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# **Service Manual**

## **MDKAU**

**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

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Thoroughly read the **OPERATOR'S MANUAL** before operating the genset. Safe operation and top performance can only be attained when equipment is operated and maintained properly.

The following symbols in this manual alert you to potential hazards to operators, 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, hot engine coolant, moving parts and batteries present hazards which can result in severe personal injury or death.

## GENERAL PRECAUTIONS

- Keep children away from the genset.
- Do not step on the genset when entering or leaving the generator room. Parts can bend or break leading to electrical shorts or to fuel, coolant or exhaust leaks.
- To prevent accidental or remote starting while working on the genset, disconnect the negative (–) battery cable at the battery.
- Let the engine cool down before removing the coolant pressure cap or opening the coolant drain. Hot coolant under pressure can spray and cause severe burns.
- Do not use evaporative starting fluids. They are highly explosive.
- Keep the genset, drip pan and compartment clean. Oily rags can catch fire. Gear stowed in the compartment can restrict cooling.

- Make sure all fasteners are secure and properly torqued.
- Do not work on the genset when mentally or physically fatigued or after having consumed alcohol or drugs.
- You must be trained and experienced to make 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 U. S. state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Ethylene glycol, used as engine antifreeze, is toxic to humans and animals. Clean up spills and dispose of used engine coolant in accordance with local environmental regulations.
- Keep multi-class ABC fire extinguishers handy. Class A fires involve ordinary combustible materials such as wood and cloth; Class B fires, combustible and flammable liquid fuels and gaseous fuels; Class C fires, live electrical equipment. (ref. NFPA No. 10)
- Genset installation and operation must comply with all applicable local, state and federal codes and regulations.

## GENERATOR VOLTAGE IS DEADLY

- Generator electrical output connections must be made by a trained and experienced electrician in accordance with applicable codes.
- The genset must not be connected to shore power or to any other source of electrical power. Back-feed to shore power can cause electric shock resulting in severe personal injury or death and damage to equipment. 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, stand on a dry wooden platform or rubber insulating mat and use tools with insulated handles.

## ENGINE EXHAUST IS DEADLY

- Never sleep in the boat while the genset is running unless the boat is equipped with properly working carbon monoxide detectors.
- 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.
- Inspect for exhaust leaks every startup and after every eight hours of operation.
- For more information about carbon monoxide see American Boat and Yacht Council (ABYC) publication TH-22—*Educational Information About Carbon Monoxide*.

## DIESEL FUEL IS COMBUSTIBLE

- Do not smoke or turn electrical switches ON or OFF where fuel fumes are present or in areas sharing ventilation with fuel tanks or equipment. Keep flames, sparks, pilot lights, arc-producing equipment and all other sources of ignition well away.
- Fuel lines must be secured, free of leaks and separated or shielded from electrical wiring.

## BATTERY GAS IS EXPLOSIVE

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

## 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, and other moving parts.

## FLAMMABLE VAPOR ENVIRONMENT

Flammable vapor can cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury or death. ***Do not operate a diesel-powered genset in a flammable vapor environment created by fuel spill, leak, etc.*** The owners and operators of the genset are solely responsible for operating the genset safely.

**POST THESE SUGGESTIONS IN POTENTIAL HAZARD AREAS OF THE BOAT**

# 1. Introduction

## ABOUT THIS MANUAL

This is the service manual for the MDKAU Series of generator sets (gensets). Read and carefully observe all of the instructions and precautions in this manual.

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

**⚠ WARNING** *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.*

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

See the Parts Manual for part identification numbers and required quantities and for exploded views of the genset subassemblies. Genuine Onan® replacement parts are recommended for best results.

When contacting Onan for parts and product information, be ready to provide the model and serial numbers on the genset nameplate. Figure 1-1 illustrates the nameplate and its location. The numbers in the gray boxes are typical model and serial numbers. Every character in these numbers is significant. (The last character of the model number is the specification letter, which is important for obtaining the right parts.)

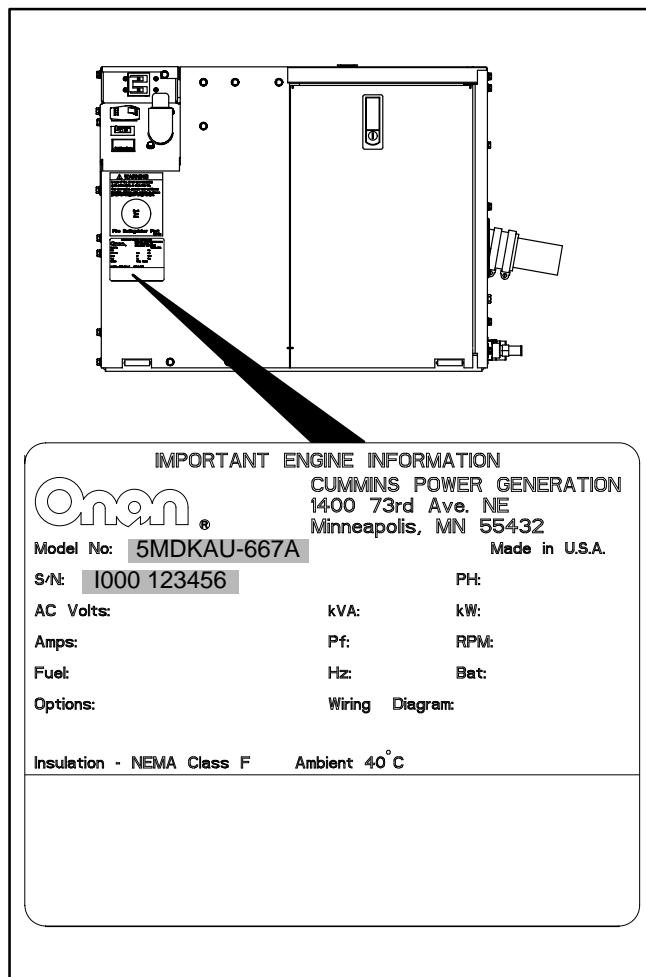


FIGURE 1-1. TYPICAL NAMEPLATE



## FUEL RECOMMENDATIONS

High quality fuel is necessary for good performance and long engine life. Use No. 2 diesel fuel (American Society for Testing and Materials [ASTM] Grade 2-D). The Cetane number should not be less than 45 and sulfur content 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° F (6° C) 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 multi-class ABC fire extinguisher handy.*

## ENGINE OIL RECOMMENDATIONS

Use API (American Petroleum Institute) performance Class **CH-4**, **CG-4** or **CF-4** engine oil, which may be in combination with performance Class SJ, SH or SG (for example: SJ/CH-4). Also look for the SAE (Society of Automotive Engineers) viscosity grade. Referring to Figure 1-2, choose the viscosity grade appropriate for the ambient temperatures expected until the next scheduled oil change. Multi-grade oils such as SAE 15W-40 are recommended for year-round use.

## STARTING BATTERIES

The genset requires a 12 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* (Page 1-3) for battery requirements and *Periodic Maintenance* (Page 3-6) for battery care.

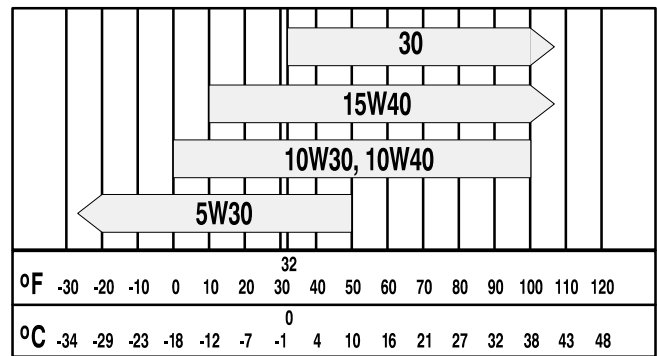


FIGURE 1-2. SAE VISCOSITY GRADE vs. AMBIENT TEMPERATURE

## SPECIFICATIONS

<b>GENERATOR:</b> Two-Bearing, 2-Pole Rotating Field, Microprocessor Regulated. See Genset Nameplate for Rating		
<b>FUEL CONSUMPTION:</b>		
60 Hz:	Full Load Half Load	0.60 gph (2.3 liter/hr) 0.35 gph (1.3 liter/hr)
50 Hz:	Full Load Half Load	0.50 gph (1.9 liter/hr) 0.29 gph (1.1 liter/hr)
Engine/Generator Speed:		
60 Hz		2900/3600 rpm
50 Hz		2400/3000 rpm
<b>ENGINE:</b> 4-Stroke Cycle, Indirect Injection Diesel, Water Cooled, Microprocessor Governed (Isochronous)		
Number of Cylinders		2
Bore		2.52 inch (64 mm)
Stroke		2.45 inch (62.2 mm)
Displacement		24.41 inch <sup>3</sup> (400 cm <sup>3</sup> )
Compression Ratio		23:1
Firing Order (Clockwise Rotation)		1-2
Fuel Injection Timing		18° – 20° BTDC
Fuel Injection Pressure		1991 psi (13.73 MPa)
Valve Lash (cold)		0.0059 – 0.0073 INCH (0.145 – 0.185 MM)
Engine Oil Capacity		2.2 quart (2.1 liter)
Engine Oil Drain Connection		3/8 NPT
Coolant Capacity		2.2 quart (2.1 liter)
Coolant Flow:	60 Hz 50 Hz	3.5 gpm (13 liter/min) 3.0 gpm (16 liter/min)
Raw Water Flow:	60 Hz 50 Hz	5.0 gpm (19 liter/min) 4.0 gpm (15 liter/min)
Maximum Raw Water Pump Lift		4 feet (1.2 m) with 5/8 inch ID hose
Raw Water Inlet Connection		5/8 inch (15.9 mm) ID Hose
Maximum Fuel Pump Lift		4 feet (1.2 m) with 3/8 inch ID fuel line
Recommended Fuel Line Size		3/8 inch (9 mm) ID
Fuel Supply Connection		1/8 NPT female
Fuel Return Connection		1/8 NPT female
Maximum Exhaust Back Pressure		3 INCH (76 MM) HG
Wet Exhaust Outlet Connection		2.0 INCH (50.8 MM) ID HOSE
Combustion Air		18 CFM (30 M <sup>3</sup> /HR)
Generator Cooling Air		60-80 CFM (100-135 M <sup>3</sup> /HR)
<b>BATTERIES:</b>		
Nominal Battery Voltage		12 volts
Minimum CCA Rating		360 amps
Battery Charging Output		10 amps
<b>SIZE, WEIGHT, NOISE:</b>		
Size: L x W x H		26 x 20.1 x 20.6 inch (662 x 511 x 524 mm)
Weight (dry)		350 lbs (159 kg)
Noise:	60 Hz 50 Hz	71 dB(A) 68 dB(A)

## 2. Operation

### CONTROL PANEL

#### Genset (Local) Control Panel

The control panel is located in the front, upper left hand corner of the genset (Figure 2-1).

**Control Switch** – This switch is used to prime the fuel system, start and stop the genset and display the shutdown codes.

- Hold the switch in its **START** position to pre-heat, crank and start the genset. (Preheat is the period of time prior to engine cranking when the glow plugs preheat the combustion chambers. The time is automatically varied by the genset controller on the basis of engine temperature.)
- Press the switch to its **STOP(Prime)** position to stop the genset.
- Hold the switch in its **STOP(Prime)** position to prime the fuel system (starts in 2 seconds).
- See *Troubleshooting* (Page 9-1) about displaying the shutdown codes.

**Status Indicator Lamps**– There are two LED (light emitting diode) lamps in the control switch. The *amber* status lamp lights during priming, blinks rapidly during pre-heat and cranking and goes out when the engine is up to speed. If the genset shuts down abnormally, this lamp will slowly blink a code to indi-

cate the cause of shutdown. See *Troubleshooting* (Page 9-1). The *green* status lamp lights when the engine is up to speed and stays on while the genset runs.

**Emergency Stop Switch** – In an emergency, push this rocker switch to **STOP**. Push the switch to **RUN** after all necessary repairs to the genset and connected equipment have been made.

**Line Circuit Breaker** – The line circuit breaker protects the AC power leads connected to the genset from overloads and equipment short circuits.

**Hour Meter** – The hour meter records genset operating time in hours. It cannot be reset.

**Oil Fill Neck**– The oil fill neck is located on the control panel. The fill plug has a flexible dipstick attached for checking engine oil level.

#### Remote Control Panel

The boat probably has one or two remote control panels for starting and operating the genset. Panels with Onan engine gauges have green, yellow and red LEDs. GREEN indicates normal operation. YELLOW and RED warn of an abnormal engine condition requiring maintenance or service. RED is more severe than YELLOW. See *Periodic Maintenance* (Page 3-1).

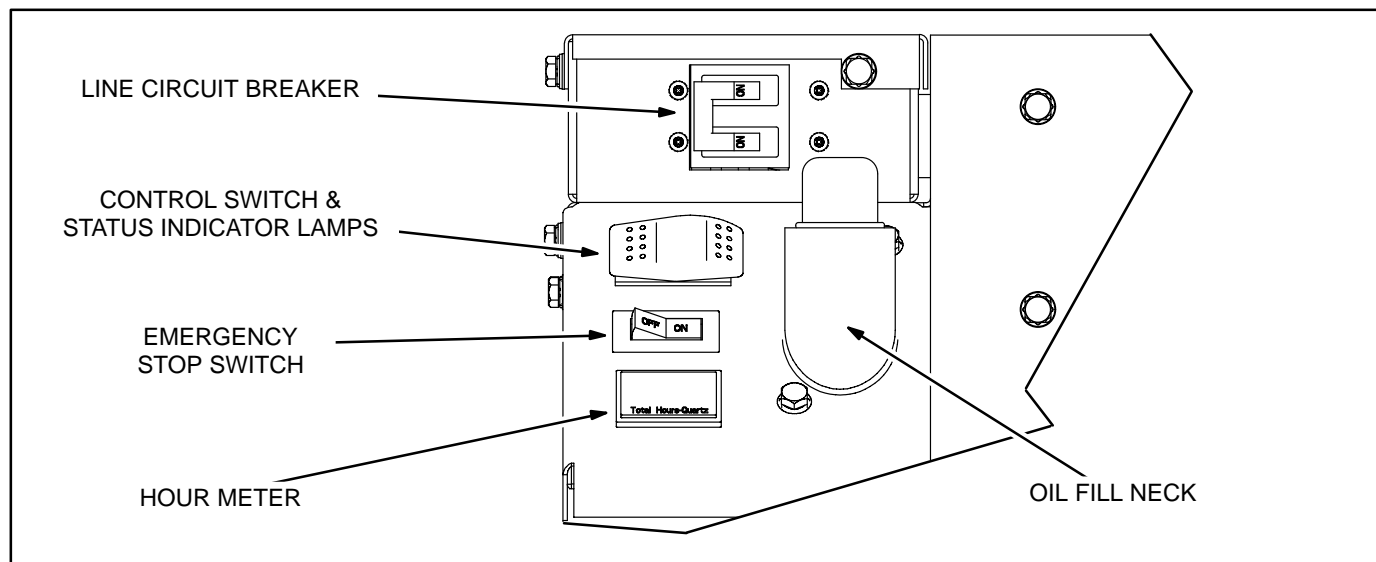


FIGURE 2-1. GENSET CONTROL PANEL

**⚠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 boat when the genset is running unless the cabin has a working carbon monoxide detector.**

**Look over the entire exhaust system and listen for leaks every time you start up the genset and after every eight hours of operation. Shut down the genset immediately if there is a leak. Do not run the genset until the leak has been repaired. The exhaust system must be installed in accordance with the genset Installation Manual.**

## STARTING AND STOPPING THE GENSET

### Pre-Start Checks

Conduct general inspections (Page 3-2) before the first start of the day and after every eight hours of operation. Perform periodic maintenance that may be due and maintenance required to return the genset to service if the boat has been in storage. Before each start:

1. Make sure all CO detectors on board are working properly.
2. Check for swimmers that might be exposed to the engine exhaust.
3. Turn off air conditioners and other large appliances.

### Priming the Fuel System

If the genset ran out of fuel, prime the fuel system by holding the control switch at **STOP/PRIME** for 30 seconds. (The *amber* status lamp will light.)

### Starting the Genset

1. Push and hold the control switch at **START** until the genset starts. The *amber* status lamp will blink rapidly. The *amber* status lamp will go out and the *green* status lamp will light when the engine is up to speed. (Depending on how cold the engine is, preheat can take up to 15 seconds before cranking starts.)

2. For longer engine life, let the engine warm up for two minutes before turning on air conditioners and other large appliances.
3. Check for water, coolant, fuel and exhaust leaks. Stop the genset immediately if there is a leak. Repair fuel leaks immediately.
4. Monitor the engine gauges if the remote control panel is so equipped. Perform maintenance or service as necessary if a gauge indicates an abnormal engine condition. See *Periodic Maintenance* (Page 3-1).
5. **If the genset fails to start**, cranking will discontinue in 20 to 60 seconds, depending on how cold the engine is, and the *amber* status lamp will blink Shutdown Code No. 4 (Page 9-5). See *Troubleshooting* (Page 9-1) if the genset does not start after two or three tries.

**⚠CAUTION Do not continue cranking and risk burning out the starter or flooding the engine (exhaust flow during cranking is too low to expel water from the exhaust system). Find out why the genset does not start and make necessary repairs.**

6. **If the genset shuts down**, the *amber* status lamp will blink one of the shutdown codes. See *Troubleshooting* (Page 9-1).

### Stopping the Genset

Turn off air conditioners and other large appliances and let the genset run for two minutes to cool down. Then touch the Control Switch to **STOP(Prime)**.

## Emergency Stop

Push the **EMERGENCY STOP SWITCH** to **STOP** (Page 2-1). After all necessary repairs have been made, push the switch to **RUN** so that the genset can be operated.

## OPERATION

### Connecting Shore Power

If the boat has provisions for connecting shore power, it must also have an approved device to keep the genset and shore power from being interconnected.

**⚠WARNING** *Backfeed to shore power can cause electric shock resulting in severe personal injury or death and damage to equipment. The boat must have an approved device to prevent the genset from being interconnected with shore power.*

### New or Re-Built Engine Care

Change the oil and oil filter after the first 50 hours of operation with a new or re-built engine (Page 3-4).

### No-Load Operation

**Keep no-load operation to a minimum.** During no-load operation cylinder temperatures drop to the point where fuel does not burn completely, causing fuel wetting and white smoke. It is best to run the genset at 1/4 to 3/4 load.

### Exercising the Genset

Exercise the genset at least 1 hour every month if use is infrequent. Run the genset at 1/4 to 3/4 load. A single exercise period is better than several shorter periods. Exercising a genset drives off moisture, re-lubricates the engine, uses up fuel before it becomes stale and removes oxides from electrical contacts and generator slip rings. The result is better starting, more reliable operation and longer engine life.

### Cold Temperature Operation

Do not let raw water freeze in the heat exchanger (Page 3-12) during cold weather when the genset is

not operating. Freezing water can damage the raw water tubes in the heat exchanger. Engine coolant, but not raw water, is protected from freezing. Drain the heat exchanger if there is a danger of freezing.

## Storing the Genset

**Storing the Genset:** Proper storage is essential for preserving top genset performance and reliability when the genset will be idle for more than 120 days.

1. Change the engine oil (Page 3-4) and attach a tag indicating viscosity grade (Page 1-2).
2. Disconnect the battery cables (negative [–] first) from the battery (Page 3-6). Follow the manufacturer's recommendations when storing the battery.

**⚠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.*

3. Check coolant level and add as necessary (Page 3-7). Test the coolant mixture if freezing temperatures are possible and change if necessary.
4. If freezing temperatures are expected, drain the heat exchanger (Page 3-12), hoses and muffler to prevent damage from freezing water.
5. Clean and lightly oil parts that can rust.

### Returning the Genset to Service:

1. Check the oil tag on the genset and change the oil (Page 3-4) if the viscosity is not appropriate for the temperatures expected (Page 1-2).
2. Reconnect the battery cables (negative [–] last) (Page 3-6).
3. Replace the raw water pump impeller if it was installed more than a year ago (Page 3-10).
4. Perform the maintenance required (Page 3-1), conduct the pre-start checks (Page 2-2) and prime the fuel system (Page 2-2).
5. Start and run the genset (Page 2-2).

# 3. Periodic Maintenance

Periodic maintenance is essential for good performance and long genset life. Use Table 3-1 as a guide for normal periodic maintenance.

Maintenance, replacement or repair of emission control devices and systems may be performed by any engine repair establishment or individual. How-

ever, warranty work must be completed by an authorized Onan dealer.

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

**TABLE 3-1. PERIODIC MAINTENANCE SCHEDULE**

PROCEDURE	FREQUENCY								
	After first 50 Hrs	Every Day/ 8 Hrs	Every Month/ 100 Hrs	Every Year/ 200 Hrs	Every Year/ 500 Hrs	Every 800 Hrs	Every 2 years	Every 5 years/ 2000 Hrs	P a g e
General Inspection <sup>1</sup>		x							3-2
Check Engine Oil Level		x							3-3
Check Battery			x <sup>2</sup>						3-6
Check V-Belt Tension			x <sup>3</sup>						3-10
Drain Water in Fuel			x						3-5
Check Siphon Break			x						3-8
Change Oil & Oil Filter	x			x					3-4
Change Fuel Filter					x				3-5
Replace Raw Water Impeller					x				3-10
Adjust Valve Lash						x <sup>5</sup>			–
Change Coolant, Pressure Cap & Thermostat							x <sup>4</sup>		3-7
Check Generator Bearings, Drive Belt, Belt Tensioner & Drive Coupling								x <sup>5</sup>	–
1 - Includes Oil Level, Coolant Level, Fuel System, Exhaust System and Battery Checks. 2 - See battery manufacturer's recommendations. 3 – Check for slippage, cracking and wear (pump drive belt only). 4 – There is no zinc anode to replace. 5 - Must be performed by a trained and experienced mechanic (authorized Onan dealer) in accordance with the engine and genset Service Manuals.									

## GENERAL INSPECTION

Inspect the genset before the first start of the day and after every eight hours of operation.

### Oil Level

Check engine oil level (Page 3-3).

### 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.

Check that all CO monitors are working properly.

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

### Fuel System

Check for leaks at hose, tube and pipe fittings in the fuel supply and return systems while the genset is running and while it is stopped. Check flexible fuel hose for cuts, cracks, abrasions and loose hose clamps. Make sure fuel lines do not rub against other parts. Replace worn or damaged fuel line parts before leaks occur. Replace hose with with USCG TYPE A1 or ISO 7840-A1 fuel hose.

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

Prime the fuel system (Page 2-2) if the genset ran out of fuel.

## Coolant Level Check

Keep the level of coolant in the recovery tank between COLD and HOT. The recovery tank is designed to maintain coolant level; not to fill the system. If the tank is empty, check for and repair any coolant leaks and refill the system through the fill neck on the engine (Filling the System, Page 3-8). Then refill the recovery tank up to the COLD mark. Use the recommended mixture of antifreeze (Page 3-8).

## Raw Water System

Clean out the sea water strainer if necessary and make sure the sea cock is open for genset operation. Also, when a water/exhaust separator is provided (see Installation Manual), open the sea cock for the water drain hose.

## Battery Connections

Check the battery terminals and keep them clean and tight (Page 3-6). Loose or corroded terminals have high electrical resistance, which can cause hard starting and short starter life.

## Mechanical

Look for mechanical damage. Start the genset and look and listen for any unusual noises and vibrations.

Check the genset mounting bolts to make sure they are secure.

Check to see that the genset air inlet and outlet openings are not clogged with debris or blocked. Keep the genset and generator compartment clean.

Monitor the engine gauges, if so equipped, whenever the genset is running.

## CHECKING ENGINE OIL LEVEL

Shut off the genset before checking engine oil level.

