Cummins Onan

Service Manual

Marine Generator Set

MDKAL (Spec A–C)
MDKAA (Spec A–B)
MDKAB (Spec A–B)

English
Original Instructions

09-2016

981–0524 (Issue 2)

California

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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Safety Precautions

Thoroughly read the OPERATOR'S MANUAL before operating the genset. Safe operation and top performance can be obtained only by proper operation and maintenance.

The following symbols in this Manual alert you to potential hazards to the operator, service personnel and equipment.

⚠ DANGER ***alerts you to an immediate hazard which will result in severe personal injury or death.***

⚠ WARNING ***alerts you to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***alerts you to a hazard or unsafe practice which can result in personal injury or equipment damage.***

Electricity, fuel, exhaust, moving parts and batteries present hazards which can result in severe personal injury or death.

GENERAL PRECAUTIONS

- Keep ABC fire extinguishers handy.
- Make sure all fasteners are secure and torqued properly.
- Keep the genset and its compartment clean. Excess oil and oily rags can catch fire. Dirt and gear stowed in the compartment can restrict cooling air.
- Let the engine cool down before removing the coolant pressure cap or opening the coolant drain. Hot coolant under pressure can spray out and cause severe burns.
- Before working on the genset, disconnect the negative (–) battery cable at the battery to prevent starting.
- Use caution when making adjustments while the genset is running—hot, moving or electrically live parts can cause severe personal injury or death.
- Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Do not work on the genset when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Do not step on the genset, as when entering or leaving the engine room. The stress can break genset parts leading to possible fuel or exhaust leaks or electrocution.

GENERATOR VOLTAGE IS DEADLY!

- Generator output connections must be made by a qualified electrician in accordance with applicable codes.
- The genset must not be connected to the public utility or any other source of electrical power. Connection could lead to electrocution of utility workers, damage to equipment and fire. An approved switching device must be used to prevent interconnections.
- Use caution when working on live electrical equipment. Remove jewelry, make sure clothing and shoes are dry and stand on a dry wooden platform on the ground or floor.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Fuel lines must be secured, free of leaks and separated or shielded from electrical wiring.
- Use approved non-conductive flexible fuel hose for fuel connections at the genset.

ENGINE EXHAUST IS DEADLY!

- Learn the symptoms of carbon monoxide poisoning in this manual.
- Never sleep in the vessel with the genset running unless the vessel is equipped with a working carbon monoxide detector.
- The exhaust system must be installed in accordance with the genset Installation Manual and be free of leaks.
- Make sure the bilge is adequately ventilated with a power exhauster.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not wear loose clothing or jewelry near moving parts such as PTO shafts, fans, belts and pulleys.
- Keep hands away from moving parts.
- Keep guards in place over fans, belts, pulleys, etc.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- When disconnecting or reconnecting battery cables, always disconnect the negative (–) battery cable first and reconnect it last to reduce arcing.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. ***Do not operate a diesel-powered genset where a flammable vapor environment can be created by fuel spill, leak, etc., unless the genset is equipped with an automatic safety device to block the air intake and stop the engine.*** The owners and operators of the genset are solely responsible for operating the genset safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

POST THESE SUGGESTIONS IN POTENTIAL HAZARD AREAS OF THE VESSEL

m-9

Introduction

ABOUT THIS MANUAL

This is the Service Manual for the model MDKAL, MDKAA and MDKAB generator sets (gensets). Observe carefully all of the instructions and precautions in this manual.

Operation, *Periodic Maintenance Schedule* and *Maintenance Procedures* in the Operator's Manual have been duplicated here for your convenience.

The DC control schematic (Figure 25), the wiring harness diagram (Figure 26) and the generator reconnection diagrams (Figure 27) are in the back of this manual for quick reference. If there is a conflict, the schematic printed on the genset control box cover takes precedence over the schematic in this manual.

See the Installation Manual for important recommendations and for a list of the installation codes and standards for safety which may be applicable.

See the Parts Catalog for service part numbers.

See the Engine Workshop Manual for engine service procedures. See *Specifications* in this manual to determine the engine model.

⚠WARNING ***Improper service or replacement of parts can lead to severe personal injury or death and damage to equipment and property. Service personnel must be qualified to perform electrical and mechanical service.***

⚠ CAUTION ***Unauthorized modifications or replacement of fuel, exhaust, air intake or speed control system components that affect engine emissions are prohibited by law in the State of California.***

MODEL IDENTIFICATION

When contacting Onan for parts, service or product information, be ready to provide the model number and the serial number on the genset nameplate. See Figure 1.

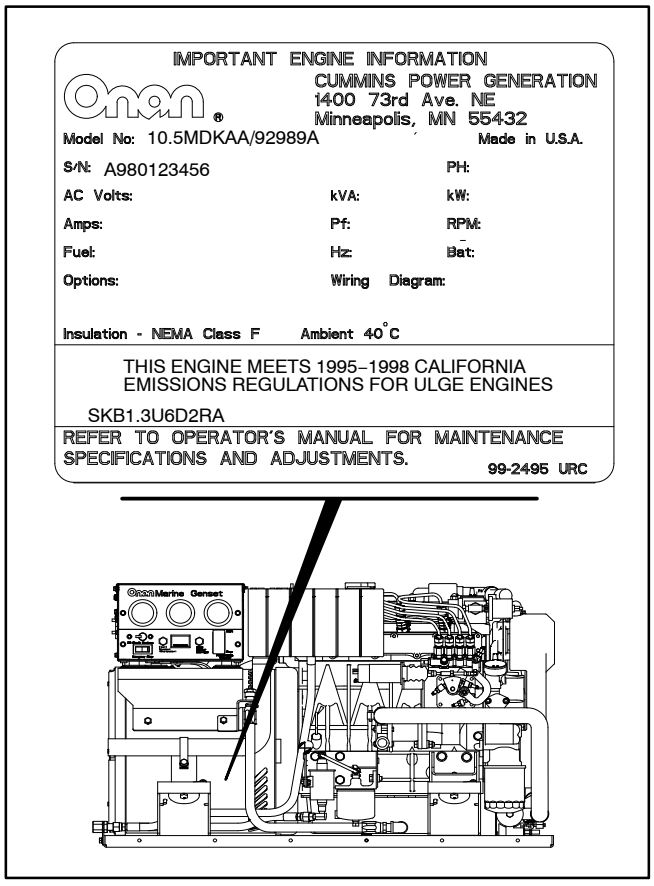

FIGURE 1. TYPICAL NAMEPLATE

FUEL RECOMMENDATIONS

High quality fuel is necessary for good performance and long engine life. Use No. 2 diesel fuel (ASTM 2-D) with a Cetane number of not less than 45 and sulfur content of not more than 0.5 percent (by weight). Where fuel is exposed to cold ambient temperatures, use fuel that has a cloud point (temperature at which wax crystals begin to form) at least 10 degrees below the lowest expected fuel temperature.

⚠WARNING ***Diesel fuel is combustible and can cause severe personal injury or death. Do not smoke near fuel tanks or fuel-burning equipment or in areas sharing ventilation with such equipment. Keep flames, sparks, pilot flames, electrical arcs and switches and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

ENGINE OIL RECOMMENDATIONS

Use premium quality motor oil. Look for the API (American Petroleum Institute) classification and use Class CG-4, CF-4, CF or better oil. Also look for the SAE (Society of Automotive Engineers) viscosity grade. Referring to Figure 2, choose the viscosity grade appropriate for the range of ambient temperatures expected before the next scheduled oil change. Multi-grade oils such as SAE 15W-40 are recommended for year-round use.

BATTERIES

The genset requires either a 12 volt or 24 volt battery to power its control and starting circuits. Reliable genset starting and starter service life depend upon adequate battery system capacity and maintenance. See *Specifications* for battery requirements.

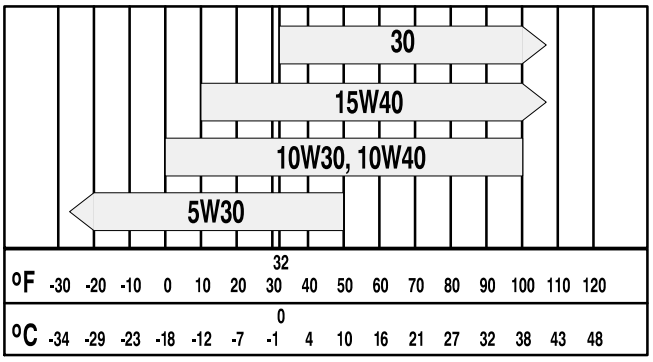

FIGURE 2. SAE VISCOSITY GRADE vs. AMBIENT TEMPERATURE

SAFETY

There are hazards in servicing gensets. Study *Safety Precautions* and become familiar with the hazards listed in Table 1. Note the following safeguards and ways of avoiding hazards:

- ***Use personal protection:*** Wear protective safety equipment, such as safety shoes and safety glasses.

  Do not wear rings or jewelry and do not wear loose or damp clothing that might get caught in equipment or conduct electricity.

- ***Reduce the hazard:*** A safe, orderly workshop area and well-maintained equipment reduce the hazard potential. Keep guards and shields in place on machinery and maintain equipment in good working condition. Store flammable liquids in approved containers; away from fire, flame, spark, pilot light, switches, arc-producing equipment and other ignition sources. Keep the workshop clean and well lighted and provide adequate ventilation.

- ***Develop safe work habits:*** Unsafe actions cause accidents with tools and machines. Be familiar with the equipment and know how to use it safely. Use the correct tool for the job and check its condition before starting. Comply with the warnings in this manual and take special precautions when working around electrical equipment. Do not work alone, if possible, and do not take risks.

- ***Be prepared for an accident:*** Keep fire extinguishers and safety equipment nearby. Agencies such as the Red Cross and public safety departments offer courses in first aid, CPR and fire control. Take advantage of this information to be ready to respond to an accident. Learn to be safety-conscious and make safety procedures part of the work routine.

TABLE 1. HAZARDS AND THEIR SOURCES

Fire and Explosion	• Leaking or spilled fuel • Hydrogen gas from battery • Oily rags improperly stored • Flammable liquids improperly stored
Burns	• Hot exhaust pipes • Hot engine and generator surfaces • Electrical shorts
Poisonous Gas	• Operating genset where exhaust gases can accumulate
Electrical Shock (AC)	• Improper generator connections • Faulty wiring • Working in damp conditions • Jewelry touching electrical components
Rotating Machinery	• Fan guards not in place
Slippery Surfaces	• Leaking or spilled oil
Heavy Objects	• Removing genset from vessel • Removing heavy components

SERVICE TOOLS

The following special tools are necessary:

- Torque wrench: 0–75 lbs-ft (0–100 N-m)
- Tachometer or frequency meter
- Digital multi-meter: AC and DC Volts, Ohms
- Load test panel, leads and ammeter
- 500 VDC Megger for winding insulation resistance measurements
- 0.01 ohm precision digital ohmmeter or Wheatstone bridge for winding resistance measurements
- AVR/Generator test adapter (p. 32)

REMOVING GENSET FROM VESSEL

Contact the manufacturer of the vessel or the installer if a good way to remove the genset is not obvious. There are four bolt holes for securing the genset to the floor or supporting structure of the vessel. A lifting eye is accessible through the access opening in the top panel of the sound shield.

WARNING ***Gensets are heavy and can cause severe personal injury or death if dropped. Use adequate lifting devices and keep hands and feet clear while lifting.***

The following disconnections will have to be made to remove the genset from the vessel:

1. Battery cables (negative [–] cables first).

   WARNING ***Arcing at battery terminals or in a light switch or other equipment, flames and sparks can ignite battery gas causing severe personal injury. Ventilate the battery compartment before connecting or disconnecting battery cables—Disconnect the negative (–) cable first and reconnect it last—Wear safety glasses—Do not smoke—Switch lights ON and Off away from the battery.***

2. Fuel lines. *First close all fuel shutoff valves.*

   WARNING ***Diesel fuel is combustible and can cause severe personal injury or death. Do not smoke near fuel tanks or fuel-burning equipment or in areas sharing ventilation with such equipment. Keep flames, sparks, pilot flames, electrical arcs and switches and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

3. Remote control wiring.
4. AC output wiring.
5. Exhaust hose.
6. Sea water supply hose (***first close sea cock***).
7. Coolant hoses to a keel cooler (if provided).

Specifications

	MDKAL (Spec A)	MDKAL (Spec B)
GENERATOR: Single-Bearing, 4-Pole Rotating Field, Brushless, Electronically Regulated. See Genset Namplate for Rating.		
FUEL CONSUMPTION:		
60 Hz: Full Load Half Load	0.8 gph (3.0 liter/hr) 0.5 gph (1.8 liter/hr)	0.8 gph (3.0 liter/hr) 0.5 gph (1.9 liter/hr)
50 Hz: Full Load Half Load	0.7 gph (2.6 liter/hr) 0.4 gph (1.4 liter/hr)	0.7 gph (2.6 liter/hr) 0.4 gph (1.5 liter/hr)
ENGINE: Kubota 4-Stroke Cycle, Indirect Injection Diesel, Water Cooled, Mechanically Governed (5% droop)		
Model	D1005	D1105
Number of Cylinders	3	3
Bore / Stroke	2.99 inch (76 mm) / 2.90 inch (73.6 mm)	2.99 inch (76 mm) / 3.09 inch (78.4 mm)
Displacement	61 inch^3 (1001 cm^3)	68 inch^3 (1124 cm^3)
Compression Ratio	22:1	22:1
Firing Order (Clockwise Rotation)	1-2-3	1-2-3
Fuel Injection Timing	15.5°– 17.5° BTDC	15.5°– 17.5° BTDC
Valve Lash (cold)	0.0071 – 0.0087 inch (0.18 – 0.22 mm)	0.0071 – 0.0087 inch (0.18 – 0.22 mm)
Engine Oil Capacity	4.5 quart (4.3 liter)	4.2 quart (4.0 liter)
Engine Oil Drain Connection	3/8 NPT	3/8 NPT
Coolant Capacity	4.2 quart (4.0 liter)	4.2 quart (4.0 liter)
Coolant Flow Rate: 60 Hz 50 Hz	5.0 gpm (19 liter/min) 4.2 gpm (16 liter/min)	5.0 gpm (19 liter/min) 4.2 gpm (16 liter/min)
Sea Water Flow Rate: 60 Hz 50 Hz	6.0 gpm (23 liter/min) 5.0 gpm (19 liter/min)	6.0 gpm (23 liter/min) 5.0 gpm (19 liter/min)
Maximum Sea Water Pump Lift	4 feet (1.2 m)	4 feet (1.2 m)
Sea Water Inlet Connection	1.0 inch (25.4 mm) ID Hose	1.0 inch (25.4 mm) ID Hose
Maximum Fuel Pump Lift	4 feet (1.2 m)	4 feet (1.2 m)
Fuel Supply Connection	1/4 NPT female	1/4 NPT female
Fuel Return Connection	1/4 NPT female	1/4 NPT female
Maximum Exhaust Back Pressure	3 inch (76 mm) Hg	3 inch (76 mm) Hg
Wet Exhaust Outlet Connection	2.0 inch (50.8 mm) ID Hose	2.0 inch (50.8 mm) ID Hose
Dry Exhaust Outlet Connection	1-1/4 NPT	1-1/4 NPT
BATTERIES:		
Nominal Battery Voltage	12 volts*	12 volts*, #
Minimum CCA Rating	360 amps	360 amps
Charging Alternator Output	35 amps	10 amps
APPROXIMATE WEIGHTS AND DIMENSIONS:		
Without Sound Shield		
Wet Weight Dimensions: L x W x H	540 lbs (245 kg) 32.5x18.9x22.1 inch (826x479x562 mm)	540 lbs (245 kg) 32.5x18.9x22.1 inch (826x479x562 mm)
With Sound Shield		
Wet Weight Dimensions: L x W x H	625 lbs (284 kg) 36.0x22.4x23.5 inch (915x568x596 mm)	625 lbs (284 kg) 36.0x22.4x23.5 inch (915x568x596 mm)

* - Isolated battery ground available as option.
\# - 24 volt battery system available as option.

	MDKAA	MDKAB
GENERATOR: Single-Bearing, 4-Pole Rotating Field, Brushless, Electronically Regulated. See Genset Nameplate for Rating.		
FUEL CONSUMPTION:		
60 Hz: Full Load Half Load	1.0 gph (3.8 liter/hr) 0.6 gph (2.3 liter/hr)	1.2 gph (4.5 liter/hr) 0.7 gph (2.6 liter/hr)
50 Hz: Full Load Half Load	0.8 gph (3.0 liter/hr) 0.5 gph (1.9 liter/hr)	0.9 gph (3.4 liter/hr) 0.5 gph (1.9 liter/hr)
ENGINE: Kubota 4-Stroke Cycle, Indirect Injection Diesel, Water Cooled, Mechanically Governed (5% droop)		
Model	V1305	V1505
Number of Cylinders	4	4
Bore / Stroke	2.99 inch (76 mm) / 2.90 inch (73.6 mm)	3.07 inch (78 mm) / 3.09 inch (78.4 mm)
Displacement	81.5 $inch^3$ (1335 cm^3)	91.4 $inch^3$ (1498 cm^3)
Compression Ratio	22:1	22:1
Firing Order (Clockwise Rotation)	1-2-4-3	1-2-4-3
Fuel Injection Timing	15.5°– 17.5° BTDC	15.5°– 17.5° BTDC
Valve Lash (cold)	0.0071 – 0.0087 inch (0.18 – 0.22 mm)	0.0071 – 0.0087 inch (0.18 – 0.22 mm)
Engine Oil Capacity	4.5 quart (4.3 liter)	4.5 quart (4.3 liter)
Engine Oil Drain Connection	3/8 NPT	3/8 NPT
Coolant Capacity	5.3 quart (5.0 liter)	5.3 quart (5.0 liter)
Coolant Flow Rate: 60 Hz 50 Hz	5.0 gpm (19 liter/min) 4.2 gpm (16 liter/min)	5.0 gpm (19 liter/min) 4.2 gpm (16 liter/min)
Sea Water Flow Rate: 60 Hz 50 Hz	6.0 gpm (23 liter/min) 5.0 gpm (19 liter/min)	6.0 gpm (23 liter/min) 5.0 gpm (19 liter/min)
Maximum Sea Water Pump Lift	4 feet (1.2 m)	4 feet (1.2 m)
Sea Water Inlet Connection	1.0 inch (25.4 mm) ID Hose	1.0 inch (25.4 mm) ID Hose
Maximum Fuel Pump Lift	4 feet (1.2 m)	4 feet (1.2 m)
Fuel Supply Connection	1/4 NPT female	1/4 NPT female
Fuel Return Connection	1/4 NPT female	1/4 NPT female
Maximum Exhaust Back Pressure	3 inch (76 mm) Hg	3 inch (76 mm) Hg
Wet Exhaust Outlet Connection	2.0 inch (50.8 mm) ID Hose	2.0 inch (50.8 mm) ID Hose
Dry Exhaust Outlet Connection	1-1/4 NPT	1-1/4 NPT
BATTERIES:		
Nominal Battery Voltage	12 volts*, #	12 volts*, #
Minimum CCA Rating	500 amps	500 amps
Charging Alternator Output	10 amps	10 amps
APPROXIMATE WEIGHTS AND DIMENSIONS:		
Without Sound Shield		
Wet Weight Dimensions: L x W x H	625 lbs (284 kg) 37.3x18.9x22.1 inch (946x479x562 mm)	625 lbs (284 kg) 37.3x18.9x22.1 inch (946x479x562 mm)
With Sound Shield		
Wet Weight Dimensions: L x W x H	710 lbs (322 kg) 40.8x22.4x23.5 inch (1037x568x596 mm)	710 lbs (322 kg) 40.8x22.4x23.5 inch (1037x568x596 mm)

* - Isolated battery ground available as option.
\# - 24 volt battery system available as option.

