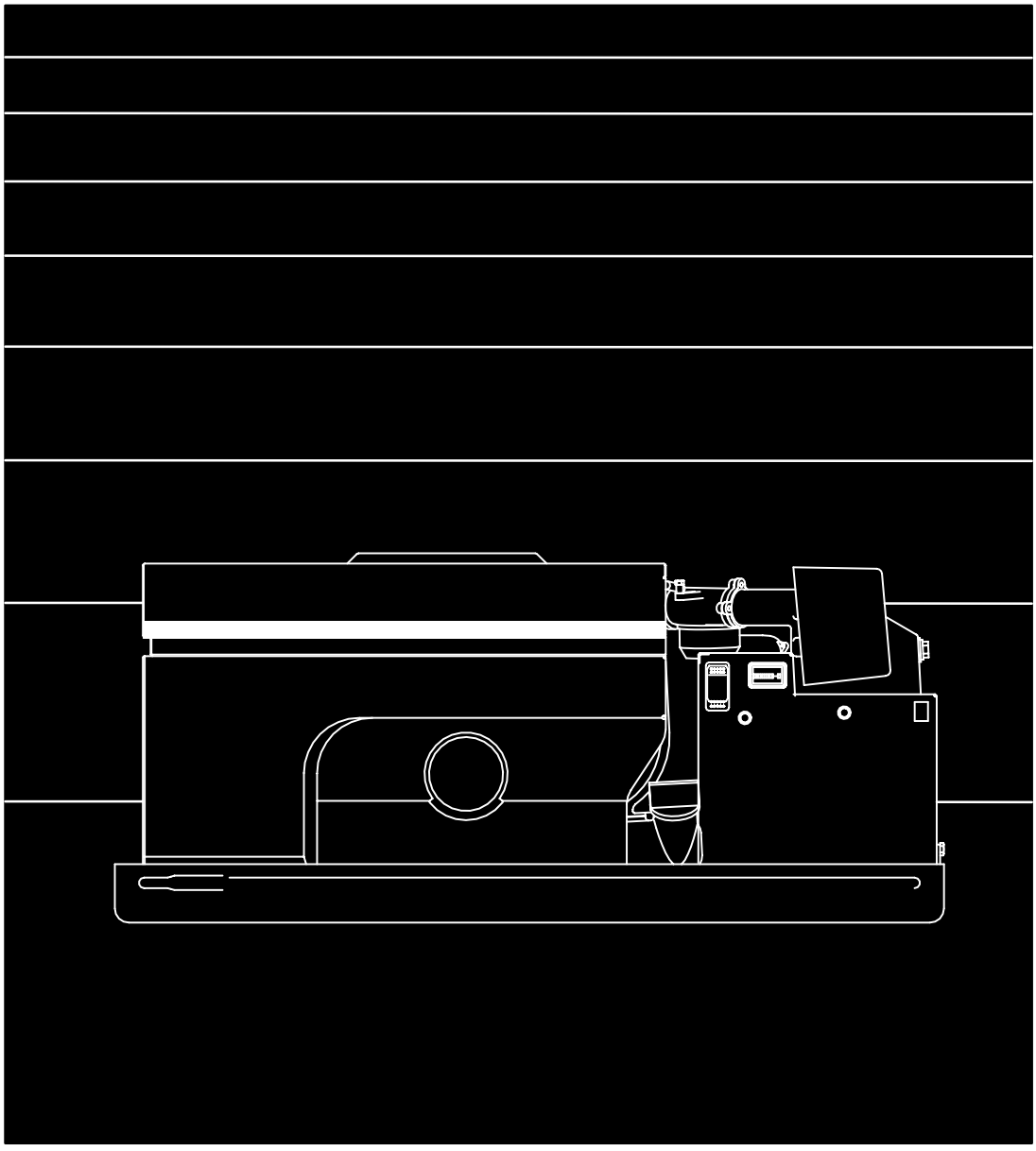
Caution: This document contains mixed page sizes (8.5 x 11 or 11 x 17), which may affect printing. Please adjust your printer settings according to the size of each page you wish to print.

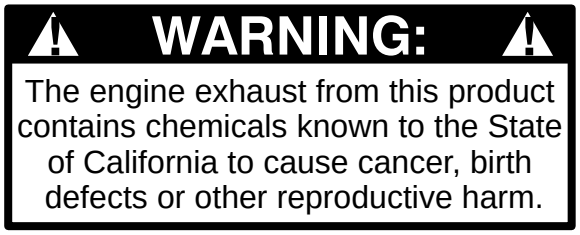
Service Manual

TGHAA



Printed in U. S. A.

965-0501B



This generator set is for statonary applications only. Non-stationary applications may be in violation of Federal regulations

Table of Contents

Safety Precautions

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

The following symbols in this manual alert you to potential hazards to the operator, service person 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, batteries and moving parts present hazards which can result in severe personal injury or death.

GENERAL PRECAUTIONS

- Keep ABC fire extinguishers handy.
- Make sure all fasteners are secure and torqued properly.
- Keep the genset and its compartment clean. Excess oil and oily rags can catch fire. Dirt and gear stowed in the compartment can restrict cooling air.
- Before working on the genset, disconnect the negative (**-**) battery cable at the battery to prevent starting.
- Use caution when making adjustments while the genset is running—hot, moving or electrically live parts can cause severe personal injury or death.
- Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Do not work on the genset when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.

GENERATOR VOLTAGE IS DEADLY!

- Generator output connections must be made by a qualified electrician in accordance with applicable codes.
- The genset must not be connected to the public utility or any other source of electrical power. Connection could lead to electrocution of utility workers 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 and stand on a dry wooden platform.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Fuel lines must be secured, free of leaks and separated or shielded from electrical wiring.
- Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LPG sinks when released and can accumulate inside housings and basements and other below-grade spaces. Prevent leaks and the accumulation of gas.

ENGINE EXHAUST IS DEADLY!

- Learn the symptoms of carbon monoxide poisoning in this manual.
- The exhaust system must be installed in accordance with the genset Installation Manual.
- Do not use engine cooling air to heat a room or compartment.
- Make sure there is ample fresh air when operating the genset in a confined area.

BATTERY GAS IS EXPLOSIVE

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

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

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

telco-1

Introduction

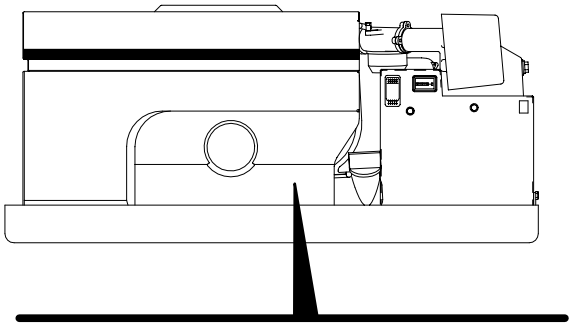
This is the Service Manual for the Series TGHAA generator sets (gensets). Read and carefully observe all of the instructions and precautions in this manual. For quick reference, this manual includes *Operation* and *Periodic Maintenance*, which are also covered in the Operator's Manual.

See the Parts Catalog for part identification numbers. Genuine Onan® replacement parts are recommended for best results. When contacting Onan for parts, service or product information, be ready to provide the model number and the serial number, both of which appear on the genset nameplate. See Figure 1.

⚠WARNING ***Improper service or parts replacement 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. Figure 2 is an illustration of a typical genset installation. Figures 85 and 86 are typical genset outline drawings.



NAMEPLATE WITH TYPICAL MODEL AND SERIAL NUMBER DATA

IMPORTANT ENGINE INFORMATION

Onan®

CUMMINS POWER GENERATION
1400 73rd Ave. NE
Minneapolis, MN 55432

Model No: **5.6TGHAA11381C** Made in U.S.A.

S/N: **A960123456** PH:

AC Volts: kVA: kW:

Amps: Pf: RPM:

Fuel: Hz: Bat:

Options: Wiring Diagram:

Insulation - NEMA Class F Ambient 40°C

THIS ENGINE MEETS U.S. EPA PH1 AND 1995-1999 CALIFORNIA EMISSION REGULATIONS FOR ULGE ENGINES

VN5980U1C2RA **980 cc**

REFER TO OPERATOR'S MANUAL FOR MAINTENANCE SPECIFICATIONS AND ADJUSTMENTS.