**⚠WARNING** *Crankcase pressure can blow hot engine oil out the fill opening causing severe burns. Always stop the genset before removing the oil fill plug.*

1. Pull the plug and dipstick out of the oil fill neck (Figure 3-1). The plug may be difficult to pull straight out. It is easier if you tilt the plug in its socket while pulling out. Wipe off the dipstick and thread it back into the fill neck and seat the plug, which snaps into its socket. Remove the plug and dipstick again and check the oil level on the dip stick.
2. Add or drain oil as necessary. See ENGINE OIL RECOMMENDATIONS (Page 1-2). Keep the oil level between the high and low beads on the end of the dipstick, as shown. It is not necessary to add oil between oil changes if the oil has not dropped more than 1/3 of the way between the high and low beads. A full quart (0.9 liter) can be added if the oil level is at the lower bead.

**⚠CAUTION** *Too much oil can cause high oil consumption. Too little oil can cause severe engine damage. Keep the oil level between the high and low beads on the dipstick.*

3. Secure the oil fill plug, which snaps into its socket.

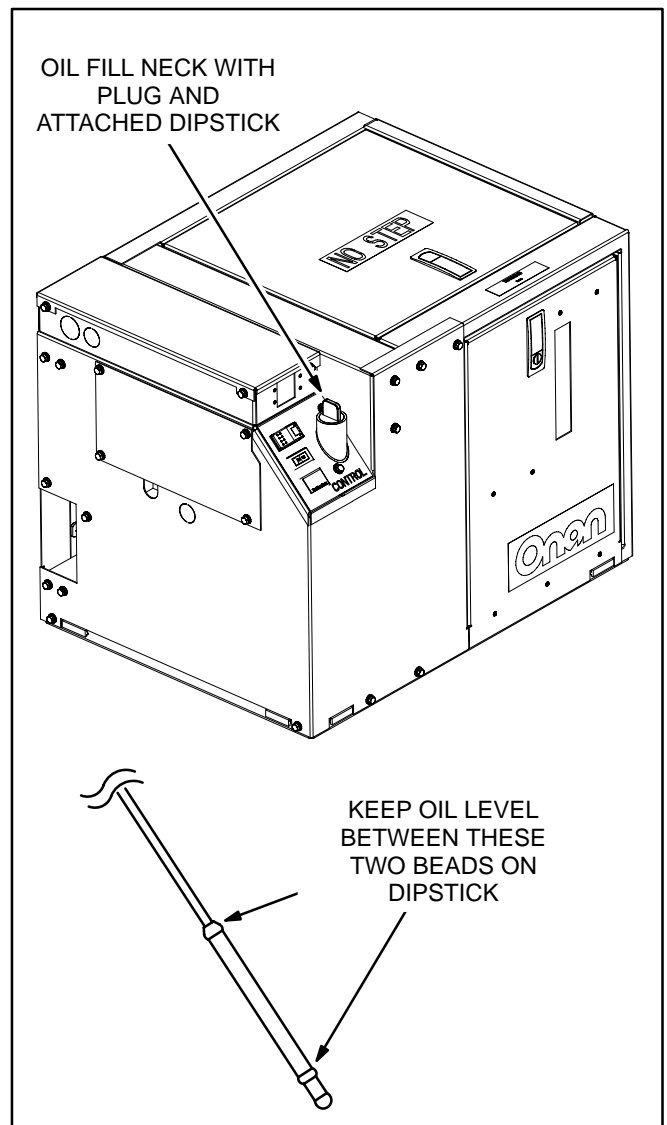


FIGURE 3-1. OIL FILL NECK AND DIPSTICK



## CHANGING ENGINE OIL AND FILTER

**⚠WARNING** *U. S. state and federal agencies have determined that contact with used engine oil can cause cancer or reproductive toxicity. Avoid skin contact and breathing of vapors. Use rubber gloves and wash exposed skin.*

See Table 3-1 for scheduled oil change.

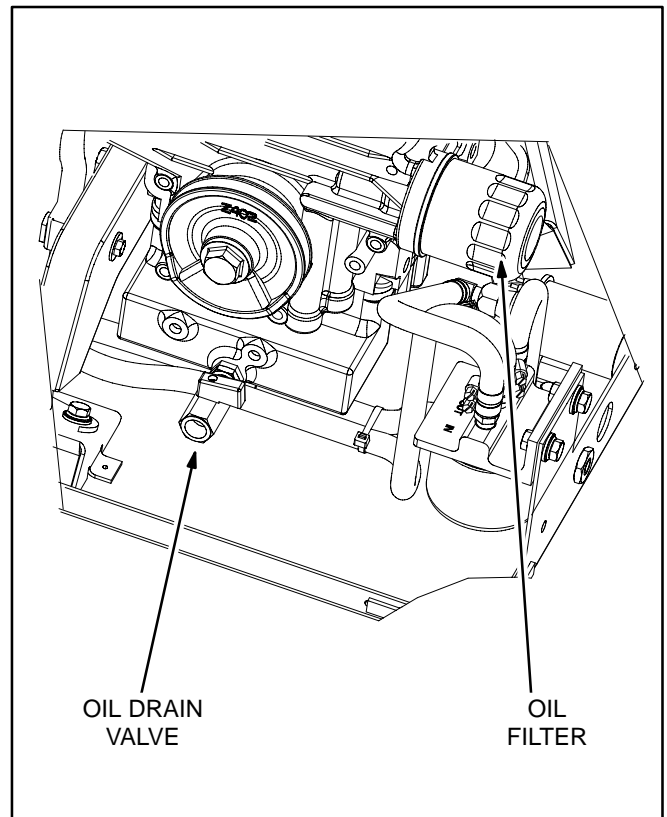
1. Run the genset under load until it is up to operating temperature, stop it and disconnect the negative (–) battery cable at the battery.

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

2. Remove the oil fill plug (Figure 3-1), open the front access door and drain the engine oil into a container by opening the drain valve (Figure 3-2). (The drain valve has a 3/8 NPT outlet for connecting a hose fitting to facilitate oil draining.) If an oil pump-out system is installed, follow the instructions provided.
3. Close the oil drain valve.
4. Spin off the old oil filter (Figure 3-2) and wipe off the filter mounting surface. (A filter wrench is available from Onan.) Remove the old gasket if it does not come off with the filter.
5. Apply a film of oil to the filter gasket and spin the new filter on by hand until the gasket just touches the mounting pad and tighten 3/4 turn.
6. Refill with 2.2 quarts (2.1 l) of oil. See ENGINE OIL RECOMMENDATIONS (Page 1-2).
7. Start and run the genset for five minutes and check for leaks. Stop the genset and check oil level (Page 3-3). Add or drain oil as necessary.

**⚠CAUTION** *Too much oil can cause high oil consumption. Too little oil can cause severe engine damage. Keep the oil level between the high and low beads on the dipstick.*

8. Close the access door and dispose of the used oil and oil filter in accordance with local environmental regulations.



**FIGURE 3-2. OIL FILTER AND DRAIN VALVE**

## DRAINING / CHANGING FUEL FILTER

**⚠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 multi-class ABC fire extinguisher handy.*

**Fuel Handling Precautions:** Keep dirt, water and other contaminants from entering the fuel system and corroding or clogging fuel injection components. The genset has a water separator type of fuel filter. The fuel supply system should also have a water separator and filter.

Humid air condenses on the walls of fuel tanks and is the primary source of water in fuel. Water clogs fuel passages by freezing and causes corrosion by forming sulfuric acid with the sulfur in the fuel. Keeping fuel tanks full reduces condensation by reducing the area on which condensation can take place.

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

**Draining Water and Sediment:** Drain water and sediment more often than scheduled (Table 3-1) if

fuel quality is poor or condensation cannot be avoided.

1. Disconnect the negative (–) cable at the battery to prevent the engine from starting and close the fuel supply valve, if provided, to prevent loss of prime.
2. Open the front access door and drain the filter (about 1/2 cup [120 ml]) into a suitable container by removing the drain plug (bottom of filter).
3. *Re-install the drain plug*, close the access door and dispose of the drain-off in accordance with local environmental regulations.

**Changing Fuel Filter:** See Table 3-1 for scheduled change. Change the filter if the engine lacks power.

1. Disconnect the negative (–) cable at the battery to prevent the engine from starting and close the fuel supply valve, if provided, to prevent loss of prime.
2. Open the front access door and spin off the old filter (Figure 3-3) and dispose of it in accordance with local environmental regulations.
3. Clean the contact surface on the filter base, lubricate the new filter gasket and spin the new filter on hand tight.
4. Prime the engine for at least 30 seconds (Page 2-2) to fill the new filter. Run the genset and check for leaks. Tighten the filter by hand, if necessary, and close the access door.

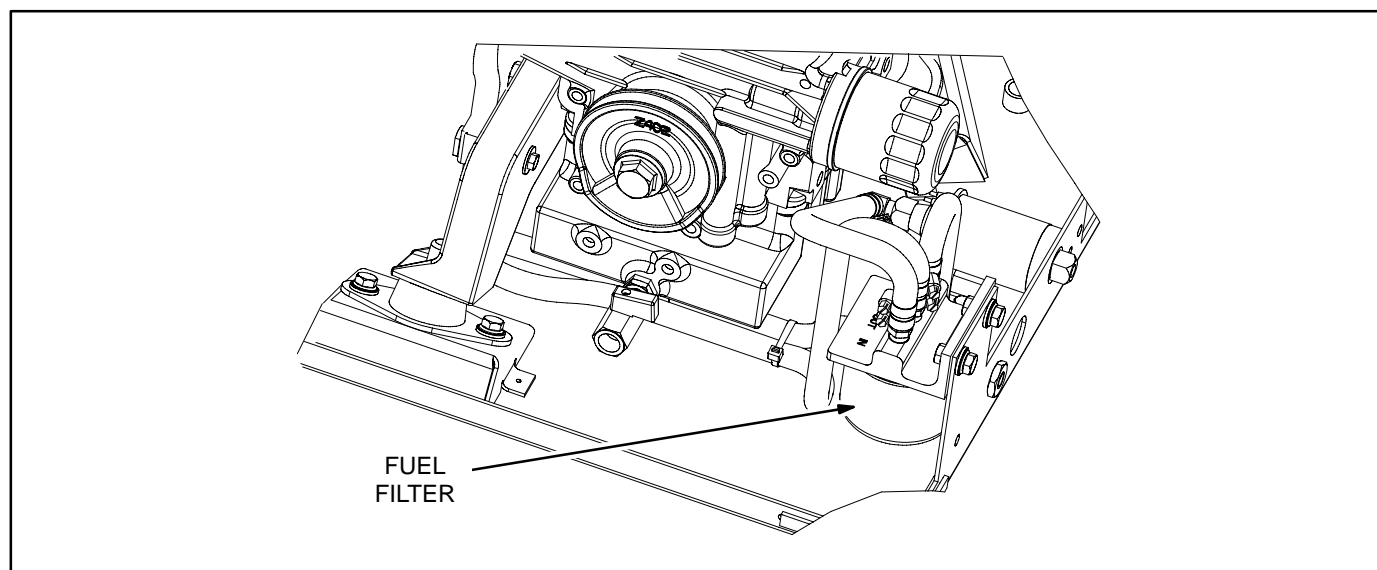


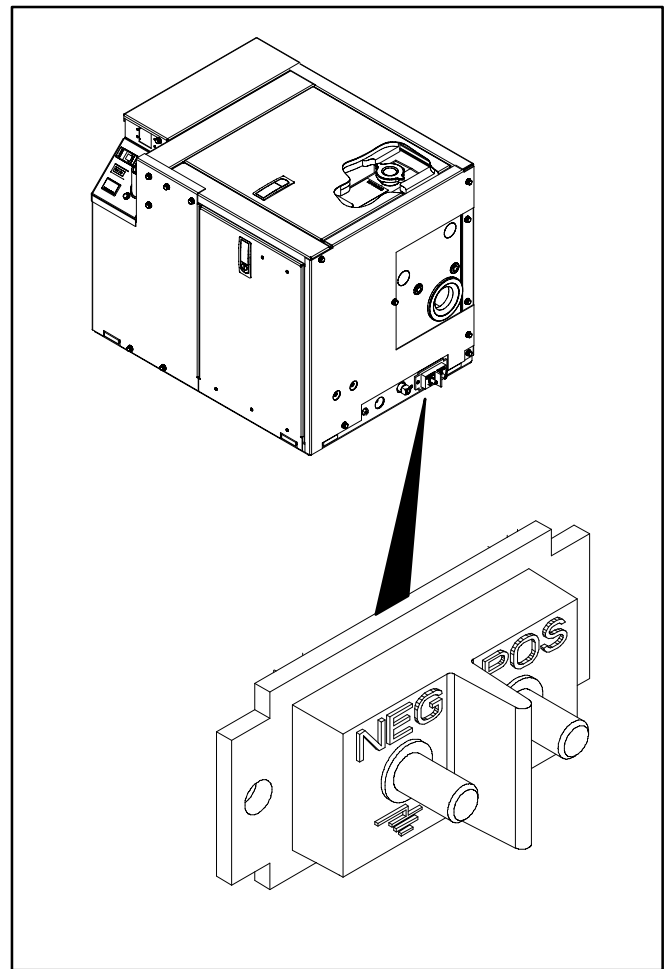
FIGURE 3-3. FUEL FILTER

## MAINTAINING BATTERY AND BATTERY CONNECTIONS

**⚠WARNING** *Flames, sparks or arcing at battery terminals, light switches or other equipment can ignite battery gas causing severe personal injury — Ventilate the battery area before working on or near the battery — Wear safety glasses — Do not smoke — Switch a work lamp ON and OFF away from the battery — Do not disconnect the battery cables while the genset is running or a battery charger is on — Always disconnect the negative (–) cable first and reconnect it last.*

See Table 3-1 for scheduled maintenance. Follow the battery manufacturer's instructions. Have the battery charging system serviced if DC system voltage is consistently low or high. Always:

1. Keep the battery case, terminals and cables clean and dry and the terminals tight at the battery and at the genset (Figure 3-4).
2. Remove battery cables with a battery terminal puller.
3. Make sure which terminal is positive (+) and which is negative (–) before making battery connections. Always remove the negative (–) cable first and reconnecting it last to reduce arcing.
4. Follow the manufacturer's recommendations when storing the battery. Disconnect the battery so that it does not discharge through the genset control during storage.



**FIGURE 3-4. BATTERY CABLE TERMINALS**

## ENGINE COOLING SYSTEM

### Cooling System Overview

Refer to Figure 3-5. 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. The exhaust manifold also serves as the engine coolant reservoir.

The heat exchanger is mounted inside the exhaust manifold. Raw water (the flotation water) is pumped through tubes in the heat exchanger to cool the engine coolant. The raw water then passes through a hose into the exhaust-water mixer where it cools the exhaust gases and is expelled. The V-belt drives the coolant and the raw water pumps.

### Replenishing Normal Coolant Loss

Keep the level of coolant in the recovery tank between COLD and HOT. The recovery tank is designed to maintain coolant level; not to fill the system. If the tank is empty, check for and repair any coolant leaks and refill the system through the fill neck on the engine (Filling the System, Page 3-8). Then refill the recovery tank up to the COLD mark. Use the recommended mixture of antifreeze (Page 3-8).

Make sure the two hoses from the recovery tank are routed through the two holes in the right side of the genset enclosure, that the coolant recovery hose is connected to the fill neck on the engine and that the overflow hose terminates in the drip pan where it will not splash coolant on electrical components.

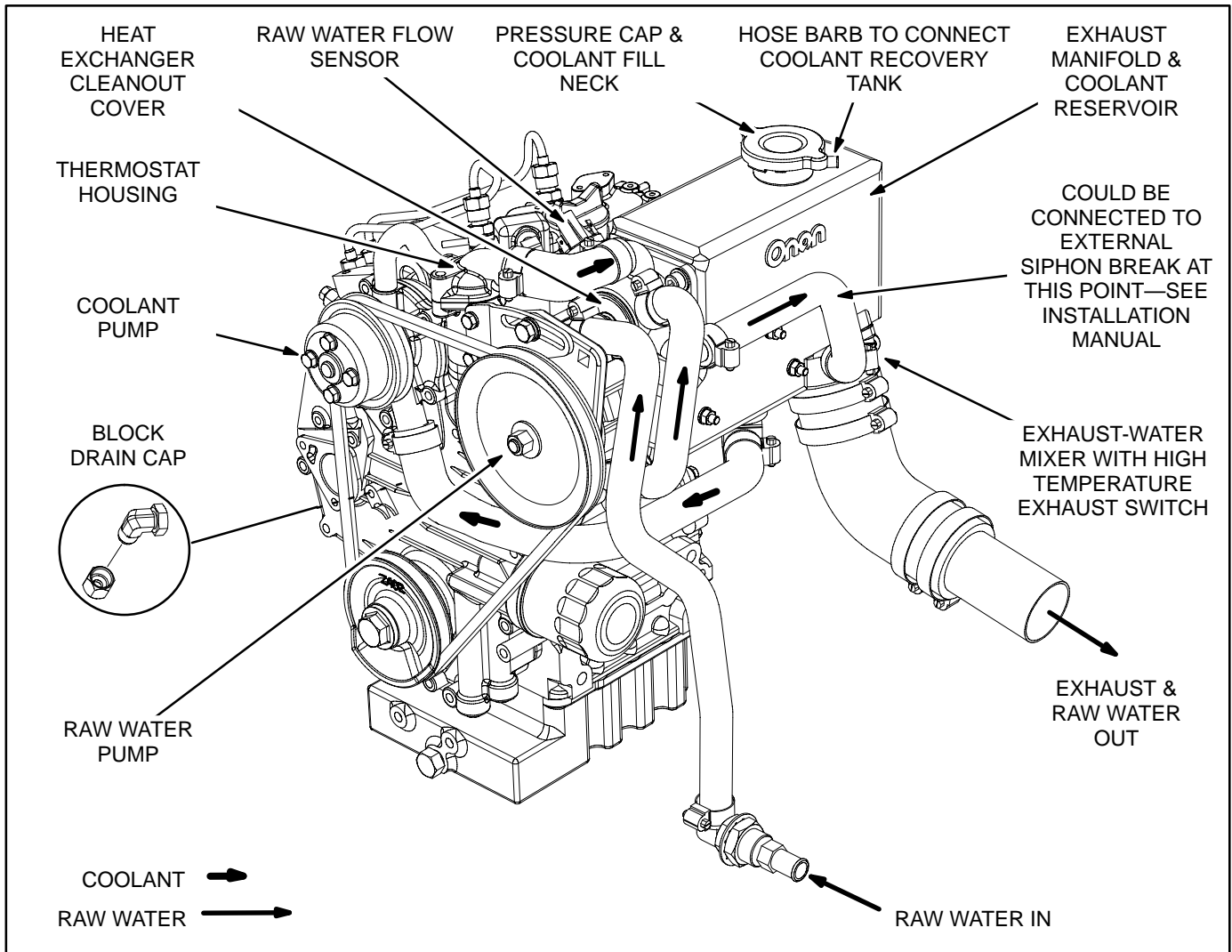


FIGURE 3-5. ENGINE COOLING SYSTEM

## 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. Use fresh water that is low in minerals and corrosive chemicals. Distilled water is best. Unless prohibited by shipping regulations, the genset is shipped with the recommended 50/50 mixture of water and ethylene glycol, which is good for -34° F (-37° C). Coolant capacity is 2.2 quarts (2.1 liters).

**⚠ WARNING** *Ethylene glycol antifreeze is considered toxic. Dispose of it according to local regulations for hazardous substances.*

## Changing Coolant

See Table 3-1 for scheduled change of coolant.

**Draining the System:** Have towels and containers ready to wipe up, collect and properly dispose of the coolant.

**⚠ WARNING** *Accidental or remote starting can cause severe personal injury or death. Disconnect the negative (–) cable from the battery 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. Disconnect the negative (–) cable at the battery to prevent the engine from starting, let the engine cool and remove the front and top access doors and the coolant pressure cap.
2. Drain the exhaust manifold/coolant reservoir by disconnecting the hose at the coolant pump inlet (Figure 3-5) and twisting it down into a container.
3. Drain the block by removing the cap on the drain fitting on the left side of the block (Figure 3-5). Use an 11/16 inch socket on a swivel and 12 to 18 inch extension. To catch the coolant and direct it into a container, insert the socket and extension through a piece of hose large enough to fit over the socket but shorter than the extension. The hose will catch the coolant as the cap is being unscrewed.

**Coolant Hoses:** Inspect and replace hoses that leak or are damaged.

**Pressure Cap:** See Table 3-1 for scheduled replacement. The pressure cap is necessary for optimal engine cooling and reduced coolant loss.

**Cleaning and Flushing the System:** Use radiator cleaning chemicals to clean and flush the cooling system before refilling with fresh coolant. Follow the cleaner 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:** Secure the block drain cap and reconnect the pump inlet hose and fill the system through the engine fill neck. 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 for a couple of minutes to dislodge air pockets and shut it down. Add as much coolant as necessary and secure the pressure cap. Then refill the recovery tank up to the COLD mark.

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

## Siphon Break

A siphon break is installed when the exhaust-water mixer (Figure 3-5) is below the water line. If of a 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, check that the vent hose is properly connected on both ends. If the vent is connected to a through-hull fitting, check for normal water flow whenever the engine is running. See the Installation Manual for more information regarding siphon breaks.

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

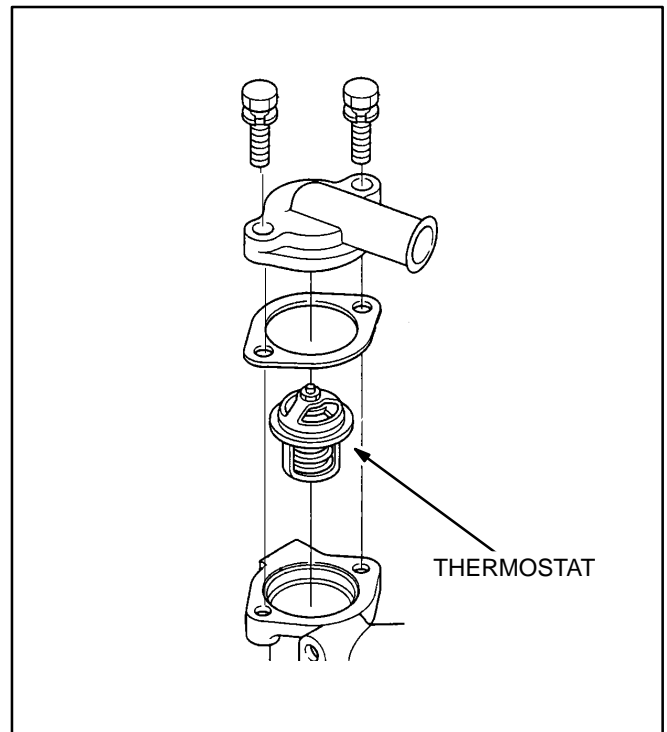
## Replacing the Thermostat

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Disconnect the negative (–) cable at the battery 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.*

See Table 3-1 for scheduled replacement. Referring to Figure 3-6, replace the thermostat as follows:

1. Disconnect the negative (–) cable at the battery to prevent the engine from starting, let the engine cool and remove the top access door and pressure cap.
2. Pack a towel around the thermostat housing flange to catch the coolant that will spill. Remove the two thermostat housing bolts and pull off the housing, thermostat and gasket. The hose does not need to come off.
3. Clean off the gasket area and install the new thermostat and gasket. Apply Three Bond 1215 liquid sealant or equivalent to the top side of the gasket.
4. Replenish any lost coolant, secure the pressure cap, secure the access door and reconnect the battery cables (negative [–] last).



**FIGURE 3-6. THERMOSTAT**

## Adjusting V-Belt Tension

Referring to Figures 3-7 and 3-8, readjust belt tension as follows:

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

1. Disconnect the negative (–) cable at the battery to prevent the engine from starting.
2. Remove the front and top access doors. If work space is limited, remove the side panel (Figure 3-8) to be able to hold the nut on the pump pivot bolt (Figure 3-7) with an open-end wrench while loosening the bolt.
3. Loosen both bolts so that the pump can pivot.
4. Pivot the pump out to tighten belt tension. Hold tension by tightening the tension adjusting bolt and check it by applying 20 pounds (10 kg) to the middle of the pulley span. Belt tension is correct when deflection is 0.4 inch (10 mm).
5. Tighten the bolts, reassemble the panels and doors and reconnect the battery cables (negative [–] last).