Operation

⚠WARNING ***EXHAUST GAS IS DEADLY!***

Engine exhaust contains carbon monoxide, a poisonous, odorless and colorless gas that can cause unconsciousness and death. Symptoms of carbon monoxide poisoning include:

- ***Dizziness***
- ***Throbbing in Temples***
- ***Nausea***
- ***Muscular Twitching***
- ***Headache***
- ***Vomiting***
- ***Weakness***
- ***Trouble Thinking Clearly***
- ***Sleepiness***

GET EVERYONE OUT INTO FRESH AIR IMMEDIATELY IF ANYONE EXPERIENCES ANY OF THESE SYMPTOMS. Seek medical attention if symptoms persist.

Never sleep in the vessel when the genset is running unless the cabins have operating carbon monoxide detectors.

Look and listen for leaks along the entire run of the exhaust system every time you start up the genset and every eight hours if the genset is being run continuously. Shut down the genset immediately if there is a leak and do not run it until the leak has been repaired.

The installation of the exhaust system must be in accordance with the genset Installation Manual.

PRE-START CHECKS

Perform the GENERAL INSPECTION (p. 17). ***Check for fuel, exhaust, oil and coolant leaks every eight hours if the genset is being run continuously.***

Check the maintenance record and perform any maintenance due (*Periodic Maintenance Schedule*). Also see GENSET BREAK-IN in this section if the genset is new and RETURNING THE GENSET TO SERVICE if the vessel has been in storage.

STARTING

1. Disconnect all loads from the genset.
2. **Preheat –** Hold the control switch in the **PREHEAT** position for **5 to 20 seconds**.

   ⚠ CAUTION ***Preheat times longer than 20 seconds can damage the glow plugs.***
3. **Start –** Immediately after **PREHEAT** push the control switch to **START** and hold it there until the engine starts. The starter will automatically disconnect as the engine starts up.

   Do not crank for more than 20 seconds at a time. Wait two minutes before trying again. See *Troubleshooting* if the engine does not start on the second try.

   ⚠ CAUTION ***Excessive cranking can overheat and damage the starter. Do not crank for more than 20 seconds at a time and wait two minutes before trying again.***
4. Connect the electrical loads after the genset has warmed up for a few minutes.
5. Check for fuel, exhaust, oil and coolant leaks and complete the GENERAL INSPECTION (p. 17). Check the engine gauges regularly (if provided).
   - ***Oil Pressure Gauge:*** Normal engine oil pressure is 28 – 64 psi (194 – 442 kPa) at normal operating temperature.
   - ***DC Voltmeter:*** Normal DC system voltage is 12.5 – 15 volts (12 volt system) or 24 – 27 volts (24 volt system) depending on battery condition and state-of-charge.
   - ***Coolant Temperature Gauge:*** Normal engine coolant temperature is 160 –195°F (71 – 91°C) depending on sea water* temperature and load.

* In this manual, “sea water” refers to floatation water.

STOPPING

Before stopping let the genset cool down by running at no-load for three to five minutes. Then touch the control switch momentarily to **STOP**.

⚠ CAUTION ***Failure to let the engine cool down before stopping can lead to engine damage. Let the genset run three to five minutes at no-load before stopping.***

POWERING APPLIANCES

The genset can power AC motors, air conditioners, AC/DC converters and other appliances. How much appliance load* can be serviced depends upon the genset power rating. The genset will shut down or its circuit breakers will trip if the total load exceeds genset rating.

To avoid overloading the genset and causing shutdowns, compare the sum of the loads of the appliances that are likely to be used at the same time (total load) to the power rating of the genset. Use Table 2 or the ratings on the appliances themselves (if so marked) to obtain the individual appliance loads. ***It may be necessary to run fewer appliances at the same time so that the total load is not greater than genset rating.***

Note that the genset may shut down due to overload, even though the total load is less than genset rating, when a large motor or air conditioner is started last or cycles off and then on again. The reason for this is that motor startup load is much larger than running load. ***It may be necessary to run fewer appliances when large motors and air conditioners are cycling on and off.***

SHORE POWER CONNECTIONS

A vessel that has provisions for connection to shore power must be equipped with an approved transfer switch to keep the genset and shore power from being interconnected.

⚠WARNING ***Backfeed to shore power can cause electrocution and damage to equipment. Use an approved device to prevent the genset from being interconnected with shore power.***

TABLE 2. TYPICAL APPLIANCE LOADS

Appliance	Load (watt)
Air Conditioner	1400-2000
Battery Charger	Up to 800
DC Converter	300-1500
Refrigerator	600-1000
Microwave Oven	1000-1500
Electric Frying Pan/Wok	1000-1500
Electric Stove Element	350-1000
Electric Water Heater	1000-1500
Electric Iron	500-1200
Electric Hair Dryer	800-1500
Coffee Percolator	550-750
Television	200-600
Radio	50-200
Electric Drill	250-750
Electric Broom	200-500
Electric Blanket	50-200

* Appliance load and genset power are measured in terms of watt (W) or kilowatt (kW), where 1 kilowatt (kW) = 1000 watt (W).

RESETTING LINE CIRCUIT BREAKERS

If a circuit breaker in the main power distribution panel in the vessel or on the genset (Figure 3) trips, there is either a short circuit or too much load. Note that the genset will continue to run after a circuit breaker trips.

If a circuit breaker trips, disconnect or turn off as many appliances as possible and reset the circuit breaker. (Push the circuit breaker **OFF** to reset it and then **ON** to reconnect the circuit.) If the circuit breaker trips right away, either the electrical distribution system has a short or the circuit breaker is faulty. Call a qualified electrician.

If the circuit breaker does not trip, reconnect a combination of appliances that does not overload the genset or cause the circuit breaker to trip. An appliance that causes a circuit breaker to trip right away probably has a short.

Electrical appliances must be properly grounded and in good working condition.

⚠WARNING ***Electrical shock can cause severe personal injury or death. Read and follow the appliance manufacturer's instructions and warnings.***

ENGINE BREAK-IN

Change the oil and oil filter after the first 35 hours of operation. See *Maintenance Procedures*.

NO-LOAD OPERATION

Keep no-load operation to a minimum. During no-load operation combustion chamber temperatures drop to the point where fuel does not burn completely, causing slobbering and white smoke. Always have some load connected when the genset is run for long periods.

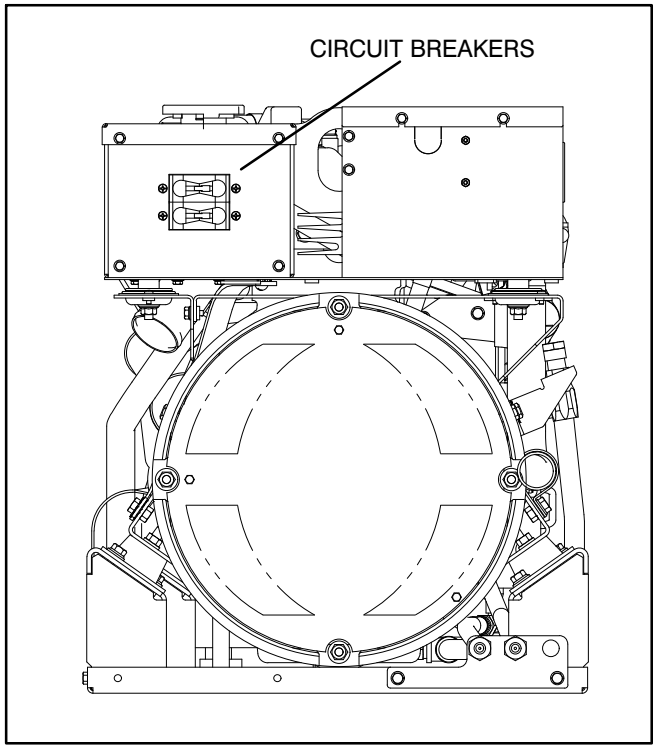

FIGURE 3. GENSET MOUNTED LINE CIRCUIT BREAKERS

GENSET EXERCISE

If use is infrequent, run the genset at approximately 1/2 rated power for an hour every week. Exercising the genset results in better starting, longer engine life and increased genset reliability by driving off moisture, re-lubricating the engine, using up fuel before it becomes stale and removing oxides from electrical contacts. One longer period during which the engine and generator warm up thoroughly is better than several shorter periods.

GENSET STORAGE

If the genset will be inactive for more than 30 days and it is impractical to have someone exercise it, prepare it for storage as follows:

1. Run the genset until it has thoroughly warmed up and shut it down.

   ⚠WARNING ***Crankcase pressure can blow out hot oil and cause severe burns. Stop the engine before checking the oil level or opening the fill cap.***

2. Change the oil and oil filter while still warm and attach a tag to the dip stick indicating the oil viscosity grade. See CHANGING OIL AND OIL FILTER in *Maintenance Procedures*.

   ⚠WARNING ***Arcing at battery terminals or in a light switch or other equipment, flames and sparks can ignite battery gas causing severe personal injury. Ventilate the battery compartment before connecting or disconnecting battery cables—Disconnect the negative (–) cable first and reconnect it last—Wear safety glasses—Do not smoke—Switch lights ON and Off away from the battery.***

3. Disconnect the battery cables (negative [–] cables first) and store the battery(ies) in accordance with the manufacturer's recommendations.

   ⚠WARNING ***Hot coolant is under pressure and can cause severe burns when loosening the pressure cap. Let the engine cool before loosening the pressure cap.***

4. Check the coolant level and add coolant as necessary. Test the coolant mixture if freezing temperatures are possible and change if necessary. See ENGINE COOLING SYSTEM in *Maintenance Procedures.*

5. If freezing temperatures are possible, drain the heat exchanger of sea water by removing the drain plug in the bottom of the heat exchanger (Figure 5). Replace the plug when the water has drained.

6. Clean the genset and lightly oil parts that can rust.

RETURNING GENSET TO SERVICE

1. Check the tag on the dipstick and change the oil if the viscosity is not suitable for present and anticipated ambient temperatures.

2. Reconnect the battery(ies) (negative [–] cables last) and service as necessary in accordance with the manufacturer's instructions.

3. Prime the fuel system (p. 25).

4. Replace the sea water pump impeller if it was installed more than a year ago. If less, remove the impeller cover and wet the internal surfaces of the pump with water to establish initial lubrication and pump suction. See Replacing the Sea Water Pump Impeller (p. 23).

5. Perform PRE-START CHECKS and start and run the genset according to STARTING. Perform maintenance or service as required before placing the genset in service.

Periodic Maintenance Schedule

Periodic maintenance is essential for top genset performance and long service life. Use Table 3 as a guide and follow the *Maintenance Procedures.*

WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent starting while working on the genset.***

TABLE 3. PERIODIC MAINTENANCE SCHEDULE

PROCEDURE	FREQUENCY								
	After first 35 Hrs	Every Day/ 8 Hrs	Every Month/ 100 Hrs	Every 6 Months/ 200 Hrs	Every Year/ 500 Hrs	Every 800 Hrs	Every 2 years	Every 5 years	Page
Inspect Genset		x[1]							17
Check Oil Level		x							17
Check Coolant Level		x							17
Check Fuel Level		x							17
Check Exhaust System		x							17
Check Battery			x[2]						–
Check V-Belt Tension			x[3]						21
Drain Water in Fuel			x						24
Check Siphon Break			x						22
Clean Genset				x					17
Change Oil & Oil Filter	x			x					18
Change Fuel Filter				x					24
Change Zinc Anode					x				22
Replace Sea Water Impeller					x				23
Check Generator Bearing					x[4]				–
Adjust Valve Lash						x[4]			–
Change Coolant, Pressure Cap, Thermostat, Hoses, V-belt							x		19
Replace Generator Bearing								x[4]	–

1 - Check for oil, fuel, coolant and exhaust system leaks.
2 - See battery manufacturer's recommendations.
3 - Check for slippage.
4 - Must be performed by an authorized Onan dealer. Check every year for evidence of outer race rotation.

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Maintenance Procedures

GENERAL INSPECTION

Perform these checks and inspections every time the genset is started or every eight hours if the genset is being run continuously.

Oil Level Check

⚠WARNING ***Crankcase pressure can blow out hot oil and cause severe burns. Stop the engine before checking the oil level or opening the fill cap.***

Shut down the genset to check engine oil level and wait a few minutes for the oil to drain down to the crankcase to get an accurate indication of oil level.

Keep the oil level between FULL and ADD on the dipstick (Figure 4). See ENGINE OIL RECOMMENDATIONS in *Introduction* for the type of oil to add.

⚠ CAUTION ***Too little oil can lead to severe engine damage and too much oil to high oil consumption and foaming, which can cause engine shutdown. Keep the oil level between FULL and ADD.***

Coolant Level Check

Replenish the normal loss of coolant by keeping the level in the coolant recovery tank between COLD and HOT. See COOLING SYSTEM for the recommended mixture of antifreeze.

Sea Water Pump, Strainer and Sea Cocks

Clean out the sea water strainer if necessary and make sure the sea cock is open. When a water separator is part of the exhaust installation make sure the exhaust water sea cock is open.

If the sea water pump is located higher than the load waterline and it has been a week or more since the genset has been run, it is recommended that the impeller cover be removed and the internal surfaces of the the pump be wetted with water to establish initial lubrication and pump suction. See Replacing the Sea Water Pump Impeller (p. 23).

⚠ CAUTION ***Wet the internal surfaces of the pump as often as necessary to prevent dry startups, which severely shorten impeller life.***

Exhaust System Inspection

Wet Exhaust System: Inspect the exhaust system for leaks and loose hose clamps at the exhaust manifold, exhaust elbow, muffler, water separator and hull fittings. Replace damaged sections of exhaust hose.

Dry Exhaust System: Inspect the exhaust system for leaks at all joints, welds and gaskets. Replace rusted sections of exhaust pipe.

⚠WARNING ***EXHAUST GAS IS DEADLY! Do not operate the genset until all exhaust leaks have been repaired.***

Fuel System Inspection

Check for leaks at all fuel line fittings and gaskets. Replace fuel hose that has been abraded or cut and install new hose in such a way that it will not become kinked, rub against other parts or come in contact with sharp edges, hot surfaces or wiring.

⚠WARNING ***Fuel leaks can lead to fire. Repair leaks immediately. Do not run the genset if there is a fuel leak.***

Prime the fuel system if the genset ran out of fuel or a fuel filter was replaced. See FUEL SYSTEM.

Battery Inspection

Check for clean, tight battery connections. Looseness and corrosion cause high electrical resistance, which makes for hard starting.

⚠WARNING ***Arcing at battery terminals or in a light switch or other equipment, flames and sparks can ignite battery gas causing severe personal injury. Ventilate the battery compartment before connecting or disconnecting battery cables—Disconnect the negative (–) cable first and reconnect it last—Wear safety glasses—Do not smoke—Switch lights ON and Off away from the battery.***

Mechanical Inspection

Check for unusual noises and vibrations, loose genset mounts and signs of mechanical damage. Check the engine gauges regularly (if provided). See *Operation* for normal gauge readings.

Keep the genset clean. Do not clean the genset while it is running. Protect the generator, control

panel, and electrical connections from cleaning solvents.

CHANGING OIL AND OIL FILTER

⚠WARNING ***State and federal agencies have determined that contact with used engine oil can cause cancer or reproductive toxicity. Take care to limit skin contact and breathing of vapors. Use protective gloves and wash exposed skin.***

Table 3 specifies the maximum intervals for oil and oil filter change. See ENGINE OIL RECOMMENDATIONS in *Introduction* for the oil to use and *Specifications* for the amount.

⚠WARNING ***Crankcase pressure can blow out hot oil and cause severe burns. Stop the engine before checking the oil level or opening the fill cap.***

Draining Engine Oil: To drain the engine oil, run the engine until thoroughly warm and then stop it. If an oil pump-out system is installed, follow the instructions provided. If not, unscrew the plug on the end of the drain hose (Figure 4) and drain the oil into a suitable container. When the oil is completely drained, reinstall the plug and return the hose to its storage position. Two wrenches are necessary to keep from twisting the hose when removing and tightening the plug.

Changing Oil Filter: To change the oil filter, place a container under the oil filter (Figure 4) to catch oil that drips out and then spin off the oil filter. Clean the filter mounting surface, apply oil to the new filter gasket and spin the filter on until the gasket just touches the mounting pad. Then tighten an additional 3/4 turn.

Refilling Engine Oil: Refill with the proper amount of oil, start the engine and check for leakage around the filter gasket. ***Tighten the filter only enough to stop leakage.*** Shut off the genset, recheck the oil level and add oil as necessary.

⚠CAUTION ***Too little oil can lead to severe engine damage and too much oil to high oil consumption and foaming, which can cause engine shutdown. Keep the oil level between FULL and ADD.***

Disposing of Used Oil and Oil Filter: Dispose of the used oil and oil filter according to local environmental regulations.

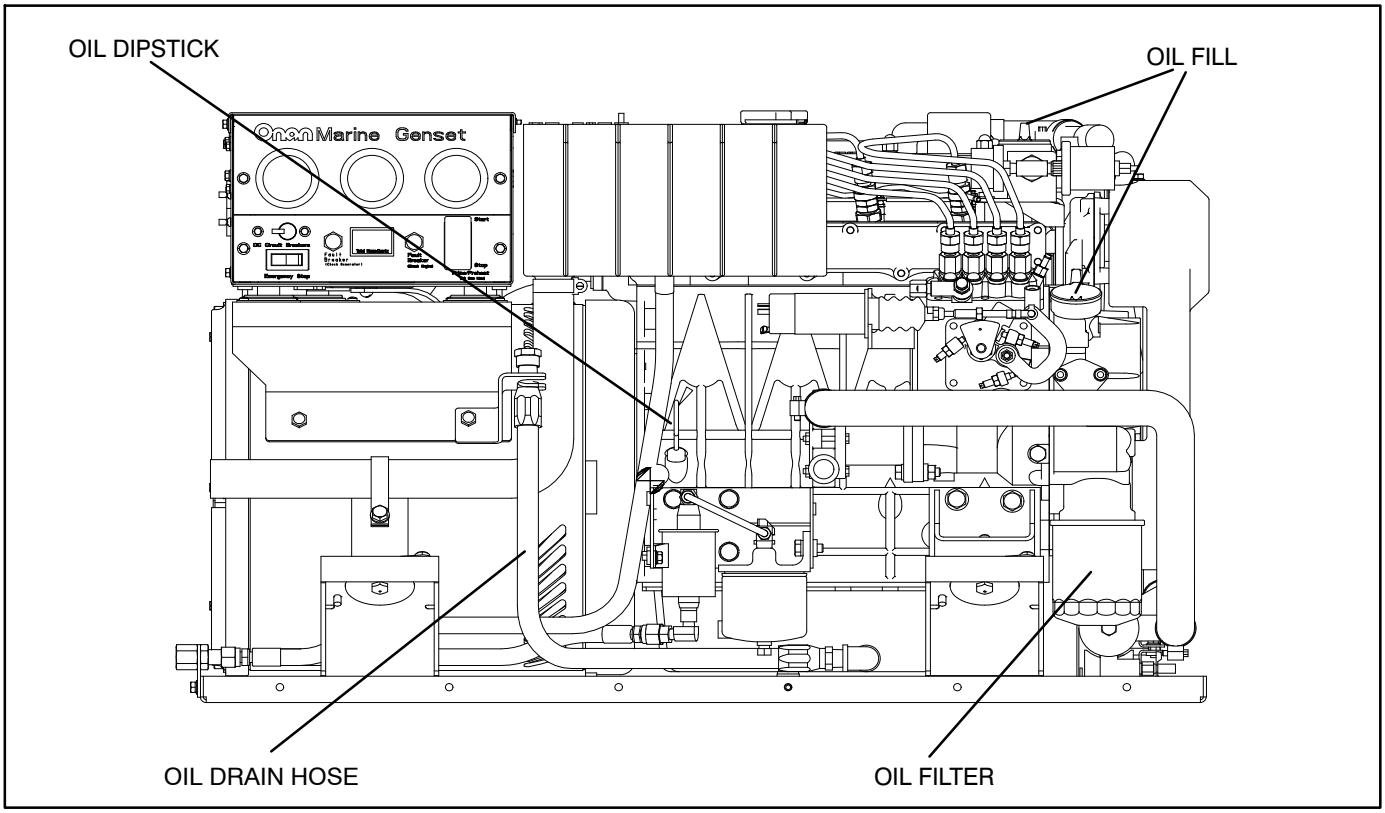

FIGURE 4. OIL CHECK, FILL, DRAIN AND FILTER

ENGINE COOLING SYSTEM

Table 3 specifies the maximum intervals for replacing coolant, hoses, pressure cap, thermostat, V-belt and zinc anode.

