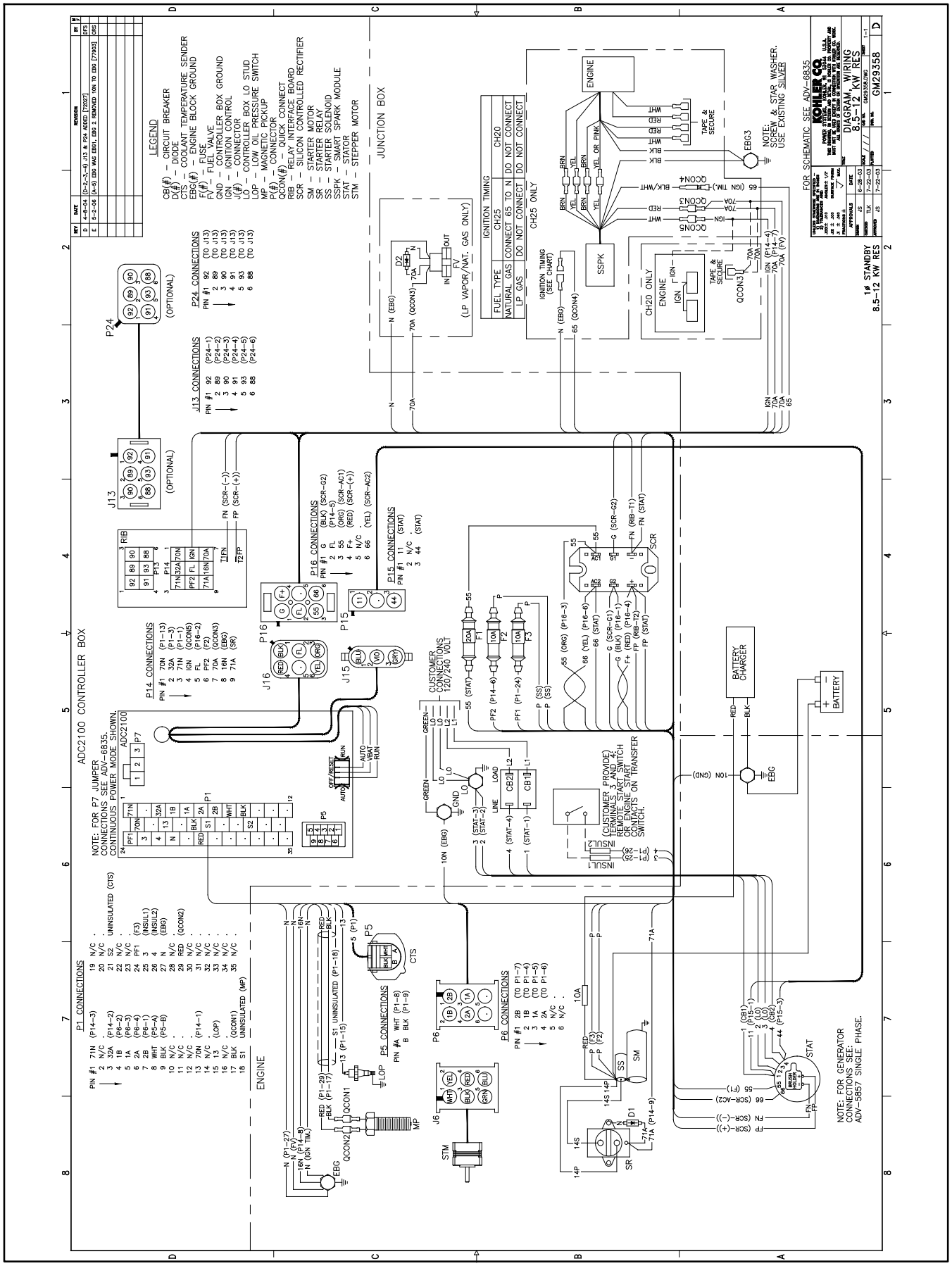


Figure 8-11 Wiring Diagram, Single-Phase, 8.5/12RES w/ADC 2100 Controller, GM29358