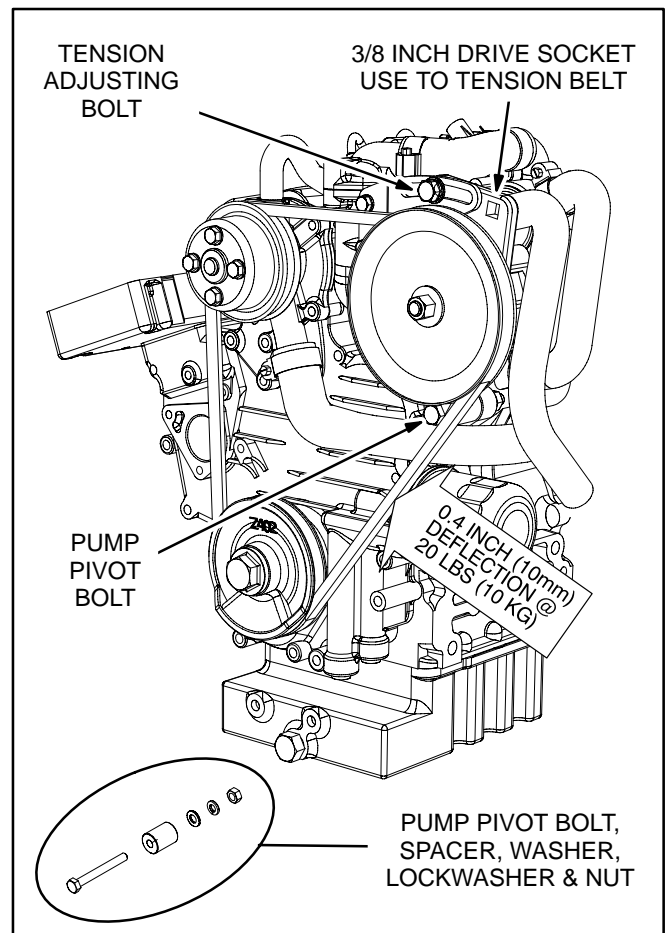


FIGURE 3-7. ADJUSTING V-BELT TENSION

## Replacing the Raw Water Pump Impeller

See Table 3-1 for scheduled replacement. Have towels and containers ready and avoid spilling raw water on the electrical components below the pump. Referring to Figures 3-8, 3-9 and 3-10, replace the impeller as follows:

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

1. Disconnect the negative (–) cable at the battery to prevent the engine from starting, let the engine cool and *close the sea cock*.
2. Remove the front and top access doors. If work space is limited, remove the side panel (Figure 3-8) to be able to hold the nut on the pump pivot bolt (Figure 3-9) with an open-end wrench while loosening the bolt.

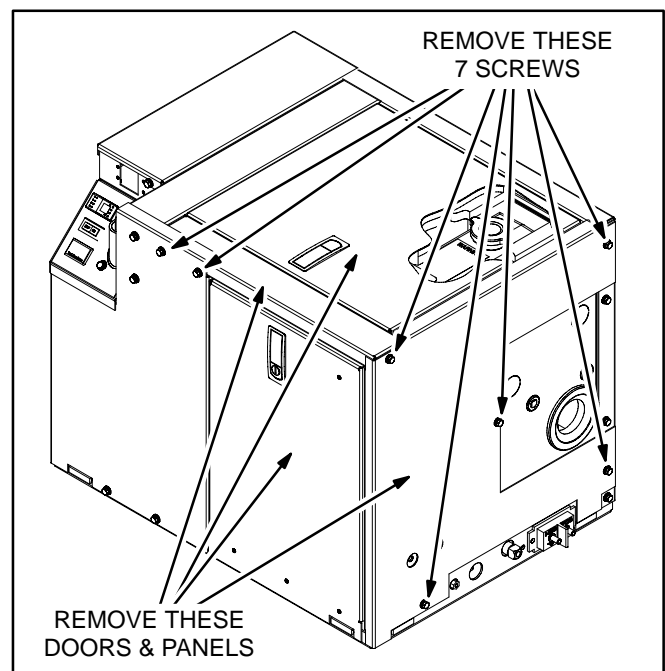
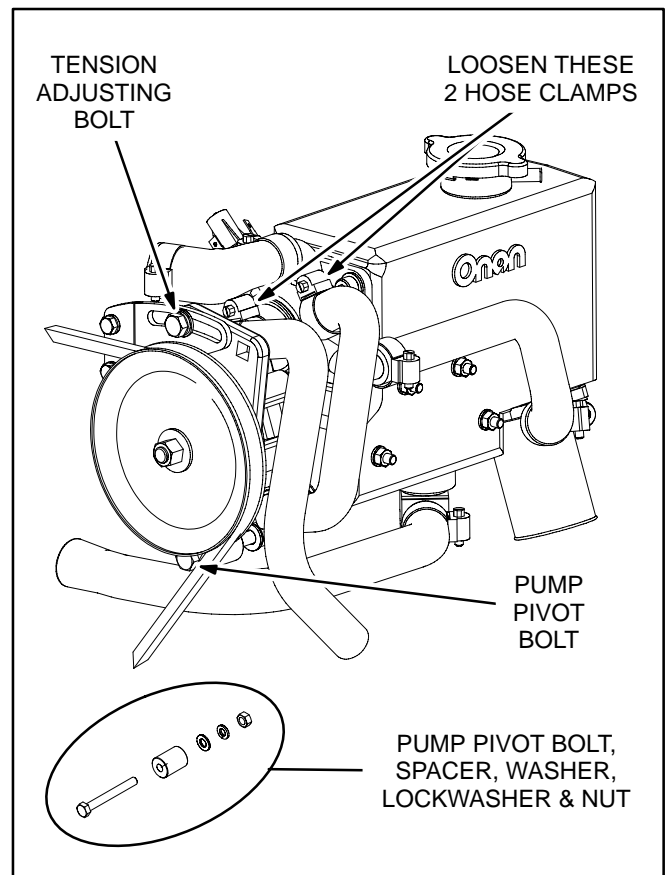


FIGURE 3-8. REMOVING ACCESS PANELS

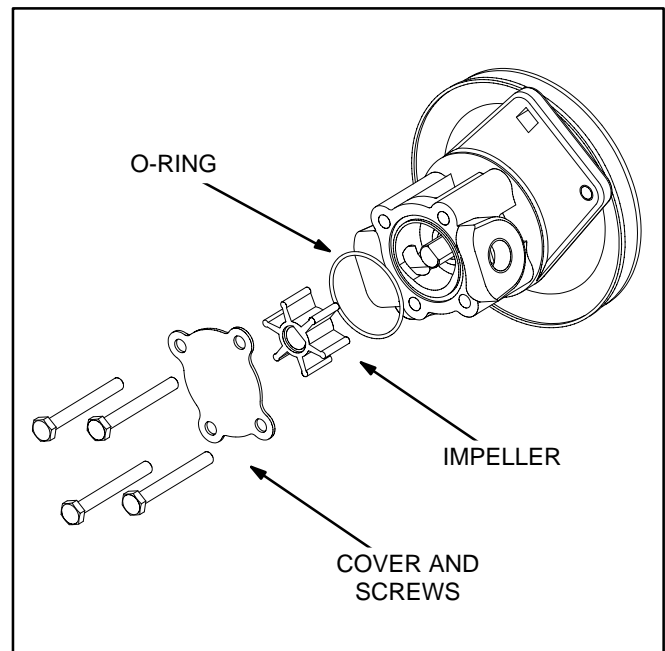
3. Loosen the hose clamps shown in Figure 3-9 and disconnect the hoses.
4. Loosen the two pump mounting bolts and remove the belt. Remove the tension adjusting bolt first and swing the pump out for access to the pivot bolt nut, lock washer and flat washer. Remove the pivot bolt and pull the pump out.
5. Remove the 4 pump cover screws (Figure 3-10) and remove the impeller and O-ring. Use two pliers to grip vanes on opposite sides if the impeller is difficult to remove. *It will be necessary to check for and cleanout pieces of the impeller from the heat exchanger and exhaust elbow if vanes have broken off.*
6. Install the new impeller. It helps to twist the impeller counter-clockwise (the way it turns) while squeezing it into the housing.
7. 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.*

8. Remount the pump, reconnect the hoses, adjust V-belt tension (Page 3-10) and reassemble the enclosure panels and doors.
9. If the sea water strainer is above the water line, fill it for faster prime and secure its cover.
10. Open the sea cock, reconnect the battery cables (negative [–] last) and start the genset. The genset will shut down within 8 seconds if there is no raw water flow and the *amber* status lamp will blink shutdown Code No. 7 (Page 9-6). If it shuts down, find out why, remove any blockage and restart the genset.



**FIGURE 3-9. REMOVING RAW WATER PUMP**



**FIGURE 3-10. REPLACING THE IMPELLER**



## Heat Exchanger

The heat exchanger has a cleanout cover and drain plug (Figure 3-11). Clean the raw water tubes if the engine keeps shutting down (Code No. 1) or the engine gauge indicates abnormally high engine temperatures. Drain the heat exchanger if there is a danger of freezing when the genset is not running or is in storage. (Freezing water can damage the raw water tubes in the heat exchanger. Engine coolant, but not raw water, is protected from freezing.)

**Cleaning and Draining the Heat Exchanger:** To clean the tubes or to drain raw water, first remove the side enclosure panel or the raw water pump (see Replacing the Raw Water Pump Impeller, Page 3-10). Have towels and containers ready to prevent spilling raw water on the electrical components below the heat exchanger.

Remove the drain plug or cleanout cover. Clean and flush the tubes. The drain plug must be removed to get all the water out of the tubes. Do not use metal rods to clean the tubes. The tubes are made of relatively soft copper alloy and can be damaged.

Use thread sealant on the drain plug and a new clean out cover gasket if the old one is torn or otherwise damaged. Reassemble all the parts that were disassembled for access.

**Removing/Installing the Heat Exchanger:** Remove the heat exchanger and have it cleaned at a radiator shop if there is hard scale in the tubes.

To remove the heat exchanger, first disconnect the two leads at the flow sensor, remove the sensor, drain the coolant and disconnect the three hoses. (To work the coolant hose elbow off the fitting on the heat exchanger, it will be necessary to loosen the hose clamps on both ends.) Then remove the four mounting bolts and withdraw the heat exchanger.

To install the heat exchanger, first clean the mating gasket faces, taking special care not to scratch the face on the aluminum manifold. Use a new gasket and torque the mounting bolts to 19 lb-ft (26 N-m). Then install the flow sensor using pipe thread sealant and reconnect the two leads in the harness. Reconnect the hoses and reassemble all the parts that were disassembled for access.

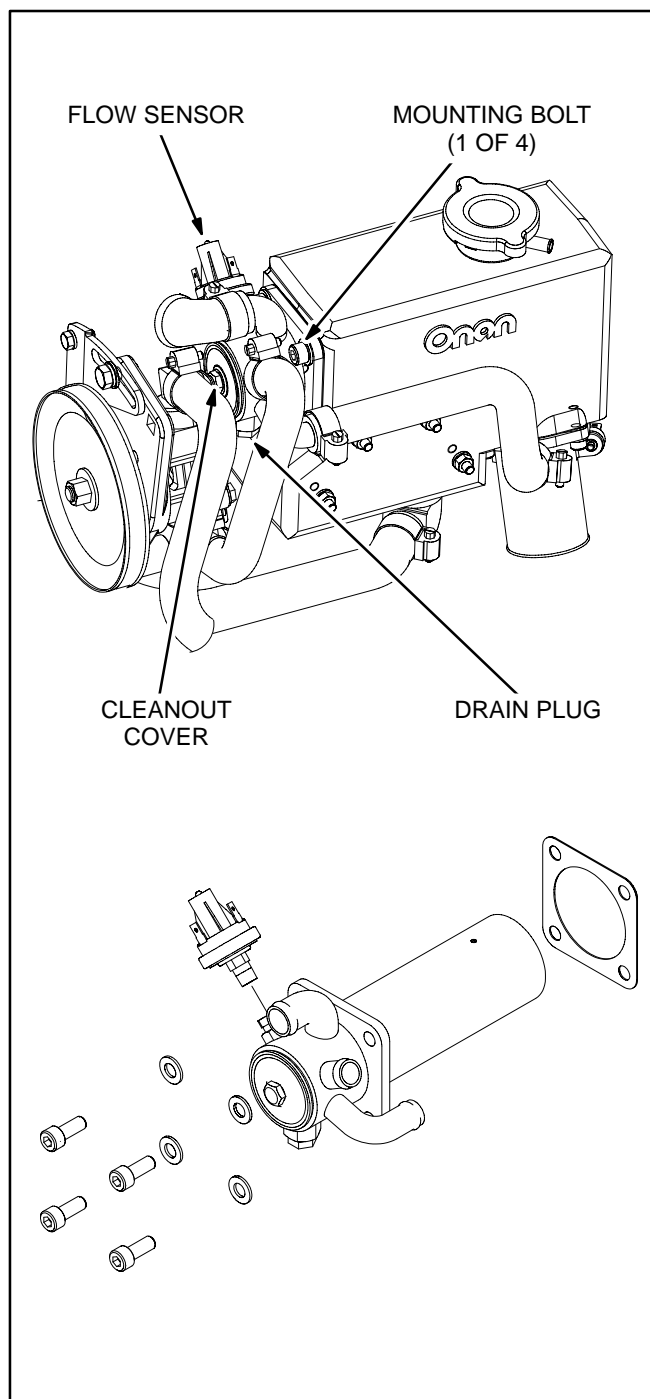


FIGURE 3-11. HEAT EXCHANGER

## 4. Enclosure, Drip Pan and Mounting System

### ENCLOSURE PANELS

The genset enclosure panels and access doors are assembled as shown (Figure 4-1).

**⚠ WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

**Back Panel:** This panel is secured by 5 screws along its left edge (looking from the back), 3 along its right edge and 7 on its back. *Remove this panel for access to the generator drive (Page 7-1).*

**Right Side Panels:** The main panel is secured by 5 screws, 1 near each corner and 1 near the center. The smaller panel is secured by 3 screws. *Removing these panels provides access to the engine components on the right side (Page 3-7).*

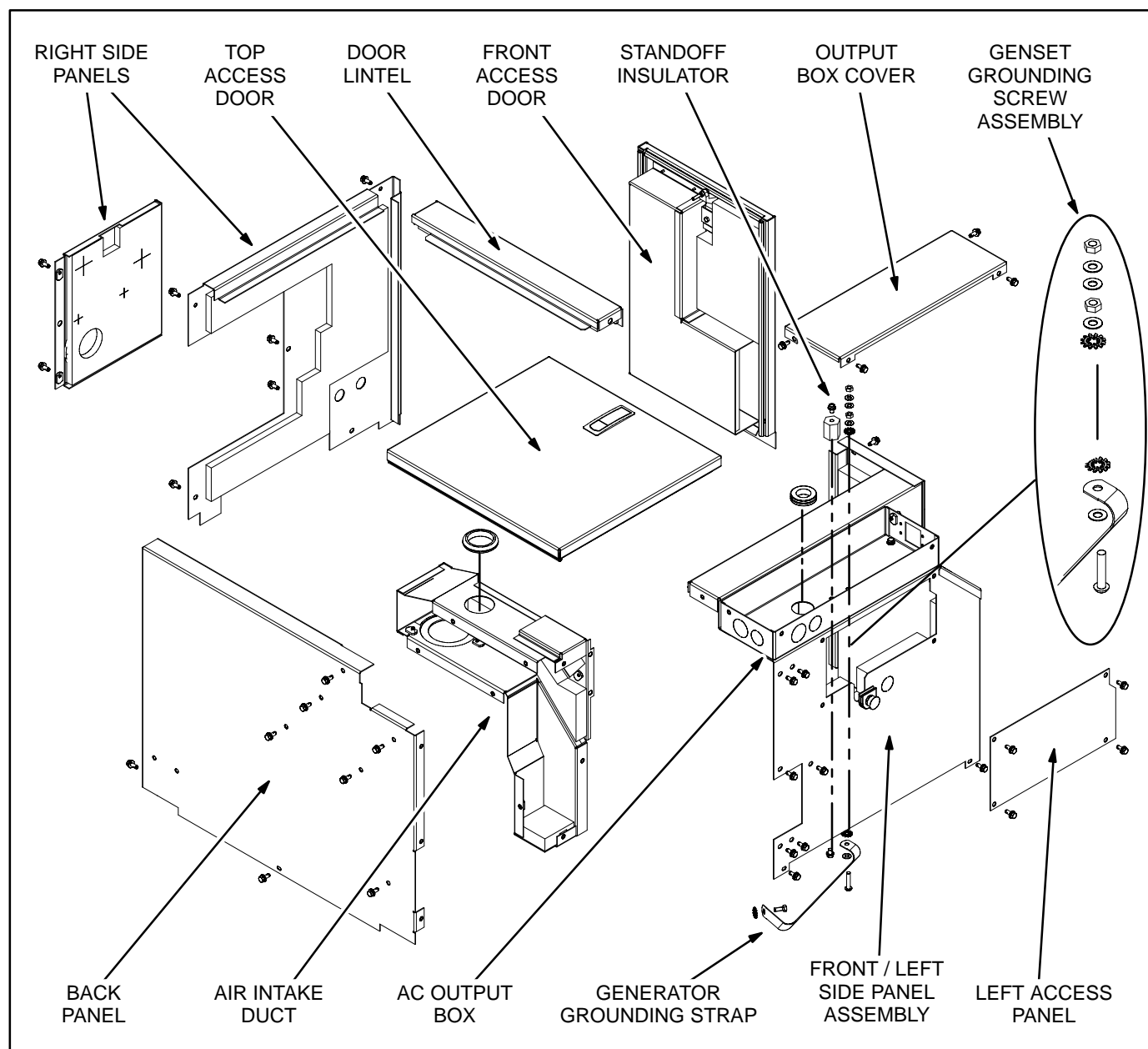


FIGURE 4-1. GENSET ENCLOSURE

**Access Doors:** The access doors are latched and the front is lockable with a key. The door lintel between them is a channel secured by 1 screw on the right side and 2 screws on the left.

**Front / Left Side Panel Assembly:** This panel assembly is secured by 2 screws to the access door lintel, 4 to the drip pan, 6 on the side and 1 in back along the top edge, right of the AC outlet box. *Remove this assembly and the access doors for full access from the top, front and left side.* To remove it, remove the 4 screws that secure the AC output box, disconnect all wiring at the control panel and remove the two screws that secure the oil fill neck to the control panel (Page 8-5). *This panel assembly can be pulled forward and removed without having to disturb connections in the AC output box.*

**AC Output Box:** The AC output box is secured by 4 screws in the bottom of the box. The genset

grounding screw and standoff insulator are for generator, load and grounding connections (Page 6-6).

**Air Intake Duct:** The duct is secured to the back by 5 screws and to the side by 3 screws.

## DRIP PAN AND MOUNTING SYSTEM

**Front Engine Support Bracket:** Torque the 3 bolts that secure the bracket to the engine to 41 lb-ft (55 N-m).

**Vibration Isolation Mounts (3):** Two of the three mounts are bolted to the engine-generator adapter (Page 7-1) and one to the front mount. Torque the through bolts and the two mounting bolts to the drip pan to 20 lb-ft (27 N-m).

**Generator End Bell Support Bracket:** See Page 6-1. Torque all the bolts to 8 lb-ft (11 N-m).

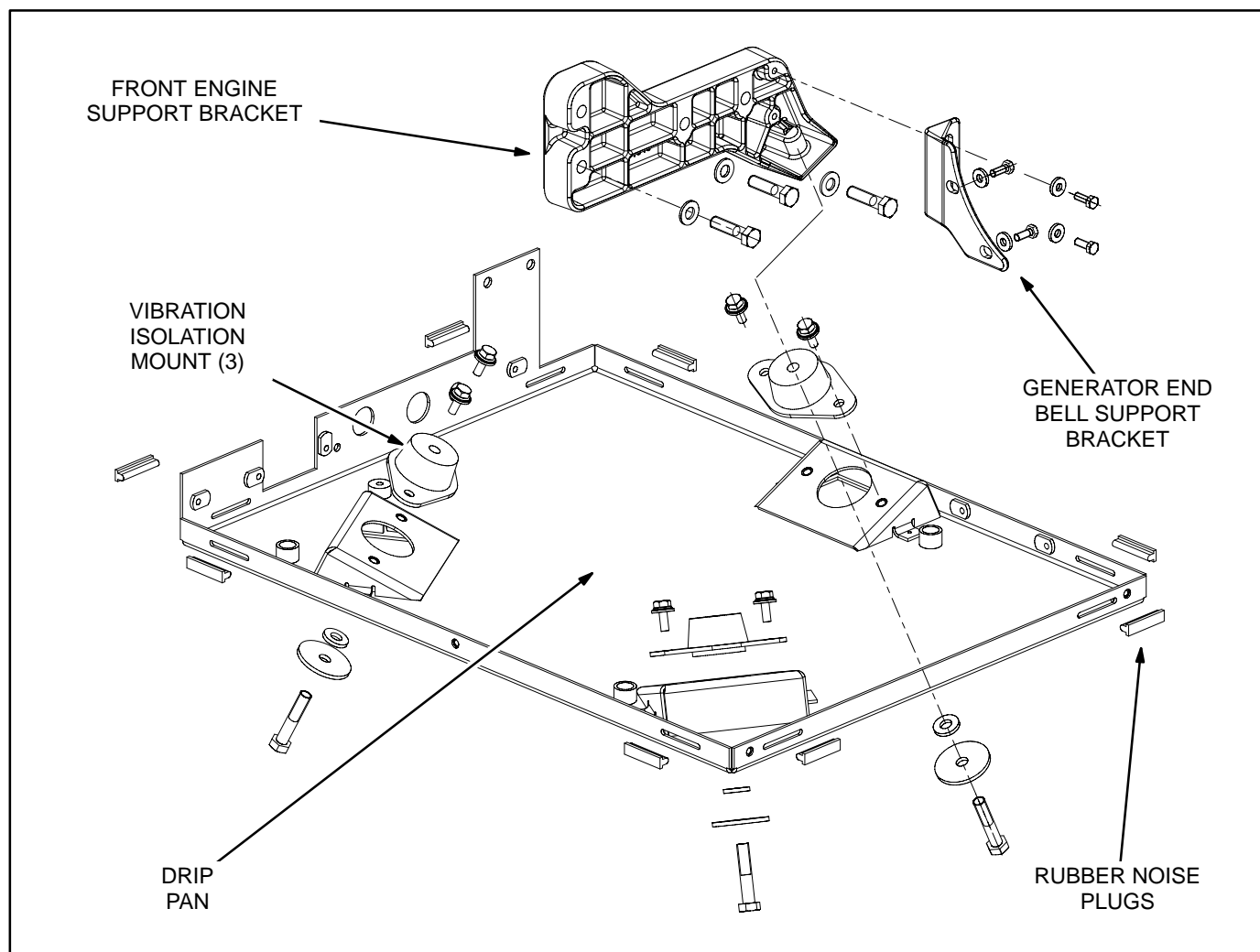


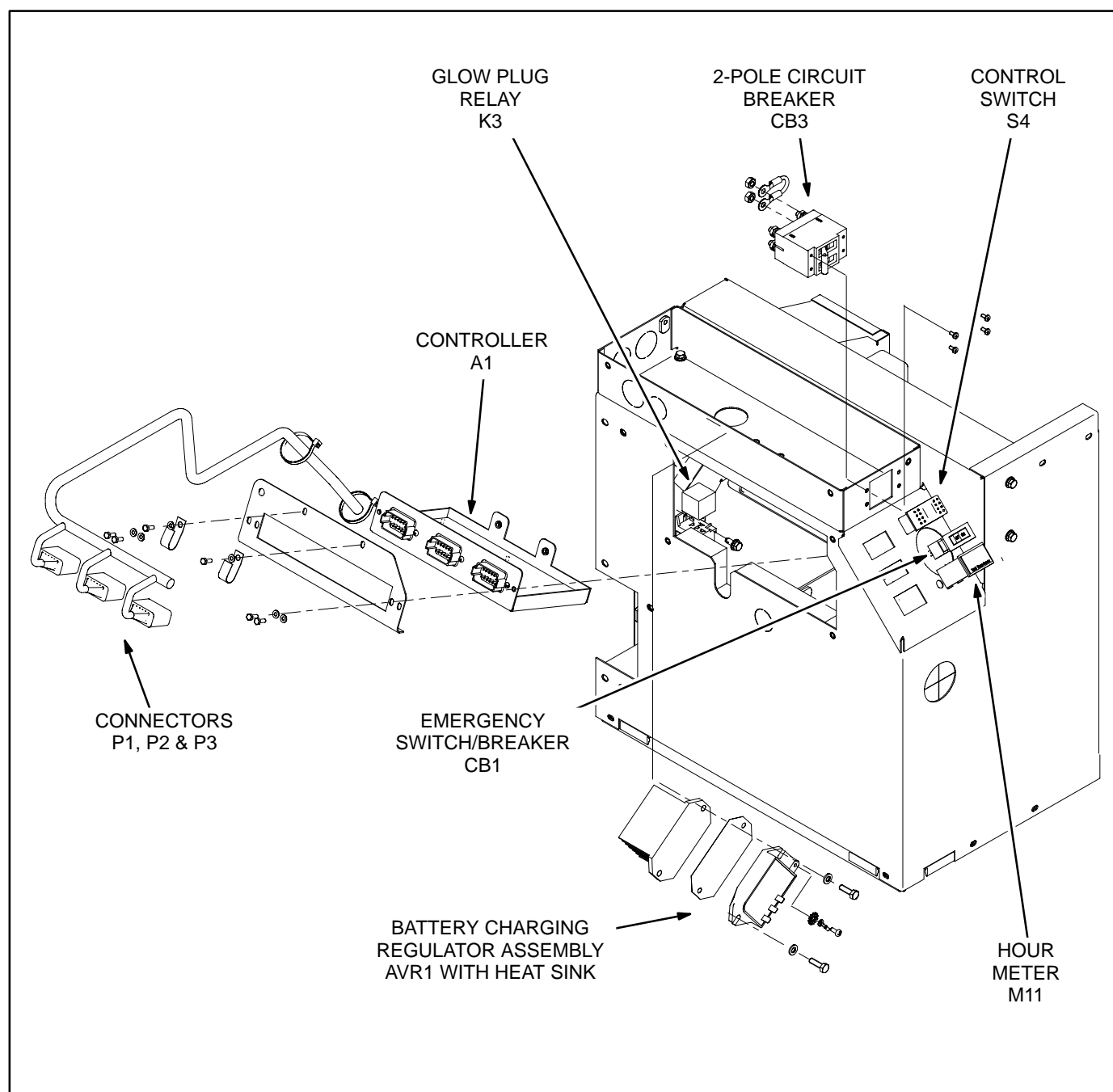
FIGURE 4-2. DRIP PAN AND MOUNTING SYSTEM

# 5. Control System

## OVERVIEW

Controller A1 is an integrated microcontroller-based engine and generator control (Figure 5-1). It provides all the control, monitoring and diagnostic

functions required to operate the genset. All connections to the controller are through connectors P1 (black), P2 (grey) and P3 (green). Refer to the wiring diagrams and wiring harness drawings on Pages A-1 and A-2.