Cooling System Overview

The engine is cooled by a pressurized, closed-loop liquid cooling system. Coolant is pumped through passages in the engine block, head and exhaust manifold and is cooled in a genset-mounted heat exchanger or keel cooler. The V-belt drives the engine coolant pump.

If the genset has a heat exchanger and/or a wet exhaust elbow, the engine is equipped with a sea water* pump driven by a power takeoff on the engine. The sea water cools the heat exchanger and/or exhaust gases and exits the vessel through the exhaust system. (There is no sea water pump if the genset is equipped for keel cooling and dry exhaust.) Figure 5 illustrates a typical installation of a genset equipped with a heat exchanger, wet exhaust elbow and sea water pump.

Recommended Coolant Mixture

Use the best quality ethylene or propylene glycol antifreeze solution available. It should be fully formulated with rust inhibitors and coolant stabilizers ***but not with stop-leak additives***. Use fresh water that is low in minerals and corrosive chemicals. Distilled water is best. Unless prohibited by shipping regulations, gensets with heat exchangers are shipped with the recommended 50/50 mixture of water and ethylene glycol, which is good for -34°F (-37°C).

See *Specifications* for coolant system fill capacity if the genset is equipped with a heat exchanger. If the genset is keel cooled, system capacity also depends on the capacity of the keel cooler.

Coolant Recovery Tank

Replenish the normal loss of coolant by keeping the level in the recovery tank between COLD and HOT. Use the recommended mixture of antifreeze. See Changing Coolant if it is necessary to fill the system.

Changing Coolant

⚠WARNING ***Hot coolant is under pressure and can cause severe burns when loosening the pressure cap. Let the engine cool before loosening the pressure cap.***

⚠WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) from the battery(ies) to prevent the engine from starting.***

Draining the System: Let the engine cool down, disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting, remove the system pressure cap and open the block and heat exchanger drain cocks (Figure 5). See the manufacturer's instructions regarding a keel cooler. Collect used coolant in containers for proper disposal.

⚠WARNING ***Ethylene glycol antifreeze is toxic. Keep away from children and animals and dispose of according to the local regulations for hazardous substances.***

Cleaning and Flushing the System: Use radiator cleaning chemicals to clean and flush the cooling system before new coolant is added. Follow the manufacturer's instructions.

⚠ CAUTION ***Filling a hot engine with cold water can cause cracks in the manifold, head and block. Follow the manufacturer's instructions for cleaning and flushing.***

Filling the System: Close all drain cocks and secure all hose clamps and fill the system through the fill opening. The system will fill only as fast as the air can escape. Fill to the bottom of the fill neck. Start and run the engine until it warms up (thermostat opens) to dislodge air pockets and shut it down. Add as much coolant as necessary and secure the pressure cap.

⚠ CAUTION ***Low coolant level can cause severe engine damage. Make sure the system is full.***

Pressure Cap

Replace the pressure cap periodically (Table 3) to maintain optimal engine cooling and minimal coolant loss.

* In this manual, "sea water" refers to floatation water.

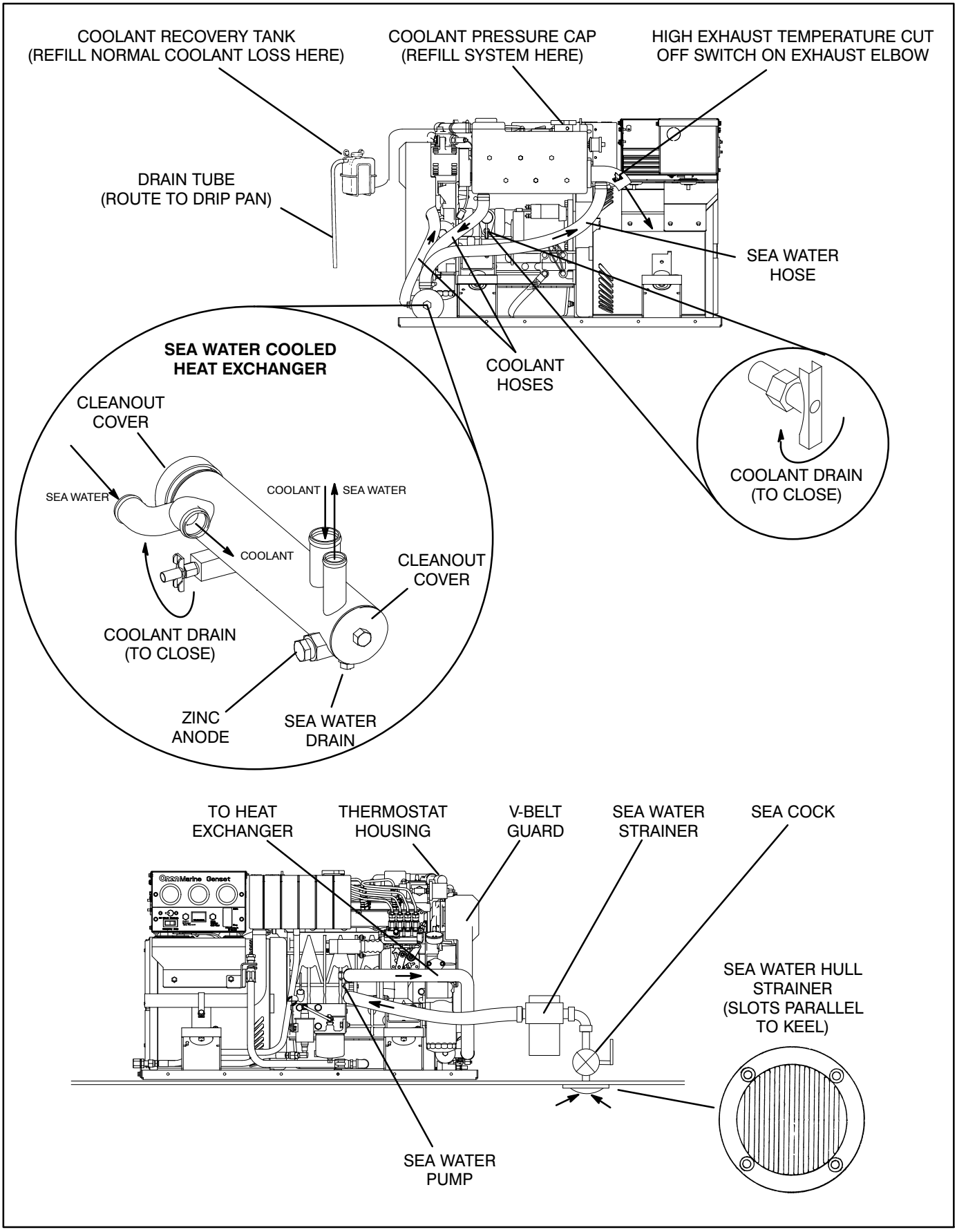

FIGURE 5. TYPICAL HEAT EXCHANGER-TYPE COOLING SYSTEM

Adjusting V-Belt Tension

The V-belt (Figure 6) drives the coolant pump and battery charging alternator.

⚠WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.***

1. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting and remove the belt guard or sound shield door.
2. Loosen the alternator pivot bolt first and then the adjusting bracket bolt on top.
3. Tighten belt tension by pivoting the alternator outwards. Hold tension by tightening the adjusting bracket bolt. Apply 20 pounds (10 kg) as shown to the middle of the pulley span and measure belt deflection, which should be 0.4 inch (10 mm). Tighten the alternator bolts when tension is correct.
4. Secure the belt guard or sound shield door and reconnect the battery cables (negative [–] last).

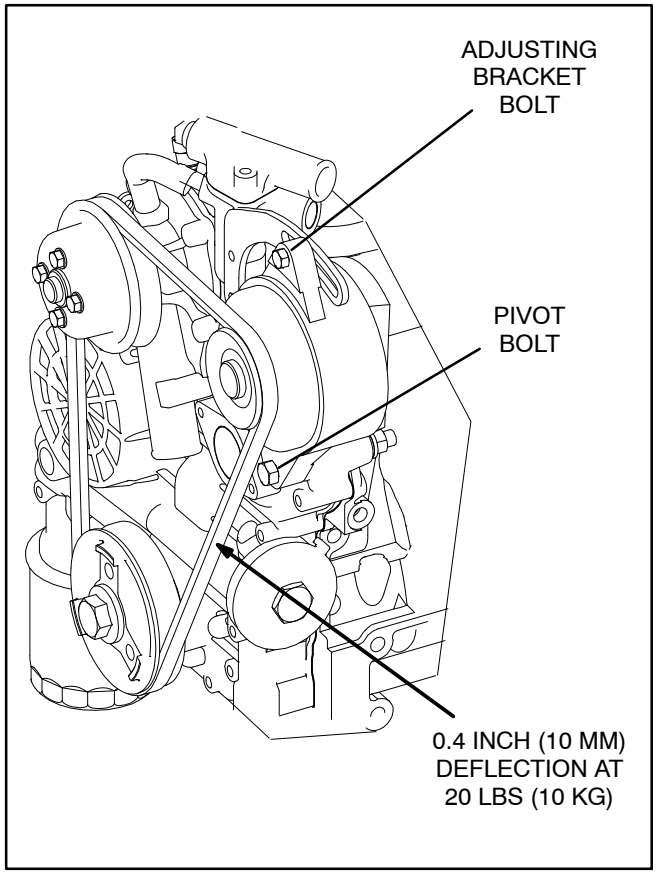

FIGURE 6. ADJUSTING V-BELT TENSION

Replacing Thermostat

Replace the thermostat periodically (Table 3) to maintain optimal engine cooling.

⚠WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.***

⚠WARNING ***Hot coolant is under pressure and can cause severe burns when loosening the pressure cap. Let the engine cool before loosening the pressure cap.***

1. Let the engine cool, loosen the pressure cap and disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.
2. Remove the two thermostat housing bolts (Figure 7) and pull off the housing, thermostat and gasket. The hose does not need to come off.
3. Clean off the gasket area and reassemble as shown with the new thermostat and gasket. Apply Three Bond 1215 liquid sealant or equivalent to the top side of the gasket.

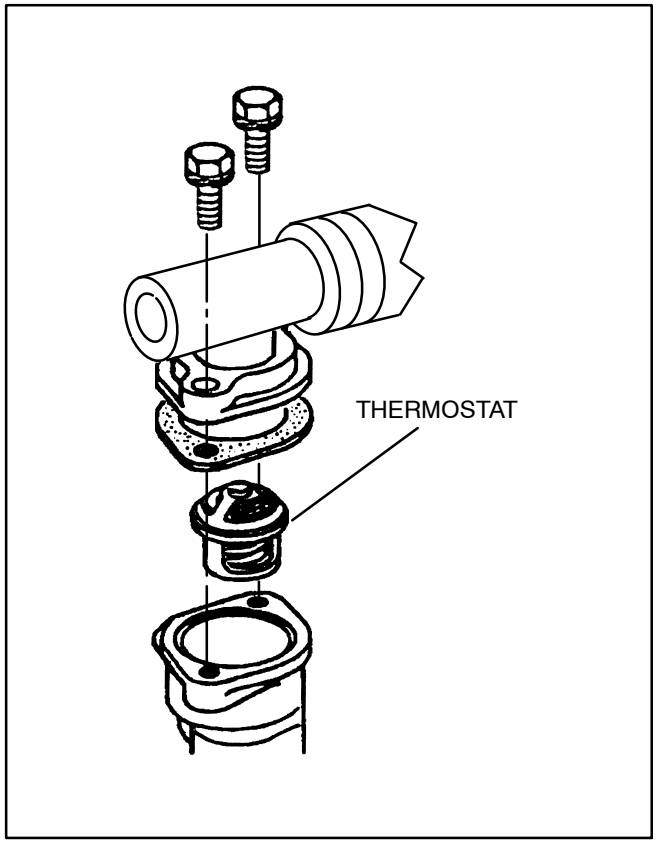

FIGURE 7. REPLACING THERMOSTAT

Heat Exchanger and Zinc Anode

The heat exchanger has cleanout covers on both ends to clean the sea water tubes. Remove the covers to clean out seaweed and pump debris. If necessary, take the heat exchanger to a radiator shop for chemical cleaning of hard deposits.

Siphon Break

A siphon break is installed when the exhaust elbow is below, or less than 6 inches (152 mm) above, the load waterline (Figure 8) to prevent flooding when the engine is not running.

If of the spring-loaded valve design, check for free movement of the plunger. Replace the device if the plunger does not move freely or the body is encrusted with deposits from leakage past the valve seat.

If of the bleed-vent type (Figure 8), check that the vent hose is properly connected on both ends. If the vent is connected to a hull fitting, check for normal water flow whenever the engine is running.

WARNING ***Bypassing a siphon break or failing to maintain it can lead to engine flooding and damage to the engine not covered under Warranty.***

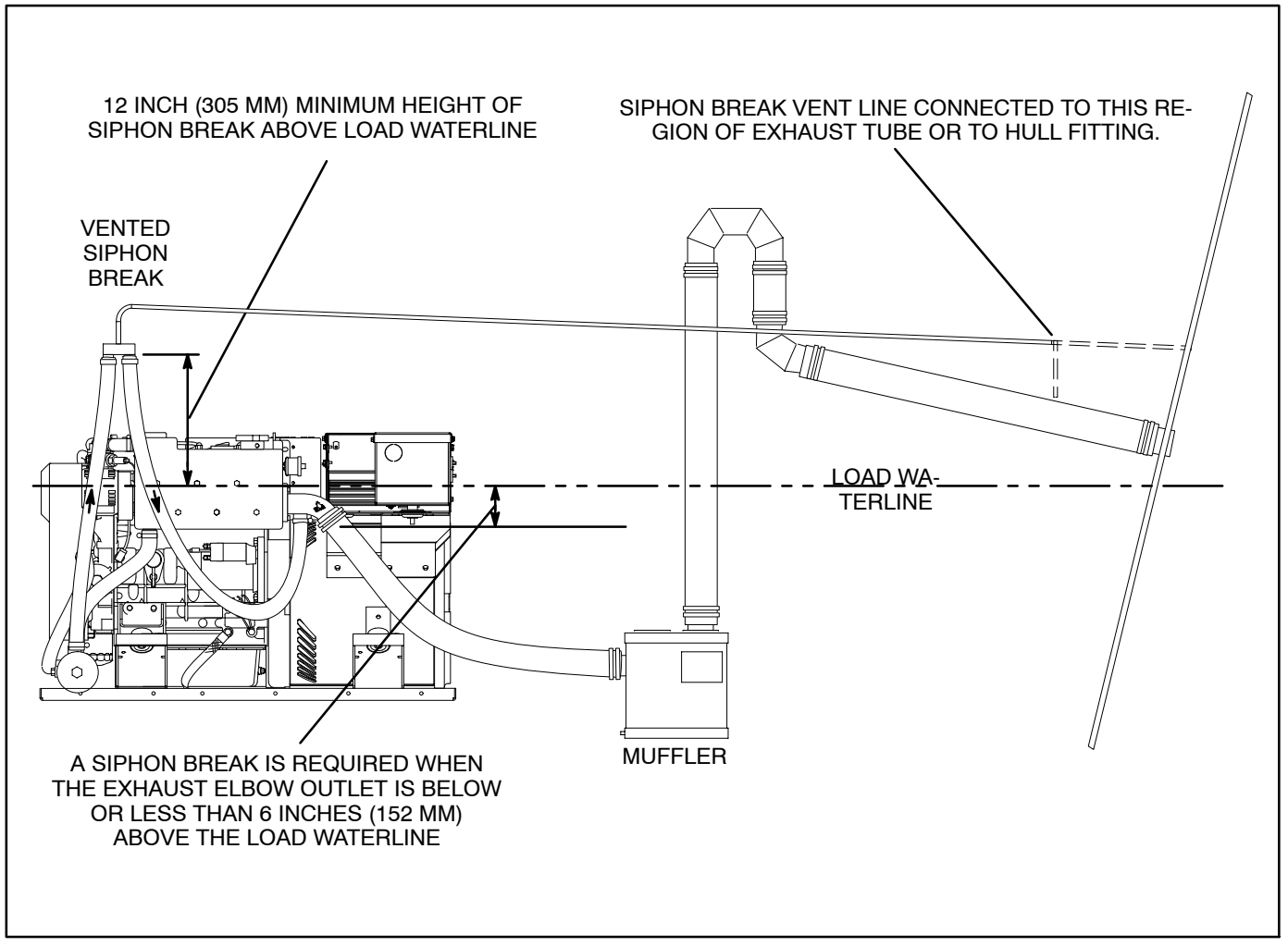

FIGURE 8. TYPICAL INSTALLATION OF A VENT-TYPE SIPHON BREAK AND WET EXHAUST SYSTEM

Replacing the Sea Water Pump Impeller

The sea water pump (Figure 9) is driven off a power takeoff on the engine. To replace the impeller:

1. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.

   ⚠WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.***

2. Close the sea cock and remove the impeller cover and O-ring.
3. Using two pairs of pliers to grip vanes on opposite sides, pull out the old impeller. *Check for and cleanout pieces of the impeller from the heat exchanger and exhaust elbow if vanes have broken off.*
4. Install the new impeller. It helps to twist the impeller clockwise while squeezing it into the housing. Push it in all the way when the keyway lines up with the key in the shaft. The vanes should all incline backwards, that is, counterclockwise; the impeller turns clockwise.
5. To provide initial lubrication and better pump suction before water reaches the pump, wet the inside of the pump and impeller with water, soap solution or a silicone lubricant and secure the O-ring and cover.

   ⚠ CAUTION ***Do not lubricate with petroleum products like grease and oil which chemically attack impeller materials.***

6. If the sea water strainer is above the waterline, remove the strainer element cover, fill it with water (which also fills the hose to the pump) and reinstall the cover.
7. Open the sea cock, reconnect the battery cables (negative [–] last) and start the genset. *Shut down the genset within 30 seconds if there is no water flow from the exhaust hull fitting. (Flow will not be visible if an exhaust water separator has been installed. In that case, feel the pump cover and shut down the genset if the pump gets hot.)* If there is no flow, find and remove the blockage before the genset is started again.