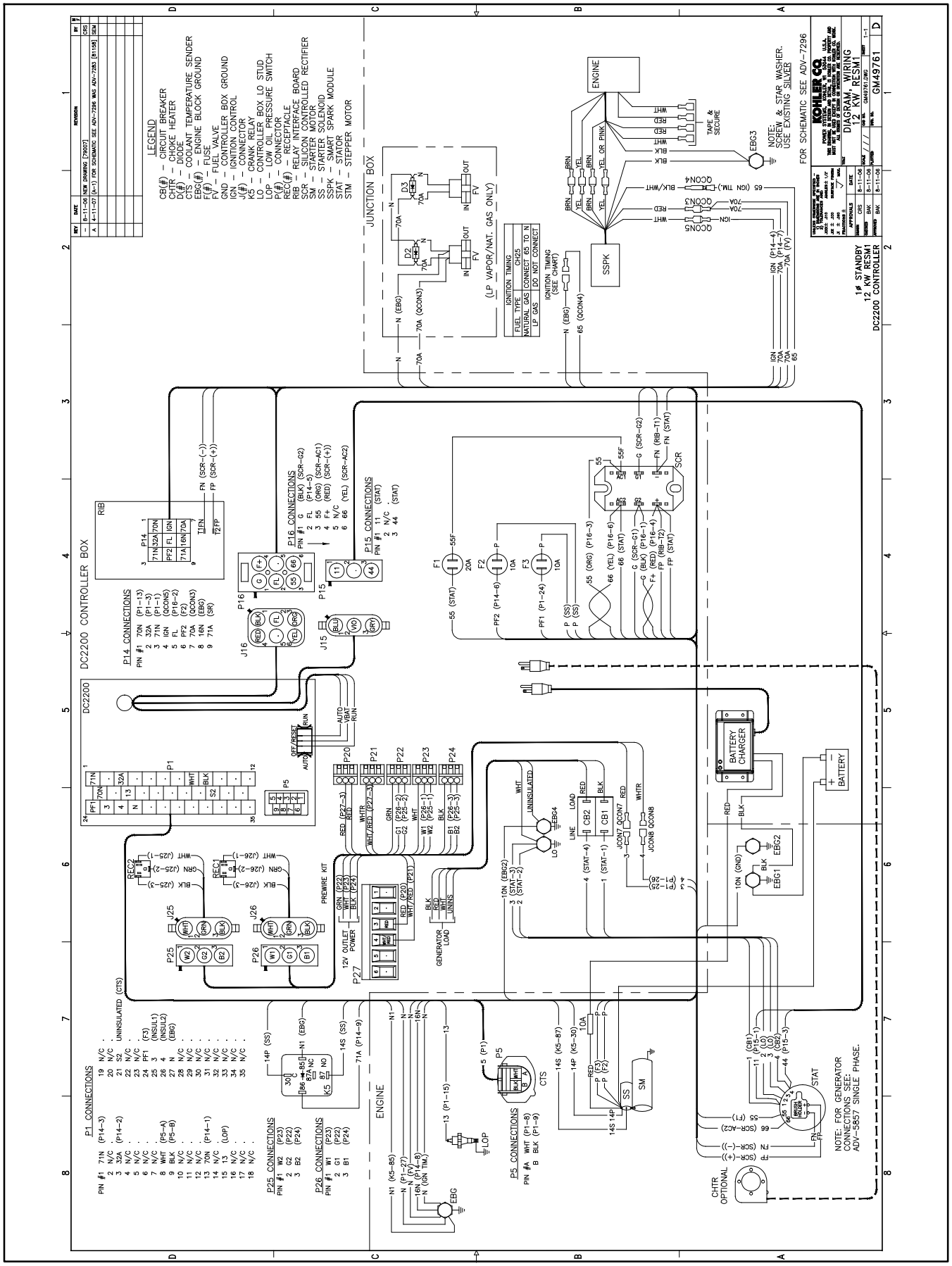


Figure 8-12 Wiring Diagram, Single-Phase, 12RESL/RESM1 w/DC 2200 Controller, GM49761