**FIGURE 5-1. CONTROL SYSTEM COMPONENTS**

## CONTROLLER A1

### Major Functions

Figure 5-2 is a block diagram of controller functions.

**Initialization:** Control initialization consists of checking memory (RAM, ROM, EEPROM) and genset configuration.

**Fuel Prime:** Press and hold the control switch at **STOP (Prime)** for more than 3 seconds to cause fuel pump E5 to prime the fuel system.

**Startup:** Press and hold the control switch at **START (Preheat)** until the genset starts. The controller:

1. Energizes fuel lift pump E5.
2. Energizes the glow plugs (two) during pre-heat and cranking. The duration of pre-heat prior to cranking is engine temperature dependent, but does not exceed 15 seconds.
3. Enables the *amber* status lamp to blink rapidly.
4. Enables some fault detection.
5. Enables cranking. The maximum allowed duration of cranking is engine temperature dependent and varies between 20 and 60 seconds.
6. Enables field flash (F1-F2).
7. Energizes governor actuator A12 (full rack).
8. Disconnects the starter (B1) at 800 rpm.
9. When operating speed is reached:
  - A. Enables output voltage.
  - B. Turns off field flash.
  - C. Turns off *amber* status lamp.
  - D. Turns on *green* run lamp.
  - E. Enables Switched B+ (J7).
  - F. Enables complete fault detection.

**Stop:** Touch the control switch to **STOP (Prime)**. The controller:

1. Disables output voltage.
2. Deenergizes the fuel lift pump and governor actuator.
3. Turns off the *green* run lamp.
4. Writes session data (number of cranks, minutes of operation, last fault, etc.) to non-volatile memory (NVM).
5. Removes processor power when idle 5 minutes.

**Note: Stop takes precedence over Start if both present due to a faulty switch or other cause.**

**Voltage Control:** The controller maintains nominal AC output voltage during steady state operation by varying field current as load varies. In response to transient loads it lowers the voltage setpoint to allow engine recovery. Field power (DC) is supplied by the quadrature windings (AC) through the controller.

**Fuel Control:** The controller maintains nominal frequency as load varies by modulating the pulse width of the current energizing governor actuator A12, which moves the fuel rack.

**Voltage Control:** The controller maintains nominal AC output voltage during steady state operation by modulating field current as load varies. In response to transient loads it lowers the voltage setpoint to allow engine recovery. Field power (DC) is supplied by the quadrature windings (AC) through the controller.

**Voltage Adjustments:** See ADJUSTING VOLTAGE (Page 6-5).

**Frequency Adjustments:** See ADJUSTING FREQUENCY (Page 6-5).

**Fault Monitoring, Shutdown and Diagnostics:** See *Troubleshooting* (Page 9-1).

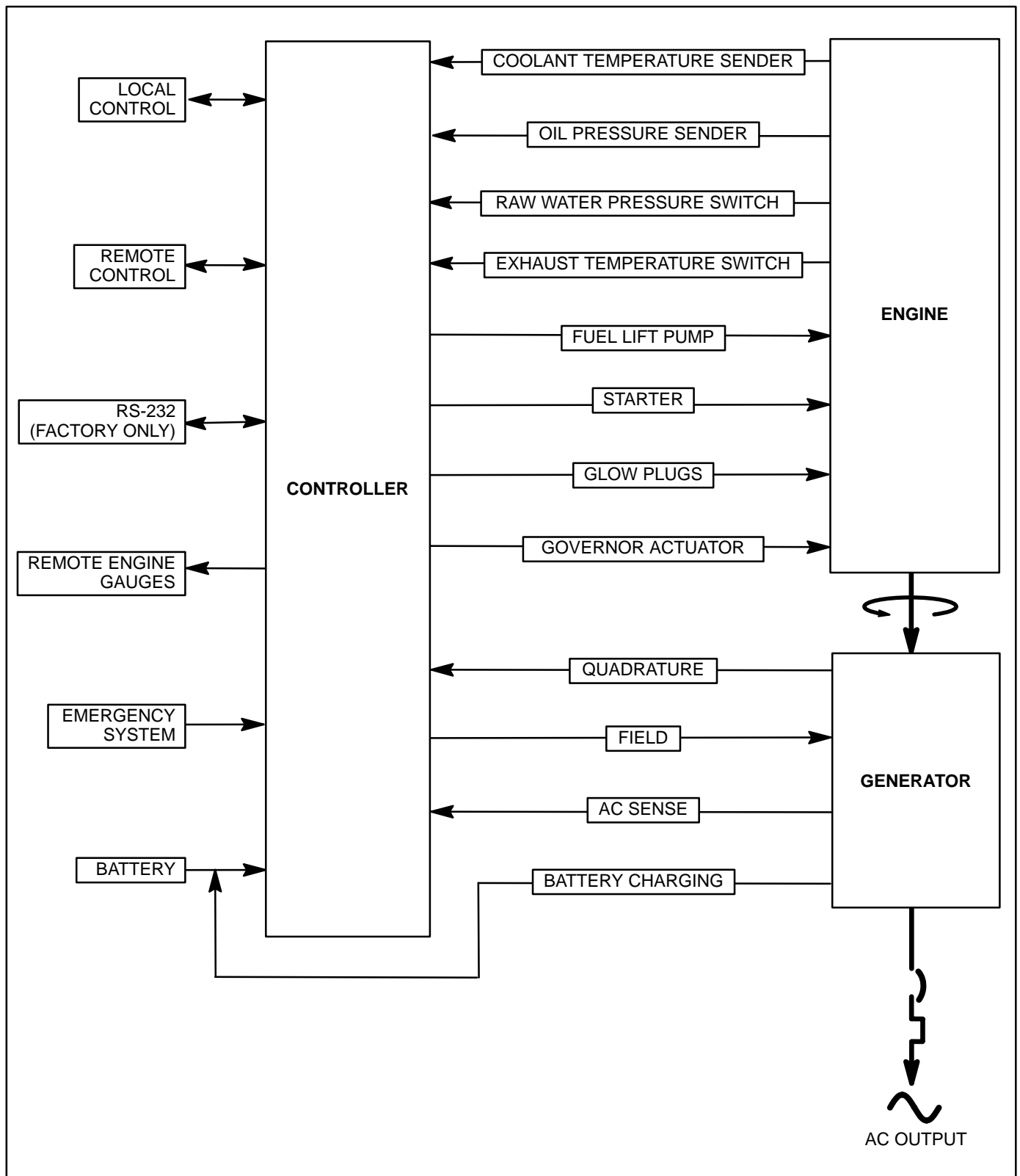


FIGURE 5-2. CONTROLLER A1 BLOCK DIAGRAM

## Controller Removal / Replacement

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

The controller is mounted in the second intake resonator chamber where it is cooled by the intake air and is accessible through the left access panel (Figure 5-1). It is easier to remove if all the screws securing the front / left side panel are loosened from the drip pan and other panels so that the panel can be shifted. Alternatively, remove the AC output box (Page 4-1).

When removing a connector plug from the controller, squeeze the locking tabs on the sides while pulling out. When reinstalling a plug, make sure the seal is in place and that the locking tabs snap into position.

Make sure to properly reconnect the generator grounding strap (Page 4-1), leads and load wiring (Page 6-6), if they have been disconnected.

### CONTROL SWITCH S4

The switch is mounted on the control panel (Figure 5-1). Unsnap the connector for access to its terminals. Replace the switch if **Start** does not close terminals 2 and 3, **Stop** does not close terminals 1 and 2, **Green** does not light when 12 VDC is applied across terminals 7 (-) and 8 (+), or **Amber** when 12 VDC is applied to terminals 7 (-) and 6 (+).

**Note:** The switch snaps in either way on the control panel. The row with 2 terminals must be up, otherwise Start and Stop will be reversed.

### EMERGENCY SWITCH/BREAKER CB1

The switch/circuit breaker is mounted on the control panel (Figure 5-1). Disconnect the leads and check electrical continuity across the two terminals. Replace the circuit breaker if it does not reset or turn ON and OFF.

### HOUR METER M11

The hour meter is mounted on the control panel (Figure 5-1).

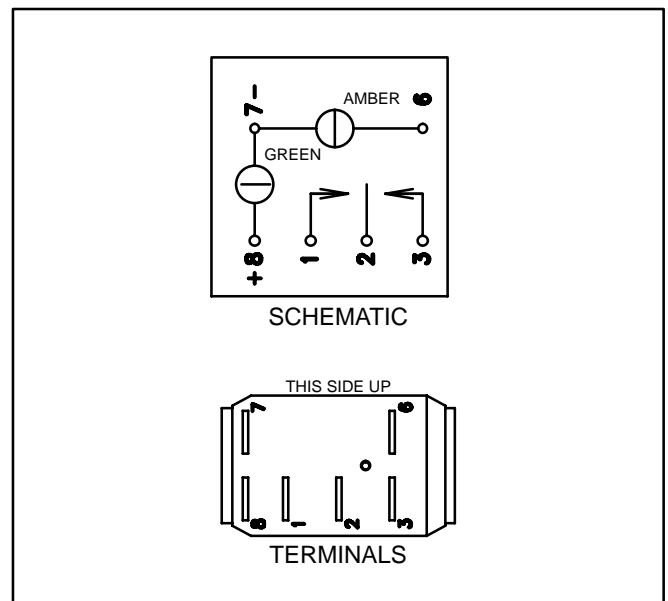


FIGURE 5-3. CONTROL SWITCH S4

## LINE CIRCUIT BREAKER CB3

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

The line circuit breaker is mounted in the AC output box as shown (Figure 5-1). Disconnect all leads and check electrical continuity across each pole. Replace the circuit breaker if either pole does not reset or turn ON and OFF. Reconnect the generator and load wires properly (Page 6-6).

### ENGINE OIL PRESSURE SENDER E1

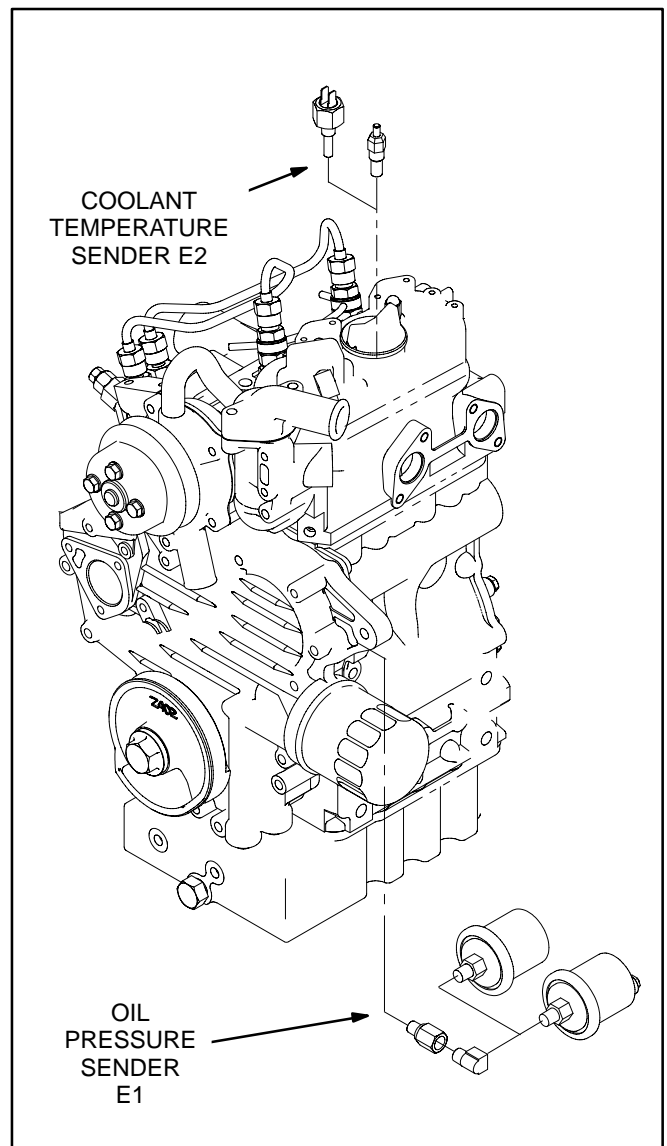
The oil pressure sender is threaded into the side of the block with pipe fittings (Figure 5-4) and is accessible by removing the right side panel or the raw water pump (Page 3-10). Use thread sealant and engage at least two full threads when installing. In isolated-ground applications the sender has two terminals.

Replace the sender if resistance is not between 227 and 257 ohms when the engine is idle (0 psi), or is not reasonably steady between 50 and 200 ohms when the engine is running and known to have normal oil pressure.

### ENGINE COOLANT TEMPERATURE SENDER E2

The engine coolant temperature sender is threaded into the top of the head (Figure 5-4) and is accessible through the top access opening. Use thread sealant and engage at least two full threads when installing. In isolated-ground applications the sender has two terminals.

Replace the sender if resistance is not approximately 800 ohms at room temperature or does not decrease rapidly when immersed in boiling water.



**FIGURE 5-4. OIL AND TEMPERATURE SENDERS**



## RAW WATER FLOW SWITCH S6

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

The raw water flow switch is threaded into the heat exchanger (Figure 5-5) and is accessible through the top access opening. Use thread sealant and engage at least two full threads when installing.

Check continuity across the switch terminals while blowing into it (1 psi). Replace the switch if it does not open and close.

## HIGH EXHAUST TEMPERATURE SWITCH S5

The high exhaust temperature switch is bolted to the ear on the side of the water/exhaust mixer (Figure 5-5). The switch is accessible by removing the enclosure back panel.

## GLOW PLUG RELAY K3

The glow plug relay is mounted on its wiring socket (Figure 5-1). Pull the relay out to test it. Apply 12 VDC across terminals 85–86. Replace the relay if the contacts across terminals 30–87 (NO) do not open and close.

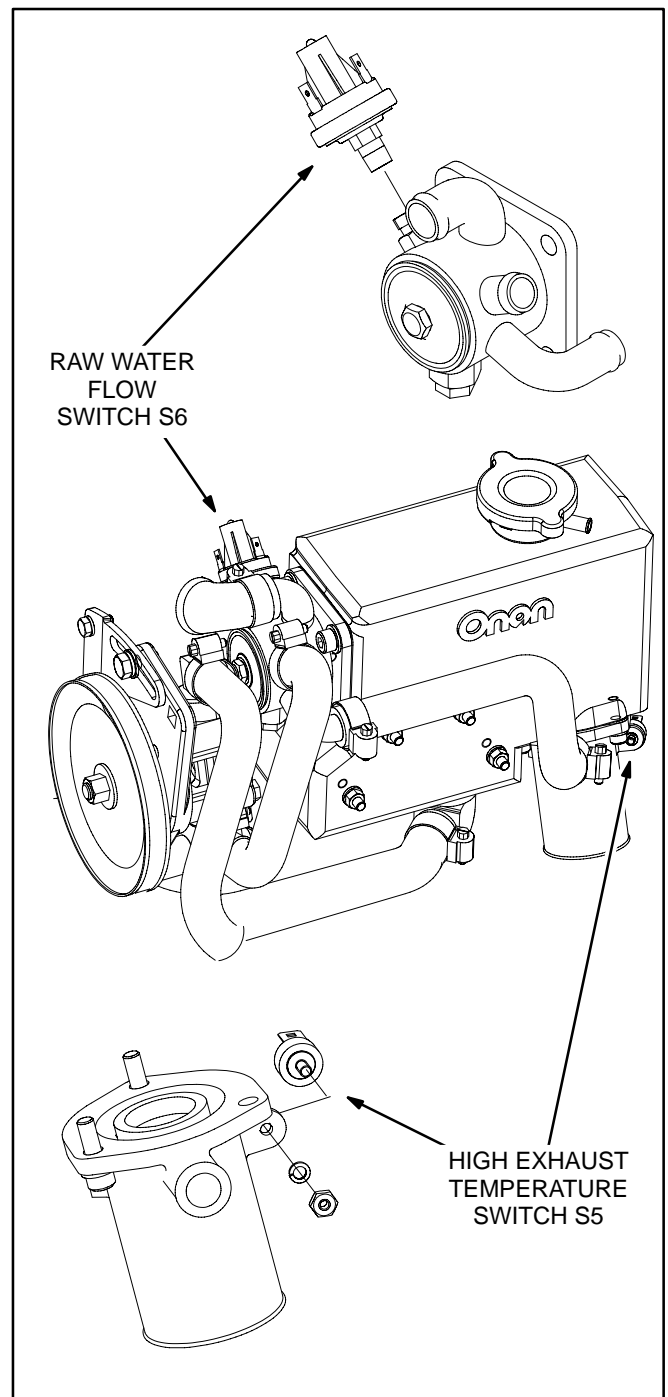
## BATTERY CHARGING REGULATOR AVR1

**Mounting:** The regulator and heat sink are mounted on the air intake duct (Figure 5-1). The regulator is easier to remove if the AC outlet box is tilted out (secured by 4 screws inside the box).

**Testing:** See Page 6-4 to test battery charge winding B1–B2. To test the regulator, remove the lead from terminal B+. If B1–B2 output is 15 to 20 VAC, but regulator output is less than 12.8 VDC, replace regulator AVR1.

## GROUND ISOLATION RELAY K9

See starter service (Page 8-9).



**FIGURE 5-5. RAW WATER FLOW AND HIGH EXHAUST TEMPERATURE SWITCHES**

## 6. Generator

### OVERVIEW

These are 2-bearing, belt-driven, 2-pole revolving-field generators with brushes and slip rings (Figure 6-1). Output voltage is regulated by microcontroller-based genset controller A1 (Page 5-1).

**Stator:** The stator consists of steel laminations with three sets of windings in the lamination slots. The main windings (T1–T2, T3–T4) are for powering the connected loads, the quadrature winding (Q1–Q2) is for field excitation and the (B1–B2) winding for battery charging.

**Rotor:** The rotor consists of a shaft with steel laminations wrapped with field windings. A molded slip ring assembly is pressed on to supply field current to

the rotor windings through the brush block assembly. The rotor shaft is supported on both ends by sealed ball bearings. The drive belt pulley and fan are center-bolted to the tapered rotor ends.

**Brush Block:** Field current passes through the brush block which has two spring-loaded carbon brushes that make contact with the rotor slip rings.

**Principle of Operation:** During startup genset controller A1 flashes the field with battery current for fast buildup of generator voltage as the engine accelerates to operating speed. During operation, the controller maintains nominal AC output voltage by varying field current in response to load. In response to transient loads, the controller lowers the voltage setpoint to allow for engine recovery.

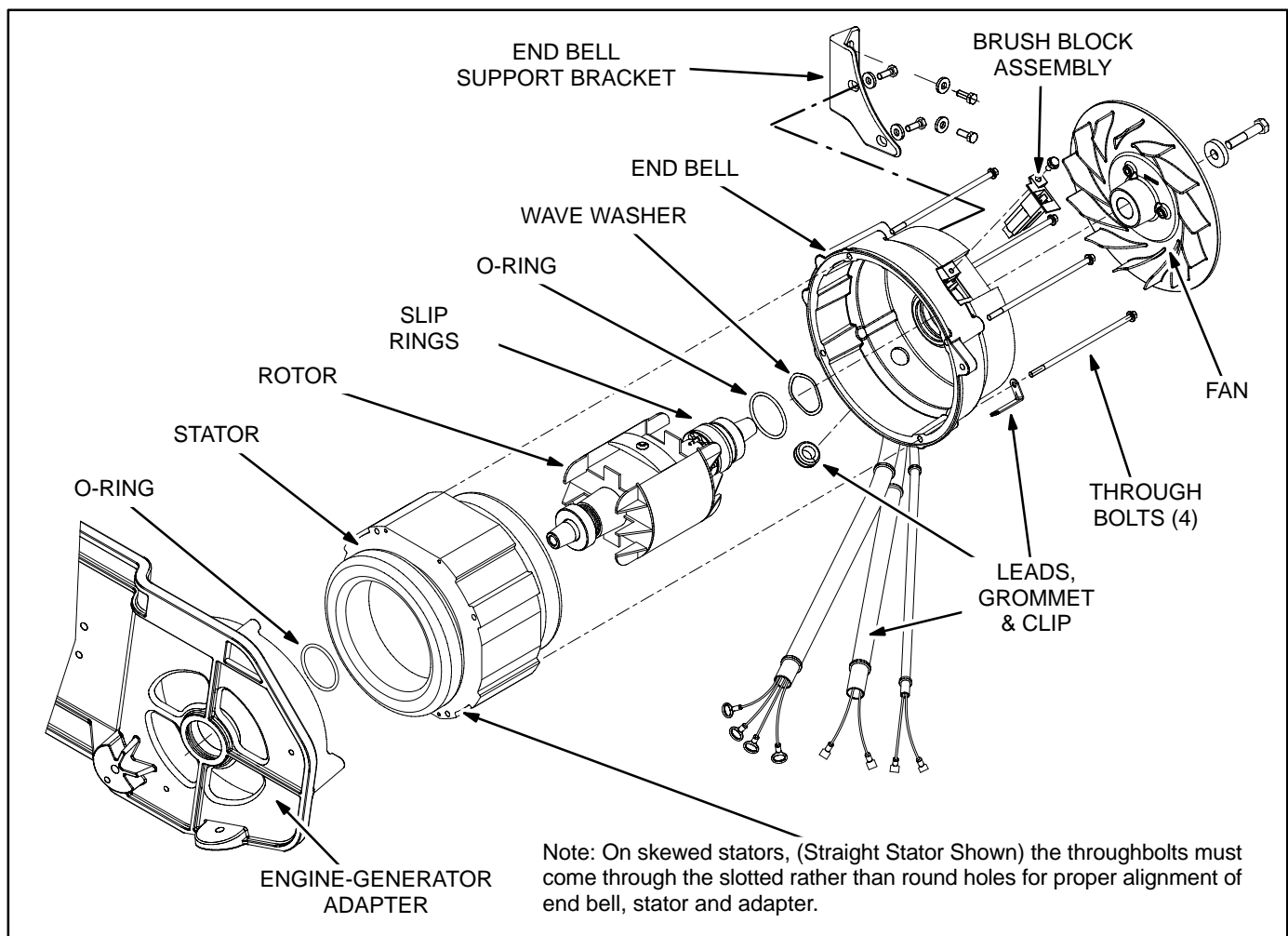


FIGURE 6-1. GENERATOR

## SERVICING THE GENERATOR

**⚠ WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

### Stator Removal

1. Disconnect the generator leads inside the AC outlet box and remove the top, front and left side access doors and panels (Page 4-1).
2. Remove the second intake resonator chamber (Page 8-2).
3. Remove the brush block (Figure 6-1).