   ⚠WARNING ***The pump gets hot quickly if there is no flow and can burn your fingers. Be cautious when touching the pump.***

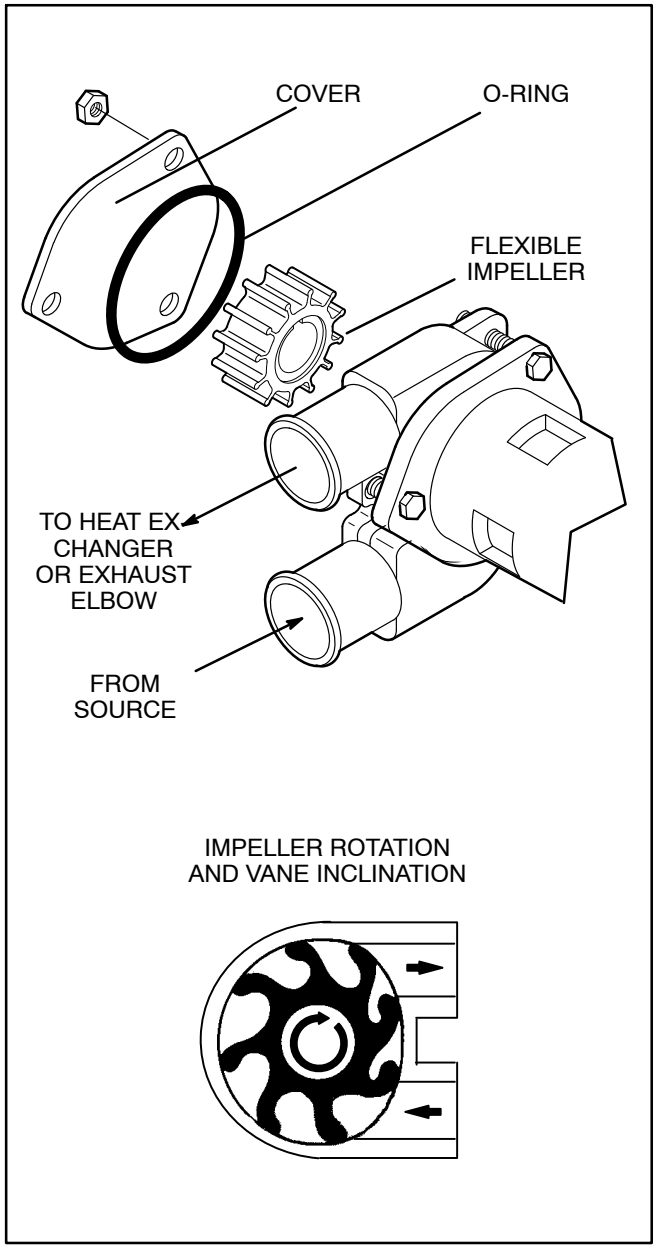

FIGURE 9. REPLACING SEA WATER PUMP IMPELLER

FUEL SYSTEM

Fuel Handling Precautions

Keep dirt, water and other contaminants from entering the fuel system and damaging, corroding or clogging fuel injection components. The genset has a water-separator type of fuel filter but the fuel supply system should have a filter and water separator installed ahead of connections at the genset.

A primary source of water in fuel, which can clog fuel passages by freezing and cause corrosion by forming sulfuric acid with the sulfur in the fuel, is the condensation of humid air on the walls of the fuel tank. Keeping fuel tanks as full as possible reduces condensation by reducing the area on which condensation can take place.

Fuel Filter

Draining Water and Sediment: See Table 3 for the regular frequency of draining water and sediment. Drain more often if fuel quality is poor or condensation cannot be avoided. To drain the filter, remove the plug (Figure 10), collect the water and sediment (about 1/2 cup [120 ml]) in a suitable container and dispose of properly. ***Reinstall the plug securely.***

Replacing the Filter Element: See Table 3 for the regular frequency of fuel filter change. Replace the filter sooner if the engine lacks power or surges.

1. Drain the filter as explained above and spin off the element.
2. Clean the contact surface of the base.
3. Lubricate the new element and its gasket, and fill the element with clean diesel fuel.
4. Spin the new element onto the base and hand tighten.
5. Start and run the genset and check for fuel leakage. Tighten the filter only enough to stop leakage. See Priming the Fuel System if the genset does not start.

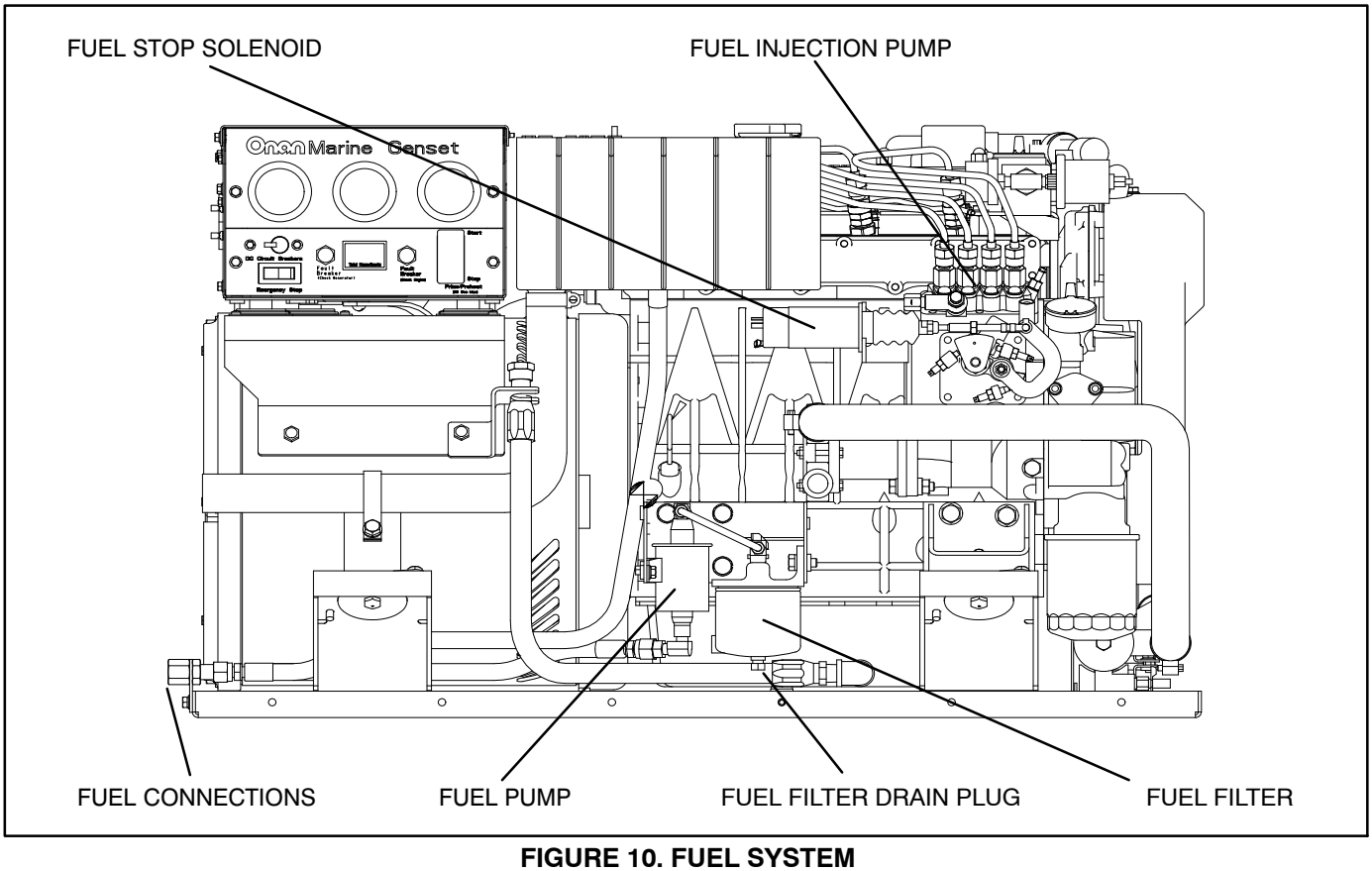

FIGURE 10. FUEL SYSTEM

Priming the Fuel System

Priming the Low-Pressure Side: The fuel lift pump (Figure 10) primes during preheat when the control switch is held in the stop position. Priming purges air from the low-pressure side of the fuel injection system.

⚠ CAUTION ***Preheating for more than 20 seconds at a time reduces the life of the glow plugs. Let the glow plugs cool for at least one minute before trying again.***

If priming for 20 seconds at a time is not enough, open the bleed screw and disconnect the engine harness lead from the glow plugs (Figure 11) and make sure it cannot ground on the block. Then press **STOP** until fuel just starts to appear at the bleed opening. Tighten the bleed screw and reconnect the lead to the glow plugs.

Priming the High-Pressure Side: This procedure should only be performed by a diesel mechanic.

⚠WARNING ***The high pressure oil spray from an injector line fitting can penetrate the skin, leading to possible blood poisoning. Wear safety glasses and keep your hands away from the spray. Do not delay getting proper medical attention if oil spray penetrates your skin.***

1. Loosen the high pressure fittings at the nozzles. Use two wrenches to keep from twisting the return fittings. Use flare-nut wrenches to keep from rounding the shoulders.
2. Crank the genset until fuel appears at the loosened fittings and then snug up each fitting. The engine should start and run when the first fitting is snugged.
3. Shut down the engine and torque the fittings to 19 – 25 lb-ft (25 – 34 N-m).

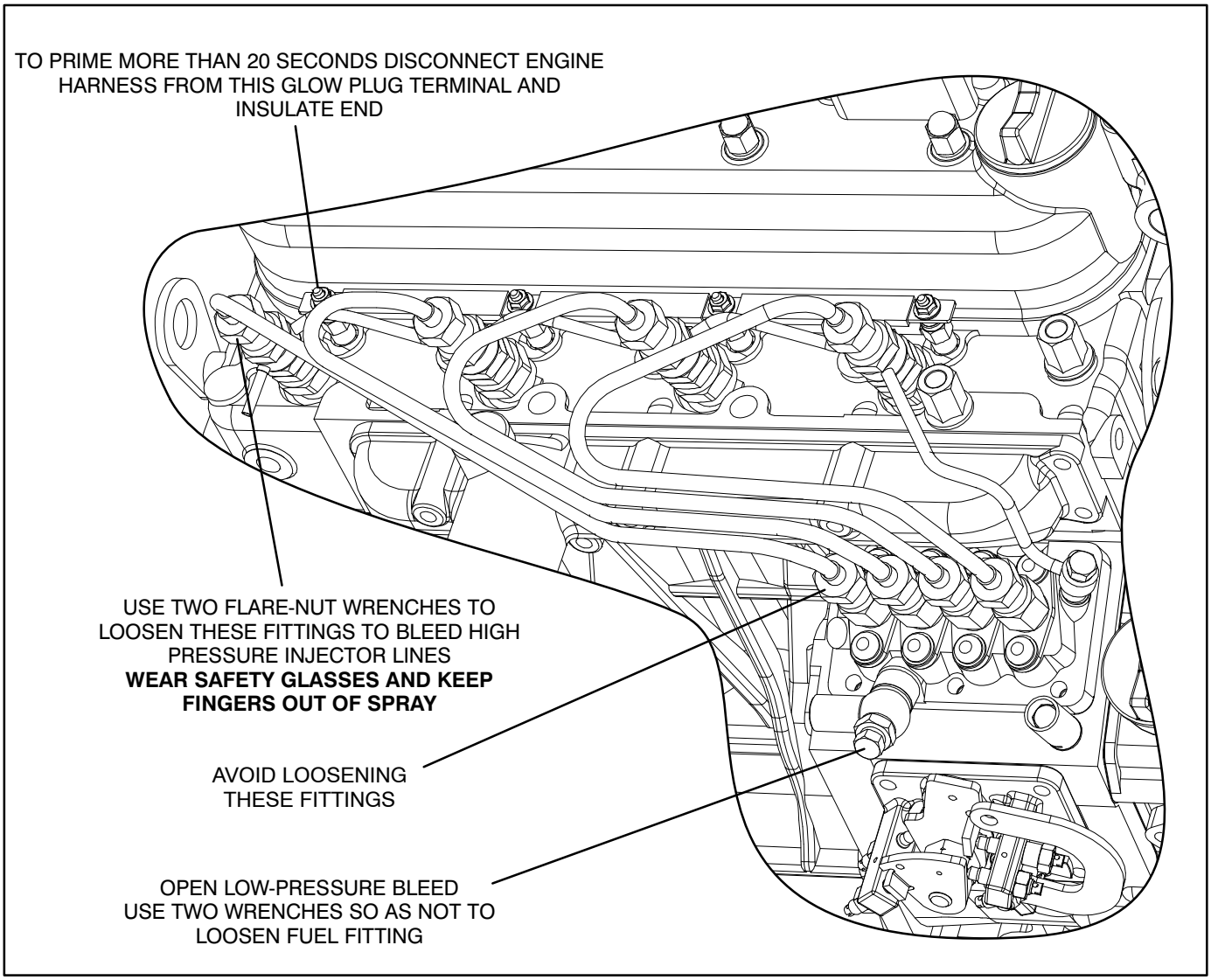

FIGURE 11. PRIMING THE FUEL SYSTEM

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Engine (DC) Control

See Figures 12 and 13 to locate the control components on the control panel and inside the control box. See Figure 14 to locate the control components mounted on the engine, such as the fuel stop solenoid, gauge senders and shutdown switches. Figures 25 and 26 at the back are the control schematic and connection diagrams.

CONTROL PANEL

Start-Stop-Prime/Preheat Switch (S1): Starts the genset when held at **Start** and stops the genset when momentarily touched to **Stop**. Holding the switch at **Stop** causes the glow plugs to preheat the combustions chambers and the fuel lift pump to prime the fuel system.

Hour Meter (M1): Indicates the number of hours the genset has run. It cannot be reset.

Engine Gauges (M2, M3, M4): Optional—indicate engine oil pressure, coolant temperature and control system DC voltage. If remote gauges have been installed, push gauge switch (S6) in to read M2 and M3 at the genset.

Gauge Switch (S6): Momentary contact switch used only when remote gauges have been installed. Push the button to read M2 and M3 at the genset.

"Check Engine" Fault Breaker (CB2): Shuts down the genset when one of the following fault conditions causes it to trip: over/undervoltage, over/underspeed, low oil pressure, high exhaust temperature, high coolant temperature and low coolant level (optional). *Push the reset button to reset.*

"Check Generator" Fault Breaker (CB5): Shuts down the genset when high generator quadrature winding current causes it to trip. *Push the reset button to reset.*

DC Circuit Breaker (CB1): Protects the high-current (DC) glow plug circuits from shorts to ground. The genset will stop if tripped. *Reset with handle.*

Emergency Stop Breaker (CB4): A rocker switch type of circuit breaker that protects the genset control circuits (DC) from shorts to ground. The genset will stop if the circuit breaker trips or the rocker is pushed to **Stop**. *Push the rocker **On** to reset.*

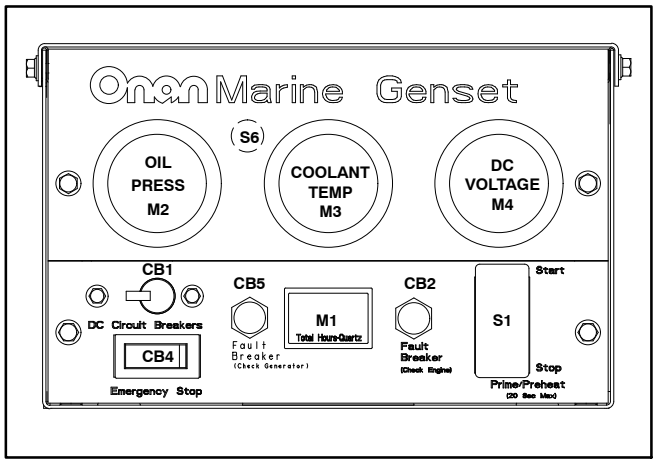

FIGURE 12. CONTROL PANEL

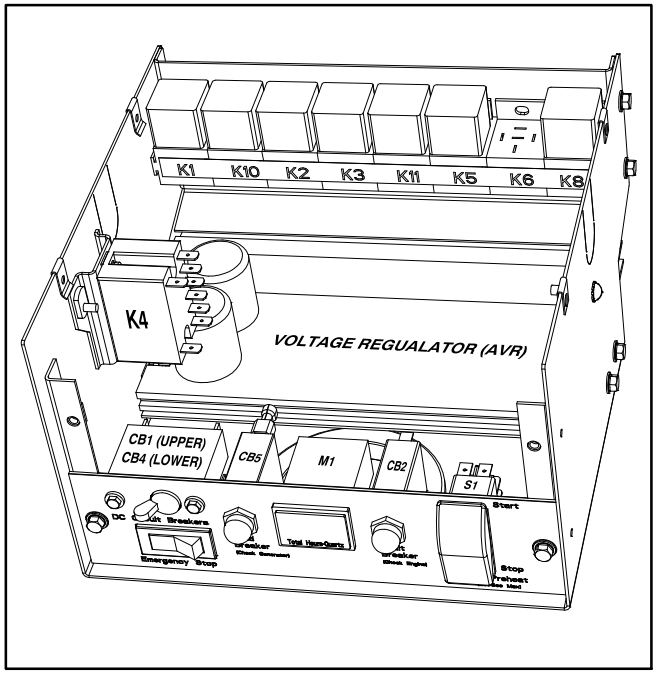

FIGURE 13. CONTROL BOX

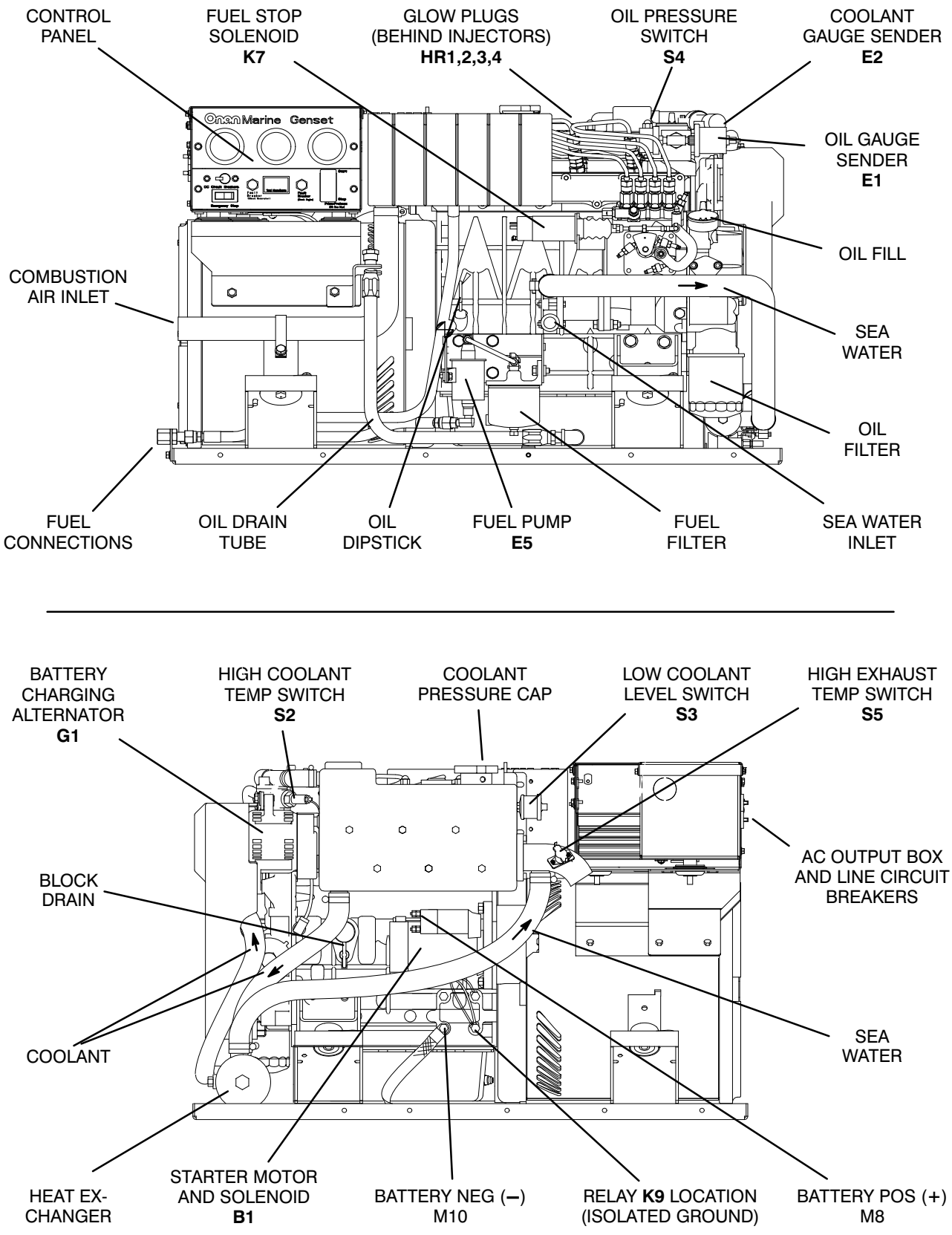

FIGURE 14. TYPICAL GENSET CONFIGURATION

SEQUENCE OF OPERATION

Refer to Figure 25 while working through the following sequences of operation.