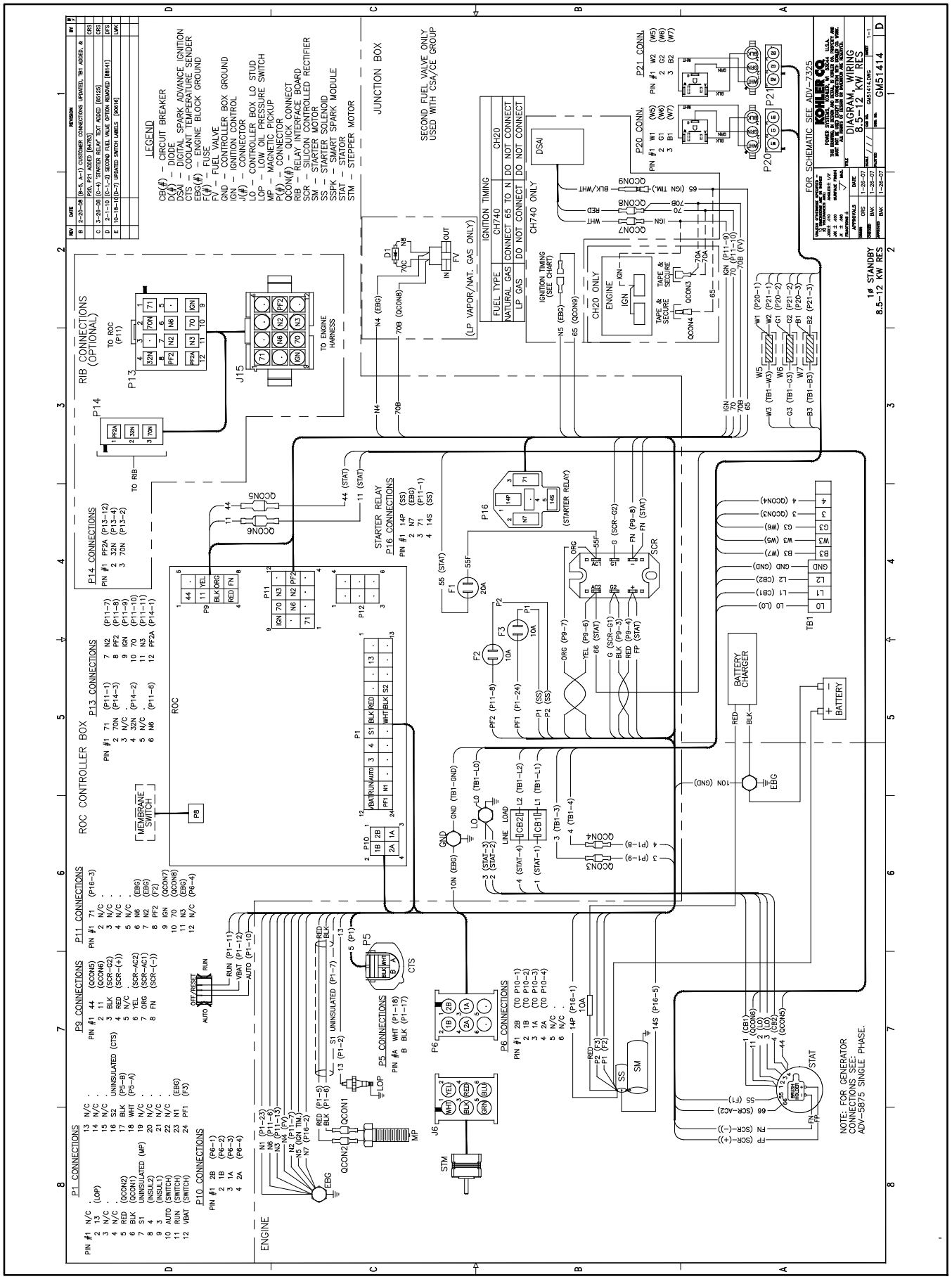


Figure 8-13 Wiring Diagram, 8.5/12RES w/ADC-RES Controller, GM51414