99-2495 URC

FIGURE 1. TYPICAL NAMEPLATE

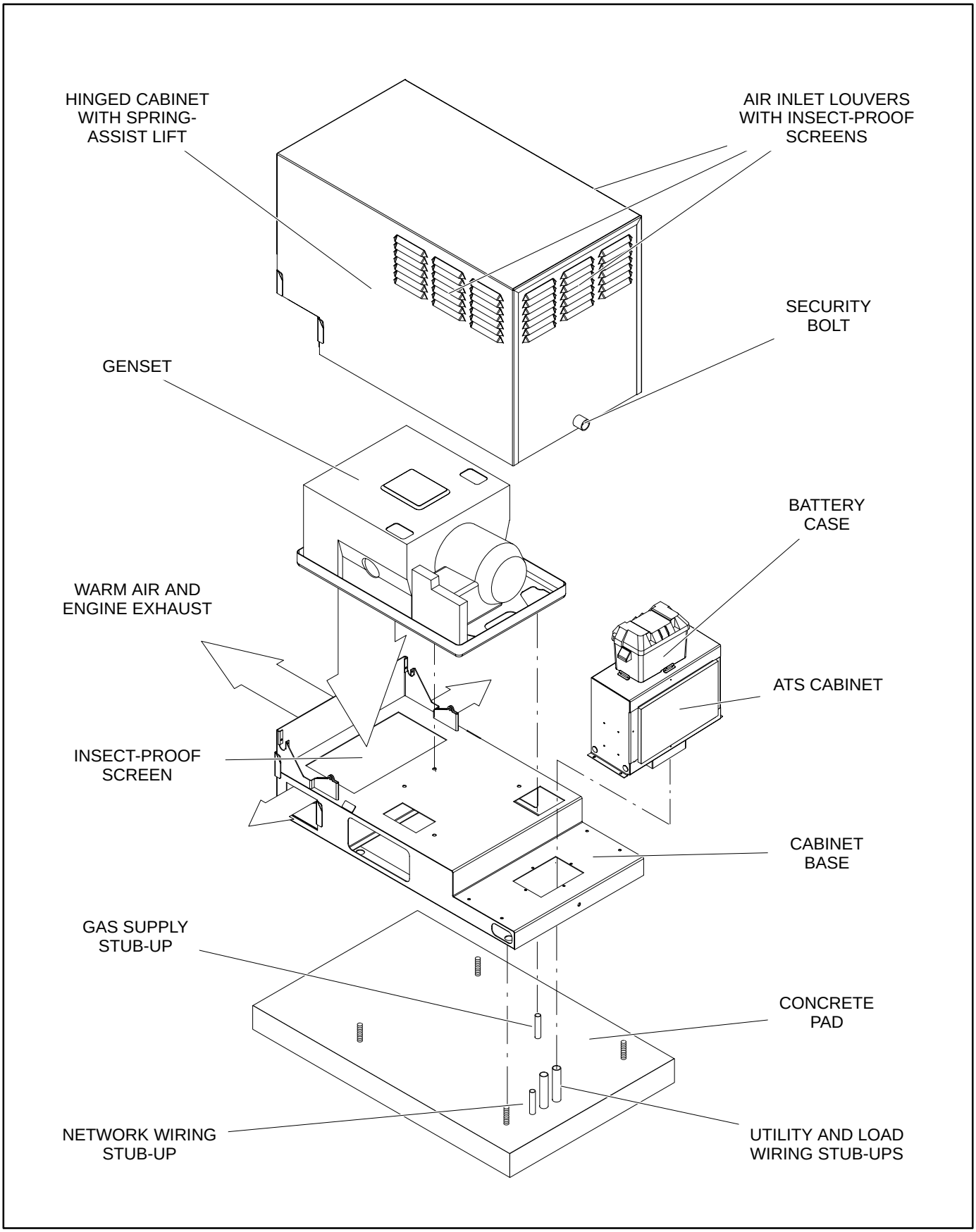


FIGURE 2. TYPICAL INSTALLATION IN AN OUTDOOR HOUSING ON A CONCRETE PAD

Specifications

GENERATOR: 4-Pole Revolving Field, Self-Excited, 1-Phase, Microcontroller Regulated			
Frequency / Speed	60 Hertz / 1800 RPM		50 Hertz / 1500 RPM
Fuel	Natural Gas	LPG	LPG
Rated Power	5.6 kW	6.0 kW	5.0 kW
Voltage	120/240 or 120 volts		230 volts
Circuit Breaker Rating	2-Pole, 25 amps		
FUEL CONSUMPTION:	Natural Gas	LPG	LPG
No-load Half-load Full-load	55 ft^3/h (1.6 m^3/h) 73 ft^3/h (2.1 m^3/h) 120 ft^3/h (3.4 m^3/h)	2.2 lb/h (1.0 Kg/h) 3.5 lb/h (1.6 Kg/h) 5.5 lb/h (2.5 Kg/h)	2.0 lb/h (0.9 Kg/h) 3.2 lb/h (1.4 Kg/h) 5.0 lb/h (2.3 Kg/h)
ENGINE: Opposed 2-Cylinder, 4-Cycle Spark-Ignited, Side-Valve, Air Cooled, Microcontroller Governed			
Bore	3.653 inch (90 mm)		
Stroke	3.000 inch (76 mm)		
Displacement	60 $inch^3$ (980 cc)		
Compression Ratio	7.0 : 1		
Min Crankcase Vacuum	10 inch (254 mm) WC (water column)		
Min Cylinder Compression Test Pressure	75 psi (517 kPa)		
Oil Capacity (with filter)*	3.5 quart (3.3 liter)		
Intake Valve Clearance (Cold)	0.005 inch (0.13 mm)		
Exhaust Valve Clearance (Cold)	0.013 inch (0.33 mm)		
Spark Plug Gap	0.025 inch (0.64 mm)		
Spark Plug Tightening Torque	8 lb-for (10 N-m)		
Ignition Timing (electronic ignition)	15° BTDC (non-adjustable)		
Natural Gas Supply Pressure	6-13 inch (152-330 mm) WC (water column)		
LPG Supply Pressure (vapor)	9-13 inch (229-330 mm) WC (water column)		
Gas Supply Connection	3/8 inch NPT		
CONTROL AND CRANKING SYSTEM:			
Nominal Battery Voltage	12 volts		
Battery Cranking Capacity	450 amps down to 0° F (-17° C) 650 amps down to -20° F (-29° C)		
Battery Charging Output	10 amps		
Fuse F1 (control B+ input)	7.5 amps		
Fuse F2 (starter solenoid)	7.5 amps		
Fuse F3 (carburetor de-icer)	25 amps		

* See *Periodic Maintenance* for oil filling instructions.

Engine Part Tolerances and Clearances

All dimensional tolerances and clearances are in inches (millimeters) unless otherwise indicated	
Cylinder Bore (Standard Size)*	3.5625-3.5635 (90.49-90.51)
Cylinder Taper (maximum)	0.003 (0.08)
Cylinder Out of Round (maximum)	0.003 (0.08)
Clearance in Cylinder	0.0070-0.0090 (0.178-0.229)
Ring Gap	0.010-0.020 (0.25-0.50)
#1 (Top) Piston Ring Groove Width	0.0602-0.0612 (0.25-0.50)
#2 Piston Ring Groove Width	0.0602-0.0612 (1.53-1.55)
#3 Piston Ring Groove Width	0.1193-0.1203 (3.03-3.06)
#1 (Top) Piston Ring Groove Width Prior to Spec F	0.080-0.081 (2.03-2.06)
#2 Piston Ring Groove Width Prior to Spec F	0.080-0.081 (2.03-2.06)
#3 Piston Ring Groove Width Prior to Spec F	0.188-0.189 (4.78-4.80)
#1 (Top) Piston Ring Side Clearance	0.002-0.008 (0.051-0.203)
Piston Pin Diameter	0.7500-0.7502 (19.05-19.06)
Piston Pin Fit in Rod	0.0002-0.0008 (0.005-0.020)
Connecting Rod Side Clearance	0.002-0.016 (0.051-0.406)
Connecting Rod Bearing Clearance	0.002-0.0033 (0.051-0.084)
Crankshaft Main Bearing Journal Diameter	1.9992-2.0000 (50.780-50.800)
Crankshaft Rod Journal Bearing Diameter	1.6252-1.6260 (41.280-41.300)
Crankshaft Main Bearing Diameter	2.0015-2.0040 (50.838-50.902)
Crankshaft Main Bearing Clearance	0.0024-0.0042 (0.061-0.107)
Crankshaft End Play	0.006-0.012 (0.15-0.30)
* - The bore is 0.005 inch oversize if the engine serial number has suffix “E”.	

All dimensional tolerances and clearances are in inches (millimeters) unless otherwise indicated	
Camshaft Journal Diameter	1.3740-1.3745 (34.90-34.91)
Camshaft Bearing Diameter	1.376-1.377 (34.95-34.97)
Camshaft Bearing Clearance	0.0015-0.0030 (0.038-0.076)
Camshaft End Play	0.011-0.048 (0.28-1.2)
Valve Spring Free Length	1.662 (42.21)
Valve Spring Compressed Length (Valve Closed)	1.375 (34.92)
Valve Spring Tension Open	71 lbs (32 kg)
Valve Spring Tension Closed	38 lbs (17 kg)
Valve Face Angle	44°
Valve Seat Angle	45°
Valve Stem Diameter (Intake)	0.3425-0.3430 (8.700-8.712)
Valve Stem Diameter (Exhaust)	0.3410-0.3420 (8.661-8.687)
Intake Valve Guide Diameter	0.344-0.346 (8.74-8.79)
Exhaust Valve Guide Diameter	0.344-0.346 (8.74-8.79)
Valve Stem Clearance (Intake)	0.0010-0.0025 (0.025-0.064)
Valve Stem Clearance (Exhaust)	0.0025-0.0040 (0.064-0.102)
Valve Lifter Diameter	0.7475-0.7480 (18.987-18.999)
Valve Lifter Bore Diameter	0.7500-0.7515 (19.050-19.088)
Valve Lifter To Block Clearance	0.0020-0.0040 (0.051-0.102)
Intake Valve Seat Diameter (Outside)	1.569-1.570 (39.85-39.88)
Exhaust Valve Seat Diameter (Outside)	1.255-1.256 (31.88-31.90)
Valve Seat Bore Diameter (Intake)	1.5645-1.5655 (39.738-39.764)
Valve Seat Bore Diameter (Exhaust)	1.2510-1.2520 (31.775-31.801)

Thread Torques

Bolt torques are in lb-ft (N-m)*	
Cylinder Head Bolts (Cold)	15-17 (20-23)
Connecting Rod Bolts	27-29 (37-39)
Rear Bearing Plate Bolts	25-27 (34-37)
Flywheel Mounting Nut	50-55 (68-75)
Oil Base Bolts	18-23 (24-31)
Gearcase Cover Bolts	8-10 (11-14)
Spark Plug	8 (10)
Exhaust Manifold Bolts	20-23 (27-31)
Intake Manifold Bolts	15 (20)
Rotor Through-Bolt	45-55 (61-75)
Starter Mounting Bolts	30-33 (41-45)
Stator Clamp Screws	10-12 (11-16)
Adapter-Engine Mounting Bolts	25-27 (34-37)
Adapter-Generator Mounting Bolts	25 (34)
Rear Vibration Isolators Center Bolt Flange to Drip Tray Screws	 30-33 (41-45) 10-12 (11-16)
Front Vibration Isolators Center Bolt Flange to Oil Base Screws	 28-32 (38-43) 19-22 (26-30)
* - Use engine oil as a lubricant for all threads EXCEPT for spark plug and rotor through-bolt threads.	

Operation

ENGINE OIL RECOMMENDATIONS

Use Mobil 1 Formula 15W-50 synthetic motor oil or equivalent.

STARTING BATTERIES

These gensets have a 12 VDC starting and control system. See *Specifications* for minimum battery requirements for genset cranking.

FUEL RECOMMENDATIONS

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, electrical switches and arc-producing equipment and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

NFPA Standard No. 58 requires all persons handling and operating LPG to be trained in proper handling and operating procedures.

When natural gas is the fuel being used, use commercially available natural gas fuel having a methane content of at least 90 percent (by volume).

When LPG (liquified petroleum gas) is the fuel being used, use grade HD-5 or equivalent consisting of at least 90 percent propane. Commercial LPG may contain more than 2.5 percent butane, which can result in poor fuel vaporization and poor engine starting in ambient temperatures below 32° F (0° C).

Satisfactory performance requires that the gas (natural gas or LPG) be supplied at a pressure within the range indicated in *Specifications*.

⚠WARNING ***High gas supply pressure can cause gas leaks which can lead to fire and severe personal injury or death. Gas supply pressure must be adjusted to Specifications by qualified personnel.***

FUEL SELECTION

LP Gensets

If the nameplate specifies “LP” as the fuel, the genset is *not* convertible for use with natural gas.

Natural Gas Gensets

If the nameplate specifies “Natural Gas” as the fuel, the genset is convertible for use with LPG (vapor withdrawal) in accordance with the instruction label on the genset (Figure 3). See Figure 4 for a layout of the fueling parts of the genset.