Start Sequence

Prime/Preheat: Holding switch **S1** in its *Stop/Preheat* position energizes relays **K5** (glow plugs) and **K11** (fuel prime).

- When relay **K5** contacts 87-30 close, glow plugs **HR1-HR3(4)** are energized to preheat the engine combustion chambers.
- When relay **K11** contacts 30-87 close, fuel lift pump **E5** is energized to lift fuel to the fuel injection pump.

Start: Holding switch **S1** in its *Start* position energizes start relay **K2**. Start relay **K2** contacts 87-30 close to energize run relay **K3**. Relay **K3** closes contacts 30-87 to energize:

- Meter **M1**, and meters **M2-M4** when provided.
- Low coolant level switch **S3** and relay **K6**, when provided.
- Field windings of battery charging alternator **G1**.
- Fuel pump **E5**.
- **AVR** start disconnect and over-speed fault circuits.
- Fueling relay **K8**. Relay **K8** closes contacts 87-30 to energize fuel stop solenoid **K7**, which pulls in to move the fuel rack to its maximum fuel position and open its internal “AUX” contacts. When the contacts open, starter relay **K1** and relay **K10** are energized. (Opening the contacts removes B+ from the ground side of the relay **K1** and **K10** coils, which are grounded through pull-in coil **P**.)
    - When relay **K1** contacts 87-30 close, starter motor **B1** is energized via its solenoid to crank the engine.
    - When relay **K10** contacts 30-87 close, glow plug relay **K5**, fuel prime relay **K11** and isolated ground relay **K9** will continue to be energized during cranking.

Start Disconnect: As the genset runs up to rated speed and voltage and the output signal from the **AVR** crosses a threshold of approximately 70 VDC, start disconnect relay **K4** opens contacts 9-10 and closes contacts 1-2 and 3-4.

- Closing contacts 1-2 keeps run relay **K3** energized and the genset running when control switch **S1** is released. The genset will not continue to run if the generator fails to develop the threshold voltage necessary to energize relay **K4**.
- Opening contacts 9-10 deenergizes starter relay **K1** and glow plug relay **K5**, stopping cranking and preheating. This will occur even before control switch **S1** is released.
- Closing contacts 3-4 arms the fault shutdown circuits. See Fault Shutdown Sequence.

Run: The genset runs up to rated speed and voltage in a few seconds. As the load varies, the **AVR** maintains rated voltage by varying generator field strength (see *Automatic Voltage Regulator*) and the internal mechanical governor maintains nominal frequency by moving the fuel rack.

Fault Shutdown Sequence

“Check Engine” Faults: The following fault switches shut down the genset by grounding terminal **2** on fault breaker **CB2**, causing it to trip:

- High engine temperature switch **S2**
- Low coolant level switch **S3**, via relay **K6**
- Low oil pressure switch **S4**
- High exhaust temperature switch **S5**
- **AVR** overspeed circuit

“Check Generator” Faults: Fault breaker **CB5** trips if generator quadrature winding current is too high.

Stop Sequence

One touch of switch **S1** to its *Stop* position connects B+ to the ground side of run relay **K3**, deenergizing it and stopping the genset by deenergizing fuel stop solenoid **K7**, shutting off fuel.

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Automatic Voltage Regulator

The automatic voltage regulator (AVR) is mounted as shown in Figure 15 on the floor of the control box and is connected as shown in Figure 16.

⚠WARNING ***HAZARDOUS VOLTAGE Touching uninsulated live parts inside the control box can result in severe personal injury or death. For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry and use tools with insulated handles.***

ADJUSTING VOLTAGE

The AVR has a voltage adjustment pot and 50/60 Hz selector switch. Do not readjust the sealed V/HZ break point pot. To adjust voltage:

1. Disconnect all generator loads.
2. Check the position of the 50/60 Hz selector switch and change it if necessary.
3. Start the genset and turn the voltage adjusting pot to obtain rated output voltage.
4. Check and readjust frequency (p. 41 or 42).
5. Readjust voltage if frequency was changed.

FLASHING THE FIELD

Disconnect **P1**/**J1** inside the control box and connect the test adapter and 6 volt dry cell battery (Figure 16) for a few seconds: B+ to F1 (P1–8) and B– to F2 (P1–1). Reconnect **P1**/**J1**. See *Troubleshooting* if flashing the field does not restore voltage.

TESTING AVR vs GENERATOR

To find out whether the AVR or the generator is faulty:

1. Disconnect all generator loads.
2. Disconnect **P1**/**J1** inside the control box and connect the test adapter and 6 volt dry cell battery (Figure 16).
3. Start the genset and close terminal K4–5 (Figure 15) to ground to disengage the starter and keep the genset running.
4. Measure voltage across the test terminals. If the AVR connections are good and generator output is 100–140 VAC across Q1–S2 and 130–150 VAC across Q1–Q2, replace the AVR. See *Troubleshooting* (p. 52) if there is no voltage.

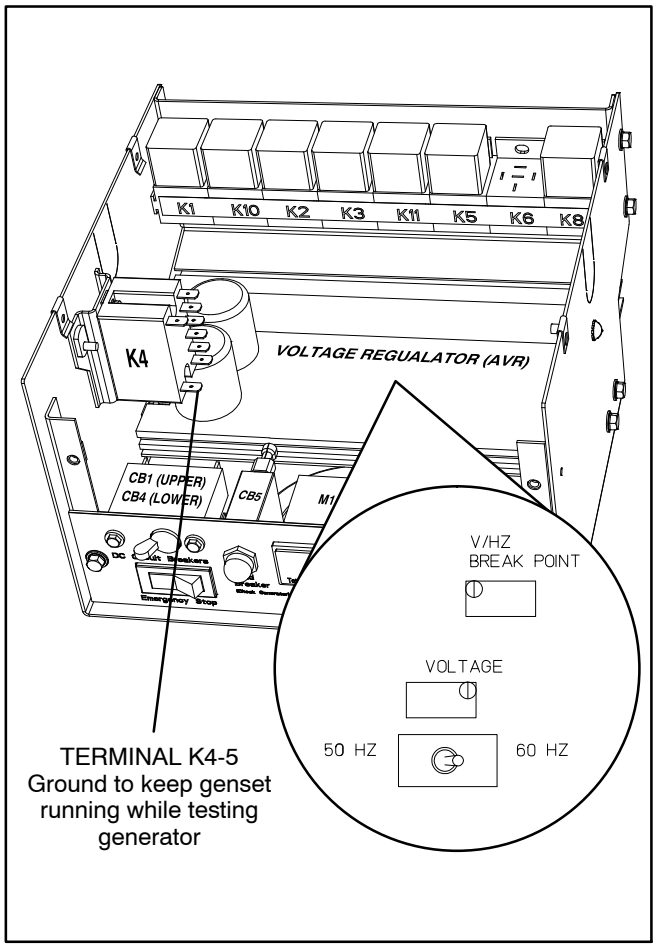
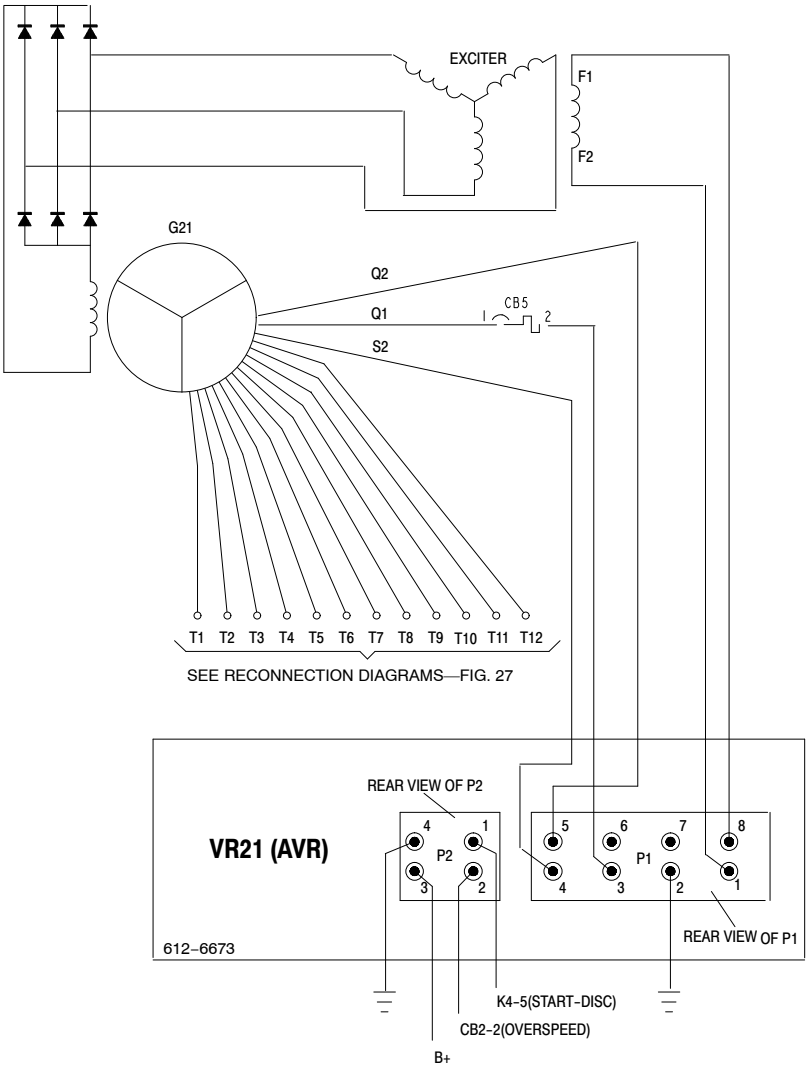
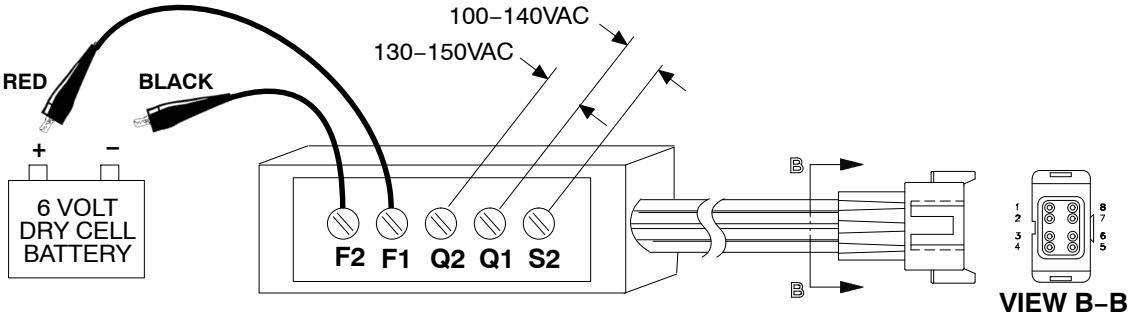


FIGURE 15. VOLTAGE REGULATOR (AVR)

AVR CONNECTIONS



SUGGESTED CONSTRUCTION OF ADAPTER FOR GENERATOR/AVR TESTING AND FIELD FLASHING



Connect Terminal F2 to PIN 8, F1 to PIN 1, Q2 to PIN 5, Q1 to PIN3 and S2 to PIN4

Use DEUTSCH connector jack DT04-08P (ONAN PN 323-1542 jack, 323-1491 pins and 323-1544 wedge) to mate connector P1. Use 18 AWG leads.

FIGURE 16. AVR CONNECTIONS AND ADAPTER FOR GENERATOR/AVR TESTING AND FIELD FLASHING

Generator

These are 4-pole, rotating-field, brushless, single-bearing, electronically regulated generators (Figure 17). See BASICS at the end of this section for a description of generator operation.

VOLTAGE REGULATION

See *Automatic Voltage Regulator*.

CONNECTIONS

Wiring connections should be made by a licensed electrician and be inspected and approved before operation. All wiring methods, connections, wire ampacities, equipment grounding, materials, etc. must comply with the applicable codes.

⚠WARNING ***Improper wiring can cause fire or electrocution resulting in severe personal injury or death and property damage.***

Use flexible conduit and stranded conductors to make connections at the generator to take up movement and vibration. For connections, use the terminals on the terminal blocks and line circuit breakers in the output box. Make sure the generator is connected for the required voltage output (Figure 27) and that properly sized line circuit breakers have been installed.

⚠WARNING ***HAZARDOUS VOLTAGE Touching uninsulated live parts inside the output box can result in severe personal injury or death. For your protection, stand on a dry wooden platform or rubber insulating mat, make sure your clothing and shoes are dry, remove jewelry from your hands and use tools with insulated handles.***

⚠WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the engine from starting.***

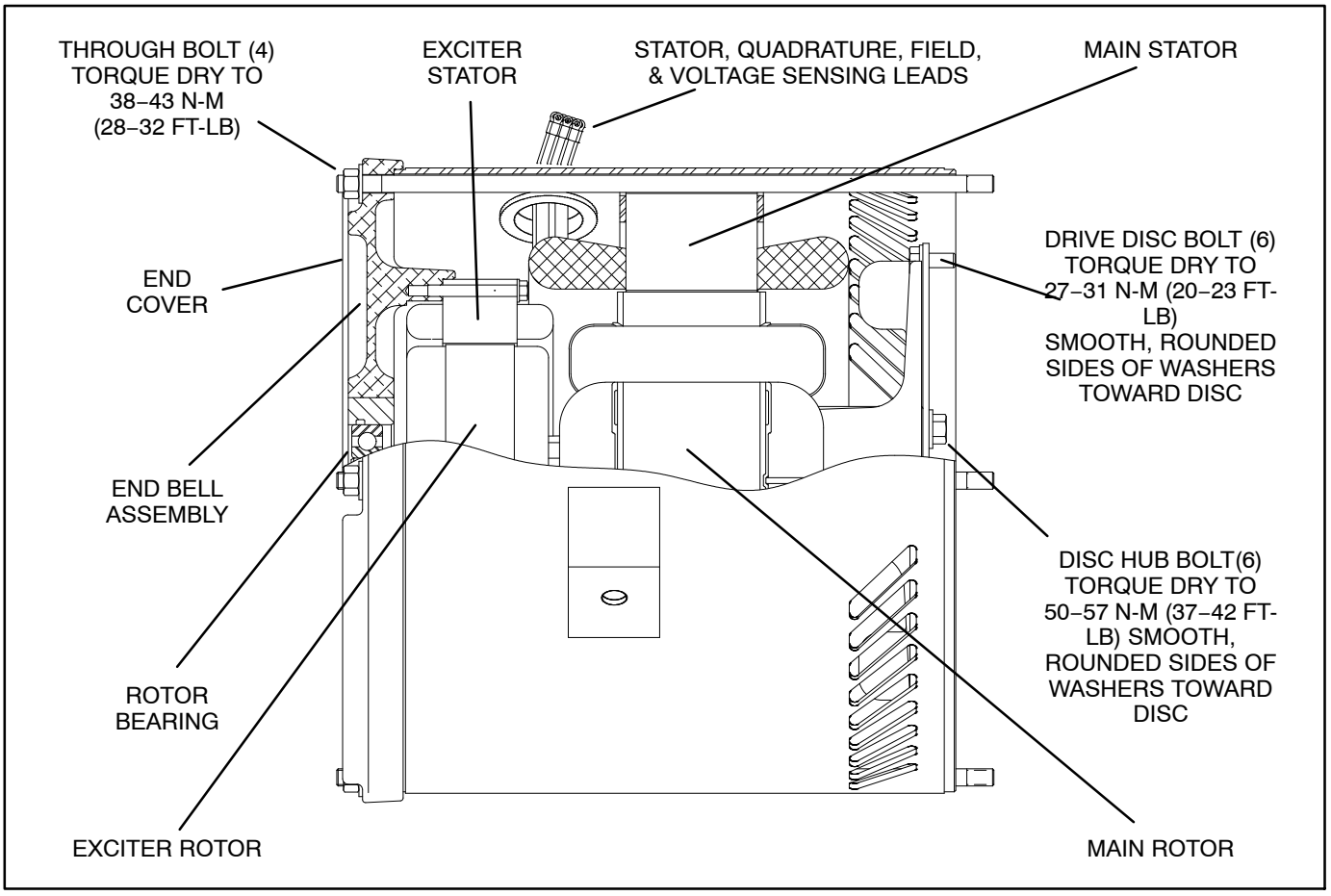


FIGURE 17. GENERATOR ASSEMBLY

TESTING

Testing Winding Insulation Resistance

A 500 VAC megger is recommended for the winding insulation resistance tests prescribed below. A test consists of applying the test potential between the winding and ground (winding laminations) for a period of 10 minutes and recording resistance at 1 minute and again at 10 minutes.

Resistance values of at least 5 megohms should be obtained for a new generator with dry windings. The polarization index should also be at least 2 (the ratio of the resistance reading at ten minutes to the reading at one minute). For a set that has been in service, the resistance reading should not be less than 1 megohm nor the polarization index less than 2.

Dry the windings if low readings are obtained or the set has been in standby for a long time in high humidity conditions and repeat the test.

Testing Winding Resistance

Use a digital ohmmeter or Wheatstone bridge to measure winding resistance. The device should have a precision of at least 0.01 ohm.

Exciter Stator

Winding Insulation Resistance: Disconnect AVR connector P1/J1 inside the control box. Using the test adapter (p. 32), connect pin **P1-1** or **P1-8** to the megger and conduct the test as instructed under Testing Winding Insulation Resistance.

Winding Resistance: Using the test adapter (p. 32), measure winding resistance between pins **P1-1** and **P1-8**. Replace the exciter stator if the resistance is not as specified in Table 4.