**⚠ CAUTION** *The brushes can be damaged if the brush block is not removed before removing the end bell.*

4. Remove the fan hub bolt and fan. (To keep the rotor from turning while loosening the fan bolt, hold the pulley bolt with a wrench.) To pull the fan off the shaft taper, secure a three-point wheel puller to the three holes in the fan hub with M6 or 1/4 inch self-tapping screws.
5. Remove the end bell support bracket from the engine bracket and the end bell (4 bolts).
6. Free the 8 generator leads from their connections and the clip on the side of the generator.
7. Scribe a line across the adapter, stator laminations and end bell to make realignment easier during reassembly.
8. Block the stator so that it does not fall against the rotor, and then remove the four generator through bolts.
9. Pull the generator end bell straight out. Examine the bearing bore and replace the end bell if it is scored or otherwise damaged by the bearing.
10. Pull the stator assembly straight out, taking care not to damage rotor or stator windings.
11. Block the rotor to support its hanging weight to prevent damage to the adapter and bearing.

## Stator Reassembly

Reassembly is the reverse of removal. Note the following:

1. Loosen the end bell support bracket bolts, if not already removed, so that the bracket does not interfere with proper stator and end bell alignment.
2. Align the stator and end bell with the line scribed on them during disassembly.

**Note:** Figure 6-1 shows a straight stator and the through bolts lined up to pass through round holes in the stator laminations. On models with skewed stators the through bolts must pass through slotted holes for the end bell, stator and adapter to line up properly.

3. Relubricate the bearing bore in the end bell with molybdenum disulfide paste (Onan PN 524-0118 or equivalent).
4. Make sure the wave washer and O-ring are in place in the bearing bore.
5. Torque the stator through bolts and end bell bracket bolts to 8 lb-ft (11 N-m) and the fan hub bolt to 45 lb-ft (61 N-m). (To keep the rotor from turning while tightening the fan bolt, hold the pulley bolt with a wrench.)
6. Make sure to tie the generator leads to the clip on the side of the generator.

## Rotor

To remove the rotor, remove the stator and then the drive pulley (Page 7-2) and pull the rotor straight out to the front. When reassembling, lubricate the bearing bores in the end bell and adapter with molybdenum disulfide paste (Onan PN 524-0118 or equivalent). Make sure the wave washer is in place in the end bell and that the O-rings are in place in the bearing bore grooves in both ends.

Use an adhesive when installing new bearings on the rotor shaft. Apply the adhesive to the shaft (Loctite 680 or equivalent) and primer (activator) to the bearing (Loctite 747 or equivalent). Press each bearing on up to its shaft shoulder using a bench press.

**⚠ CAUTION** *Apply force only to the bearing inner race to avoid damage to the bearing.*

## SERVICING BRUSHES AND SLIP RINGS

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

### Brush Block

**Access:** For access to the brush block, remove the enclosure front / left side assembly (Page 4-1) or swing it out to the left. Move the second resonator chamber (Page 8-2) out of the way by removing the bolt that secures it to the generator and by loosening the clamp at the intake manifold.

**Service:** Disconnect the field leads from the brush block (Figure 6-2), remove the mounting screw and withdraw the brush block from the generator end bell. Replace the brush block assembly if either brush is shorter than 7/16 inch (11 mm), binds in the brush block or is damaged in any way.

Reconnect the field leads, **F–** (black) to the outside terminal, and **F+** (red) to the inside terminal.

### Slip Rings

Remove the brush block and inspect the slip rings for grooves, pits, or other damage. Use a Scotch Brite pad or commutator stone to remove light wear or corrosion.

## TESTING FIELD FLASH

Field flash can be tested by measuring output voltage while cranking with the governor actuator leads (Page 8-6) disconnected to keep the engine from starting. If output voltage increases at least 1 volt while cranking, the whole field excitation system—controller, brushes, slip rings and rotor—are probably in working order and the problem lies elsewhere. See *Troubleshooting* (Page 9-1).

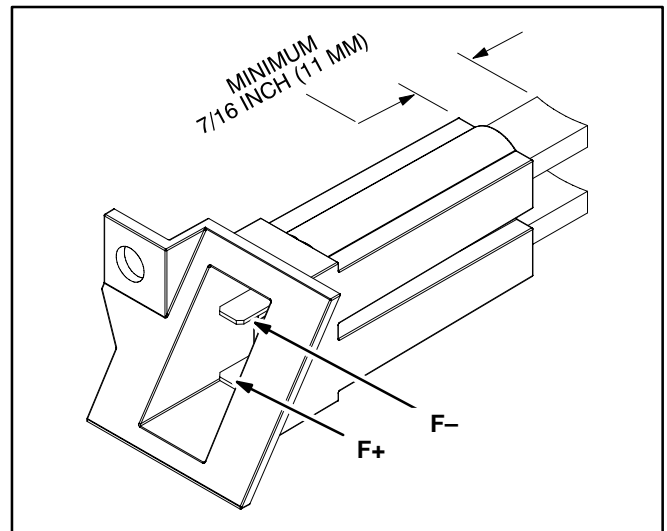


FIGURE 6-2. BRUSH BLOCK

## TESTING GENERATOR WINDINGS

### Testing the Rotor

**Field Resistance Test:** Disconnect field leads F1 and F2 from controller A1 by pulling green connector P3 and measure resistance across pins 7 and 8. If resistance is not as specified in Table 6-1:

1. Check for and repair faulty field leads.
2. Service brush block and slip rings (Page 6-3).
3. Check rotor resistance across the slip rings (Figure 6-3). Replace the rotor if resistance is not as specified.

**Ground Test:** Using a megger or the highest scale on a digital ohmmeter, measure resistance between the rotor and either slip ring (Figure 6-4). Replace the rotor if its winding has less than one megohm resistance to ground.

### Testing the Stator

Disconnect T1, T2, T3 and T4 from the terminals in the output box. Disconnect B1 and B2 from charging regulator AVR1 (Page 5-1). Disconnect Q1 and Q2 from controller A1 by pulling green connector P3 (Pins 4 and 5).

**Open Winding Test:** Measure resistance across each winding lead pair (Table 6-1). Replace the stator if any winding is open (zero ohms).

**Winding Resistance Test:** Use a meter (Wheatstone Bridge) having 0.001 ohm precision to measure resistance across each winding lead pair (Table 6-1). Replace the stator if resistance in any winding is not as specified.

**Ground Test:** Using a megger or the highest scale on a digital ohmmeter, measure resistance between the stack and each stator lead. Replace the stator if any winding has less than one megohm resistance to ground.

TABLE 6-1. GENERATOR WINDING RESISTANCES

WINDING	RESISTANCE (OHMS) @ 77° F (25° C) $\pm$ 10%
T1-T2, T3-4	0.353
Q1-Q2	2.93
B1-B2	0.114
F1-F2	32

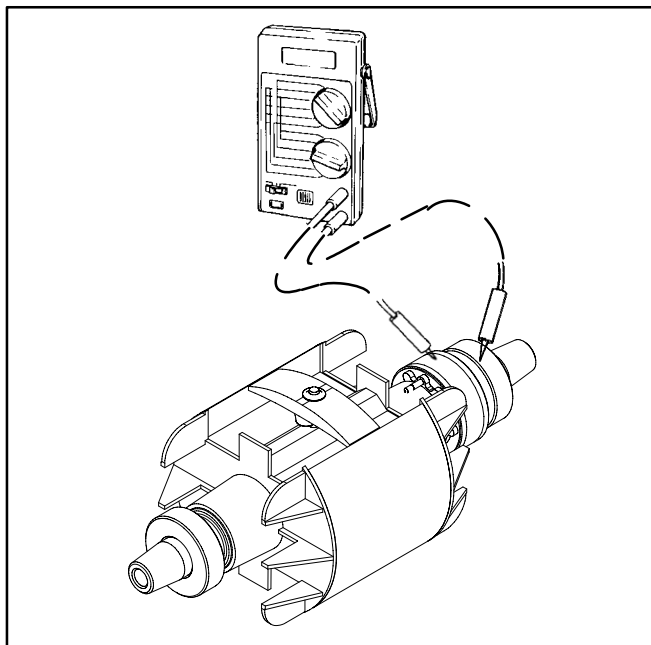


FIGURE 6-3. OPEN OR SHORTED ROTOR TEST

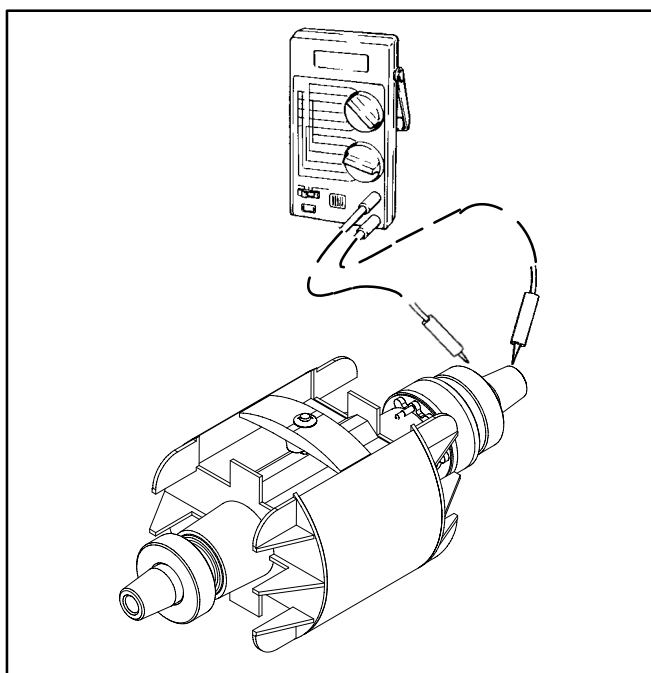


FIGURE 6-4. GROUNDED ROTOR TEST

## RECONNECTING THE GENERATOR

Reconnect the generator properly for the application. See Page 6-6.

### ADJUSTING FREQUENCY

If it is necessary to change the output frequency for the application, remove the access cover on the left end of the genset. Find the leads marked **J8 HZ**, **60 HZ** and **50 HZ** in the wiring harness (Page A-2). Connect **60 HZ** or **50 HZ** to **J8 HZ**, as appropriate, and secure the access cover (4 screws).

### ADJUSTING VOLTAGE

Output voltage may need to be readjusted for the application, especially if it was necessary to change the frequency and/or reconnect the generator (Page 6-6). Recheck generator reconnections and reconsider whether frequency needs to be changed before attempting voltage adjustments.

Voltage is adjusted by means of the control switch. Rapidly pressing the switch to **START** 6 times *during the first minute after startup* puts the genset controller into *voltage set mode*. The *amber* status indicator lamp will begin blinking once every second to confirm voltage set mode. The *green* status indicator lamp will remain on. The controller resumes normal operating mode 20 seconds after the last adjustment.

**Note:** If a fault shutdown occurs or the control switch is pressed to **STOP** during voltage set mode, voltage adjustments will not be stored in controller memory.

To adjust voltage:

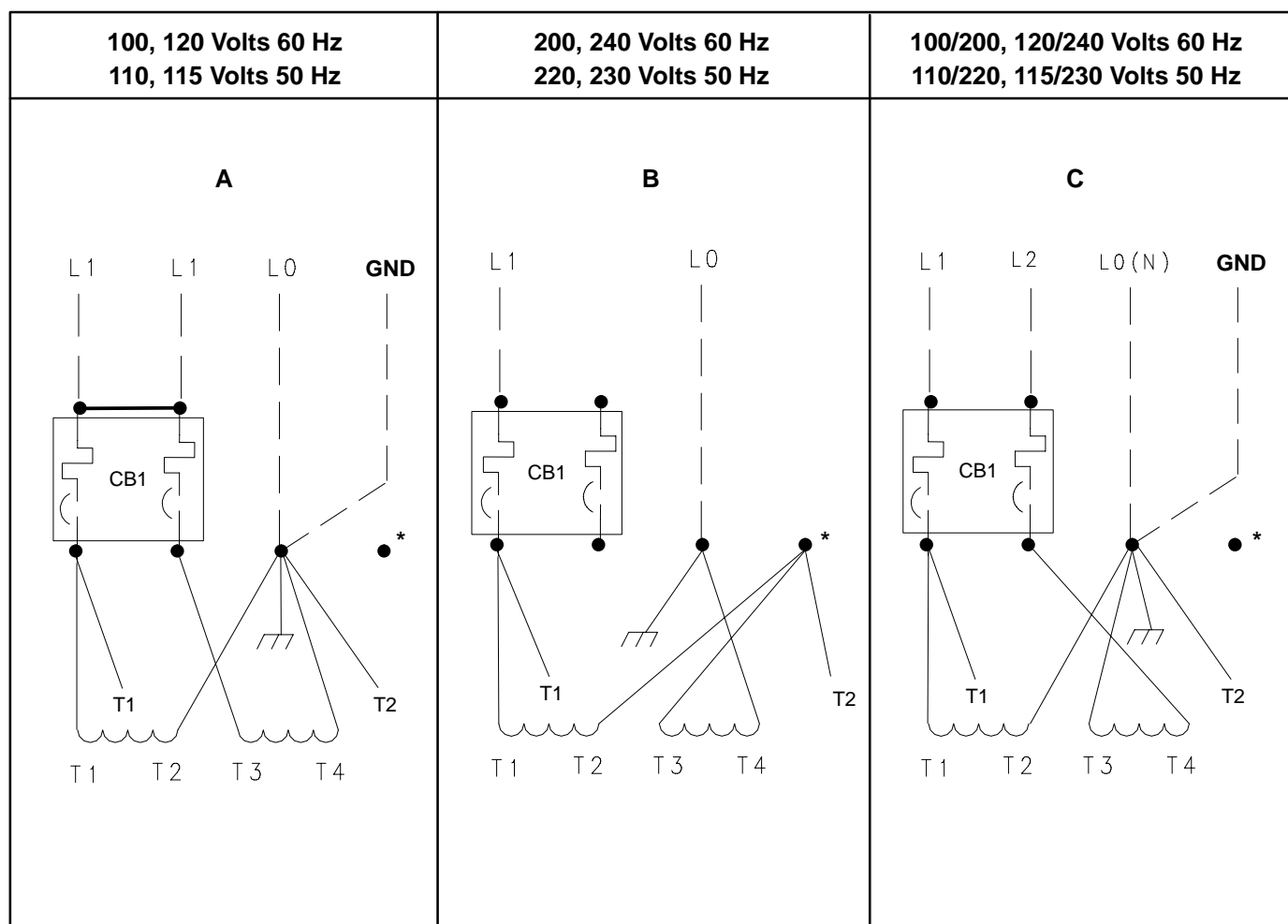
4. Disconnect all generator loads and connect accurate meters to measure AC volts and frequency.

#### **⚠WARNING**

#### **HAZARDOUS VOLTAGE!**

***Touching uninsulated live parts inside the genset or connected equipment 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.***

5. Start the genset and let voltage and frequency stabilize for 5 to 10 seconds.
6. Rapidly press the control switch to **START** 6 times within 10 seconds.
7. **To adjust voltage up**, press the control switch to **START** and release quickly. Each time the switch is released, voltage will rise approximately 0.6 volt.
8. **To adjust voltage down**, press the control switch to **START** and release in 1 second. Each time the switch is released, voltage will drop approximately 0.6 volt.
9. Normal operation will resume in 20 seconds after the last adjustment. The last adjustment will be retained by the controller.



**A** – Jumper the two load terminals of the circuit breaker so that there is no imbalance of loads between the generator windings and both windings are available for large motor and air conditioner starting. Bolt **T2/T2/T4/L0/GND** to the grounding stud in the outlet box.

**B** – Bolt **T2/T2/T3** to the isolated terminal on the red standoff block in the outlet box. Bolt **L0/T4** to the grounding stud in the outlet box. *Generator grounding must be in accordance with codes.*

**C** – Bolt **T2/T2/T3/L0(N)/GND** to the grounding stud in the control box unless codes require an isolated neutral (N).

**Note: Always bolt the T1 voltage sense lead with the T1 winding lead and the T2 voltage sense lead with the T2 winding lead.**

\* – Isolated terminal on red standoff block.

**FIGURE 6-5. GENERATOR RECONNECTIONS**

# 7. Generator Drive

## OVERVIEW

The engine drives the generator by means of a 6-rib "Poly-Vee" belt (Figure 7-1). The drive pulley is mounted on the engine flywheel by means of a flex-

ible coupling. The generator pulley is center-bolted to the tapered end of the rotor shaft. The pulley must be removed to remove the generator rotor from the engine-generator adapter.

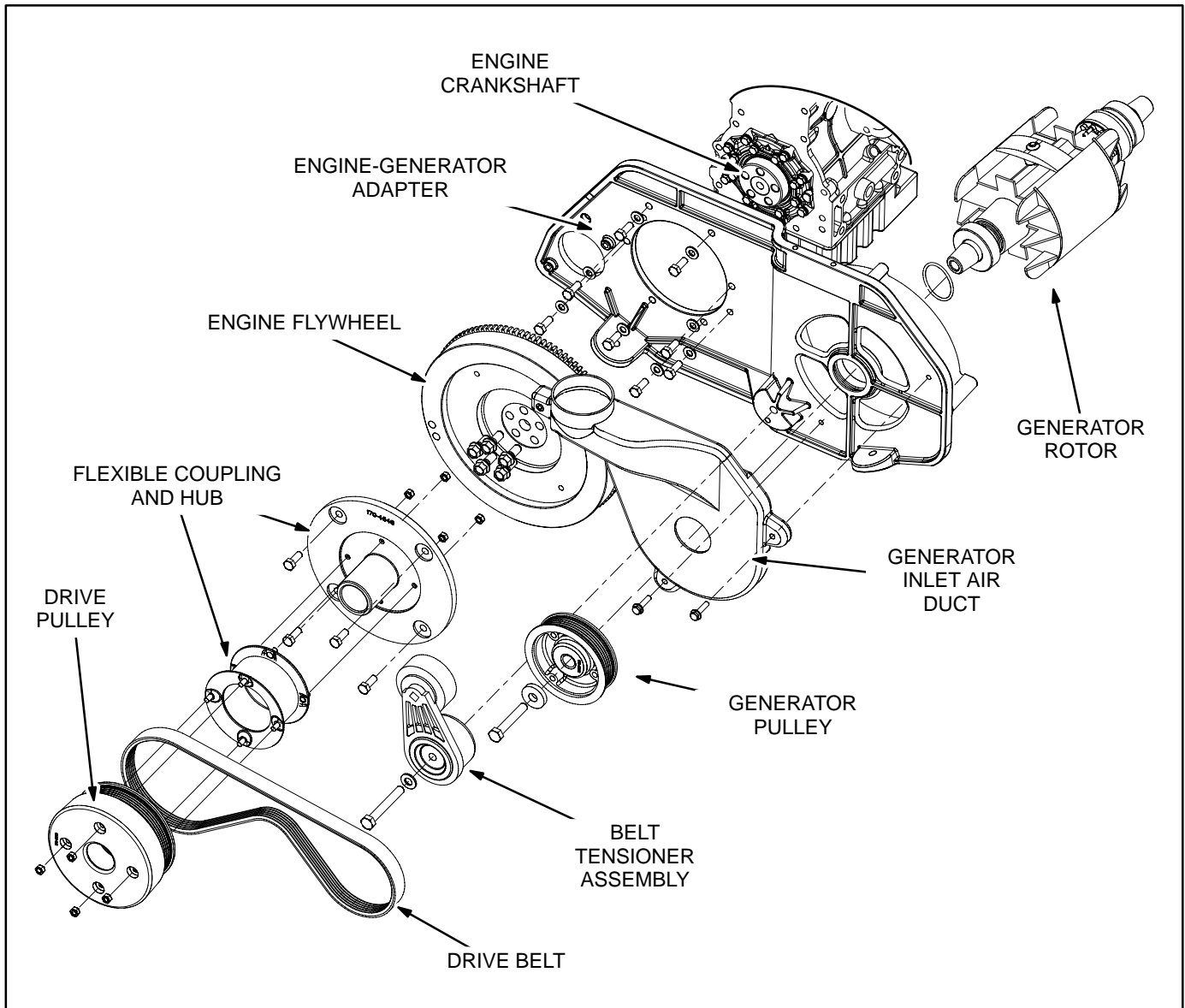


FIGURE 7-1. GENERATOR DRIVE



## INSPECTING DRIVE AND BEARINGS

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

Remove the back panel (Page 4-1) to inspect the drive and bearings:

1. Pivot the belt tensioner away from the belt with a 3/8 inch drive and remove the belt. Examine the belt for cracks, worn spots and other signs of deterioration. Replace the belt if necessary or if it has been in service 5 years or 2000 hours.
2. Remove the drive pulley and coupling as an assembly from the flywheel and then the pulley from the coupling. Examine the coupling for wear and deterioration and replace it if necessary. Examine the two split-sleeve bearings in the pulley hub for wear and scoring and replace them if necessary.

When reassembling, torque the coupling nuts to 8 lb-ft (12 N-m) and the 4 hub-to-flywheel bolts to 21 lb-ft (29 N-m).

3. Spin the idler pulley. Replace the bearing if it does not spin smoothly or is noisy. Replace the idler assembly if it does not pivot smoothly from one end of its travel to the other.
4. Spin the generator pulley by hand to determine if there is any noise, looseness or grinding. Check for side-to-side and up-and-down looseness of the bearing. If necessary, disassemble the generator (Page 6-2) to determine the cause of the looseness or noise. Replace the rotor assembly if it is evident that either bearing has spun on the shaft. Replace the end bell or adapter if it is evident that the bearing has spun in the bore. Replace the bearings if they have been in service 5 years or 2000 hours.

## SERVICE

### Generator Pulley

Remove the belt and pulley center bolt and use a claw-type wheel puller to break the pulley free of the generator shaft taper. (To keep the rotor from turning while loosening the pulley bolt, hold the fan bolt

with a wrench.) Torque the center bolt to 45 lb-ft (60 N-m) when reassembling. Make sure to install the generator inlet air duct before installing the pulley.

### Generator Inlet Air Duct

Torque the three mounting bolts to 8 lb-ft (12 N-m). Make sure to install it before installing the pulley.