For LPG - Turn the fuel type selector on the carburetor *clockwise* as far as it will go, remove the cap over the hose fitting on the air cleaner adapter and *clamp* the balance hose onto the fitting.

For Natural Gas - Turn the fuel type selector on the carburetor *counterclockwise* as far as it will go, *disconnect* the balance hose from the hose fitting on the air cleaner adapter and *clamp* a hose fitting cap over the hose fitting. Secure the balance hose out of the way of vibrating parts so that it will not get pinched.

⚠ CAUTION ***Wrong fuel selection can result in hard starting, poor genset performance and fault shutdown.***

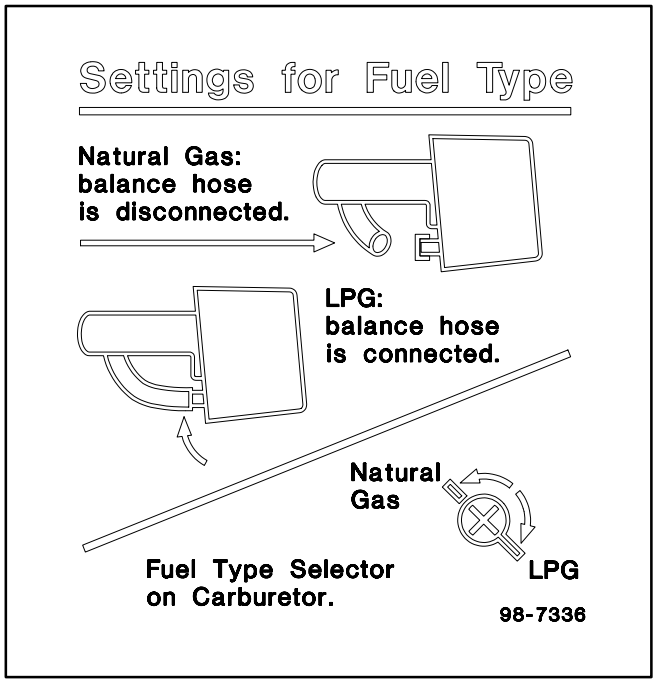


FIGURE 3. FUEL SELECTION INSTRUCTIONS

GENSET CONFIGURATION AND CONTROL

Figure 4 is a layout of a typical genset. The control features are as follows:

Controller - The controller uses two microcontrollers with embedded software. One microcontroller supports the traditional functions of genset control and the other serial communications with external systems.

Control Switch - This is a three-position **Run-Off-Auto** switch with a status/diagnostics light. The **Run** and **Off** positions are for manual starting and stopping of the genset at the site. The **Stop** position is also used for resetting the controller following a fault shutdown. The **Auto** position is for automatic network or transfer switch control.

Status/Diagnostics Light - This is an LED (light emitting diode) in the control switch. It blinks rapidly during cranking. It will blink in a coded fashion to indicate the nature of a genset shut down or of maintenance required to keep the genset running. See *Troubleshooting*.

Blinking stops in five minutes but can be restored by pushing the control switch to **OFF** and then returning it to **AUTO**. ***This also resets the controller.***

Code No. 6 will blink if the control switch is left in the **OFF** position more than 5 seconds.

RJ45 Service Jack - This connector provides for direct communications with a PC (laptop). Special software is required for the PC. See your authorized Onan dealer for details.

Network Connector - This 12-pin connector provides for serial communications with a network. A modem is required. See your authorized Onan dealer for details.

Transfer Switch Connector - This 8-pin connector provides for the Start/Stop and Emergency/Utility status signals from and Remote Test signals to the transfer switch.

Cabinet Interface Connector - This 3-pin connector provides for cabinet fault (**Code No. 8**) and low supply gas pressure fault (**Code No. 9**) signals.

Major/Minor Alarm Connector - This 8-pin connector provides for remote alarm signals.

Fuses F1, F2 and F3 - These fuses protect the control circuits of the genset.

Hour Meter - The hour meter records the total running time of the genset. It cannot be reset.

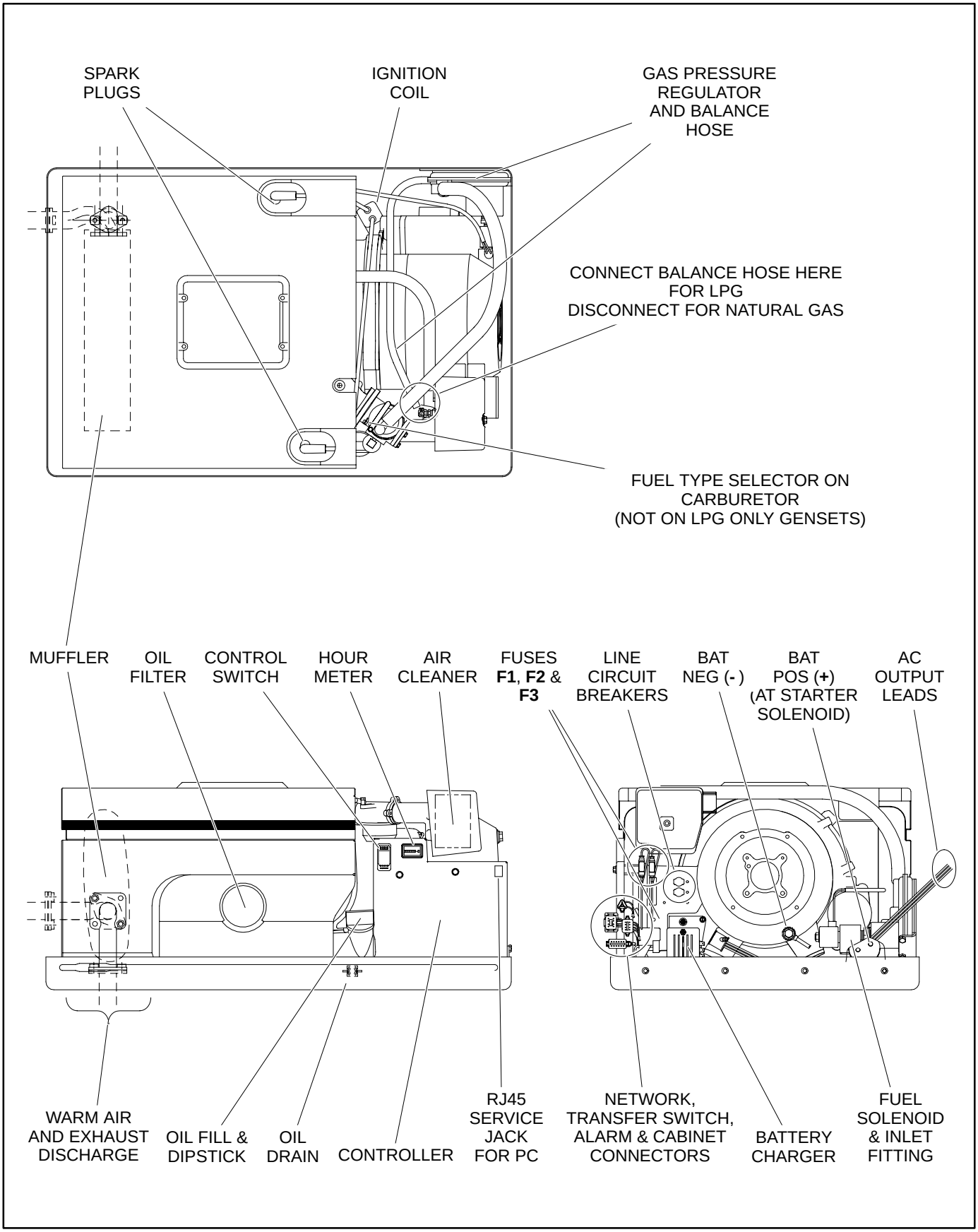


FIGURE 4. TYPICAL AC GENSET

⚠WARNING ***EXHAUST GAS IS DEADLY!***

All engine exhaust contains contain carbon monoxide, an odorless, colorless, poisonous gas that can cause unconsciousness and death. Symptoms of carbon monoxide poisoning include

- ***Dizziness***
- ***Headache***
- ***Weakness and Sleepiness***
- ***Nausea***
- ***Vomiting***
- ***Inability to Think Coherently***

IF YOU EXPERIENCE ANY OF THESE SYMPTOMS, GET INTO FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the genset and do not operate it until it has been inspected and repaired.

The exhaust system must be installed in accordance with the genset Installation Manual. Make sure there is ample fresh air when operating the genset in a confined area.

STARTING AND STOPPING THE GENSET

Pre-start Checks

If at the site, perform the maintenance instructed in GENERAL INSPECTION (Page 19). Service the genset and make repairs as required if a fault shutdown code displays (see *Troubleshooting*). Perform the required maintenance when a maintenance or service code displays: No. 3 (100 hours), No. 4 (low oil level), No. 39 (weak battery) or No. 43 (1000 hours)[1]. Also, see GENSET BREAK-IN and GENSET STORAGE in this section before placing in service a new or rebuilt genset or one that has been in storage.

Manual Starting

Push the control switch to **Run**. The engine should crank, start and run up to governed speed in a few seconds. The starter will disconnect automatically as the status light stops blinking.

If the engine does not start (after five 10 second cranks with 30 second rests), the starter will disengage and the status light will display **Code No. 5**. See *Troubleshooting* if the engine does not start.

Check for fuel and exhaust leaks. Stop the genset immediately if there is a fuel or exhaust leak and have it repaired before continuing operation.

Whenever possible, allow the engine to warm up for a few minutes before connecting the electrical loads.

Manual Stopping

Push the control switch to **Off**. Whenever possible, allow the engine to cool down with the electrical loads disconnected for a few minutes before stopping the genset.

The status light blinks **Code No. 6** when the switch is in the **Off** position to remind you to push the switch to the **Auto** position before leaving the site.

⚠CAUTION ***Failure to push the control switch to AUTO before leaving the site will render the genset unavailable for automatic standby service.***

Automatic Starting and Stopping

Push the control switch to **Auto** for remote, automatic starting and stopping (transfer switch or network).

Code No. 7 (Loss of Utility Power Alert) will blink if there is a loss of utility power and the genset is called upon by the automatic transfer switch to make up for the loss of utility power.

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from starting up while working on it.***

1. Code No. 3 and Code No. 43 can be turned off only by means of network commands or commands from a PC with appropriate software. See your authorized Onan dealer.

POWERING EQUIPMENT

Genset Loading

How much electrical equipment (system load) can be connected at one time depends upon how much power is available from the genset. If the genset is “overloaded”, either its circuit breaker(s) will trip or its controller will shut it down.

To get an idea of how much equipment can be operated at one time add up the watt ratings of the individual system loads that are likely to be used at the same time and compare the sum to the kW (kilowatt) rating of the genset. Note that 1 kW = 1000 watts. If power consumption, as totaled up, exceeds genset power output, you may have to consider operating some system loads in sequence, one after another, rather than all at the same time.