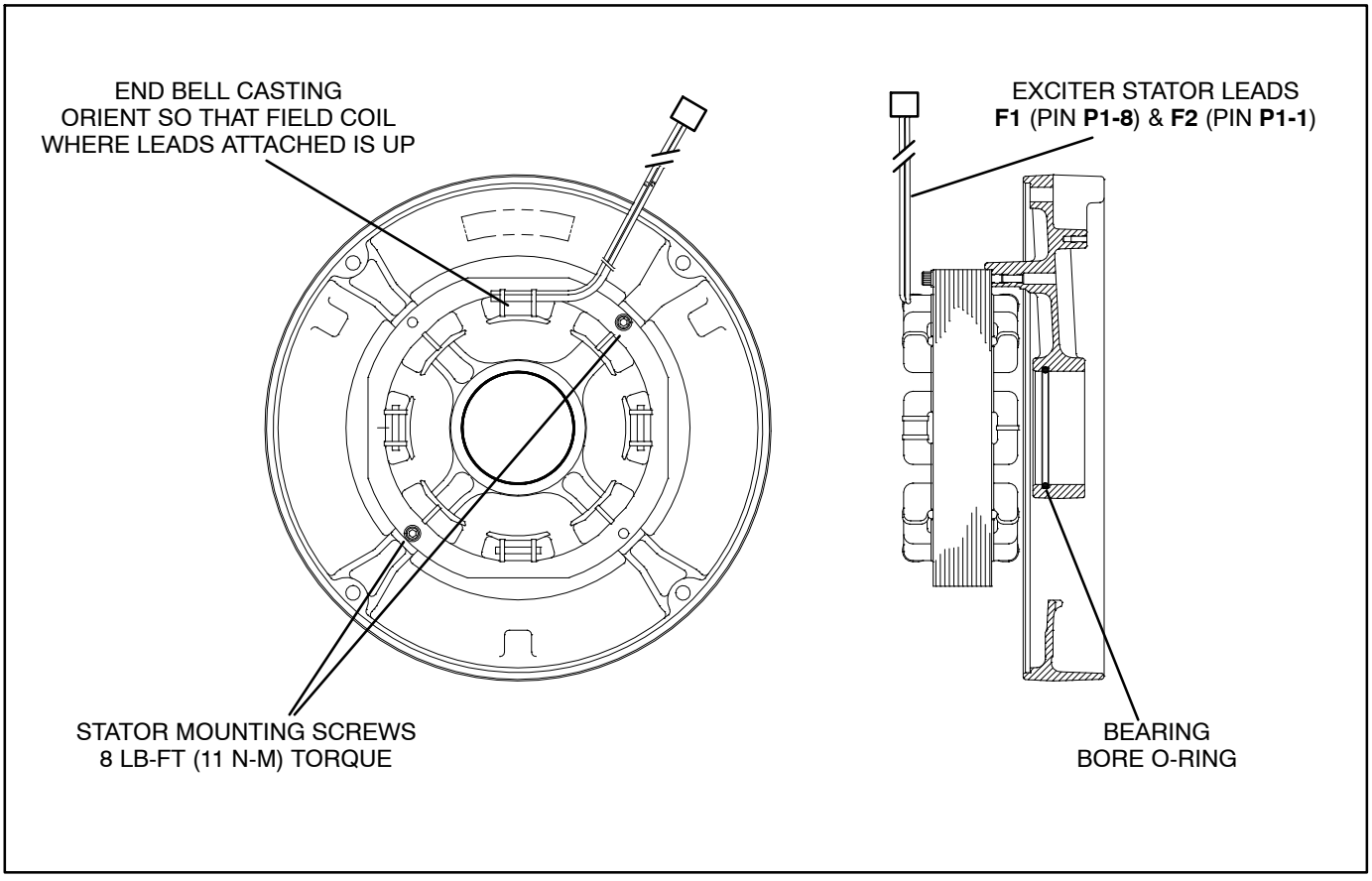


FIGURE 18. EXCITER STATOR AND END BELL

Exciter Rotor

Winding Insulation Resistance: Disconnect all six exciter rotor leads from diode terminals **CR1** through **CR6** and isolate them from ground. Connect any lead to the megger and conduct the test as instructed under Testing Winding Insulation Resistance.

Winding Resistance: Measure electrical resistance across each pair of rotor windings: **T11-T12**, **T21-T22**, **T12-T13**, **T22-T23**, **T13-T11** and **T23-T21**. See the connection schematic. Replace the exciter rotor if the resistance of any winding is not as specified in Table 4.

Rotating Rectifiers

The rotating rectifier assembly is mounted on the back face of the exciter rotor. It consists of one positive (+) and one negative (–) diode assembly. Each assembly carries three diodes in an epoxy potting. Each diode has a terminal for connecting the appropriate lead from the exciter rotor (**CR1-CR6**). Each assembly has a field terminal (**F1+** or **F2–**) for connecting the leads from the main rotor (generator field).

Diode Resistance: Measure electrical resistance between diode terminals **CR1**, **CR2** and **CR3** and field terminal **F1+** on the positive diode assembly and between diode terminals **CR4**, **CR5** and **CR6** and field terminal **F2–** on the negative diode assembly. Reverse the meter test probes and repeat the tests. The electrical resistance across each diode should be high in one direction and low in the other. If the resistance is high or low in both directions, replace the whole diode assembly.

Replacing Diode Assembly: Make sure the replacement diode assembly is of the correct polarity, positive (+) or negative (–). Then disconnect all leads from the defective diode assembly and remove the two mounting screws. Mount the new diode assembly, reconnect all leads and torque the terminal screws to 24 lb-in (2.6 N-m).

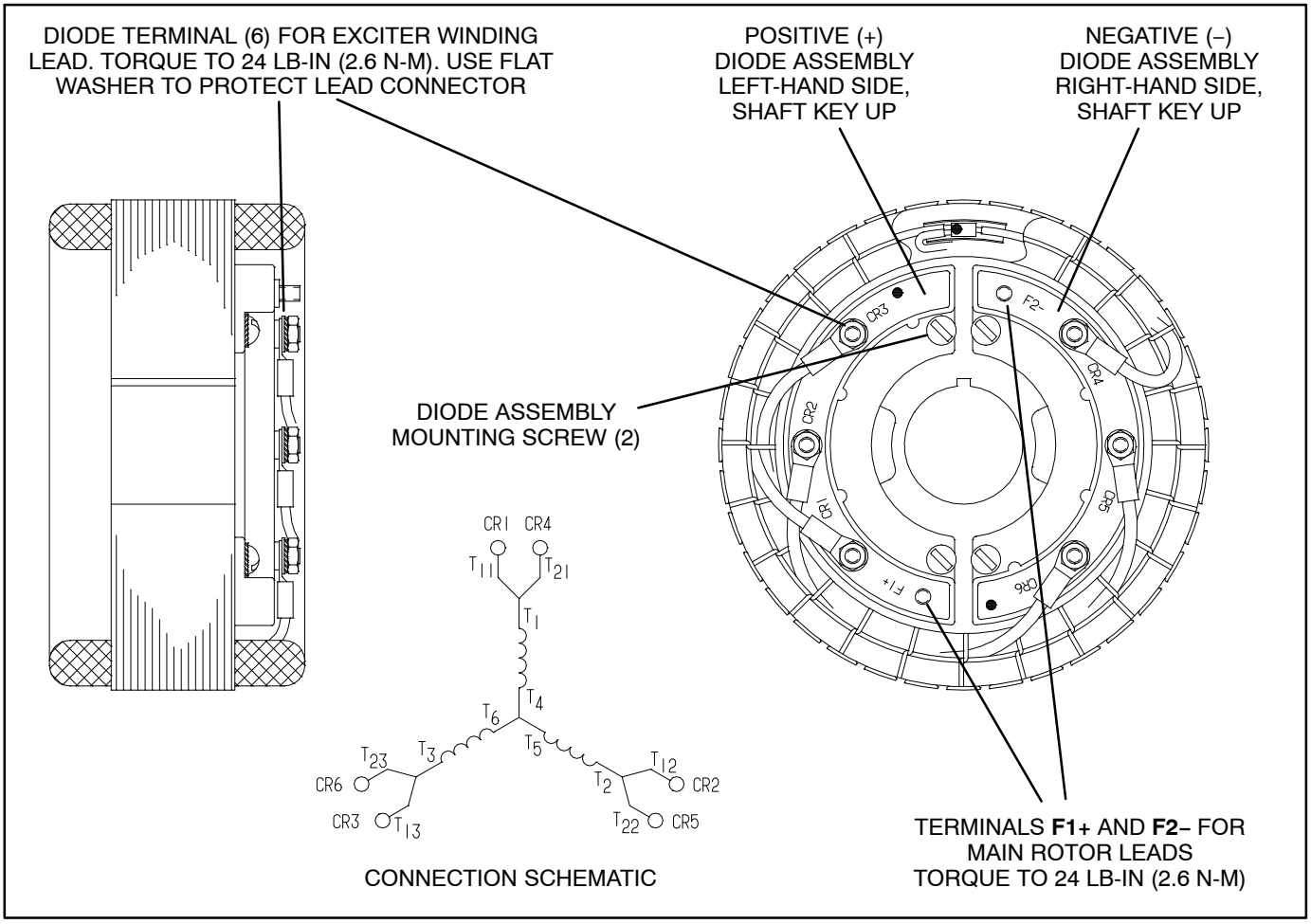


FIGURE 19. ROTATING RECTIFIER ASSEMBLY

Main Rotor

Winding Insulation Resistance: Disconnect the main rotor leads from terminals **F1+** and **F2+** on the rotating rectifier assemblies and isolate them from ground. Tag and mark each lead with its terminal number (**F1+** or **F2+**).

⚠ CAUTION ***Because of the opposing residual magnetism of the rotor, it might be difficult to re-establish self excitation if the polarity of the main rotor leads is reversed upon reassembly.***

Connect either or both leads to the megger and conduct the test as instructed under Testing Winding Insulation Resistance.

Winding Resistance: Disconnect the main rotor leads from terminals **F1+** and **F2+** on the rotating rectifier assemblies and measure electrical resistance between them. Replace the rotor if the resistance is not as specified in Table 4.

Reconnect the rotor leads and torque the terminals to 24 lb-in (2.7 N-m) when reassembling.

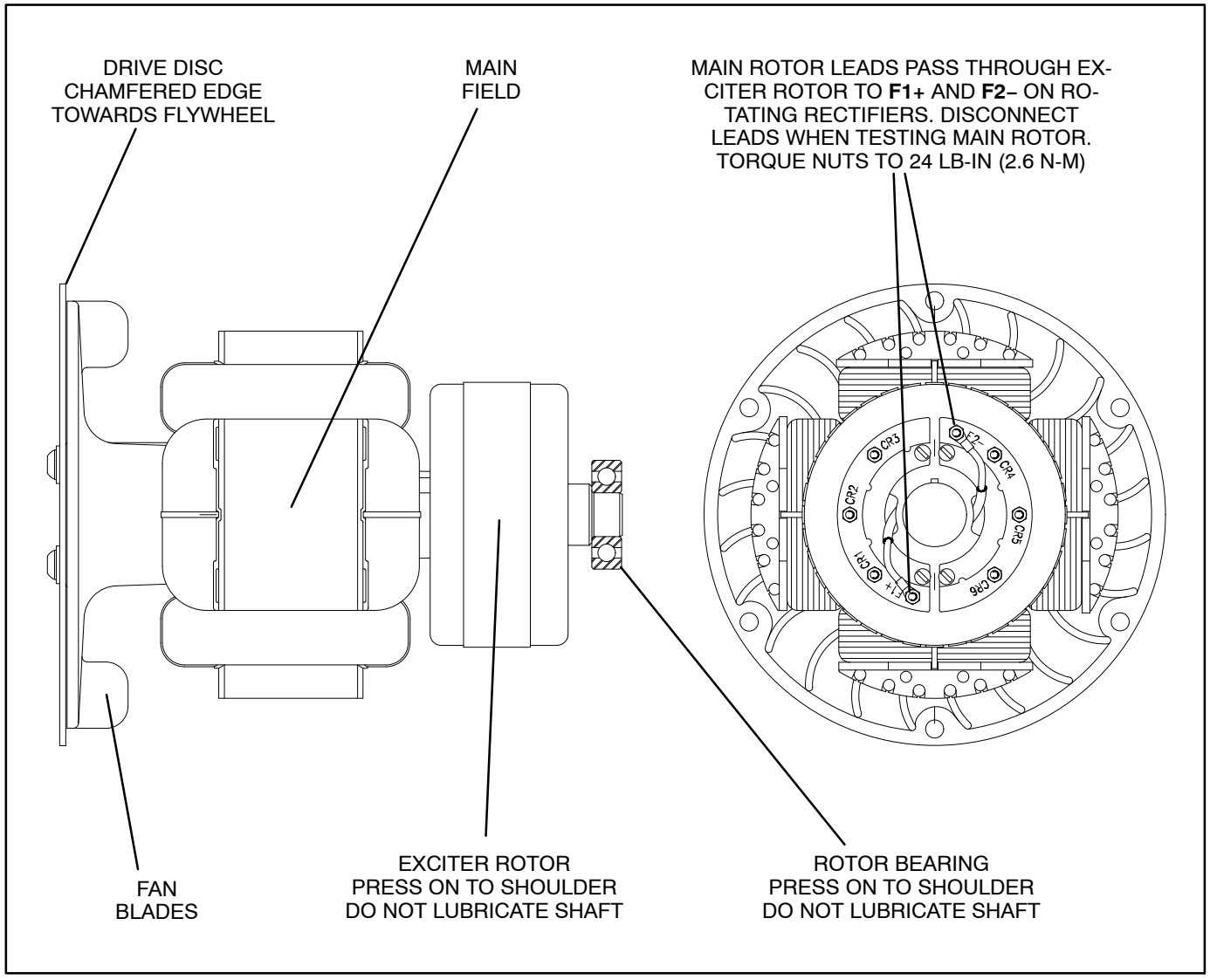


FIGURE 20. ROTOR ASSEMBLY

Main Stator

Quadrature Winding Insulation Resistance: Disconnect AVR connector P1/J1 inside the control box. Using the test adapter (p. 32), connect pin **P1-4** or **P1-5** to the megger and conduct the test as instructed under Testing Winding Insulation Resistance.

Quadrature Winding Resistance: Using the test adapter (p. 32), measure winding resistance between pins **P1-4** and **P1-5** with a Wheatstone bridge. Replace the stator assembly if the resistance is not as specified in Table 4.

Main Winding Insulation Resistance: Test each winding separately. Disconnect the winding lead from its grounded neutral connection and isolate it. Leave the other windings grounded. Connect either or both winding leads to the megger and conduct the test as instructed under Testing Winding Insulation Resistance.

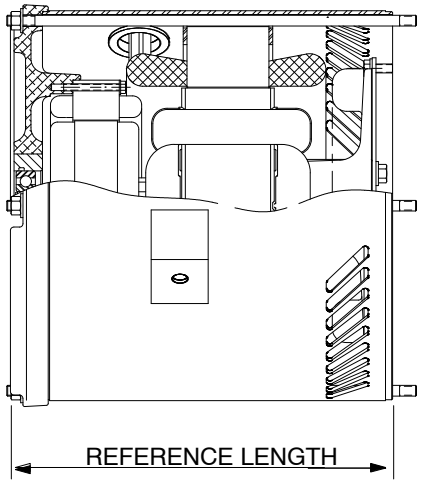
Main Winding Resistance: Disconnect all main stator leads from the terminals to which they are connected and measure resistance across the following lead pairs:

- 4-Lead Generators—**T1–T2** and **T3–T4**.
- 12-Lead Generators—**T1–T4**, **T2–T5**, **T3–T6**, **T7–T10**, **T8–T11**, **T9–T12**.

Replace the stator assembly if the resistance of any winding is not as specified in Table 4.

TABLE 4. GENERATOR STATOR AND ROTOR WINDING RESISTANCES

REFERENCE LENGTH MILLIMETERS (INCHES)[1]	MAIN WINDING RESISTANCE OHMS[2, 3]	QUADRATURE WINDING RESISTANCE OHMS[2]	MAIN ROTOR WINDING RESISTANCE OHMS[2]	EXCITER ROTOR WINDING RESISTANCE OHMS[2]	EXCITER STATOR WINDING RESISTANCE OHMS[2]
4-Lead Generators (Single-Phase)					
341 (13.4)	0.17–0.22	1.33–1.63	2.60–3.20	0.58–0.71	13–16
378 (14.9)	0.09–0.12	0.79–0.97	2.17–2.65	0.58–0.71	13–16
12-Lead Generators (Three-Phase)					
341 (13.4)	0.36–0.44	2.32–2.83	2.60–3.20	0.58–0.71	13–16
378 (14.9)	0.15–0.19	1.83–2.23	2.17–2.65	0.58–0.71	13–16



1. Measure this length to identify the generator. The corresponding rotor stack lengths are slightly greater.
2. If high, recheck winding resistance after the windings have cooled to room temperature.
3. The main windings are probably good if some of the resistances fall outside the range but are all within 10 percent of each other.

DISASSEMBLY

The generator is heavy. You will need an assistant and hoist of sufficient capacity.

WARNING ***Accidentally dropping the generator can damage it and cause severe personal injury or death. Use a hoist and straps of sufficient capacity and attach them so that the load cannot shift.***

Disconnect the negative (–) cable(s) at the battery(ies) to prevent the genset from starting.

WARNING ***Accidental starting can cause severe personal injury or death. Disconnect the negative (–) cable(s) at the battery(ies) to prevent the genset from starting.***

1. Disconnect all power output and remote control connections and conduit at the generator. For easier reconnections later, make sure each lead is clearly marked.
2. Disconnect engine harness connector P5/J5, AVR connectors P1/J1 and P2/J2, the connector P1 lead secured to the grounding stud inside the control box and the control box grounding strap secured to the generator. Remove the control box, output box and saddle as an assembly.
3. Hook the genset lifting eye with a hoist, remove the throughbolts in the two generator mounts, tip the generator end up slightly with the hoist and block the flywheel housing to support the engine while the generator is being serviced.
4. Cinch a strap around the middle of the generator stator and take up slack with the hoist.
5. Scribe lines before separating the end bell from the stator and the stator from the flywheel housing to register the parts for reassembly.
6. Remove the four nuts on the throughbolts and tap the end bell free of the stator.
7. Tap the stator free of the flywheel housing, carefully draw the stator straight back until it clears the ends of the throughbolts and remove the throughbolts.
8. Cinch a strap around the rotor and remove the six disc-to-flywheel bolts (Figure 17). When removed, cradle the rotor horizontally in wooden blocks to prevent damage to windings, laminations and drive disc.
9. Use a gear puller to remove the rotor bearing or exciter rotor (Figure 20).

REASSEMBLY

Reassembly is the reverse of disassembly. Note the following when reassembling the generator:

1. Press a new exciter rotor or rotor shaft bearing on up to its locating shoulder on the shaft. Do not lubricate the shaft (Figure 20).
2. Torque the six disc-to-hub bolts (Figure 17) to 50–57 N-m (37–42 lb-ft). Make sure that:
   A. The chamfered edge on the drive disc perimeter faces out to make assembly with the flywheel easier.
   B. The rounded edges of the washers are on the disc side.
3. Torque the six disc-to-flywheel bolts (Figure 17) to 27–31 N-m (20–23 lb-ft). Make sure the rounded edges of the washers are on the disc side.
4. Use the four throughbolts to help guide the stator on. Thread the ends with less thread into the flywheel housing and make sure the threads bottom.
5. Make sure the scribed stator-flywheel index lines (Step 5, Disassembly) register.
6. Torque the two exciter stator screws (Figure 18) to 11 N-m (8 lb-ft). The pole to which the leads are tied must be up.
7. Wipe the bearing bore in the end bell lightly with molybdenum disulfide grease and make sure the rubber O-ring (Figure 18) is in place.
8. Assemble the end bell to the stator, making sure the scribed index lines (Step 5, Disassembly) register and the rotor bearing seats fully in the bore. Pull the field leads out the same opening as the stator leads. Torque the nuts on the generator throughbolts to 38–43 N-m (28–32 lb-ft).
9. Secure the end bell cover plate and torque the four screws to 3.8 N-m (8 lb-in).
10. Reassemble all the remaining components. Make sure to resecure the ring terminals of grounding straps and leads with two star washers, one on each side, for good electrical continuity.