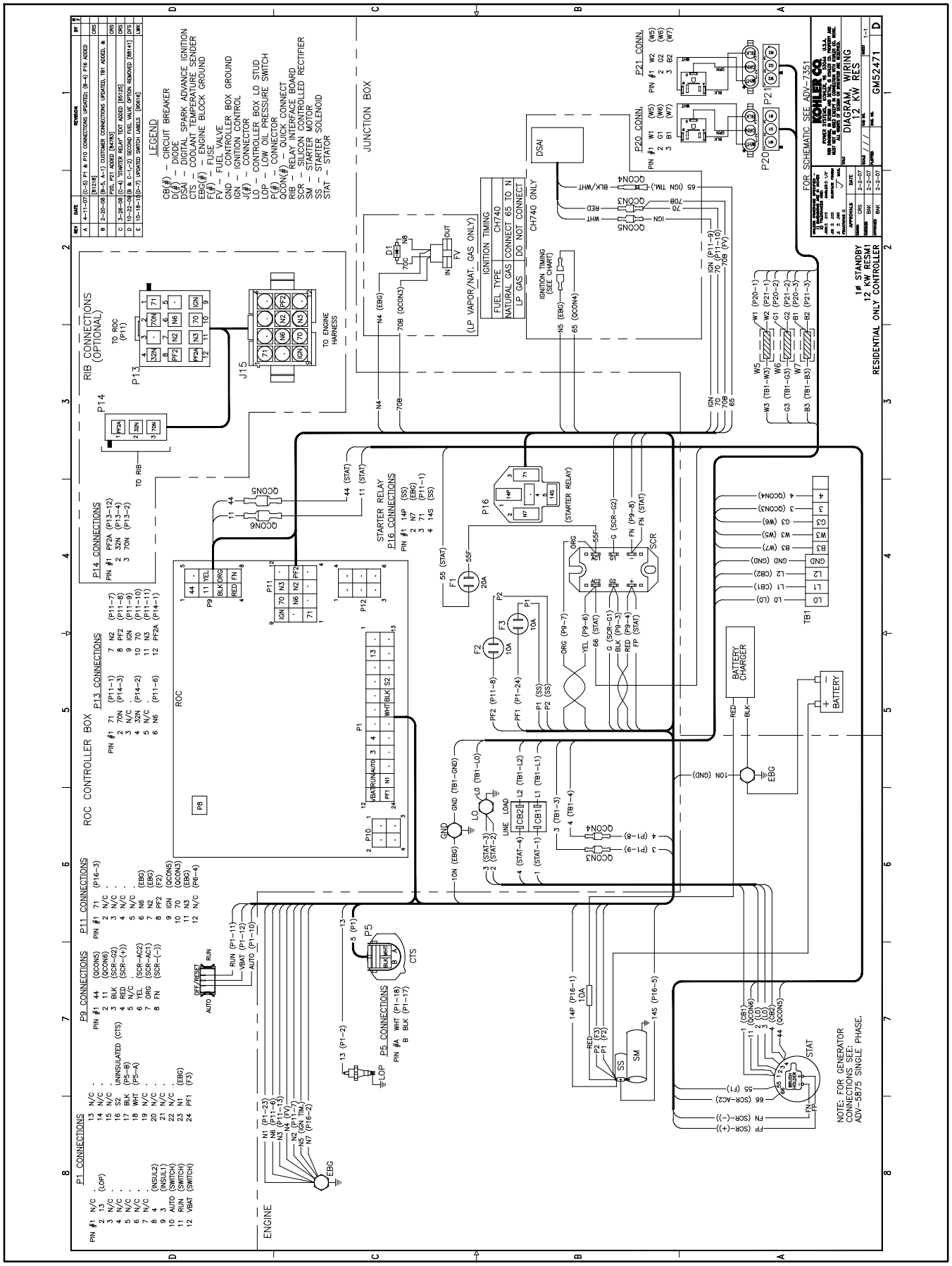


Figure 8-14 Wiring Diagram, Single-Phase, 12RESL/RESM1/RESNT w/DC-RET Controller, GM52471