Note that when a genset is loaded nearly to full power and one of the large motor load “cycles on”, an undervoltage or under frequency fault shutdown (Code Nos. 13 and 15) could occur. The reason for this is that for a brief moment at startup a motor draws up to three times its rated power. You may, therefore, have to consider shutting off some loads at times when large motor loads are “On”.

Note that air density is less at higher altitudes, resulting in less available engine power. Power decreases approximately 3.5 percent of rated power each 1000 feet (305 m) of increase in elevation above sea level. Power also decreases approximately 1 percent each 10° F (5.5° C) increase in ambient temperature above 85° F (24° C).

Restarting The Genset

If the genset shuts down, disconnect or turn off as many system loads as possible and try restarting the genset as instructed under *Starting and Stopping*. Reconnect the loads one by one up to a total load that does not overload the genset or cause the circuit breaker to trip.

Resetting Circuit Breakers

If a circuit breaker in the main power distribution panel or on the genset (Figure 4) trips, there is either a short circuit or too many loads being operated at the same time. Note that the genset will continue to run after a circuit breaker trips.

If a circuit breaker trips, disconnect or turn off as many loads as possible and reset the circuit breaker. If the circuit breaker trips right away, either the main distribution system has a short or the circuit breaker is faulty.

If the circuit breaker does not trip, reconnect the loads, one by one, up to a total load that does not overload the genset or cause the circuit breaker to trip. If a circuit breaker trips right away when a load is connected, the load probably has a short.

Connecting The System To Utility Power

An approved device must be provided to keep the genset and utility from being interconnected.

⚠WARNING ***Interconnecting the genset and the public utility (or any other power source) can lead to the electrocution of utility workers and damage to equipment and fire. An approved switching device must be used to prevent interconnections.***

VARYING OPERATING CONDITIONS

Cold Weather

Perform maintenance due according to *Periodic Maintenance*. Use Mobil 1 Formula 15W-50 synthetic motor oil or equivalent.

Thermostatically controlled heaters for the engine oil sump and battery are recommended for more reliable starting in ambient temperatures down to -30 ° F (-22° C).

Hot Weather

Perform maintenance due according to *Periodic Maintenance*. Make sure nothing blocks airflow to and from the genset. Keep the cooling fins clean.

High Altitude

See *Powering Equipment* for information on how altitude affects the maximum power output of the genset.

Dusty Conditions

Keep the cooling fins clean. Perform air cleaner maintenance and change engine oil and oil filter more often than usual. See *Periodic Maintenance.*

GENSET BREAK-IN

Proper engine break-in on a new genset or on one with a rebuilt engine is essential for top engine performance and acceptable oil consumption. For proper break-in, run the genset at 1/2 rated power for the first 2 hours and then at 3/4 rated power for 2 more hours. See *Powering Equipment*.

Proper engine oil and oil level are especially critical during break-in because of the higher engine temperatures that can be expected. Use Mobil 1 Formula 15W-50 synthetic motor oil or equivalent. Check the oil level twice a day or every 4 hours during the first 24 hours of operation and change the oil after the first 50 hours of operation.

GENSET EXERCISE

If use is infrequent the genset should be exercised at least 1 hour each week at 1/2 rated power. See *Powering Equipment*. Exercising the genset drives off moisture, re-lubricates the engine and removes oxide from electrical contacts and generator slip rings, thereby promoting better starting, more reliable operation and longer engine life.

See the transfer switch operator's manual for instructions on how to adjust and activate the genset exerciser clock.

GENSET STORAGE

If the genset is to be stored for 120 days or more, proper storage is essential for preserving top genset performance and reliability.

Storing the Genset

1. Push the genset line circuit breakers **OFF** (Figure 4).

2. Remove the air filter and start the genset. While the genset is running, spray an engine fogger (OnaGard™)[2] into the carburetor, following the instructions on the container label, and then stop the genset. (A fogger coats the intake, cylinder and exhaust systems with a protective coat of oil.)

3. Change the engine oil and oil filter, and the air filter if it is dirty.

4. Disconnect the battery cables (negative [**-**] cable first) from the starting battery and store the battery according to the battery manufacturer's recommendations.

5. Close the fuel supply valve. If the genset is being removed from the premises, cap or plug any unused fuel line to prevent gas leakage if a fuel shutoff valve is opened inadvertently.

⚠WARNING ***Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LPG sinks when released and can accumulate inside housings and basements and other below-grade spaces. Prevent leaks and the accumulation of gas.***

Returning The Genset To Service

1. Reconnect the starting battery (negative [**-**] cable last). See BATTERY CARE under *Periodic Maintenance*.

2. Open the fuel supply valve.

3. Inspect the genset. See GENERAL INSPECTION under *Periodic Maintenance*.

4. Start the genset at the genset control panel. The initial startup may be slow and there may be smoke and rough operation for a few minutes until the oil in the cylinders from the fogger burns off. If the engine does not start, clean or replace the spark plugs as they may have been fouled by the fogger.

5. Push the genset line circuit breaker to **ON** (Figure 4) and the control switch to **Auto** for remote, automatic starting and stopping (transfer switch or network).

⚠CAUTION ***Failure to push the control switch to AUTO before leaving the site will render the genset unavailable for automatic standby service.***

2. OnaGard is a trademark of the Onan Corporation.

Periodic Maintenance

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from starting up while working on it.***

Periodic maintenance is essential for top performance and long genset life. Use Table 1 as a guide for normal periodic maintenance. Under hot or dusty operating conditions some maintenance operations should be performed more frequently, as indicated by the footnotes in the table. Keep a log of maintenance performed and the hours run. Recording maintenance will help you keep it regular and provide a basis for supporting warranty claims.

Maintenance, replacement or repair of emission control devices and systems may be performed by any engine repair establishment or individual. However, warranty work must be completed by an authorized Onan dealer or distributor.

TABLE 1. PERIODIC MAINTENANCE SCHEDULE

MAINTENANCE OPERATION	MAINTENANCE FREQUENCY			
	Each Site Visit[1]	Yearly, or Every 100 Hours[2]	Every 1000 Hours[3]	Page
General Inspection	X			19
Check Engine Oil Level	X			19
Clean and Check Starting Battery	X			22
Change Engine Oil and Oil Filter		X[4, 5]		20
Replace Engine Air Filter		X[4]		21
Clean Gas Supply Screen and Sediment Trap		X		-
Replace Spark Plugs and Cables			X[6]	21
Clean Engine Cooling Fins			X[6, 7]	-
Adjust Engine Valve Clearance (Lash)			X[6, 7]	-
Clean Combustion Chambers			X[6, 7]	-

1. Maintenance Alert Codes 4 (low oil level) and 39 (weak battery) can be network monitored.
2. Maintenance Alert Code 3 occurs every 100 hours of operation and can be network monitored.
3. Service Alert Code 43 occurs every 1000 hours of operation and can be network monitored.
4. Perform more often when operating in dusty conditions.
5. Perform more often when operating in hot weather.
6. Perform sooner if engine performance deteriorates.
7. Must be performed by a qualified mechanic (authorized Onan dealer).

GENERAL INSPECTION

Inspect the genset during each site visit.

Oil Level

Check the engine oil level as explained under CHECKING ENGINE OIL LEVEL in this section.

Exhaust System

Look and listen for exhaust system leaks while the genset is running. Shut down the genset if a leak is found and have it repaired before operating the genset.

Fuel System

Check the fuel supply line and fittings for leaks while the genset is running. Check flexible fuel hose sections for cuts, cracks, and abrasions. Make sure the fuel line is not rubbing against other parts. Replace worn or damaged fuel line parts before leaks occur.

⚠WARNING ***Gaseous fuels are highly flammable and explosive and can cause severe personal injury or death. Repair leaks immediately.***

Battery Connections

Check the battery terminals for clean, tight connections. Loose or corroded connections have high electrical resistance which makes starting harder. Shut the genset off and disconnect corroded or loose battery cables (negative [**-**] cable first) and clean and reconnect them as instructed under BATTERY CARE in this section.

⚠WARNING ***Batteries give off explosive gases that can cause severe personal injury. Do not smoke near batteries. Keep flames, sparks, pilot lights, electrical arcs and arc-producing equipment and all other ignition sources well away.***

Do not disconnect the battery cables while the genset is cranking or running: the arcing can ignite the explosive battery gases.

Mechanical

Look for mechanical damage. Start the genset and look, listen and feel 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 blocked or clogged with debris.

Clean accumulated dust and dirt from the genset. Do not clean the genset while it is running or still hot. Protect the generator, air cleaner, control panel, and electrical connections from water, soap and cleaning solvents. Always wear safety glasses when using compressed air, a pressure washer or a steam cleaner.

⚠WARNING ***Always wear safety glasses when using compressed air, a pressure washer or a steam cleaner to avoid severe eye injury.***

CHECKING ENGINE OIL LEVEL

Shut off the genset before checking the engine oil level.

1. Remove the oil fill cap/dipstick (Figure 5), wipe it clean, screw the cap back on and then remove it again to check the oil level on the dipstick.

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

2. Add oil as necessary until the full mark is reached. Use Mobil 1 Formula 15W-50 synthetic motor oil or equivalent. DO NOT FILL TO A LEVEL ABOVE THE FULL MARK ON THE DIPSTICK. Drain the excess oil if too much has been added.

   ⚠CAUTION ***Too much oil can cause high oil consumption, high operating temperatures and oil foaming. Too little oil can cause severe engine damage. Keep the oil level between the Full and Add marks on the dipstick.***

3. Screw the oil fill cap on securely to prevent oil leakage.

CHANGING ENGINE OIL AND OIL FILTER

Refer to Table 1 for scheduled engine oil change. In hot weather and dusty conditions the oil should be changed more often.

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

1. Place a pan under the oil drain plug. Run the engine until it is warm and shut it off.
2. Remove the oil fill cap (Figure 5), open the oil drain valve and allow all of the oil to drain from the engine.
3. Close the oil drain valve.
4. Spin off the oil filter canister and discard it according to local regulations.
5. Thoroughly wipe off the filter mounting surface.
6. Make sure the gasket is in place on the new filter canister and apply a thin film of oil to the gasket.
7. Spin on the new filter canister by hand until the gasket just touches the mounting pad and then turn it an additional 1/2 to 3/4 turn. Do not overtighten.
8. Refill with Mobil 1 Formula 15W-50 synthetic motor oil or equivalent. See *Specifications* for oil capacity. Check oil level.
9. Screw the oil fill cap on securely to prevent oil leakage.
10. Used oil is harmful to the environment if it is not disposed of properly. Pour used oil into a sealed container and deliver it to the nearest recycling center or automotive service station.