BASICS

Refer to Figure 21 while working through the following explanation.

1. The generator field (main rotor) is rotated by the engine to induce output current (AC) in the main stator windings.
2. Generator output is proportional to field strength, which is varied to match the load. Nominal output voltage and frequency are maintained by the AVR and engine governor, respectively.
3. Field strength is proportional to field current, which is supplied by the exciter through a full-wave rectifier bridge which converts exciter output (3-phase AC) to DC. The rectifier bridge (rotating rectifiers) is mounted on the rotor.
4. Exciter rotor output is proportional to exciter field (stator) strength, which, in turn, is proportional to exciter field current.
5. The AVR regulates exciter field current by comparing generator output voltage and frequency with reference values. Power for exciter field current is supplied by quadrature windings in the main stator assembly.
6. Residual field magnetism and a permanent magnet in one of the exciter stator poles initiates “self-excitation” during startups.

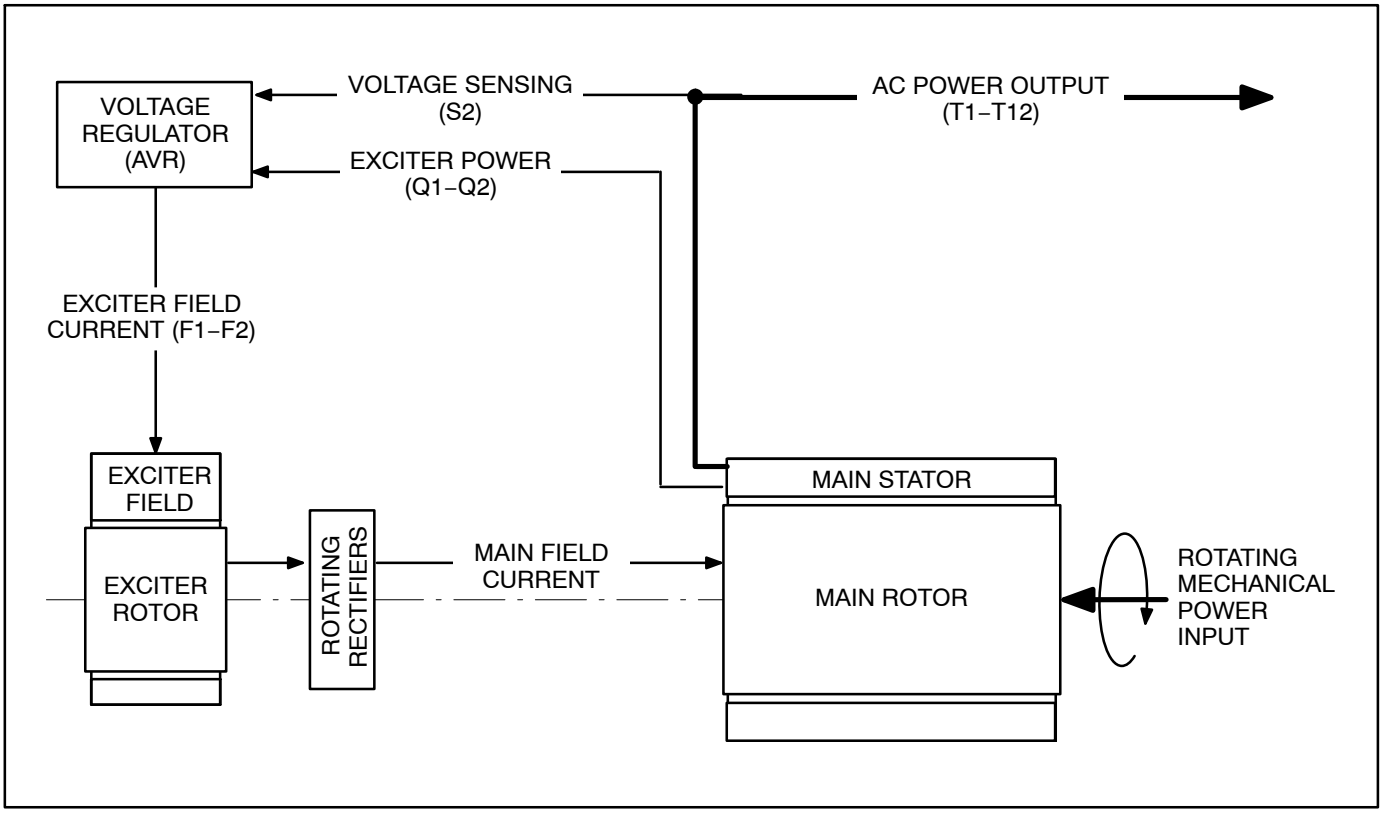


FIGURE 21. GENERATOR BASICS

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Adjusting the Fuel Stop and Frequency

FUEL STOP (EXCEPT MDKAL SPEC A)

1. Make sure the fuel stop solenoid is secure.
2. If the seal on the lever stop screw is broken:
   A. Back out the stop screw so that it does not touch the governor stop lever when turned clockwise as far as it will go.
   B. Turn the screw back in one half turn past the point where it just touches the lever.
   C. Set the locknut and seal the adjustment.
3. Push the solenoid in until it seats, rotate the stop lever towards the solenoid and adjust the length of the link so that its end lines up with the hole in the lever. Then increase the length one turn (counterclockwise) to make sure the solenoid will seat and open its AUX contacts when energized.
4. Set the locknut and secure the link and lever with the spring clip.

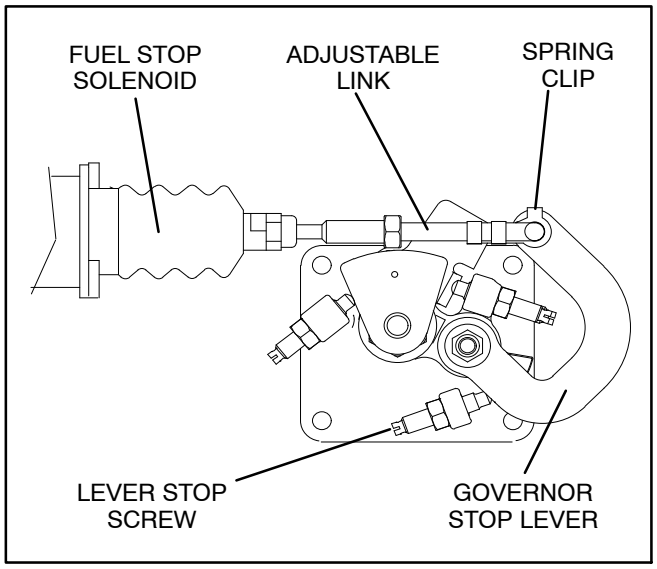


FIGURE 22. FUEL STOP ADJUSTMENT (EXCEPT MDKAL SPEC A)

FREQUENCY (EXCEPT MDKAL SPEC A)

50 Hz Frequency Adjustment

1. Make sure the AVR frequency selector switch (p. 31) is set at **50 Hz**.
2. Back off screw **A** (Figure 23) to free the front (60 Hz) lever and prevent overspeed shutdown, snug screw **D** and set the locknuts.
3. Disconnect all loads and start the genset.
4. Back off screw **C**, turn screw **B** to obtain a *no-load frequency* of **52.5 Hz**, snug screw **C** and set the locknuts. There is no droop adjustment.
5. Readjust frequency and voltage (p. 31) as necessary.

60 Hz Frequency Adjustment

1. First adjust genset frequency to 50 Hz if the adjustment seal on screw **B** (Figure 23) is broken. Snug screw **C** if necessary.
2. Stop the genset, reset the AVR frequency selector switch (p. 31) to **60 Hz** and restart.
3. Back off screw **D**, turn screw **A** to obtain a *no-load frequency* of **63 Hz**, snug screw **D** and set the locknuts. There is no droop adjustment.
4. Readjust frequency and voltage (p. 31) as necessary.

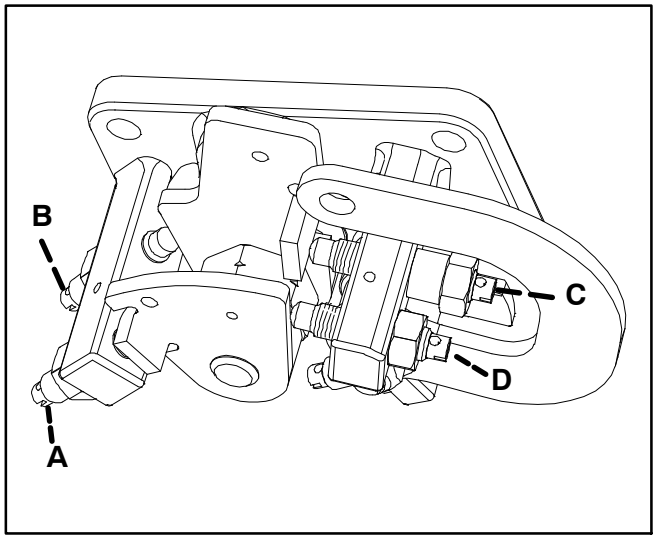


FIGURE 23. FREQUENCY ADJUSTMENT (EXCEPT MDKAL SPEC A)

FUEL STOP (MDKAL SPEC A)

1. Make sure the fuel stop solenoid is securely mounted.
2. If the seal on the lever stop screw is broken:
   A. Back out the stop screw so that it does not touch the governor stop lever when turned clockwise as far as it will go.
   B. Turn the screw back in one half turn past the point where it just touches the lever.
   C. Set the locknut and seal the adjustment.
3. Push the solenoid in until it seats, rotate the stop lever towards the solenoid and adjust the length of the link so that its end lines up with the hole in the lever. Then increase the length one turn (counterclockwise) to make sure the solenoid will seat and open its AUX contacts when energized.
4. Set the locknut and secure the link and lever with the spring clip.

FREQUENCY (MDKAL SPEC A)

1. Check the position of the AVR frequency selector switch (p. 31) and set as required for **50 Hz** or **60 Hz**.
2. Make sure that the internal governor spring is right for **50 Hz** or **60 Hz**. Change the spring if necessary in accordance with the *Engine Workshop Manual.*
3. Disconnect all loads from the generator and start the genset.
4. Back out the speed stop screw (Figure 24) and turn the speed screw to obtain the required *no-load frequency* of **52.5 Hz** or **63 Hz**. Snug the speed stop screw and locknuts. There is no droop adjustment.
5. Readjust frequency and voltage (p. 31) as necessary.

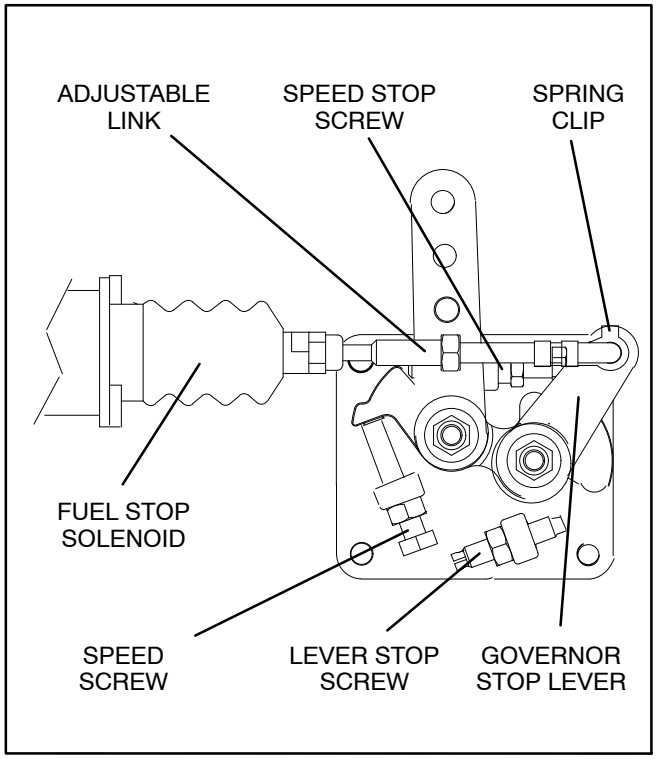


FIGURE 24. FUEL STOP AND FREQUENCY ADJUSTMENTS (MDKAL SPEC A)

Troubleshooting

Fault Circuits

"Check Generator" Fault: If the "Check Generator" fault breaker trips, as indicated by the extended reset button, the genset may have been overloaded. *Push the reset button.*

"Check Engine" Fault: The "Check Engine" faults are: low engine oil pressure, high coolant temperature, low coolant level (optional), high exhaust temperature, over/underspeed and over/undervoltage. The "Check Engine" fault breaker will trip, as indicated by the extended reset button. *Push the reset button.*

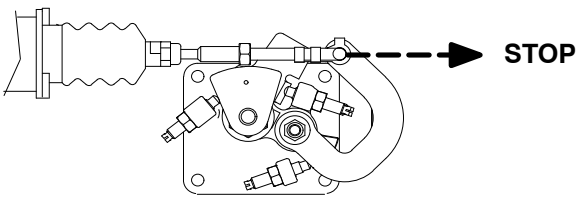
Engine Gauges

Time can be saved if abnormal engine gauge readings were noted before shutdown; that is, whether shutdown was due to low oil pressure or to high engine temperature. Shutdown occurs when oil pressure falls below 14 psi (97 kPa) or engine temperature reaches 222°F (106°C).

Troubleshooting Tables

The following troubleshooting tables are designed to help you think through genset problems. The problem could be as simple as an empty fuel tank, closed fuel shutoff valve or tripped circuit breaker.

⚠ CAUTION ***A replacement AVR can be damaged if troubleshooting does not uncover generator repairs that may be required.***

ENGINE DOES NOT STOP RUNNING	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Faulty stop solenoid or governor	a. Push the governor stop lever to the right and hold it there until the engine stops (see figure). b. Make sure that the fuel stop solenoid is mounted securely. c. Disconnect the linkage at the governor stop lever and check for internal binding in the fuel stop solenoid. Replace the solenoid if the armature binds or the internal spring does not positively and smoothly push the armature out to its fully extended position. d. Readjust the fuel stop link (p. 41 or 42). e. Repair the internal governor mechanism according to the *Engine Workshop Manual*. 

ENGINE DOES NOT CRANK FROM REMOTE PANEL	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Tripped DC Circuit Breaker CB1	a. Push ON to reset (p. 27). b. If the breaker trips again, reconnect the glow plug lead if loose and touching ground (p. 25).
2. OFF or tripped Emergency Stop Breaker CB4	a. Push ON to reset (p. 27). b. If the breaker trips again, open the control box (p. 27) and reconnect any loose wiring that may be touching ground.
3. “Check Engine” fault	See “CHECK ENGINE” FAULT SHUTDOWN.
4. Fault in remote circuit	If the genset starts at the genset panel, repair the remote circuit as necessary.

ENGINE DOES NOT CRANK FROM GENSET PANEL	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Tripped DC Circuit Breaker CB1	a. Push ON to reset (p. 27). b. If the breaker trips again, reconnect the glow plug lead if loose and touching ground (p. 25).
2. OFF or tripped Emergency Stop Breaker CB4	a. Push ON to reset (p. 27). b. If the breaker trips again, open the control box (p. 27) and reconnect any loose wiring that may be touching ground.
3. “Check Engine” fault	See “CHECK ENGINE” FAULT SHUTDOWN.

ENGINE DOES NOT CRANK FROM GENSET PANEL (CONT.)	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
4. Low cranking voltage	a. Clean and tighten or replace the positive (+) and negative (–) battery cable connectors and cables. b. Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80°F (27°C). c. Readjust or replace the V-belt if loose or worn (p. 21). d. Repair or replace the battery charging alternator (G1) if normal battery charging voltage is not 12.5–15 volts for a 12 volt battery system or 24–27 volts for a 24 volt battery system.
5. Disconnected engine harness connector J5/P5	Reconnect J5/P5.
6. Faulty starter motor/solenoid	Check for B+ at terminal SW on the starter solenoid while holding control switch S1 at Start: • ***B+ present:*** Repair or replace the starter/solenoid. • ***B+ absent:*** Go to Step 7.

7. Faulty stop solenoid or link adjustment (AUX contacts must open to energize relay K1) or governor	Hold control switch S1 at Start and check for solenoid action. If none, disconnect the red lead (solenoid + POS terminal) and check for B+ at the end of the lead:
	• ***B+ absent:*** Go to Step 8.
	• ***B+ present:*** Reconnect the red lead, disconnect the link and hold S1 at Start:
	  • ***Solenoid pulls in and engine cranks:***
	  • Readjust the fuel stop link (p. 41 or 42).
	  • Check for internal binding of the governor mechanism and repair as necessary according to the *Engine Shop Manual*.
	  • ***Solenoid pulls in but engine does not crank:*** Disconnect the white wire (AUX) and replace the solenoid if there is B+ at the AUX terminal.
	  • ***Solenoid does not pull in:*** Replace the solenoid.

ENGINE DOES NOT CRANK FROM GENSET PANEL (CONT.)	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
8. Faulty start/run control circuit	a. Open the control box (p. 27) and check for B+ at: • The load terminal on CB1 • Terminal 2 on CB4 • Terminal 3 on CB2 • Terminal 2 on switch S1. Repair or reconnect wiring and components as necessary. b. Disconnect the leads from control switch S1. Replace switch S1 if contacts 2–3 are open when the switch is held at Start. c. Disconnect the leads from terminals 9 and 10 on start disconnect relay K4. Replace relay K4 if 9–10 (NC) is open. d. Remove starter relay K1 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K1 if contacts 87–30 (NO) do not close. e. Remove start relay K2 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K2 if contacts 87–30 (NO) do not close. f. Remove run relay K3 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K3 if contacts 87–30 (NO) do not close. g. Remove fueling relay K8 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K8 if contacts 87–30 (NO) do not close. h. If the relays and switch are good, reconnect or repair wiring as necessary.

ENGINE CRANKS BUT DOES NOT START

⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***

Possible Cause	Corrective Action
1. Blocked or restricted fuel supply	a. Open any closed shutoff valve. b. Check fuel level and refill as necessary. c. Prime the fuel system (p. 25). d. Check for fuel (air) leaks at all fittings and tighten as necessary. e. Replace the fuel filter (p. 24) and any other filter in the fuel supply system. f. Disconnect the two leads to the fuel pump (p. 28) and check for B+ at the red lead while cranking and for ground continuity at the black lead. • If there is no B+ at the red lead, check for and reconnect or repair wiring between run relay K3 terminal 87 and engine harness connector pin J5–3. • Repair or replace the black lead if there is no ground continuity. • If there is B+ and ground continuity, go to Step g. g. Check for fuel pump operation by priming with the low pressure bleed open (p. 25). Replace the fuel pump (p. 28) if it does not pump. h. Check fuel pump (p. 28) static pressure by connecting a 0–15 psi (0–100 kPa) gauge at the outlet. Replace the pump if fuel pressure does not stabilize at 3.5–6 psi (24–41 kPa).
2. Blocked air inlet	Service as necessary.
3. Low engine temperature	a. Plug in, repair or install heaters for the engine coolant and oil. b. Replace the engine oil if it is not of the recommended viscosity for the ambient temperature.