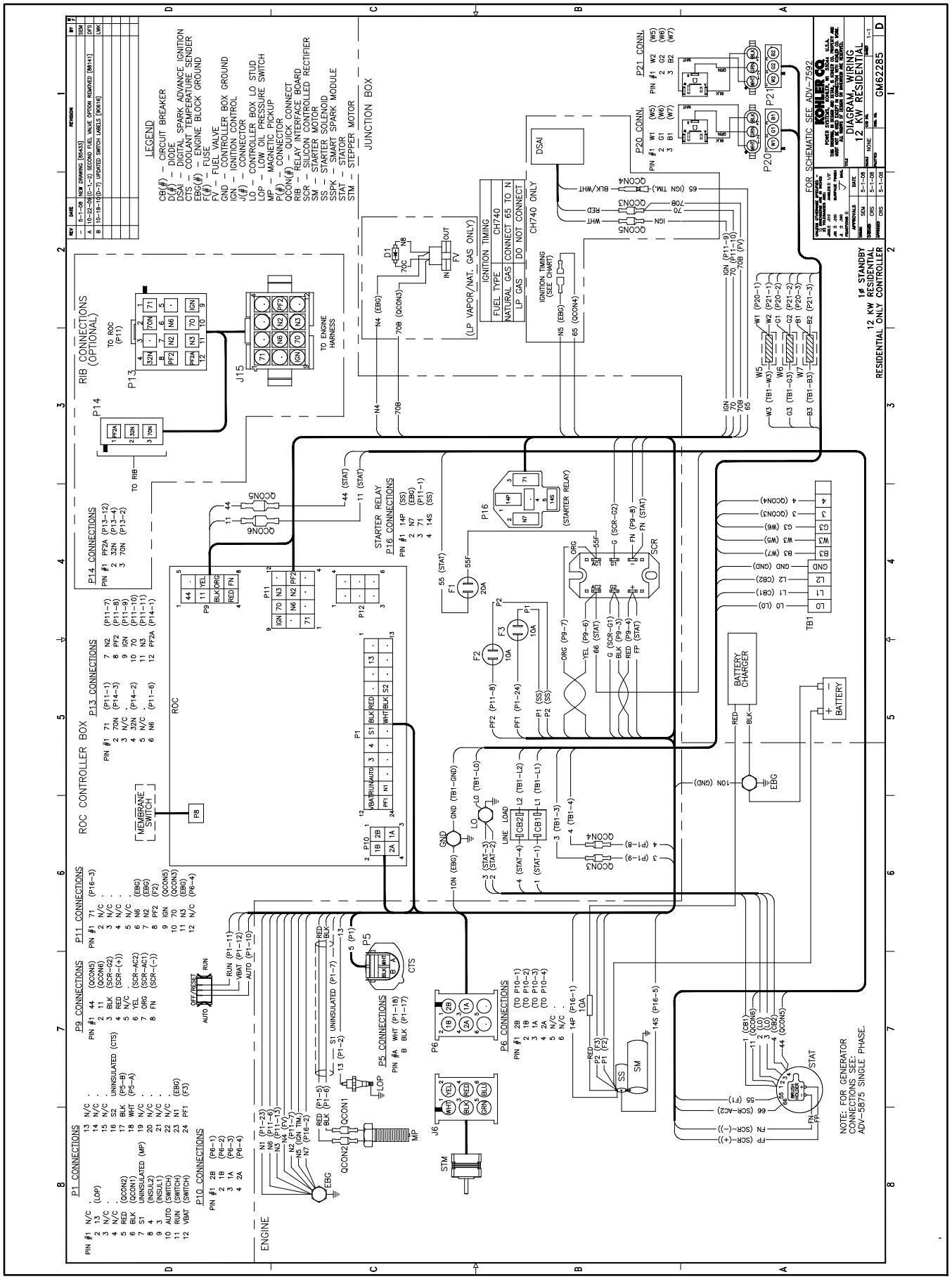


Figure 8-15 Wiring Diagram, Single-Phase, RGEN12 w/ADC-RES Controller, GM66285