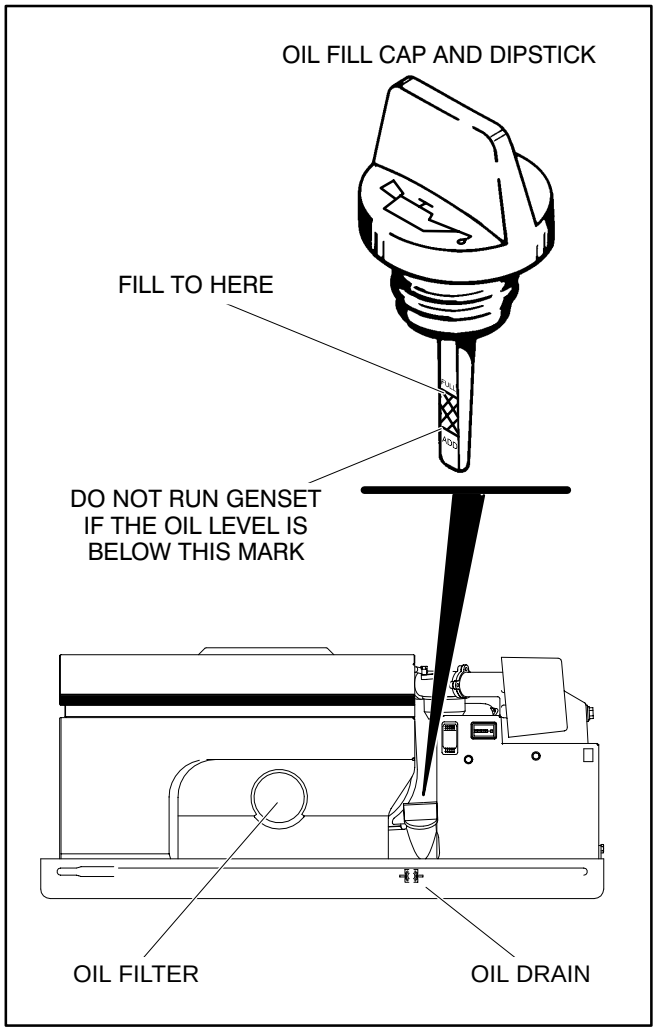


FIGURE 5. OIL LEVEL CHECK

AIR FILTER

Refer to Table 1 for scheduled air filter replacement. In dusty conditions the air filter element and wrapper should be inspected and changed more frequently for best operation.

To change the air filter element and wrapper, remove the through-bolt and cover (Figure 6). Reassemble the air filter with a new air filter element and wrapper. *Do not oil the filter or wrapper.* Do not over-tighten the through bolt as that can distort the filter element or cover and lead to air leaks around the air filter element.

SPARK PLUGS

Refer to Table 1 for scheduled spark plug replacement. (The genset has two spark plugs, Figure 7.) The spark plugs must be in good condition for proper engine starting and performance. A spark plug that fouls frequently or has heavy soot deposits indicates the need for engine service. See *Troubleshooting*.

To prevent crossthreading a spark plug, always thread it in by hand until it seats and then torque to 8 lb-ft (10 N-m).

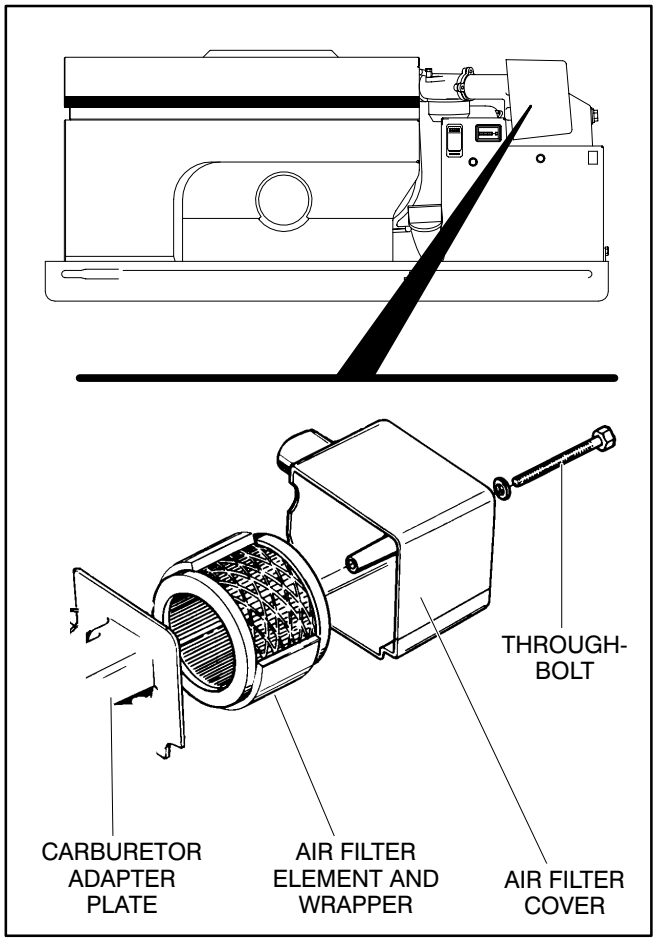


FIGURE 6. AIR FILTER ELEMENT AND WRAPPER

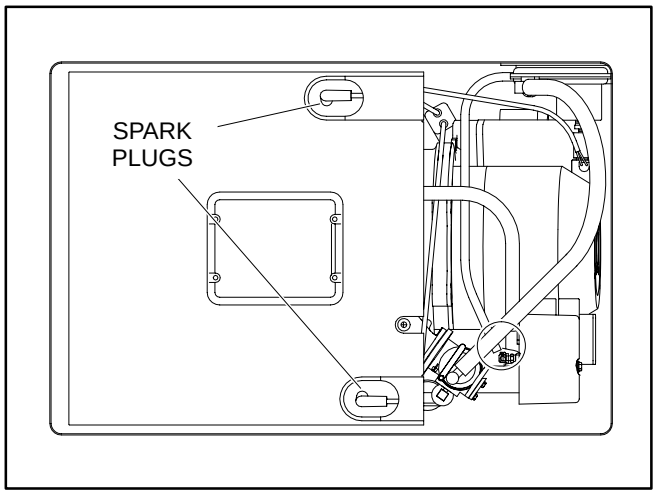


FIGURE 7. SPARK PLUGS

BATTERY CARE

Refer to Table 1 for scheduled battery maintenance and to the battery manufacturer's recommendations and instructions for battery care.

⚠WARNING ***Batteries give off explosive gases that can cause severe personal injury. Do not smoke near batteries. Keep flames, sparks, pilot lights, electrical arcs and arc-producing equipment and all other ignition sources well away.***

Do not disconnect the battery cables while the genset is cranking or running: the arcing can ignite the explosive battery gases.

⚠WARNING ***Battery electrolyte can cause severe eye damage and skin burns. Wear goggles, rubber gloves and a protective apron when working with batteries.***

Maintain the battery as follows unless the battery manufacturer has other instructions and recommendations:

1. Keep the battery case clean and dry.
2. Make certain that the battery cable connections are clean and tight. Use a terminal puller tool to remove the battery cables.
3. Identify the cable as positive (**+**) or negative (**-**) before making the battery connections. Always remove the negative (**-**) cable first and connect it last, to reduce the risk of arcing.

Preparations for Service

SAFETY

There are hazards in servicing gensets. Study *Safety Precautions* and become familiar with the hazards listed in Table 2. Note the following safeguards and ways of avoiding hazards:

- ***Reduce the hazard:*** A safe, orderly workshop area and well-maintained equipment reduce the hazard potential. Keep guards and shields in place on machinery and maintain equipment in good working condition. Store flammable liquids in approved containers; away from fire, flame, spark, pilot light, switches, arc-producing equipment and other ignition sources. Keep the workshop clean and well lighted and provide adequate ventilation.
- ***Develop safe work habits:*** Unsafe procedures lead to accidents when using tools and machines. Be familiar with the equipment and its safe use. Use the correct tool for the job and check its condition before using it. Observe the warnings in this manual. Take special precautions when working around electrical equipment. Do not work alone, if possible. Do not take risks.
- ***Use personal protection:*** Wear appropriate protective safety equipment, such as safety shoes and safety glasses. Do not wear rings or jewelry and do not wear loose or damp clothing that might get caught in equipment or conduct electricity.
- ***Be prepared for an accident:*** Keep fire extinguishers and safety equipment nearby. Agencies such as the Red Cross and public safety departments offer courses in first aid, CPR and fire control. Take advantage of this information and be ready to respond to an accident. Learn to be safety-conscious and make safety procedures part of the work routine.

TABLE 2. HAZARDS AND THEIR SOURCES

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

SPECIAL TOOLS

The following tools are necessary for servicing the genset:

Engine Tools

Torque wrench: 0-75 lb-ft (0-100 N-m)

Hole gauge: 0.300-0.400 inch (5-10 mm)

Outside micrometer set: 0-4 inch (0-100 mm)

Telescoping gauge set: up to 4 inch (100 mm)

Feeler gauge

Plasti-Gage bearing clearance guide

Spark plug gap gauge

Oil pressure gauge: 0-30 psi (0-200 kPa)

Manometer: 14 inch (350 mm) WC

Inclined Manometer: 1 inch (25 mm) WC range with 0.01 inch (0.1 mm) WC divisions

Cylinder compression tester

Flywheel puller

Crankshaft gear puller ring, bolts and puller (or special shoulder bolts and flywheel puller)

Snap ring pliers

Combination main and cam bearing remover

Combination main and cam bearing driver

Oil seal loader and driver

Cylinder ridge reamer

Piston ring spreader

Piston groove cleaner

Piston ring compressor

Cylinder hone

Valve spring compressor

Valve lock replacer

Valve seat cutter kit

Valve guide driver

Slide hammer

Lead or dead-blow hammer

Generator and Control Tools

Rotor removal tool (headless bolt)

Commutator stone

Battery hydrometer

Digital multi-meter

Load test panel and leads

REMOVING THE GENSET

See *Troubleshooting* to determine the probable cause of the problem before removing the genset for service.

Removal from the Cabinet

Make sure that the genset is firmly supported before loosening any mounting bolts. There are four bolt holes in the base pan for securing the genset to the floor or supporting frame of the cabinet.

⚠WARNING ***Gensets are heavy and can cause severe personal injury if dropped during removal. Use adequate lifting devices. Keep hands and feet clear while lifting.***

Disconnections at the Genset

1. Push the control switch to **Off** to prevent accidental starting.

2. Disconnect the negative (**-**) battery cable *from the battery* and then disconnect the battery cables from the genset.