ENGINE CRANKS BUT DOES NOT START (CONT.)	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
4. Low cranking voltage	a. Clean and tighten or replace the positive (+) and negative (–) battery cable connectors and cables. b. Recharge or replace the battery. Specific gravity for a fully charged battery is approximately 1.260 at 80° F (27° C). c. Readjust or replace the V-belt if loose or worn (p. 21). d. Repair or replace the battery charging alternator (G1) if normal battery charging voltage is not 12.5–15 volts for a 12 volt battery system or 24–27 volts for a 24 volt battery system.
5. Faulty glow plugs	a. Reconnect the glow plug lead (p. 25) if loose. b. Check for B+ at the glow plug bus bar while cranking. • ***B+ absent:*** • Open the control box (p. 27) and remove relay K10 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K10 if contacts 87–30 (NO) do not close. • Remove relay K5 from its socket. Apply battery voltage across coil terminals 85–86. Replace relay K5 if contacts 87–30 (NO) do not close. • If the relays are good, reconnect or repair wiring as necessary. • ***B+ present:*** Remove the glow plug bus bar and check for ground continuity across each glow plug. Replace all three (four) glow plugs if any glow plug is open. **Note: If a glow plug does not come out after unscrewing it, or the end has broken off, it will be necessary to remove the engine head to remove the glow plug and/or debris from the cylinder. (Glow plugs can swell if preheat voltage is greater than 14 volts, such as when a battery booster is used for starting.)**

ENGINE STARTS BUT DOES NOT RUN	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. "Check Generator" fault	a. Reset "Check Generator" fault breaker CB5 (p. 27). b. Run with fewer loads, especially when low power factor loads are connected or large motor loads are cycling on and off.
2. Faulty start disconnect circuit	a. Open the control box (p. 27) and check for B+ at terminal 6 on start disconnect relay K4. Reconnect wiring as necessary. b. If loose, reconnect wiring at terminals 1 and 2 on start disconnect relay K4 and terminals 1 and 2 on "Check Generator" fault breaker CB5. c. Ground terminal 5 on start disconnect relay K4 (p. 31) when the engine starts up: • ***Engine stops:*** Replace relay K4. • ***Engine runs:*** Check generator output voltage: • ***Normal output:*** Disconnect AVR connector P2/J2. Check for ground continuity at pin P2–4 and continuity between pin P2–1 and K4–5. Reconnect or repair wiring as necessary. If that does not help, replace the AVR. • ***No output:*** • Check electrical continuity across fault breaker CB5 and replace if necessary. • Flash the field (p. 31). • If there is still no output voltage, conduct the AVR/GENERATOR TEST (p. 31). Based on the results, replace the AVR or go to FAULTY GENERATOR.

"CHECK ENGINE" FAULT SHUTDOWN

⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***

Possible Cause	Corrective Action
1. High exhaust temperature (check whether exhaust hose feels hotter than usual)	a. Open the sea cock. b. Remove blockage in the sea water strainer. c. Prime the sea water pump (p. 23). d. Replace the sea water pump impeller (p. 23). e. Clean the heat exchanger (p. 23). f. Remove blockage covering the sea water hull strainer.
2. Low engine oil pressure	a. Check oil level, repair leaks and fill to proper level (p. 18). b. Service the engine lubrication system in accordance with the *Engine Workshop Manual*. c. Replace switch S4 if it closes above 14 psi (97 kPa).
3. High engine temperature or low coolant level	a. Check coolant level, repair leaks and fill to proper level (p. 19). b. Check V-belt tension and adjust as necessary (p. 21). c. Clean and service the cooling system as required to restore full cooling capacity (p. 19). d. Replace switch S2 if it closes below 222°F (106°C).
4. Improper AVR selector position (***60 Hz gensets***)	Check whether the 50/60 Hz selector switch (p. 31) is at 50 Hz and set it to 60 Hz. Readjust frequency (p. 41 or 42). (Overspeed cutout when the AVR is set at 50 Hz is approximately 64 Hz.)
5. Over/Underspeed	a. Readjust frequency (p. 41 or 42). b. Check for internal binding of the governor mechanism and repair as necessary according to the *Engine Shop Manual*. c. Run with fewer loads, especially when low power factor loads are connected or large motor loads are cycling on and off.

ENGINE UNSTABLE OR LACKS POWER

⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***

Possible Cause	Corrective Action
1. Air leaks or fuel restriction	a. Check for fuel (air) leaks at all fittings and tighten as necessary. b. Replace the fuel filter (p. 24) and any other filter in the fuel supply system. c. Check fuel pump (p. 28) static pressure by connecting a 0–15 psi (0–100 kPa) gauge at the outlet. Replace the pump if fuel pressure does not stabilize at 3.5–6 psi (24–41 kPa).
2. Improper 50/60 Hz selector switch position on AVR	Set the 50/60 Hz selector switch in the proper position for the application (p. 31).
3. Misadjusted frequency or fuel stop linkage or faulty governor	a. Readjust frequency (p. 41 or 42). b. Readjust the fuel stop link (p. 41 or 42). c. Check for internal binding of the governor mechanism and repair as necessary in accordance with the *Engine Shop Manual*.
4. Air trapped in water separator	a. Reconnect the fuel lines to any alternative fittings on the water separator. b. Install a different model of water separator. c. Relocate the genset fuel pickup tube to reduce pickup of aerated fuel returned from the propulsion engines.
5. Contaminated fuel	Connect the engine to a container of known fuel quality. Replace the fuel in the supply tank if performance improves.
6. Worn engine or fuel injection system or improper injection timing	Service in accordance with the *Engine Workshop Manual*.

NO OUTPUT VOLTAGE	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Line circuit breakers **OFF**	Find out why the breaker was turned **OFF**, make sure it is safe to reconnect power and then throw **ON** the breaker.
2. Line circuit breakers tripped	Clear the short circuit or ground fault that caused tripping and then **RESET** the breaker.
3. Line circuit breakers faulty	Shut down the genset, disconnect all other sources of power, **RESET** the breaker and then check for electrical continuity across each pole. Replace a breaker if there is measurable resistance across any pole.

FAULTY GENERATOR (PAGE 31)	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Open exciter field windings	Check and replace as necessary (p. 34)
2. Open exciter rotor windings	Check and replace as necessary (p. 35)
3. Faulty rotating rectifier assembly	Check and replace as necessary (p. 35)
4. Open main rotor windings	Check and replace as necessary (p. 36)
5. Open stator windings (main or quadrature)	Check and replace as necessary (p. 37)

OUTPUT VOLTAGE TOO HIGH OR TOO LOW

⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***

Possible Cause	Corrective Action
1. Improper voltage adjustment	Readjust voltage (p. 31).
2. Improper frequency adjustment	Readjust frequency (p. 41 or 42).
3. Improper generator connections	Reconnect according to Figure 27 (p. 57).
4. Faulty rotating rectifier assembly	Check and replace as necessary (p. 35).
5. Shorted quadrature winding	Check and replace as necessary (p. 37).
6. Faulty voltage regulator	Replace the voltage regulator (p. 31).

UNSTABLE OUTPUT VOLTAGE

⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***

Possible Cause	Corrective Action
1. Improper AVR selector position (***50 Hz gensets***)	Check whether the 50/60 Hz selector switch (p. 31) is at 60 Hz and set it to 50 Hz. Readjust frequency (p. 41 or 42). (Because frequency is below 60 Hz, the AVR will attempt to "unload" the engine by reducing voltage.)
2. Improper frequency adjustment	Readjust frequency (p. 41 or 42).
3. Improper voltage adjustment	Readjust output voltage (p. 31).
4. Unstable engine speed	See ENGINE UNSTABLE OR LACKS POWER.

UNSTABLE OUTPUT VOLTAGE (CONT.)	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
5. Unevenly distributed loads	Measure output current in each phase (leg) and redistribute the loads as necessary.
6. Faulty voltage regulator	Replace the voltage regulator (p. 31).

UNBALANCED PHASE CURRENTS	
⚠ WARNING ***There are hazards present in troubleshooting that can cause equipment damage, severe personal injury or death. Troubleshooting must be performed by qualified persons who know about the hazards of fuel, electricity and machinery. Read Safety Precautions and observe all instructions and precautions in this manual.***	
Possible Cause	**Corrective Action**
1. Unevenly distributed loads	Measure output current in each phase (leg) and redistribute the loads as necessary.
2. Improper generator connections	Reconnect according to Figure 27 (p. 57).
3. Faulty stator windings	Check stator winding resistances (p. 37).
4. Ground or short in load circuit	Service the faulty equipment as necessary.

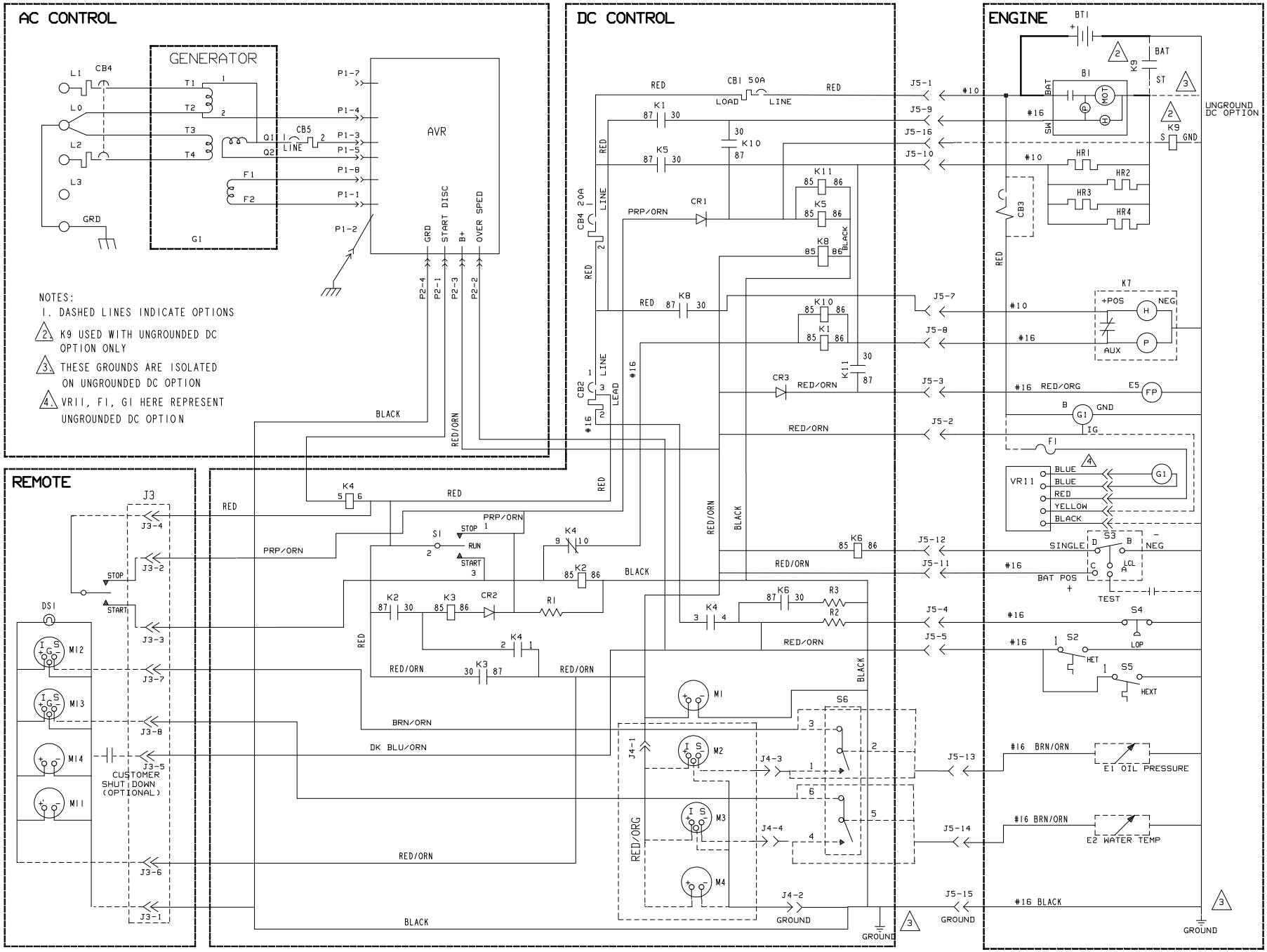


FIGURE 25. DC CONTROL SCHEMATIC

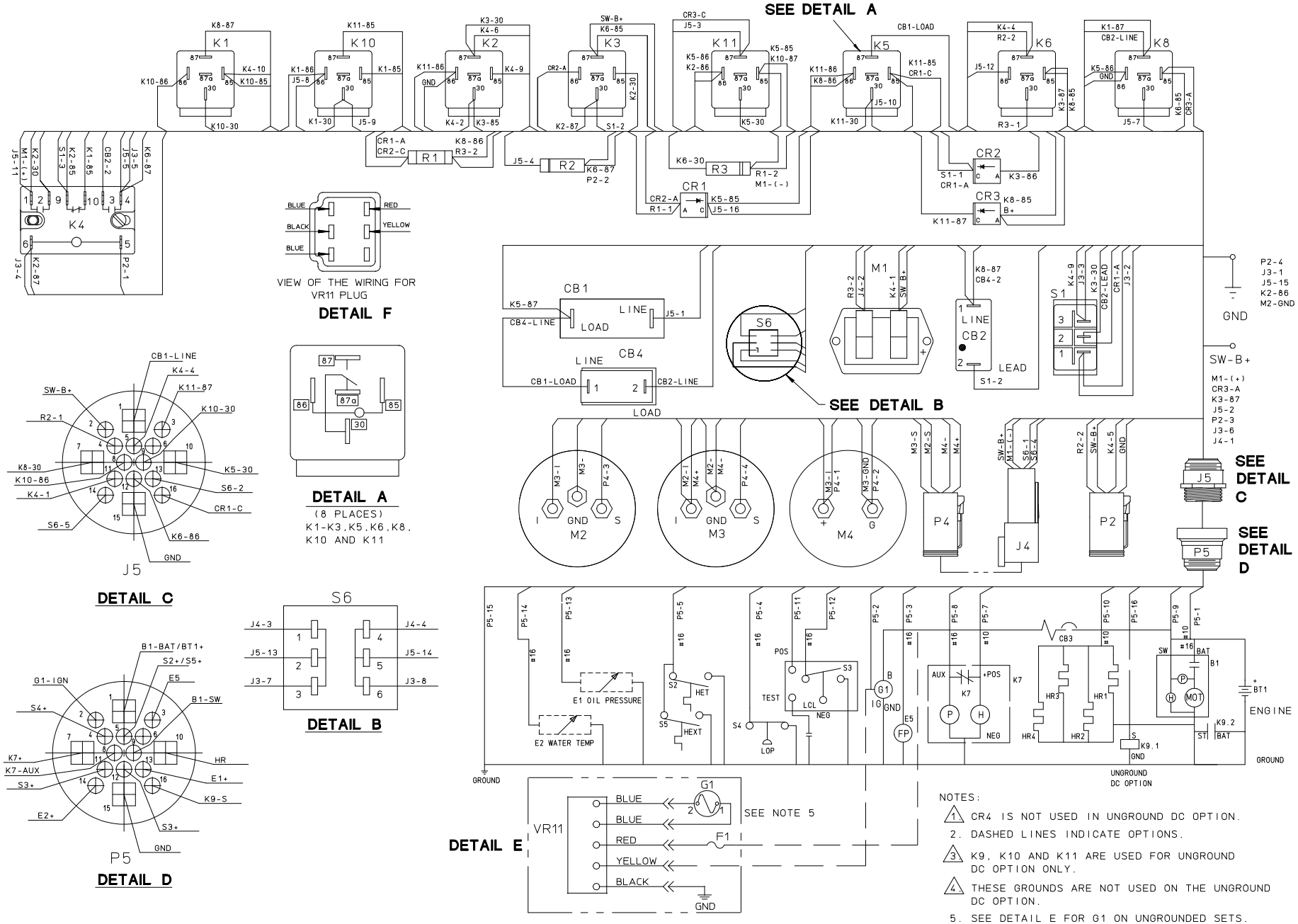
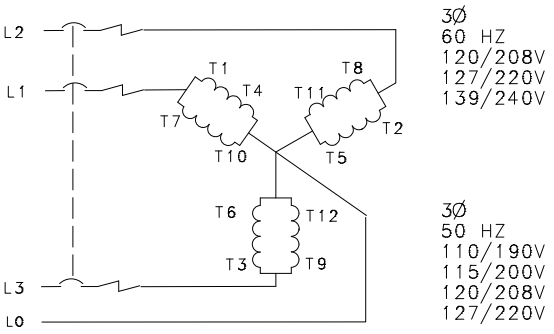


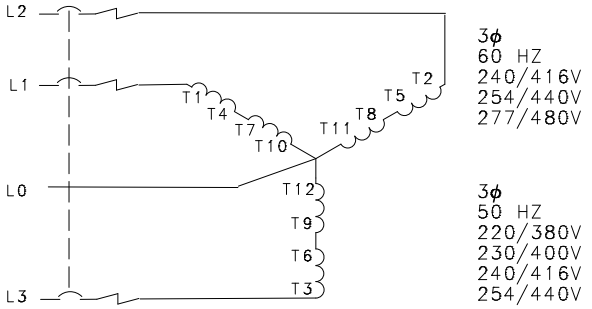
FIGURE 26. WIRING HARNESS DIAGRAM

3-PHASE GENERATORS



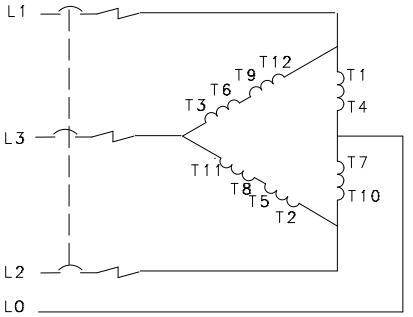
3Ø
60 HZ
120/208V
127/220V
139/240V

3Ø
50 HZ
110/190V
115/200V
120/208V
127/220V



3ϕ
60 HZ
240/416V
254/440V
277/480V

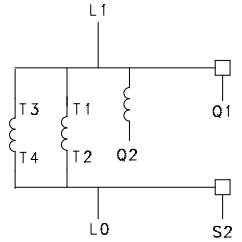
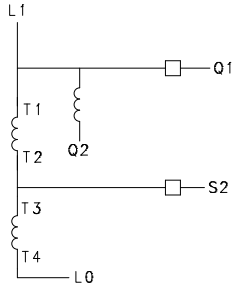
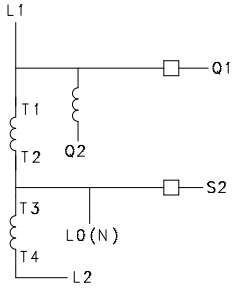
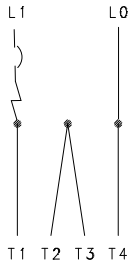
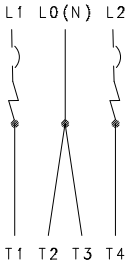
3ϕ
50 HZ
220/380V
230/400V
240/416V
254/440V

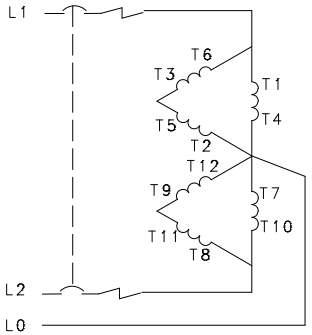


3ϕ
50 HZ
110/220V
115/230V
120/240V

3ϕ
60 HZ
120/240V
110/220V
115/230V

1-PHASE GENERATORS

	A	B	C	HZ
VOLTAGE	100 120	200 240	100/200 120/240	60
	110 115	220 230	110/220 115/230	50
SCHEMATIC				
DIAGRAM				



1Ø
50 HZ
110/220V
115/230V
120/240V

1ϕ
60 HZ
120/240V

FIGURE 27. GENERATOR RECONNECTION DIAGRAMS

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