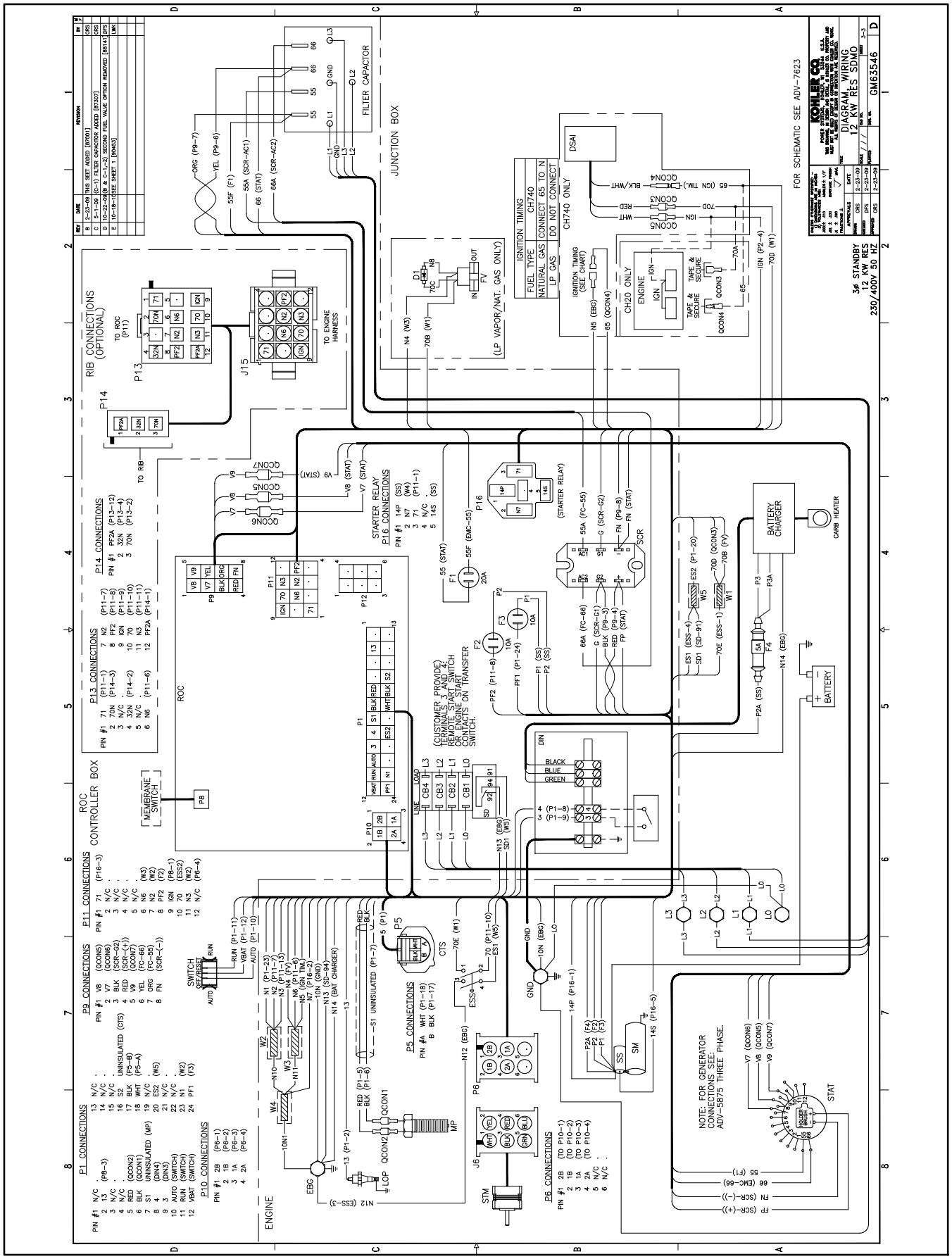


Figure 8-16 Wiring Diagram, Three-Phase, 12TRES w/ADC-RES Controller, GM63546, Sheet 3