   ⚠CAUTION ***Sparks and high current could cause fire and other damage to the battery, battery cables and equipment if the loose ends of cables connected to the battery touch. Always disconnect the negative (-) battery cable from the battery before disconnecting the battery cables from the genset.***

3. Disconnect all four connectors for remote control, cabinet faults and alarms.

4. Disconnect the generator output wiring and conduit from the cabinet. Tag all wires to make reconnections easier.

5. Disconnect the exhaust tailpipe from the outlet of the muffler if necessary for removal of the genset.

6. Close the fuel supply shut valve. To purge the fuel supply line and genset as much as possible, run the genset (if it starts) until it runs out of fuel with the shut off valve closed. Disconnect the gas supply at the fuel solenoid fitting on the genset. Cap the end of the fuel supply line with a threaded pipe cap to prevent fuel from escaping if someone inadvertently opens the shutoff valve.

⚠WARNING ***Gaseous fuel is flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, electrical arcs and arc-producing equipment and all other sources of ignition well away. Keep a Type ABC fire extinguisher handy.***

Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LPG sinks when released and can accumulate inside housings and basements and other below-grade spaces. Prevent leaks and the accumulation of gas.

NFPA Standard No. 58 requires all persons handling and operating LPG to be trained in proper handling and operating procedures.

TEST STAND

When testing and servicing the genset on a workbench or test stand make sure the warm air opening in the base pan is free and clear. Also, make sure there is ample fresh air when operating the genset.

⚠WARNING ***EXHAUST GAS IS DEADLY! Engine exhaust must be vented outside if the genset is operated inside a building.***

⚠CAUTION ***Restricting the air inlet and outlet openings could lead to damage to the genset due to overheating.***

It may be possible to perform some of the service procedures on engine subsystems without removing the genset from the cabinet.

CRANKCASE VACUUM TEST

Crankcase vacuum should be at least ***10 inches (254 mm) WC (water column)***. Low vacuum indicates a malfunctioning crankcase breather assembly (p. 34) or air leak into the crankcase. You can make crankcase vacuum testing on these genset engines easier if you drill and tap a barbed hose fitting into an oil fill cap that you carry with you.

CYLINDER COMPRESSION TEST

Examining the spark plugs and testing crankcase vacuum and cylinder compression pressure can tell you much about the condition of the valves, piston rings and cylinders. Test *cylinder compression pressure* as follows:

1. Start the genset and let it warm up.
2. Stop the genset and remove and inspect the spark plugs. See IGNITION SYSTEM (p. 12).
3. Insert the compression gauge nozzle into one of the spark plug holes, hold the throttle open and crank the engine. Note the pressure indicated by the gauge.
4. Repeat the test on the other cylinder.
5. Refer to *Engine Block Assembly* if cylinder compression test pressures do not meet *Specifications.*

VALVE CLEARANCE (LASH) ADJUSTMENT

See Figure 8. The engine is equipped with adjustable valve tappets. Adjust the valve clearance only when the engine is at ambient temperature:

1. Remove all parts that block access to the valve tappets.
2. Remove the spark plugs to make turning the engine easier.

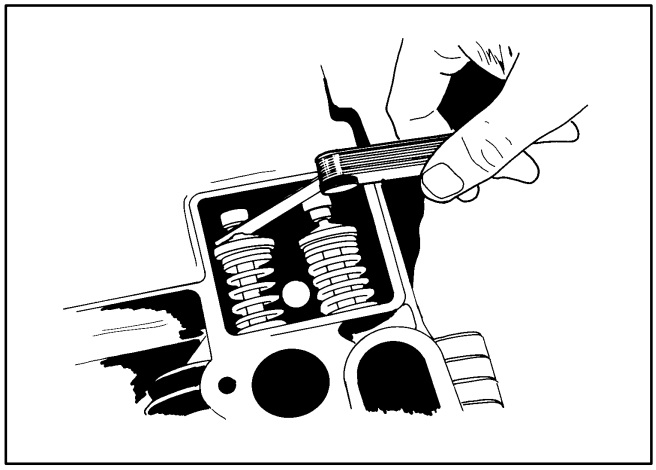


FIGURE 8. ADJUSTING VALVE CLEARANCE (LASH)

3. Remove the spark plugs and use a 3/8 inch allen wrench in the generator rotor through bolt to rotate the crankshaft counterclockwise until the right intake valve (viewed from generator end) opens and closes. Continue turning the crankshaft until the TC mark on the flywheel lines up with the TC mark on the gear cover. This should place the right piston at the top of its compression stroke. Verify that the right intake and exhaust valves are closed and that there is no pressure on the valve lifters.
4. See *Specifications* for valve clearance. When taking the clearance measurement, the feeler gauge should just pass between the valve stem and valve tappet.
5. To correct the valve clearance, turn the adjusting screw as needed. The screw is self-locking.
6. To adjust the valves on the left cylinder, turn the engine one complete revolution until the TC mark on the flywheel lines up again with the TC mark on the gear cover and then follow the same procedure as for the right cylinder.
7. Replace all parts removed.

EXHAUST SYSTEM

See Figure 9. The exhaust system consists of the exhaust manifold, muffler, tailpipe adapter and tailpipe. The muffler and tailpipe adapter are mounted inside the genset housing. The tailpipe (if provided) is supplied by the customer.

Always service a leaking exhaust system before running a genset. Never try welding a broken or leaky tailpipe, muffler or manifold.

⚠WARNING ***Exhaust gas is deadly. The exhaust system must not leak and must discharge all engine exhaust away from people and buildings.***

Liability for injury, death, damage and warranty expense due to the use of an unapproved muffler or due to modifications becomes the responsibility of the person installing the unapproved muffler or performing the modifications. Use Onan approved exhaust system parts.

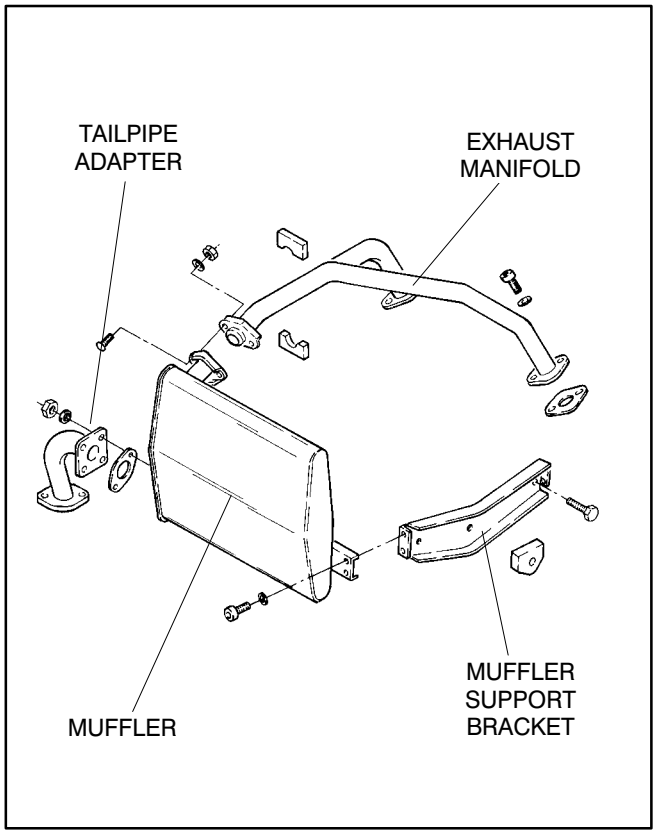


FIGURE 9. EXHAUST SYSTEM

Tailpipe

If it is necessary to replace the tailpipe, use 1-3/8 inch I. D. 18 gauge steel tubing. Because the tailpipe is connected rigidly to the engine (via the muffler) and the engine is mounted on vibration isolators, flexible shock-mount hangers must be used to support the tailpipe.

Muffler

It will probably be necessary to remove the genset from the cabinet to remove the muffler. See *Preparing to Service.*

Remove the top panel (see COOLING SYSTEM in this section). Then remove the two flange bolts of the joint between the manifold and the muffler and the four mounting bracket screws on the ends of the muffler and withdraw the muffler.

When installing the muffler make sure the self-aligning joint between the manifold and the muffler lines up properly for a leak-free joint before tightening the bracket mounting screws.

Exhaust Manifold

To remove the exhaust manifold first remove the muffler. Remove the four exhaust manifold bolts and then the manifold and gaskets. Be sure to cover the openings in the block to prevent loose parts and dirt from entering the engine.

When installing an exhaust manifold, always use new gaskets and torque the manifold bolts according to *Torque Specifications.*

COOLING SYSTEM

These are air-cooled gensets. The centrifugal blower on the crankshaft draws cooling air across the fins on the engine cylinders and heads and discharges the warm air downwards through the opening in the base pan. Figure 10 shows the housing panels which direct the air flow.

⚠WARNING ***Do not run the generator set without all the panels in place. Contact with the rotating flywheel can result in severe personal injury or death.***

⚠WARNING ***Discharge air from the engine can include deadly exhaust gas. Do not use engine discharge air for heating any space or enclosure.***

See the Installation Manual regarding the minimum free area required for the air inlet to the compartment or enclosure and the minimum clearance required at the discharge opening. The engine will overheat if the inlet and outlet openings are too small or are obstructed or if dust has accumulated on the cooling fins.

Cooling System Panel Removal

1. Disconnect the starting battery, negative (**-**) cable first, to prevent accidental starting.
2. Remove the Torx screws and the two screws on top. Through the spark plug access opening unhook the spark plug cable on the the oil filter side from the top panel and remove the panel.
3. Remove the left and right side panels. Five Torx screws and two capscrews at the top of the cylinder heads secure each.
4. Remove the end panel which is secured by the four remaining screws along its bottom edge.

Cooling System Disassembly for Engine Block Service:

1. Remove the cooling system panels, blower volutes, muffler and exhaust manifold (see EXHAUST SYSTEM in this section).
2. Remove the blower. See Blower Removal in this section.
3. Disconnect the lead connected at the low oil pressure cutoff switch (next to the oil filter).
4. Remove the four capscrews that secure the inner bulkhead to the engine and remove it.
5. Thoroughly clean the engine cooling fins.