### Tensioner Pulley Assembly

Spin the idler pulley. Replace the bearing if it does not spin smoothly or is noisy. Replace the idler assembly if it does not pivot smoothly from one end of its travel to the other. Torque the center pivot bolt 45 lb-ft (60 N-m).

### Drive Pulley and Coupling

Remove the drive pulley and coupling as an assembly from the flywheel. Then, if necessary, remove the 4 coupling nuts on each end to disassemble the coupling from the hub and the pulley. Examine the coupling for wear and deterioration and replace it if necessary. Examine the two split-sleeve bearings in the pulley hub for wear and scoring and replace them if necessary.

Torque the coupling nuts to 8 lb-ft (12 N-m) and the 4 hub-to-flywheel bolts to 21 lb-ft (29 N-m).

### Flywheel

Remove the drive pulley and coupling as an assembly for access to the flywheel mounting bolts. Scribe a line across crankshaft and flywheel to make re-alignment easier when reassembling. ***The flywheel will only go on one way because the bolts are not quite evenly spaced. Proper alignment is necessary to preserve engine balance and timing mark.***

Torque the 5 mounting bolts to 42 lb-ft (56 N-m) when remounting the flywheel.

### Engine-Generator Adapter

To remove the adapter, first remove the engine-generator assembly from its mounting (Page 4-2), the generator (Page 6-2) from the adapter and the flywheel from the engine. Torque the 6 mounting bolts to 21 lb-ft (29 N-m) when reassembling.

# 8. Engine

## MAJOR ENGINE SERVICE

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

Refer to engine Workshop Manual 981-0533 for major engine service and for adjusting valve clearance (lash), setting fuel injection timing, replacing glow plugs, cleaning the crankcase breather assembly and replacing the coolant pump.

**Note:** To preserve the existing high-idle speed adjustment, do not disturb the lock wires on the adjusting screws on the governor actuator base (Page 8-8) when removing it from the engine for engine service.

**Cooling System:** Refer to ENGINE COOLING SYSTEM (Page 3-7) for replacing thermostat, raw water impeller, heat exchanger and V-belt.

**Fuel Injection Timing Marks:** Note the fuel injection timing marks (Figure 8-1), which line up at 19° BTDC. They are visible when the back or side panel is removed (Page 4-1).

**Adjusting Valve Lash:** Do not use the fuel injection timing marks (Figure 8-1) when adjusting valve lash. Using them could lead to misadjustments.

Valve lash should be adjusted when both valves are closed at TDC for the cylinder power stroke (every other revolution). To locate this position for either cylinder, rotate the engine clockwise (looking from the front) until the intake valve push rod (Figure 8-2) just stops moving down (valve closed). Then turn the engine one half turn more and adjust lash for both valves (intake and exhaust). Repeat this procedure for the other cylinder. Adjust valve lash to 0.0059–0.0073 inch (0.145–0.185 mm).

The rocker arm cover is accessible through the top access opening (Page 4-1). To get the rocker arm cover off, remove the screw that secures the intake resonator (Page 8-2) to the cover and tilt the resonator out of the way. Also remove the glow plugs.

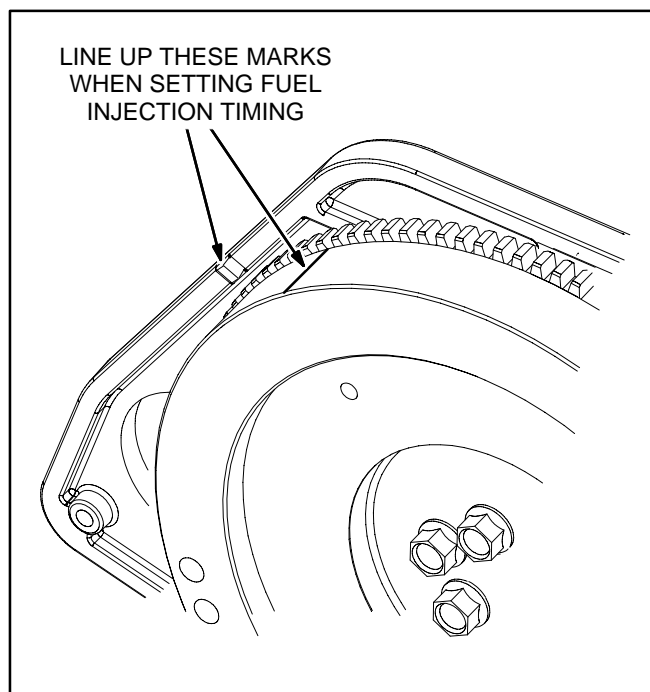


FIGURE 8-1. FUEL INJECTION TIMING MARKS

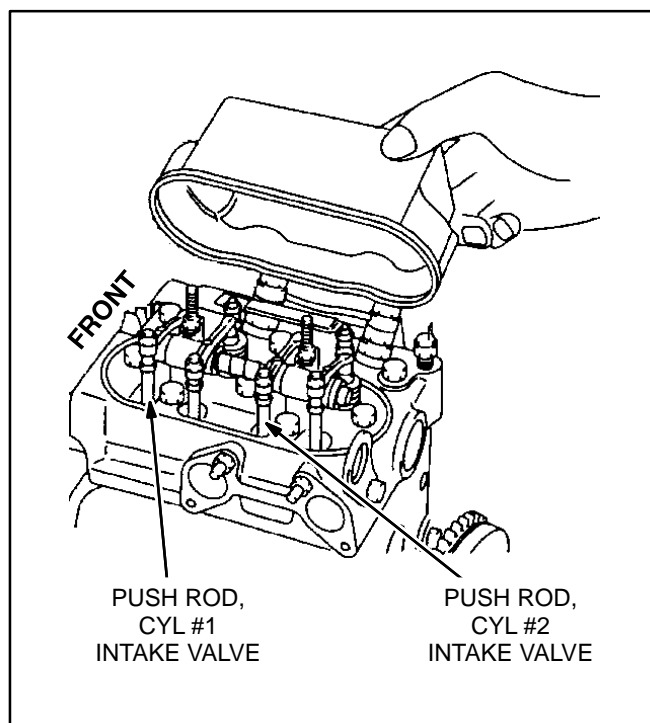


FIGURE 8-2. ROCKER ARMS AND PUSH RODS

## INTAKE RESONATOR ASSEMBLY

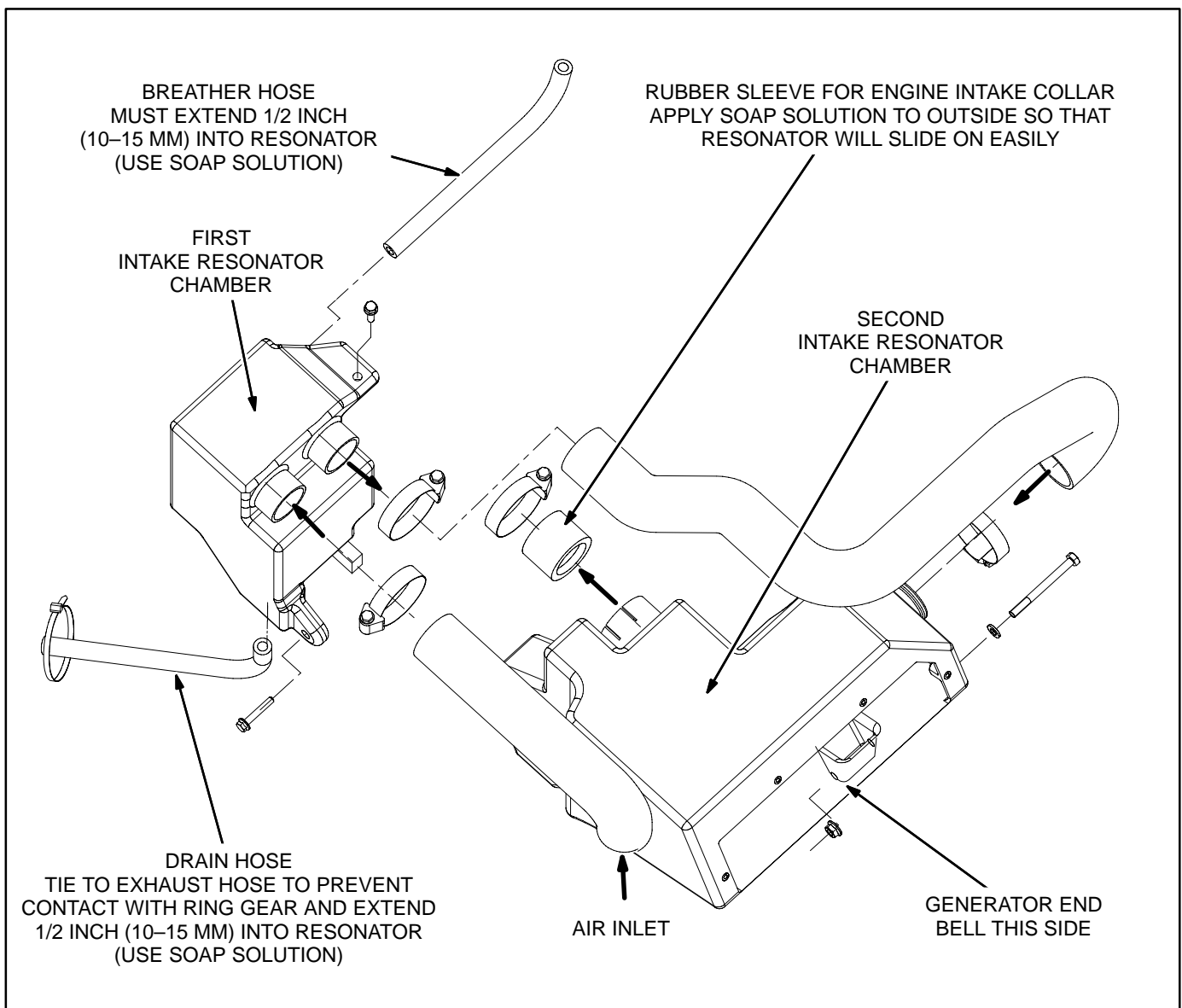
**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

Figure 8-3 illustrates how the intake resonator system is assembled. The arrows indicate the air flow. Remove the top access door and the control access panel on the left side for access (Page 4-1). When reassembling, make sure the tails on the hose

clamps will not touch the insulation on the access door.

**Before installing the second resonator chamber, make sure that:**

- The brush block leads are connected (Page 6-3).
- The fuel lines are connected at the fuel injector (Page 8-5).
- The oil fill hose is connected at the engine fill tube (Page 8-5).
- All adjustments to the governor (Pages 8-7 and 8-8) have been completed.



**FIGURE 8-3. INTAKE RESONATOR ASSEMBLY**

## EXHAUST MANIFOLD

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

Figure 8-4 illustrates how the exhaust system is assembled. Remove the front and top access doors and the right side panel for access (Page 4-1).

Use new manifold and mixer gaskets when re-assembling. Torque the 4 manifold nuts and the 3 mixer bolts to 8 lb-ft (11 N-m).

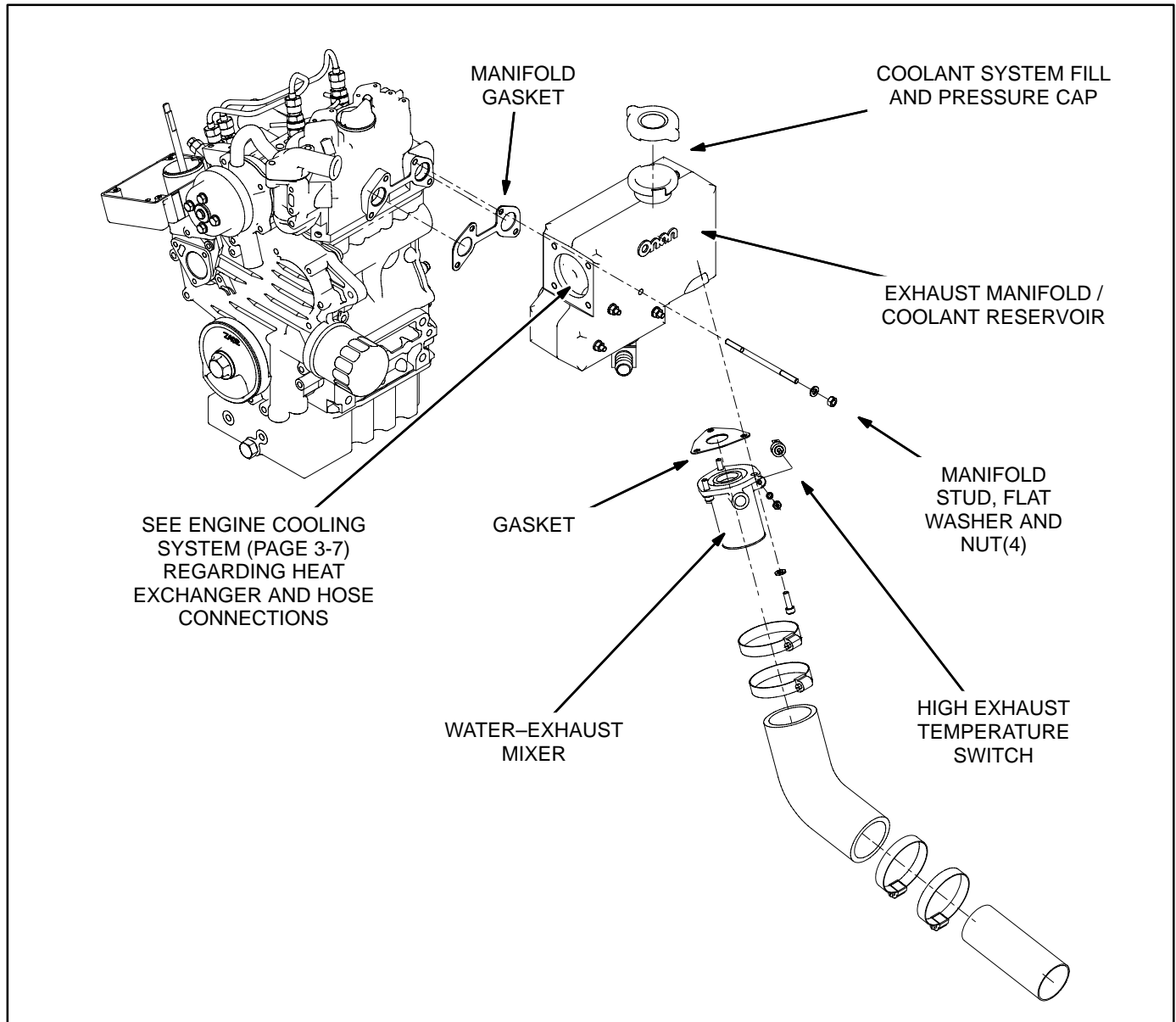


FIGURE 8-4. EXHAUST MANIFOLD

## FUEL SYSTEM

**⚠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 multi-class ABC fire extinguisher handy.*

Figure 8-5 illustrates how the fuel system is assembled for delivering fuel to and from the fuel injection system.

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable at the battery to prevent the engine from starting.*

**Fuel Filter:** See the engine Workshop Manual (981-0533) for fuel injection system service. See DRAINING / CHANGING FUEL FILTER (Page 3-5) regarding fuel filter maintenance.

**Fuel Pump Tests:** A quick test to determine if the fuel pump is weak is to pinch the fuel bypass hose (Figure 8-5) with rubber tipped visegrips. If an engine that fails to start starts and runs with bypass flow cut off, fuel delivery to the engine is weak. Service all of the fuel filters in the system and repair any restrictions to fuel flow. If fuel delivery is still weak, replace the fuel lift pump.

To test fuel lift pump delivery:

1. Disconnect the fuel return hose from the line to the supply tank and point the end into a container of known volume, such as a 1 or 2 liter (quart) bottle.
2. Prime the genset by pushing the Start/Stop switch to **STOP(Prime)** and holding it there for the duration of the test. It should not take longer

than 1-1/2 minutes to fill a 1 liter container (2/3 liter per minute).

3. If flow is less than specified, service all of the fuel filters in the system and repair any restrictions to fuel flow. If fuel delivery is still weak, replace the fuel lift pump.

**Fuel Pump Removal and Installation:** Remove the right side panel for access (Page 4-1). Alternatively, if the starter has been removed from the front, the fuel pump can also be removed from the front.

**Fuel Fittings:** The connections for fuel supply and return that extend through the side of the drip pan are pipe thread fittings. For these fittings use *liquid-type* pipe thread sealant Listed as suitable for diesel fuel. Apply the sealant sparingly to the male threads only.

**⚠CAUTION** *Excess liquid-type pipe thread sealant or pieces of Teflon-type pipe thread sealant can plug the engine fuel system. Apply liquid-type pipe thread sealant sparingly to the male threads only. Do not use Teflon tape.*

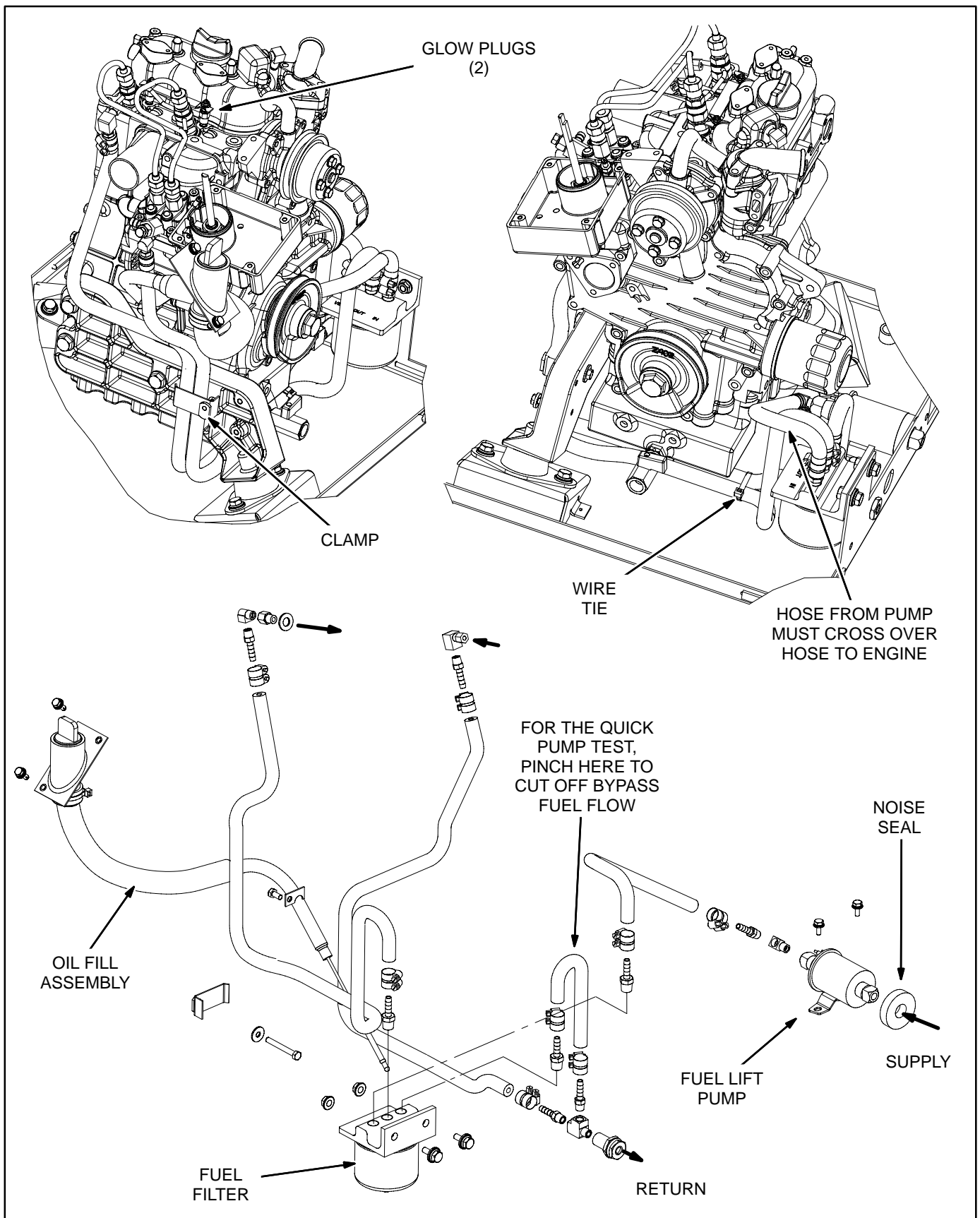
**Fuel Hose:** Replace worn or damaged fuel hose with with USCG TYPE A1 or ISO 7840-A1 fuel hose. The hoses must be long enough to be clamped and to be routed underneath the engine oil pan without rubbing on the oil pan.

**Note:** The second intake resonator chamber (Page 8-2) must be removed to connect and disconnect the supply hose at the fuel injector.

## GLOW PLUGS

Refer to engine Workshop Manual 981-0533 when replacing the glow plugs (Figure 8-5).

**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. Glow plugs can swell if preheat voltage is greater than 14 volts, such as when a battery booster is used for starting.



**FIGURE 8-5. FUEL SYSTEM AND GLOW PLUGS**

## GOVERNOR ACTUATOR

The position of the rotor in governor actuator A12 (Figure 8-6) is determined by the modulated pulse width of the current supplied by controller A1.

### Assembly / Disassembly

**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

**Stator:** Remove the front and top access doors for access (Page 4-1). To remove the stator, disconnect the 2 actuator leads and remove the cover and 4 stator screws. Pry out the leg of the return spring with a screwdriver. (Be prepared to catch the spring if it flies off.) Lift off the bearing carrier and stator.

**⚠WARNING** *The spring can fly off and cause severe eye injury. Wear safety glasses.*

Stator reassembly is the reverse of disassembly. The bearing carrier must seat squarely in the stator. Torque the stator screws to 24 lb-in (2.7 N-m).

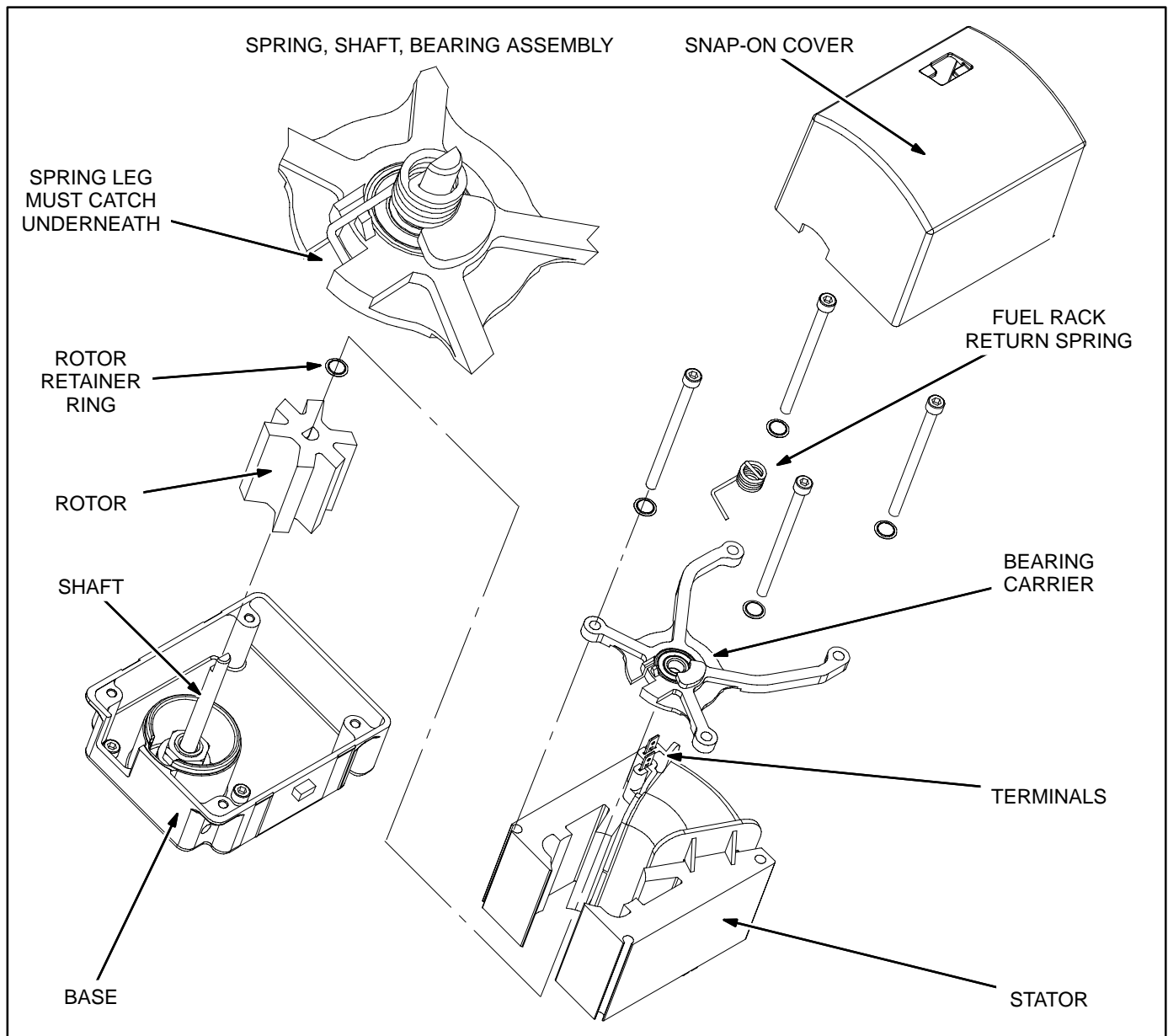


FIGURE 8-6. GOVERNOR ACTUATOR

Replace the return spring if it is worn. This spring returns the fuel rack to the no-fuel position. Push the spring on over the flat on the shaft and pry the leg into its slot (Figure 8-6). The leg below the knee must catch underneath and the spring must be pushed down as far as it will go.