Appendix A Abbreviations

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

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

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

Appendix B Common Hardware Application Guidelines

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

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

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

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

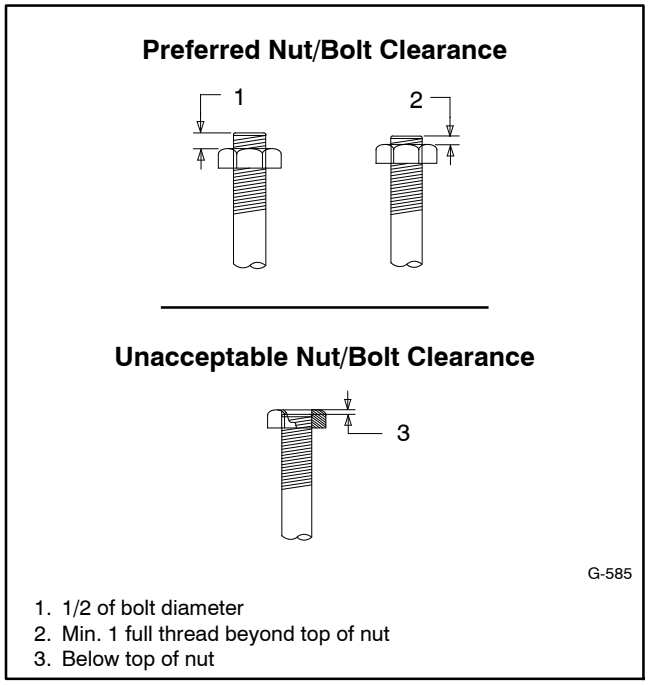


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

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

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

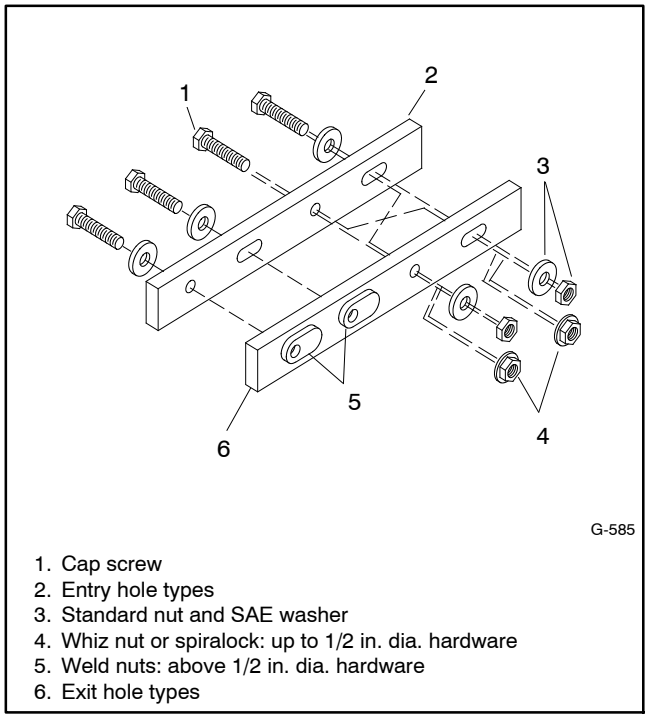


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

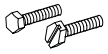
American Standard Fasteners Torque Specifications									
Size	Torque Measurement	Assembled into Cast Iron or Steel						Assembled into Aluminum Grade 2 or 5
		Grade 2		Grade 5		Grade 8		
8-32	Nm (in. lb.)	1.8	(16)	2.3	(20)	—		See Note 3
10-24	Nm (in. lb.)	2.9	(26)	3.6	(32)	—		
10-32	Nm (in. lb.)	2.9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

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

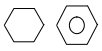
Notes:

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

Appendix D Common Hardware Identification

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

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

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

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

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

Sample Dimensions

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

1/4-20 x 1

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

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

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

Plain Washers

9/32 x 5/8 x 1/16

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

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

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

American Standard

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

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

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

Washers

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

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (Partial Thread)

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

Hex Head Bolts (Partial Thread), continued

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

Hex Head Bolts (Full Thread)

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

Hex Head Bolts (Full Thread), continued

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

Pan Head Machine Screws

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

Flat Head Machine Screws

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

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

Metric, continued

Hex Nuts

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

Washers

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

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

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TP-6196 8/17c