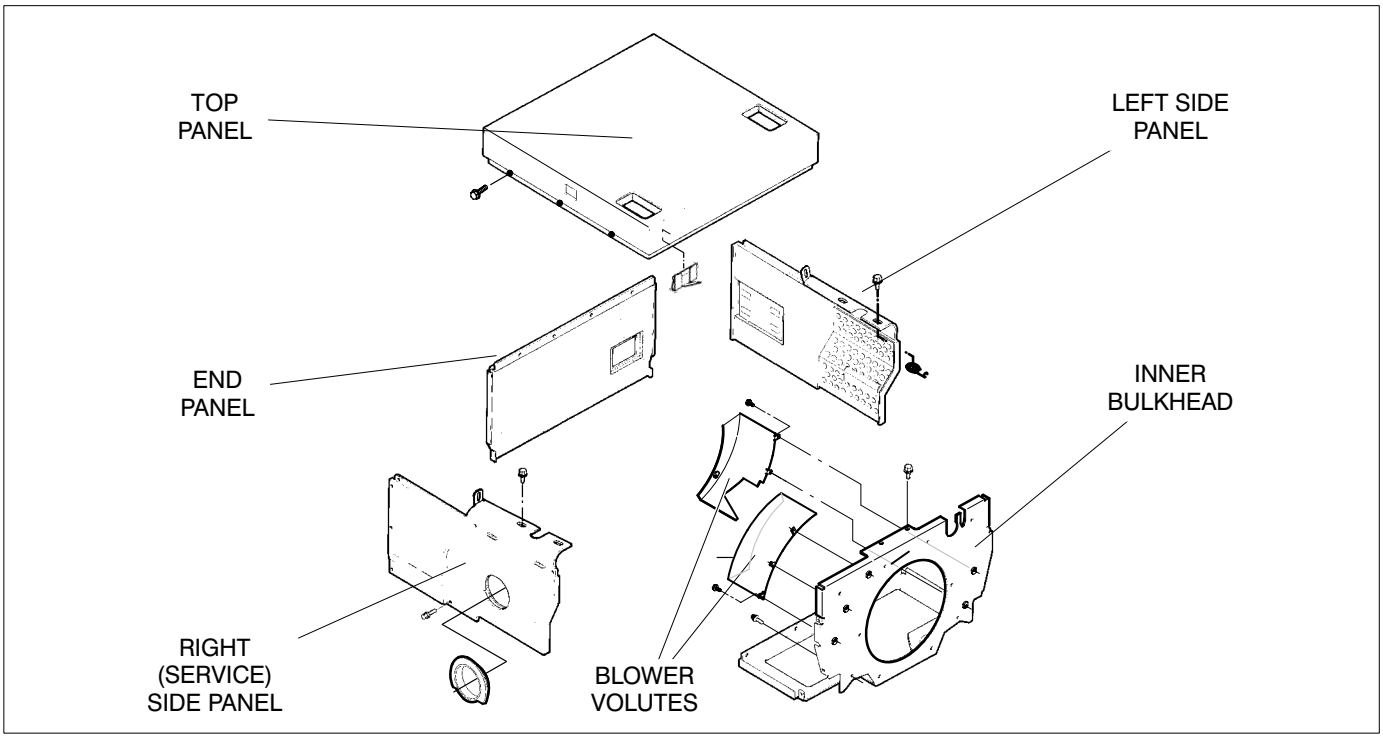


FIGURE 10. COOLING SYSTEM PANELS

Blower Removal

1. Loosen the blower hub capscrew and back it out several turns. See Figure 11.
2. Attach the puller tool to the blower hub. The tool has two jack screws that fit into the holes tapped in the hub. Tighten the puller center screw until the hub comes loose. Remove the puller, hub center screw and washer. Inspect the blower and replace it if any air vanes are missing, damaged or warped.

Cooling System Reassembly

Reassembly is the reverse of disassembly.

1. Make sure the woodruff key is in place when installing the blower hub. Use non-hardening sealer on the hub capscrew threads and tighten according to *Torque Specifications.*
2. Make sure the pieces of insulation used to seal the openings in the inner bulkhead where the two muffler support brackets and the exhaust manifold pass through are in place.
3. Make sure the lead to the low oil pressure switch has been reconnected.

   ⚠ CAUTION ***Running the genset without the low oil pressure cutoff switch connected can lead to serious engine damage in the event of low oil pressure.***

4. Make sure the spark plug cable (oil filter side) has been rehooked by the clip inside the top panel to prevent it from interfering with the governor rod and causing erratic operation.

   ⚠ CAUTION ***The engine will overheat and can be damaged if it is operated without all the cooling system panels in place (Figure 10).***

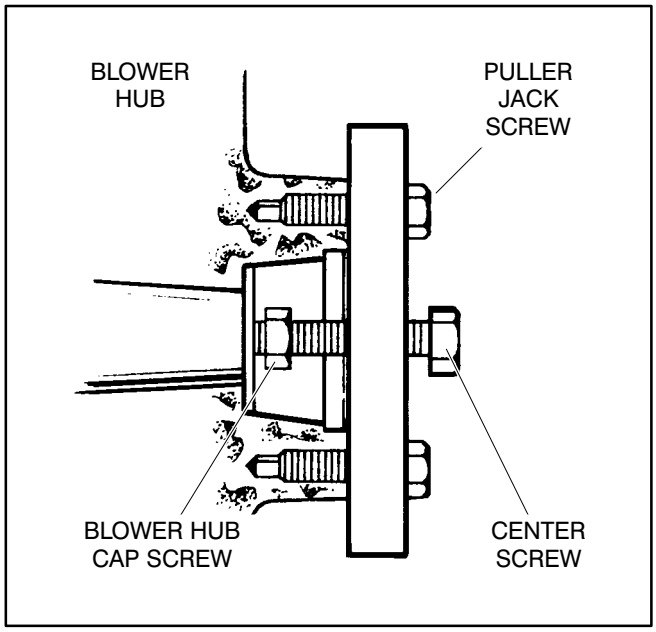


FIGURE 11. BLOWER HUB REMOVAL

IGNITION SYSTEM

The genset is equipped with an electronic ignition system consisting of a rotor, module, coil, capacitor, spark plugs and associated wiring. Energy for ignition is supplied by the 12 volt cranking battery.

Rotor

See Figure 12. The ignition rotor is keyed to the engine crankshaft. The ends have opposite magnetic polarity (north and south). One pole switches on the ignition module and the other pole switches it off, once each revolution of the crankshaft. The rotor should not normally require replacement.

Module

The ignition module is secured and grounded to the generator-engine adaptor by two cap screws. It is an electronic switch in the primary circuit of the ignition coil. See *Wiring Diagrams* for the appropriate wiring diagram. It is switched on and off once each revolution by the rotor. The module contains no serviceable parts and should not normally require replacement.

Coil

See Figure 13. The ignition coil is a transformer that fires the spark plugs at roughly 20,000 volts each revolution when the ignition module opens the primary circuit causing the coil field to collapse.

⚠ CAUTION ***The leads connected at the low voltage terminals of the ignition coil (Figure 13) should not be routed so as to pass between the high voltage terminal posts. The result could be erratic operation due to false signals induced in the primary leads.***

Capacitor

The ignition capacitor is secured and grounded to the top of the generator-engine adaptor by one cap screw. The pig tail is connected to the positive (**+**) low voltage terminal of the ignition coil.

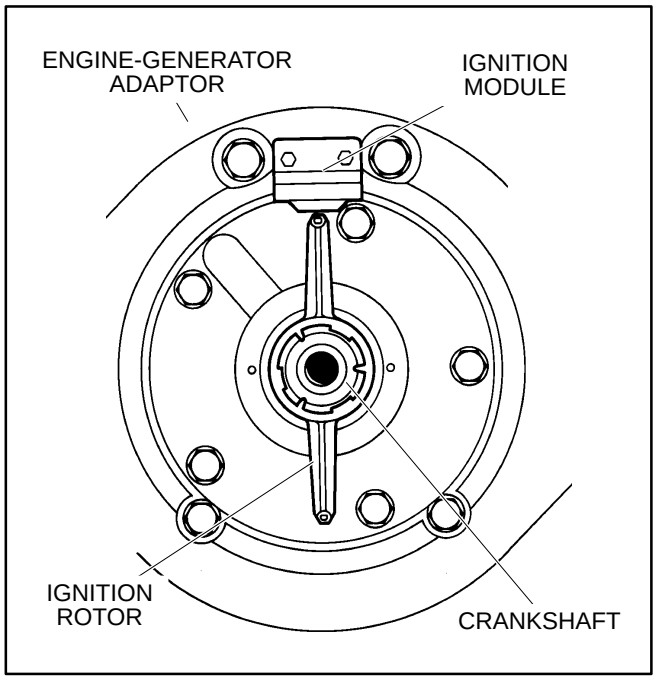


FIGURE 12. IGNITION ROTOR AND MODULE

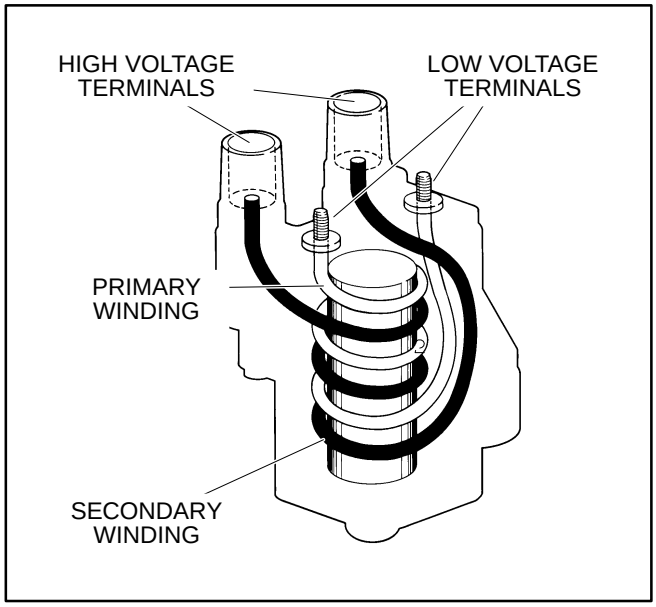


FIGURE 13. IGNITION COIL

Spark Plugs

The genset has two spark plugs. The spark plugs must be in good condition and have the proper gap for top engine performance. See *Specifications.*

To prevent crossthreading a spark plug, always thread it in by hand until it seats and then torque to 8 lb-ft (10 N-m).

If the engine misses or performance otherwise deteriorates, remove and examine the spark plugs for signs of the following problems:

Light tan, gray or reddish deposits - Normal

One spark plug fouled - Broken spark plug cable, low cylinder compression

Soot fouled - Wrong spark plug heat range (too cold), duty cycle too short for engine to reach normal operating temperature

Fuel fouled - Wrong spark plug heat range (too cold), faulty choke operation, overly rich fuel mixture, dirty air filter

Oil fouled - Malfunctioning crankcase breather, worn rings, worn valve guides or seals

Burned or overheated - Leaking intake manifold gaskets, lean fuel mixture

Worn - Spark plug service life used up.

Quick Ignition Test

If the engine misfires, test the ignition system as follows to quickly determine if the problem is in the ignition system. First recheck, clean and tighten the connections at the ignition coil terminals. See *Wiring Diagrams* for the proper connections at the "**-** " and "**+**" terminals.