**⚠ CAUTION** *The genset may not stop reliably if the fuel rack return spring is not assembled properly.*

Use wire ties to secure the cover.

**Rotor:** The rotor can be pried off the shaft after the bearing carrier has been removed.

Use a new retainer ring when reassembling. Note that the ring is concave (dished). Push the dished side up against the rotor to keep it in place on the shaft.

**Base:** See engine Workshop Manual 981-0533 if it is necessary to remove the actuator base or replace internal engine governor parts. The stator must be removed for access to the screws that secure the base to the engine.

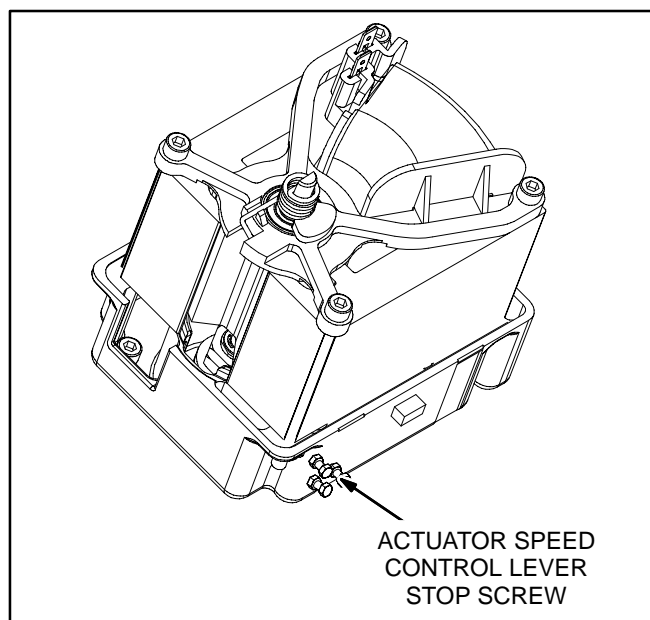
**Note:** To preserve the existing high-idle speed adjustment, do not disturb the lock wires on the adjusting screws on the governor actuator base (Page 8-8) when removing it from the engine for engine service.

### Adjusting Speed Control Lever Stop

The actuator speed control lever stop (Figure 8-7) must be adjusted whenever a different actuator base assembly is installed. The stop screw, rather than the fuel rack control lever, must stop the speed control linkage when the fuel rack is driven to the no-fuel position.

**Note:** To adjust the stop, the rotor need not be on the shaft, but the end of the shaft must be supported by the bearing carrier.

1. Remove the front and top access doors (Page 4-1) and loosen the front / left side panel assembly so that it can be swung to the left for access to the adjusting screw.
2. Loosen the stop screw locknut and back the screw out a few turns. (Top one in the group of three.)
3. Turn the stop screw in until it just makes contact and set the locknut.



**FIGURE 8-7. SPEED CONTROL LEVER STOP**



## Adjusting High-Idle Speed

**⚠WARNING** *This adjustment involves operating the genset with enclosure panels removed that guard against moving parts that can cause severe personal injury or death. Keep your hands away from the engine belt and pulleys.*

High-idle speed (Figure 8-8) must be checked each time an actuator base is reinstalled or replaced.

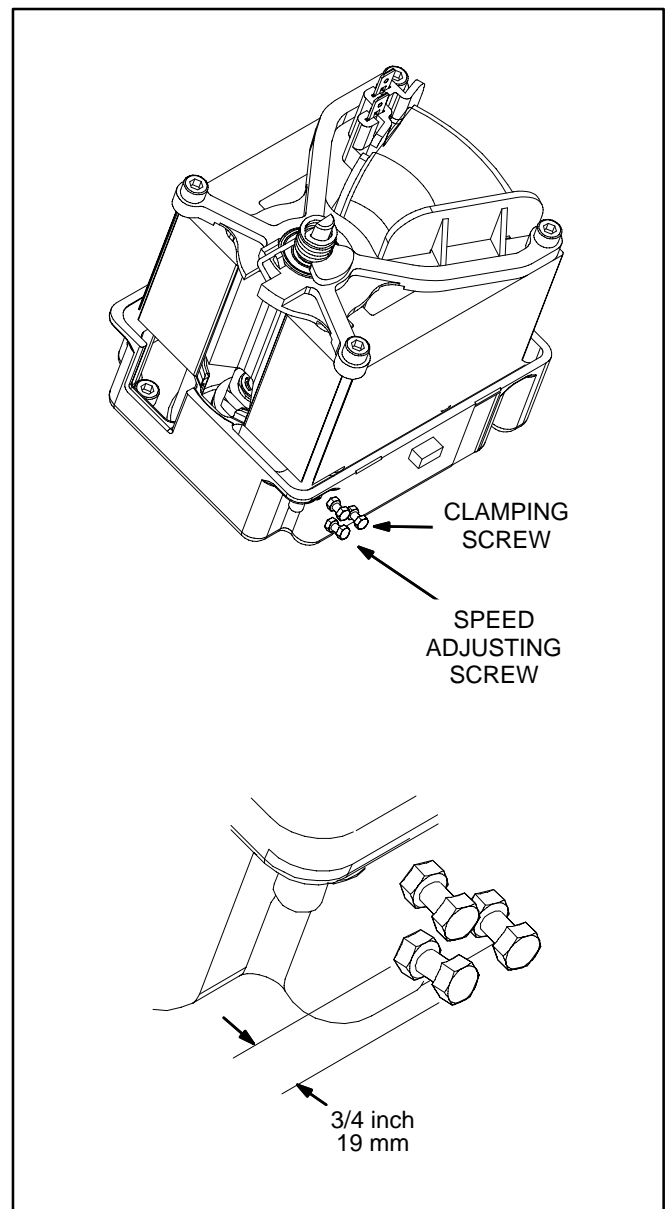
For an initial adjustment when installing a new base, (to make sure the engine stops when the actuator is deenergized), turn the high-idle speed adjusting screw in until the head of the screw is 3/4 inch (19 mm) from the base (Figure 8-8).

**Note:** Be prepared, if necessary, to clamp off the supply and the return fuel lines to stop the engine.

1. Adjust the speed control lever stop (Page 8-7).
2. For this test, measure engine speed with a strobe or injector clamp-on type tachometer.
3. Remove the front and top access doors (Page 4-1) and loosen the front / left side panel assembly so that it can be swung to the left for access to the speed adjusting screw.
4. Disconnect the actuator leads and connect a 12 volt battery to the actuator terminals *using a battery switch*. (The battery will hold the governor mechanism against the high speed stop and allow the engine to run after shutdown—probably Code No. 15.)

**⚠CAUTION** *The actuator could overheat if the battery is left on more than 10 minutes.*

5. When ready, switch the battery on, start the genset, measure engine speed (rpm) and stop the engine by switching off the battery.
6. Readjust high-idle speed, as follows, if not between 3300 and 3400 rpm:
  - A. Loosen the lock nuts on the two bottom screws and back out the clamping screw.
  - B. To increase speed, turn the speed adjusting screw in 1 turn (clockwise). To decrease speed, turn it out 1 turn (counter-clockwise).
7. Repeat Steps 5 and 6 until high-idle speed is between 3300 and 3400 rpm. Set the lock nut.
8. Run the clamping screw in by hand until snug, back it out 1-1/2 turns and set the lock nut.



**FIGURE 8-8. HIGH-IDLE SPEED SCREW**

## STARTER

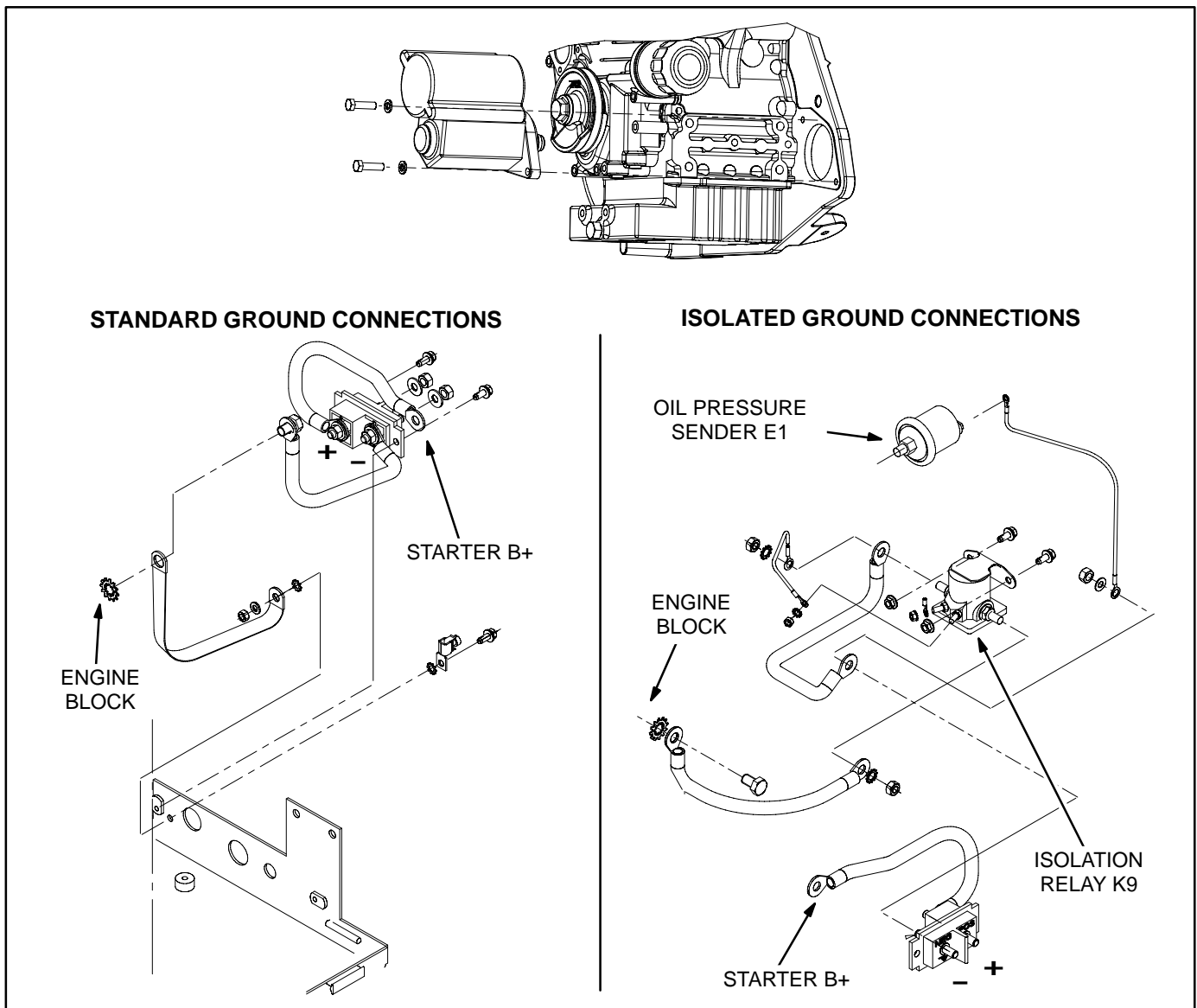
**⚠WARNING** *Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (-) cable at the battery to prevent the engine from starting.*

**Starter Removal and Replacement:** The starter motor (Figure 8-9) is accessible for removal and installation by removing the right side enclosure panel (Page 4-1). Alternatively, it can be removed and installed through the front access opening if the raw water pump is removed (Page 3-10) and the fuel filter bracket is unbolted from the drip pan and moved out of the way (Page 8-5). Parts are avail-

able for rebuilding the starter. Torque the mounting bolts to 29 lb-ft (39 N-m). Make sure starter B+ is connected to genset B+.

**Negative (Ground) Connection:** Before installing the starter motor, make sure that the engine block is grounded properly, depending on whether standard or isolated ground connections are required (Figure 8-9). The star washer must be installed between the engine block and cables. Torque the bolt to 41 lb-ft (55 N-m).

**Ground Isolation Relay K9:** The relay is accessible after the starter or side panel has been removed. Replace the relay if its contacts do not close when 12 VDC is applied to the coil terminals.



**FIGURE 8-9. STARTER MOTOR MOUNTING AND CONNECTIONS**

## 9. Troubleshooting

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TABLE 9-1 lists the shutdown codes in numerical order along with step-by-step corrective actions. First note the following:

- Maintaining engine oil and coolant levels, cleaning the sea water strainer, keeping battery connections clean and tight, watching the fuel gauge and not overloading the genset will prevent most shutdowns.
- When the genset and propulsion engines share a common fuel tank, the fuel dip tubes are usually arranged so that the genset will run out of fuel first. Marking the genset empty point on the fuel gauge will make it easier to tell when to stop the genset before running it out of fuel.

### SHUTDOWN CODES

The genset controller provides extensive diagnostics by causing the *amber* status lamp on the control switch to blink. Following a shutdown, the indicator lamp will blink 1, 2, 3, 4 or 7 times, pause, and then repeat the blinking. ***The number of blinks is the shutdown code.*** Blinking continues for five minutes and stops. Pressing **STOP** three times restores blinking. (If you press **STOP** again, blinking stops entirely and you have to start over by pressing **STOP** three times.)

- **One blink** indicates shutdown due to high engine temperature.
- **Two blinks** indicate shutdown due to low oil pressure.
- **Three blinks** indicate shutdown due to a condition normally requiring service by a trained and experienced person. To access the second-level, two-digit shutdown code, press **STOP** once. The two-digit code consists of 1 to 6 blinks, a brief pause, and then 1 to 9 blinks. The first set of blinks represents the tens digit and the second set of blinks the units digit of the shutdown code number. For example, **Shutdown Code No. 23** blinks as follows:

blink-blink—pause—blink-blink-blink—long pause—repeat

- **Four blinks** indicate shutdown due to a failure to start within the time allowed for cranking.
- **Seven blinks** indicate shutdown due to a loss of raw water flow for engine and exhaust cooling.

**Note: The last shutdown logged will blink, even though the condition that caused shutdown has been serviced.**

TABLE 9-1 . TROUBLESHOOTING

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

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### **NO POWER—GENSET RUNNING, RUN LAMP ON**

(Line circuit breaker OFF or tripped)

#### **Corrective Action:**

1. Turn on, reset or repair line circuit breaker CB3 on the genset (Page 5-5).
2. Turn on, reset or repair the line circuit breakers on the main distribution panel in the boat.

### **STARTER ENGAGES-DISENGAGES**

(Cranking voltage dips below 6 volts—low battery charge, poor connections, long cables)

#### **Corrective Action:**

1. Clean and tighten the positive (+) and negative (–) battery cable connections at the battery and genset (Page 3-6).
2. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
3. Increase battery cable size or run parallel cables.

### **RUN-DOWN STARTING BATTERY**

(Marginal battery, connections or charging system, or parasitic loads)

#### **Corrective Action:**

1. Clean and tighten the positive (+) and negative (–) battery cable connections at the battery and genset (Page 3-6).
2. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
3. Service the boat battery charging system or the genset battery charger (Page 5-6), if used.

### **ENGINE CRANKS, STARTS, ACCELERATES, BUT STOPS WHEN SWITCH LET GO**

(Open field or open or grounded quadrature circuit)

**Corrective Action:** Check for an open field or open or grounded quadrature circuit (Page 6-4) and service as necessary.

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### NO LIGHTS, NO RESPONSE

(Poor connections, faulty wiring or dead battery)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Try the local genset control switch (S4) if the remote control switch (S11) does not work, and vice versa. If neither works, go to Step 2. If only local switch S4 works, go to Step 10. If only remote switch S11 works, go to Step 11.
2. At the genset control panel, push emergency stop switch CB1 to ON.
3. Clean and tighten the positive (+) and negative (–) battery cable terminals at the battery and genset (Page 3-6).
4. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
5. Disconnect both leads from emergency stop switch CB1 (Page 5-1). Check for B+ at lead CB1-1. If there is no B+, clean and tighten connections and replace wiring as necessary. If there is B+, reconnect the lead and check for B+ at switch terminal 2, with the switch ON and then OFF. Replace switch CB1 if B+ does not turn on and off.
6. Disconnect connector P1 (black) from controller A1 (Page 5-1) and check for B+ at Pin 6. If there is no B+, check for a missing, bent or corroded pin and faulty wiring and repair as necessary.
7. Disconnect connector P2 (grey) from controller A1 (Page 5-1) and check for continuity between Pin 1 and B– (ground). If open, check for a missing, bent or corroded pin and faulty wiring and repair as necessary.
8. While P1 and P2 are disconnected, disconnect the connector on control switch S4. Check continuity between the following points: P1-7 and S4-2, P2-3 and S4-1, P2-2 and S4-3, P2-4 and S4-6, and P2-5 and S4-8. If open, check for missing, bent or corroded pins and faulty wiring and repair as necessary.
9. Replace controller A1 (Page 5-4).
10. Disconnect remote connector P4 and check for continuity in the remote wiring by checking continuity between pins 4 and 3 when the remote switch is held at START and between Pins 4 and 2 when the remote switch is held at STOP. Repair or reconnect the remote wiring as necessary.
11. Disconnect the connector on control switch S4 and check that the lamps light when B+ is applied and that there is continuity across the switch terminals in both positions (Page 5-4). Replace switch S4 if faulty.

### HIGH ENGINE TEMPERATURE—CODE NO. 1

(First-level shutdown—Engine coolant temperature exceed design limit)

**Corrective Action:**

1. Add coolant as necessary and repair leaks (Page 3-7).
2. Replace the engine thermostat, which might not be opening fully (Page 3-9).
3. Clean the raw water tubes in the heat exchanger, which might be clogged with scale (Page 3-12).
4. Flush the coolant system to remove coolant passage fouling (Page 3-8).
5. Test coolant sender E2 (Page 5-5) and replace if necessary.

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### LOW OIL PRESSURE—CODE NO. 2

(First-level shutdown—Low oil pressure)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Add engine oil as necessary (Page 3-3).
2. Drain excess oil (above top bead on dipstick).
3. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 10 and B– (ground). If resistance is greater than 257 Ohms, check for a missing, bent or corroded pin or faulty wiring or loose ring terminal on sender E1 (Page 5-5). Repair as necessary.
4. Replace the sender with a gauge, ground the sender wire (to keep engine running) and start the engine. *Shut down the engine immediately if there is no oil pressure.*
  - A. If engine oil pressure is less than 14 psi (98 kPa), service the oil lubricating system (Page 8-1).
  - B. If engine oil pressure is at least 14 psi (98 kPa), test oil pressure sender E1 (Page 5-5) and replace if necessary. Replace controller A1 (Page 5-1) if sender E1 is in working order.

### SERVICE CHECK—CODE NO. 3

(First-level shutdown—Indicates presence of second-level shutdown)

**Corrective Action:** Check the second-level shutdown code by pressing **STOP** once. The second-level shutdown code will have two-digits. The shutdowns are listed below in numerical order.

TABLE 9-1 . TROUBLESHOOTING (CONT.)

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

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#### OVERCRANK—CODE NO. 4

(First-level shutdown—Cranking exceeded 20 to 60 seconds [temperature dependent] without start)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Check the fuel tank and fill as necessary. (Note: The arrangement of pickup tubes in the fuel supply tank probably is such that the genset will run out of fuel before the propulsion engines.)
2. Open any closed fuel valves.
3. Remove any blockage in the combustion air inlet (lower rear of left side) or exhaust system.
4. Tighten loose fuel line fittings so that air cannot be drawn in by genset lift pump suction.
5. Drain the fuel filter of water and sediment (Page 3-5) and prime the fuel system (Page 2-2).
6. Replace the fuel filter (Page 3-5) and prime the fuel system (Page 2-2).
7. Drain and/or replace fuel supply system filters and prime the fuel system (Page 2-2).
8. Conduct a fuel pump flow test and service as necessary (Page 8-4).
9. Inspect and service the glow plugs (Page 8-4) as follows:
  - A. If loose, tighten the glow plug terminals.
  - B. Check for B+ at the glow plug terminals during cranking. If there is no B+, remove glow plug relay K3 from its socket and test for proper operation (Page 5-6). Replace if necessary. Also check for B+ at relay socket terminal 30, for continuity between terminal 87 and the glow plugs and for continuity between terminal 86 and B– (ground). Clean and tighten connections and replace wiring as necessary.
  - C. Check for B+ at relay socket terminal 85 while cranking. If there is no B+, disconnect connector P3 (green) from controller A1 (Page 5-1) and check for a missing, bent or corroded pin and faulty wire and repair as necessary. If the wire and connections are good, replace controller A1.
  - D. Remove the glow plug bus bar and check for electrical continuity between each glow plug terminal and B– (ground). Replace any open glow plug (Page 8-4).
10. Remove the front and top access doors and door lintel (Page 4-1) and the cover on the governor actuator (Page 8-6). Reattach the governor leads and observe the actuator rotor while cranking. The rotor should rotate smoothly through about 1/2 inch (12 mm). If it does not, apply 12 VDC to the actuator terminals and observe whether the rotor rotates smoothly. If it does not, go to Step A. If it does, go to Step C.
  - A. Check resistance across the actuator terminals with an accurate digital ohmmeter. If resistance is not between 1.7 and 2.8 ohms, replace the actuator stator.
  - B. Push the actuator rotor by hand (clockwise) to check for binding in the governor mechanism. It should rotate smoothly and return smoothly. If it binds or catches, remove the bearing carrier and stator and look for signs of physical contact between rotor and stator and service as necessary. If there are no signs of contact, remove the governor base. Replace the base or service the internal engine governor mechanism, as necessary (Page 8-1).
  - C. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 5 and A12+ and between Pin 12 and A12–. If either lead is open, check for a missing, bent or corroded pin or faulty wiring and repair as necessary.
  - D. Replace controller A1 (Page 5-1).
11. Service the engine (Page 8-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### LOSS OF RAW WATER FLOW—CODE NO. 7

(First-level shutdown—Low raw water pressure in heat exchanger)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Open the sea cock all the way.
2. Close the sea cock and clean the sea water strainer. If the strainer is above the water line, fill it with water to assist priming. Secure the strainer cover and reopen the sea cock.
3. Reconnect or replace any disconnected or leaking raw water hoses (Page 3-7).
4. Remove any blockage from the strainer on the through-hull fitting on the bottom side of the hull.
5. Replace the raw water impeller (Page 3-10).
6. Remove the top access door and check the two leads to flow switch S6 (Page 5-6). Reconnect and clean if loose or corroded.
7. Check for continuity between S6-2 and B– (ground). If open, clean and tighten connections and replace wiring as necessary.
8. Disconnect connector P1 (black) from controller A1 (Page 5-1) and check for continuity between Pin 4 and S6-1. If open, check for a missing, bent or corroded pin and faulty wiring and repair as necessary.
9. Test flow switch S6 (Page 5-6) and replace if necessary.

### OVERVOLTAGE—CODE NO. 12

(Controller unable to maintain rated voltage)

**Corrective Action:**

1. Push line circuit breaker CB3 (Page 2-1) to OFF, start the genset and measure output voltage. If output voltage is normal, the problem is in the circuits external to the genset. If there is no voltage, test for grounded field, stator or quadrature windings (Page 6-4). Replace a stator or rotor with faulty windings.
2. Check for proper connections of the field sense leads (T1, T2) and reconnect as necessary (Page 6-6).
3. Replace controller A1 (Page 5-1).



TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### UNDERVOLTAGE—CODE NO. 13

(Controller unable to maintain rated voltage)

#### Corrective Action:

1. Push line circuit breaker CB3 (Page 2-1) to OFF, start the genset and measure output voltage. If output voltage is normal, go to Step 2. If output voltage is low, go to Step 3.
2. Reduce the number of connected appliances, especially when air conditioners and battery chargers are running.
3. Service the brushes and slip rings as necessary (Page 6-3) and test the generator field, stator and quadrature windings for opens and shorts (Page 6-4). Replace a stator or rotor with faulty windings.
4. Replace controller A1 (Page 5-1).

### OVERFREQUENCY—CODE NO. 14

(Engine governor unable to maintain rated frequency)

#### Corrective Action:

1. If line circuit breaker CB3 or any other circuit breaker has tripped, start the genset before resetting the breaker. (Frequency can overshoot when a circuit breaker trips under load.) *If the genset continues to run*, turn off or disconnect all loads, reset the breaker and bring the loads on one at a time without overloading the genset. *If the genset shuts down again*, go to Step 2.
2. Tighten loose fuel line fittings so that air cannot be drawn in by genset lift pump suction.
3. Prime the fuel system to remove air in the fuel lines (Page 2-2).
4. Remove the front and top access doors and door lintel (Page 4-1) and the cover on the governor actuator (Page 8-6). Reattach the governor leads and observe the actuator rotor while cranking. The rotor should rotate smoothly through about 1/2 inch (12 mm). If it does not, apply 12 VDC to the actuator terminals and observe whether the rotor rotates smoothly. If it does not, go to Step A. If it does, go to Step C.
  - A. Check resistance across the actuator terminals with an accurate digital ohmmeter. If resistance is not between 1.7 and 2.8 ohms, replace the actuator stator.
  - B. Push the actuator rotor by hand (clockwise) to check for binding in the governor mechanism. It should rotate smoothly and return smoothly. If it binds or catches, remove the bearing carrier and stator and look for signs of physical contact between rotor and stator and service as necessary. If there are no signs of contact, remove the governor base. Replace the base or service the internal engine governor mechanism, as necessary (Page 8-1).
  - C. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 5 and A12+ and between Pin 12 and A12–. If either lead is open, check for a missing, bent or corroded pin or faulty wiring and repair as necessary.
  - D. Replace controller A1 (Page 5-1).
5. Replace controller A1 (Page 5-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

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### UNDERFREQUENCY—CODE NO. 15

(Engine governor unable to maintain rated frequency)

#### Corrective Action:

1. Reduce the number of appliances running at the same time, especially those with high motor starting loads such as air conditioners.
2. Check the fuel tank and fill as necessary. (Note: The arrangement of pickup tubes in the fuel supply tank probably is such that the genset will run out of fuel before the propulsion engines.)
3. Remove any blockage in the combustion air inlet (lower rear of left side) or exhaust system.
4. Tighten loose fuel line fittings so that air cannot be drawn in by genset lift pump suction.
5. Drain the fuel filter of water and sediment (Page 3-5) and prime the fuel system (Page 2-2).
6. Replace the fuel filter (Page 3-5) and prime the fuel system (Page 2-2).
7. Drain and/or replace fuel supply system filters and prime the fuel system (Page 2-2).
8. Conduct a fuel pump flow test and service as necessary (Page 8-4).
9. Remove the front and top access doors and lintel (Page 4-1) and the governor actuator cover (Page 8-6) and observe the actuator rotor while cranking. (Remember to reattach the leads after removing the cover.) The rotor should rotate smoothly through about 1/2 inch (12 mm). If it does not, check for binding in the governor mechanism by pushing the actuator rotor clockwise by hand (against the fuel rack return spring). It should rotate smoothly about 1/2 inch (12 mm) and return smoothly. If it binds or catches, remove the governor actuator base assembly and replace it, or service the internal engine governor mechanism as necessary (Page 8-1).
  - A. Check resistance across the actuator terminals with an accurate digital ohmmeter. If resistance is not between 1.7 and 2.8 ohms, replace the actuator stator.
  - B. Push the actuator rotor by hand (clockwise) to check for binding in the governor mechanism. It should rotate smoothly and return smoothly. If it binds or catches, remove the bearing carrier and stator and look for signs of physical contact between rotor and stator and service as necessary. If there are no signs of contact, remove the governor base. Replace the base or service the internal engine governor mechanism, as necessary (Page 8-1).
  - C. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 5 and A12+ and between Pin 12 and A12–. If either lead is open, check for a missing, bent or corroded pin or faulty wiring and repair as necessary.
  - D. Replace controller A1 (Page 5-1).
10. Readjust high idle speed (Page 8-8).
11. Service the fuel injectors and injection pump as necessary (Page 8-1).
12. Check fuel injection timing (Page 8-1).
13. Replace controller A1 (Page 5-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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**OVER-PRIME—CODE NO. 17**

(Prime mode exceed 5 minutes)

**Corrective Action:**

1. Check for and remove any object that may be holding either control switch (remote or local) in the prime position.
2. Disconnect remote connector P4 and check for continuity between Pins 4 and 2 when the remote switch is *not* held at STOP. If there is continuity, repair or reconnect the remote wiring as necessary.
3. Disconnect the connector on control switch S4 and check for continuity between terminals 1 and 2 when the switch is *not* held at STOP (Page 5-4). If there is continuity, replace switch S4.

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### GOVERNOR OVERLOAD—CODE NO. 22

(Maximum allowable time at full-duty cycle was exceeded)

#### Corrective Action:

1. Reduce the number of appliances running at the same time, especially those with high motor starting loads such as air conditioners.
2. Check the fuel tank and fill as necessary. (Note: The arrangement of pickup tubes in the fuel supply tank probably is such that the genset will run out of fuel before the propulsion engines.)
3. Remove any blockage in the combustion air inlet (lower rear of left side) or exhaust system.
4. Tighten loose fuel line fittings so that air cannot be drawn in by genset lift pump suction.
5. Drain the fuel filter of water and sediment (Page 3-5) and prime the fuel system (Page 2-2).
6. Drain and/or replace fuel supply system filters and prime the fuel system (Page 2-2).
7. Conduct a fuel pump flow test and service as necessary (Page 8-4).
8. Remove the front and top access doors and lintel (Page 4-1) and the governor actuator cover (Page 8-6) and observe the actuator rotor while cranking. (Remember to reattach the leads after removing the cover.) The rotor should rotate smoothly through about 1/2 inch (12 mm). If it does not, check for binding in the governor mechanism by pushing the actuator rotor clockwise by hand (against the fuel rack return spring). It should rotate smoothly about 1/2 inch (12 mm) and return smoothly. If it binds or catches, remove the governor actuator base assembly and replace it, or service the internal engine governor mechanism as necessary (Page 8-1).
  - A. Check resistance across the actuator terminals with an accurate digital ohmmeter. If resistance is not between 1.7 and 2.8 ohms, replace the actuator stator.
  - B. Push the actuator rotor by hand (clockwise) to check for binding in the governor mechanism. It should rotate smoothly and return smoothly. If it binds or catches, remove the bearing carrier and stator and look for signs of physical contact between rotor and stator and service as necessary. If there are no signs of contact, remove the governor base. Replace the base or service the internal engine governor mechanism, as necessary (Page 8-1).
  - C. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 5 and A12+ and between Pin 12 and A12–. If either lead is open, check for a missing, bent or corroded pin or faulty wiring and repair as necessary.
  - D. Replace controller A1 (Page 5-1).
9. Readjust high idle speed (Page 8-8).
10. Service the fuel injectors and injection pump as necessary (Page 8-1).
11. Check fuel injection timing (Page 8-1).
12. Replace controller A1 (Page 5-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

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### FAULTY OIL PRESSURE SENDER—CODE NO. 23

(Controller sensed grounded sender)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 10 and B– (ground). If there is a short to ground, repair the wiring or test and replace sender E1 (Page 5-5), as necessary.

### FAULTY TEMPERATURE SENDER—CODE NO. 24

(Controller sensed open sender)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Remove the top access door and tighten the ring terminal on sender E2 (Page 5-5) if loose. (For isolated-ground applications only, connect flag terminal E2-2 if loose. Also check continuity between E2-2 and B– [ground] and repair wire as necessary.)
2. Measure resistance across sender E2 (Page 5-5) and replace it if open.
3. Disconnect connector P1 (black) from controller A1 (Page 5-1) and check continuity between Pin 9 and ring terminal E2-1. Repair the wiring as necessary if open.

### LOSS OF VOLTAGE SENSE—CODE NO. 27

(Controller unable to sense output voltage)

**Corrective Action:** *(Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)*

1. Check for and properly reconnect voltage sense leads T1 and T2 (Page 6-6).
2. Disconnect connector P3 (green) from controller A1 (Page 5-1) and check continuity between Pin 11 and T2 and between Pin 12 and T1. If open, check for missing, bent or corroded pins and faulty wiring and repair as necessary.
3. Service the brushes and slip rings as necessary (Page 6-3) and test the generator field, stator and quadrature windings for opens and shorts (Page 6-4). Replace a stator or rotor with faulty windings.
4. Replace controller A1 (Page 5-1).

### HIGH BATTERY VOLTAGE—CODE NO. 29

(Battery system at more than 19.2 volts)

**Corrective Action:**

1. Check battery bank connections and reconnect if necessary to supply 12 volts.
2. Select a lower external battery boost charge rate.

TABLE 9-1 . TROUBLESHOOTING (CONT.)

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### CONTROL CARD FAILURE—CODE NO. 35

(Microprocessor EEPROM error during self-test)

**Corrective Action:** Replace controller A1 (Page 5-1).

### ENGINE STOPPED—CODE NO. 36

(Engine stopped without command by controller)

**Corrective Action:**

1. Open any closed fuel supply valves.
2. Check the fuel tank and fill as necessary. (Note: The arrangement of pickup tubes in the fuel supply tank probably is such that the genset will run out of fuel before the propulsion engines.)
3. Check for mechanical damage and service as necessary.
4. Remove any blockage in the combustion air inlet (lower rear of left end of genset).
5. Tighten loose fuel line fittings so that air cannot be drawn in by genset lift pump suction.
6. Drain the fuel filter of water and sediment (Page 3-5) and prime the fuel system (Page 2-2).
7. Drain and/or replace fuel supply system filters and prime the fuel system (Page 2-2).
8. Conduct a fuel pump flow test and service as necessary (Page 8-4).
9. Remove the front and top access doors and lintel (Page 4-1) and the governor actuator cover (Page 8-6) and observe the actuator rotor while cranking. (Remember to reattach the leads after removing the cover.) The rotor should rotate smoothly through about 1/2 inch (12 mm). If it does not, check for binding in the governor mechanism by pushing the actuator rotor clockwise by hand (against the fuel rack return spring). It should rotate smoothly about 1/2 inch (12 mm) and return smoothly. If it binds or catches, remove the governor actuator base assembly and replace it, or service the internal engine governor mechanism as necessary (Page 8-1).
  - A. Check resistance across the actuator terminals with an accurate digital ohmmeter. If resistance is not between 1.7 and 2.8 ohms, replace the actuator stator.
  - B. Push the actuator rotor by hand (clockwise) to check for binding in the governor mechanism. It should rotate smoothly and return smoothly. If it binds or catches, remove the bearing carrier and stator and look for signs of physical contact between rotor and stator and service as necessary. If there are no signs of contact, remove the governor base. Replace the base or service the internal engine governor mechanism, as necessary (Page 8-1).
  - C. Disconnect connector P1 (black) from controller A1 (Page 5-1) and measure resistance between Pin 5 and A12+ and between Pin 12 and A12–. If either lead is open, check for a missing, bent or corroded pin or faulty wiring and repair as necessary.
  - D. Replace controller A1 (Page 5-1).
10. Check for an open field or open or grounded quadrature circuit (Page 6-4) and service as necessary.
11. Service the engine (Page 8-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

*Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable from the battery to prevent the engine from starting.*

### INVALID GENSET CONFIGURATION—CODE NO. 37

(Controller cannot determine genset operating parameters)

**Corrective Action:** Replace controller A1 (Page 5-1).

1. Disconnect connector P2 (grey) from controller A1 (Page 5-1) and check continuity between Pin 9 and B– (ground). *Pin 9 should not be grounded.* Repair the wiring as necessary.
2. Replace controller A1 (Page 5-1).

### FIELD OVERLOAD—CODE NO. 38

(High field voltage induced by high rotor temperature or low power factor loads)

**Corrective Action:**

1. Remove blockages to generator air flow at the left side and front of genset.
2. Reduce the number of appliances running at the same time, especially those with high motor starting loads such as air conditioners.
3. Have air conditioners and other appliances checked for proper operation. (A locked compressor rotor can cause very low power factor.)
4. Check for a loose generator fan (Page 6-1) and repair or replace as necessary.
5. Service the brushes and slip rings as necessary (Page 6-3) and test the generator field, stator and quadrature windings for opens and shorts (Page 6-4). Replace a stator or rotor with faulty windings.

### GROUNDING ROTOR—CODE NO. 41

(F+ grounded)

**Corrective Action:** (Refer to Pages A-1 and A-2 when tracing wiring and connectors below.)

1. Disconnect connector P3 (green) from controller A1 (Page 5-1) and check for continuity between Pin 7 (F+) and B– (ground). ***Pin 7 should not be grounded.*** Repair or replace wiring, brushes and slip rings (Page 6-3) or rotor (Page 6-4), as necessary.
2. Replace controller A1 (Page 5-1).

### PROCESSOR FAILURE—CODE NO. 42

(Microprocessor ROM error during self-test)

**Corrective Action:** Replace controller A1 (Page 5-1).

### PROCESSOR FAILURE—CODE NO. 43

(Microprocessor RAM error during self-test)

**Corrective Action:** Replace controller A1 (Page 5-1).

TABLE 9-1 . TROUBLESHOOTING (CONT.)

**⚠WARNING** *Some genset service procedures present hazards that can result in severe personal injury or death. Only trained and experienced service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.*

*Accidental or remote starting can cause severe personal injury or death. Before removing a panel or access door, disconnect the negative (–) cable from the battery to prevent the engine from starting.*

### **PROCESSOR FAILURE—CODE NO. 48**

(Controller unable to sense field voltage)

**Corrective Action:** Replace controller A1 (Page 5-1).

### **HIGH EXHAUST TEMPERATURE—CODE NO. 58**

(Exhaust temperature exceeded design limits)

**Corrective Action:**

1. Open the sea cock all the way.
2. Close the sea cock and clean the sea water strainer. If the strainer is above the water line, fill it with water to assist priming. Secure the strainer cover and reopen the sea cock.
3. Reconnect or replace any disconnected or leaking raw water hoses (Page 3-7).
4. Remove any blockage from the strainer on the through-hull fitting on the bottom side of the hull.
5. Replace the raw water impeller (Page 3-10).
6. Disconnect connector P1 (black) from controller A1 (Page 5-1) and check continuity between Pin 11 and B– (ground). If open, check for a missing, bent or corroded pin, faulty wiring or open exhaust temperature switch S5 (Page 5-6). Repair as necessary.

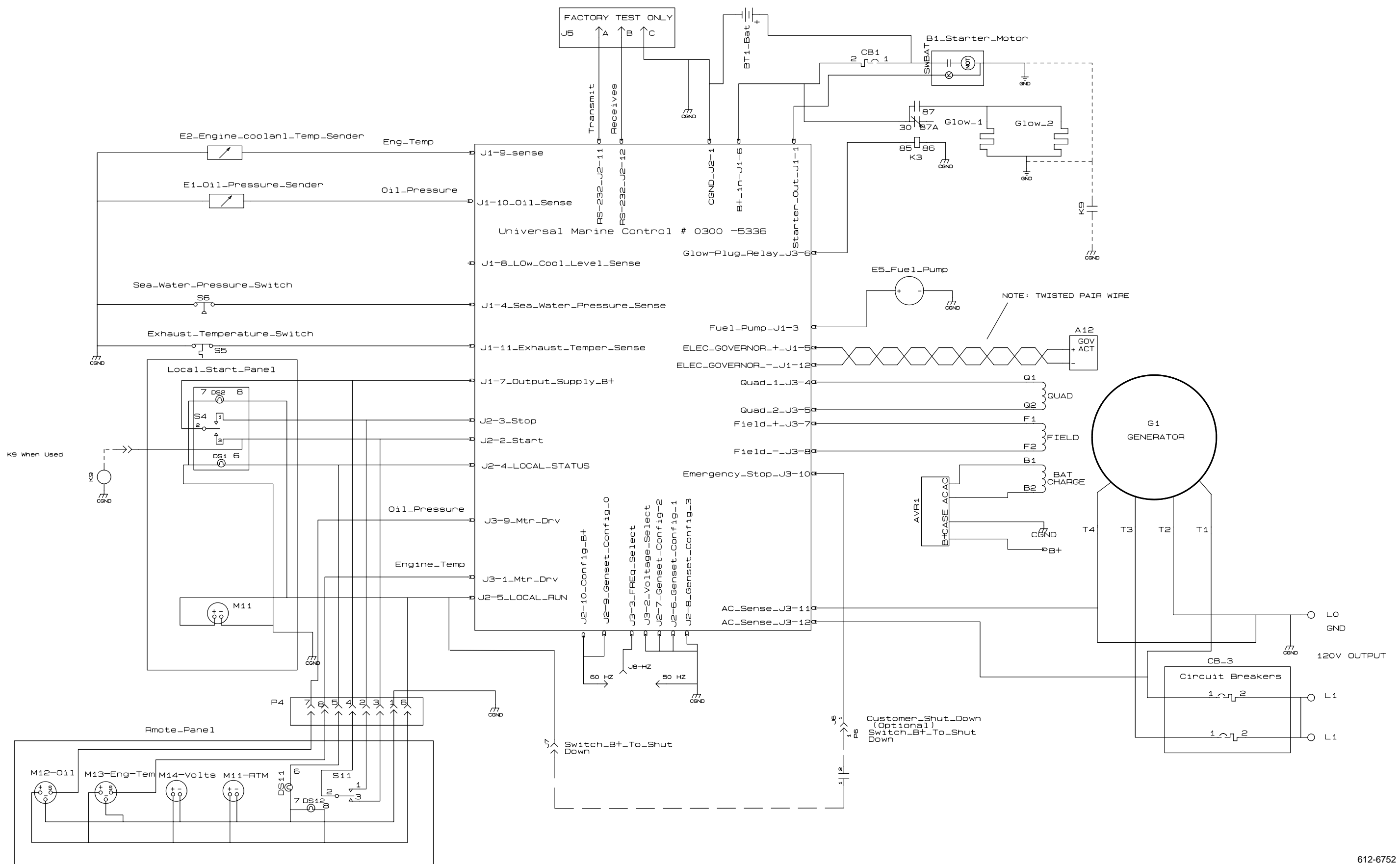
### **EMERGENCY SHUTDOWN—CODE NO. 61**

(Genset was shut down by a fire suppression system or other external control)

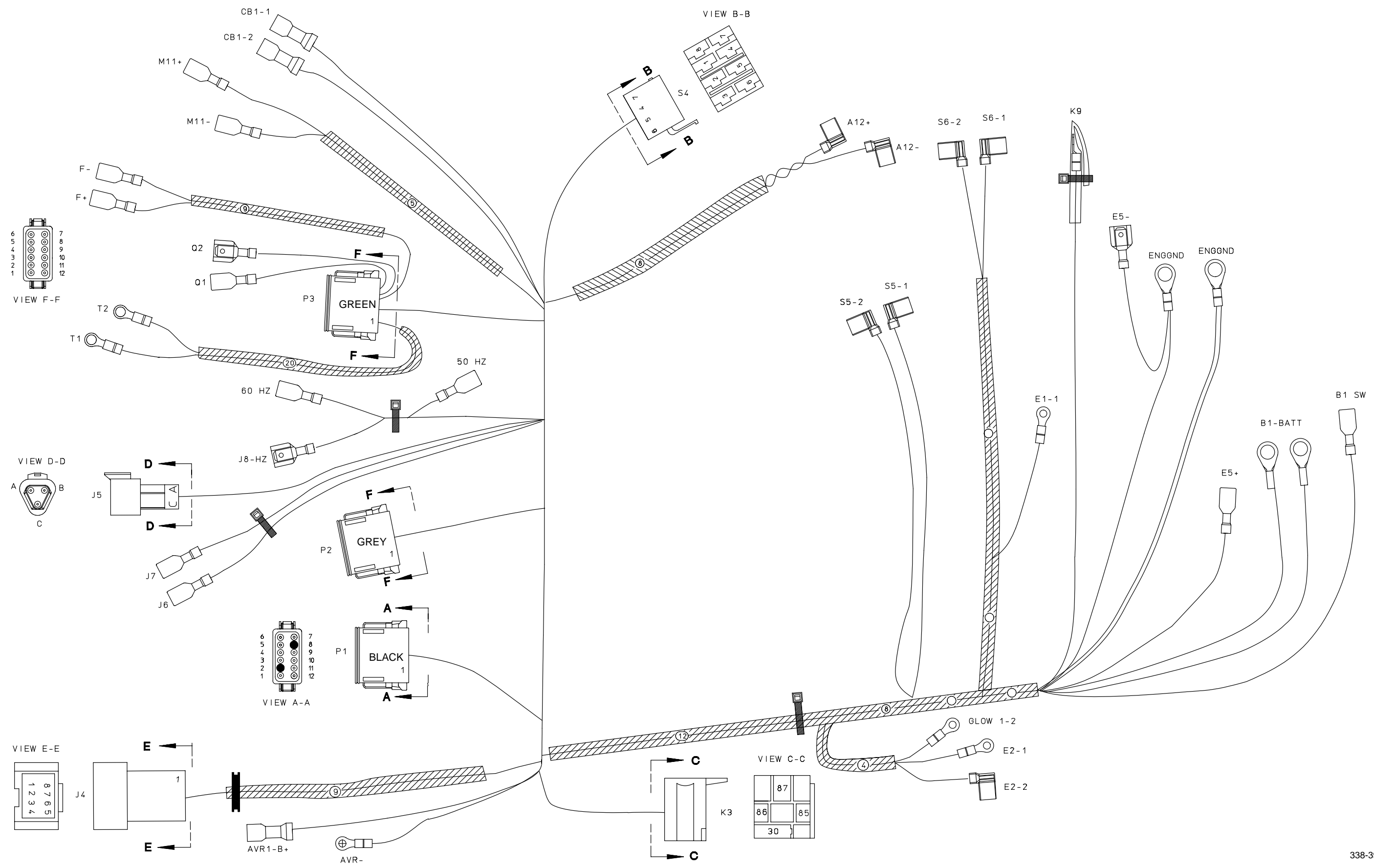
**Corrective Action:**

1. Make all necessary repairs to the genset and connected equipment and reset the external control which shut down the genset.
2. Disconnect the external wiring connected at connector J6 and check for B+. If there is B+, find out why and reconnect or repair the external control circuit.





WIRING DIAGRAM



WIRING HARNESS