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Conduct this test only in a well ventilated area and make sure you cannot smell gas. Keep a Type ABC fire extinguisher handy.***

1. Move the genset to a well-ventilated area, leave the generator compartment door open for several minutes and make sure you cannot smell gas before conducting this test.

2. Remove one of the spark plugs and disconnect the lead at the fuel solenoid to prevent gas from flowing.

3. Reconnect the spark plug cable and lay the spark plug on bare engine metal to ground it.

   ⚠WARNING ***HIGH VOLTAGE. To prevent electric shock do not touch the spark plug or wire during this test.***

4. Crank the engine and observe the spark. A strong, consistent spark indicates that the ignition system is probably functioning properly and that the problem is elsewhere. See *Troubleshooting*. Service the ignition system as required if the spark is weak or inconsistent.

Spark Plug Cable Resistance Test

Remove both spark plug cables and check resistance across the ends with an ohmmeter. Replace a cable if resistance is not between 3,000 and 15,000 ohms.

Ignition Module Test

Disconnect the lead at the fuel solenoid so that the genset does not start while cranking and make sure the red lead from the ignition module is connected securely to the positive (**+**) terminal of the ignition coil and the black lead to the negative (**-**) terminal. See Figure 14.

Test 1: While cranking, ground one lead of a 12 VDC test light to a good ground on the block and touch the other lead to the negative (**-**) terminal of the ignition coil (Figure 14):

- ***If the light alternates between bright and dim***, the module is good.
- ***If the light does not come on***, go to Test 2.

Test 2: Move the test lead from the negative (**-**) terminal to the positive (**+**) terminal of the coil (Figure 14):

- ***If the light does not stay on during cranking***, reconnect or repair wiring in the circuit to the positive (**+**) terminal of the coil.
- ***If the light stays on during cranking***, go to the Ignition Coil Test. If the ignition coil is good, replace the ignition module and rotor.

Ignition Coil Test

1. Remove all wires attached to the ignition coil.
2. Remove the coil from the engine.
3. Inspect the terminals for corrosion, looseness, cracks or other damage. Look for carbon runners around the high tension terminals indicating electrical leakage. Replace a damaged or leaking coil.
4. Clean the outside of the coil with a cloth dampened in parts cleaning solvent.
5. Measure primary coil resistance (across the positive [**+**] and negative [**-**] terminals). Replace the ignition coil if primary resistance is not between 3 and 5 ohms.
6. Measure secondary coil resistance (across the spark plug cable terminals). Replace the ignition coil if secondary resistance is not between 10,000 and 40,000 ohms. See Figure 15.

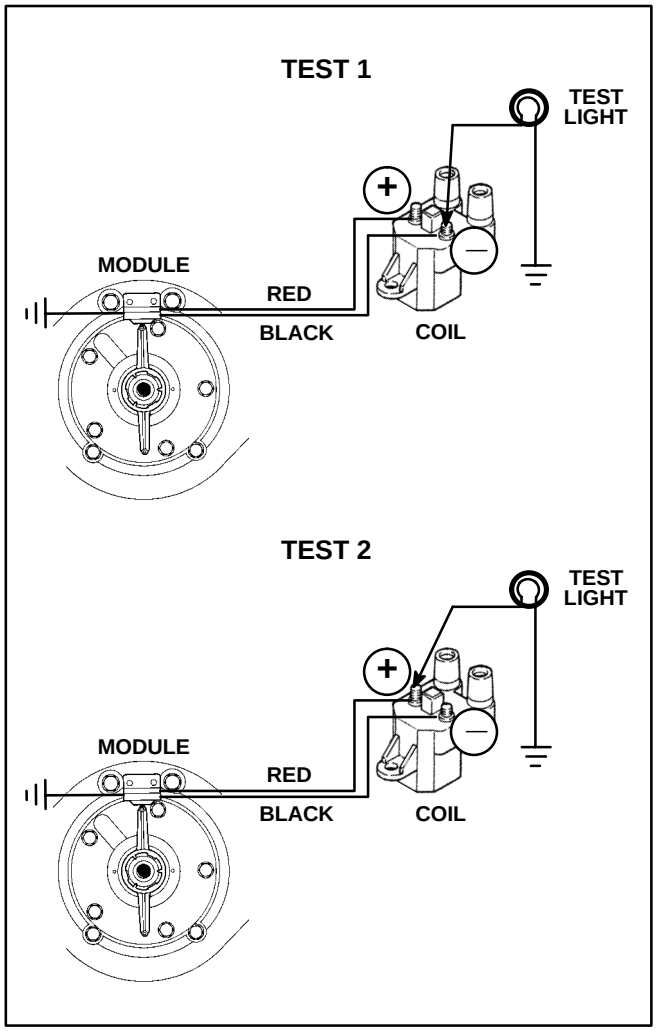


FIGURE 14. TESTING THE IGNITION MODULE

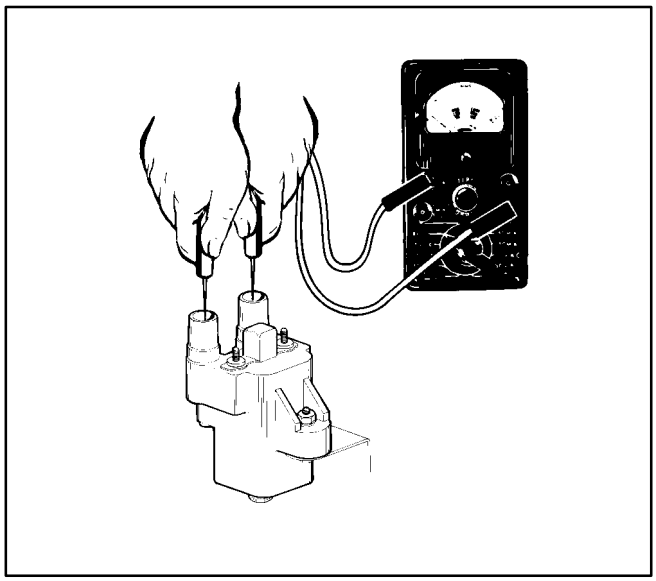


FIGURE 15. TESTING THE IGNITION COIL

CRANKCASE BREATHER ASSEMBLY

See Figure 16. The crankcase breather is a reed valve assembly that opens to discharge crankcase vapors on the down-stroke of the piston and closes on the up-stroke, resulting in a negative pressure in the crankcase when the engine is running. The crankcase vapors (blowby gases, moisture, air) are routed to the carburetor for burning in the cylinders. A dirty or sticking reed valve can cause oil leaks, high oil consumption, rough idle, reduced engine power and sludge formation within the engine.

Crankcase vacuum should be at least 10 inches (254 mm) WC (water column). See CRANKCASE VACUUM TEST (p. 26).

Disassembly: The breather assembly is serviced by disassembling it and cleaning all the parts in parts cleaning solvent. The assembly comes apart when the capscrew is removed.

⚠WARNING ***Most parts cleaning solvents are flammable and corrosive and can cause severe burns and inflammation. Use only as recommended by the manufacturer.***

Reassembly: Reassemble using a new gasket. Replace the reed valve if it does not lie flat across the discharge orifice. Torque the cover capscrew to 12-24 lb-in (1.3-2.6 N-m).

⚠CAUTION ***Over-tightening the capscrew can distort the cover allowing dirt and air to enter the engine.***

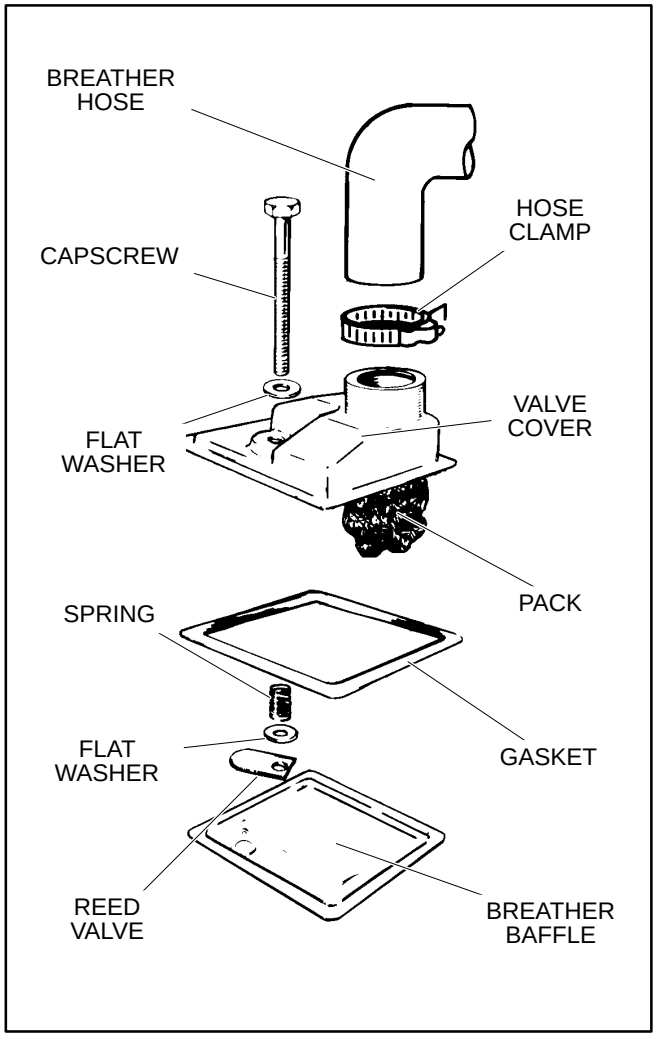


FIGURE 16. CRANKCASE BREATHER ASSEMBLY

LUBRICATION SYSTEM

An oil pump (See OIL PUMP under *Engine Block Assembly*) provides a constant flow of oil to the engine parts and a full-flow, spin-on filter keeps the oil clean. The oil collects in the oil base where it is picked up by the oil pump pick-up cup. An oil bypass valve is used to control oil pressure.

Oil pressure should be at least at least 20 psi (138 kPa) when the engine is at normal operating temperature. If pressure drops below this value at governed speed, inspect the oil system for faulty components.

Oil Filter And Adapter

To remove the oil filter and adapter:

1. Open the oil drain valve and drain the crankcase oil.

2. Remove the filter by turning it counterclockwise with a filter wrench.

3. Loosen the two capscrews that secure the adapter to the engine block and remove the adapter and gasket. The low oil pressure cutoff switch is installed in a threaded hole in the filter adapter. See Figure 17.

To reassemble the oil filter and adapter, perform these steps in reverse order. Install a new adapter gasket so that the two small oil holes are aligned with the oil holes in the block. **This gasket should be installed dry**. Coat the threads of each capscrew with non-hardening sealer and torque to specifications.

Oil Base

Drain the oil before removing the oil base. Always use a new gasket when replacing the oil base. See Figure 18.

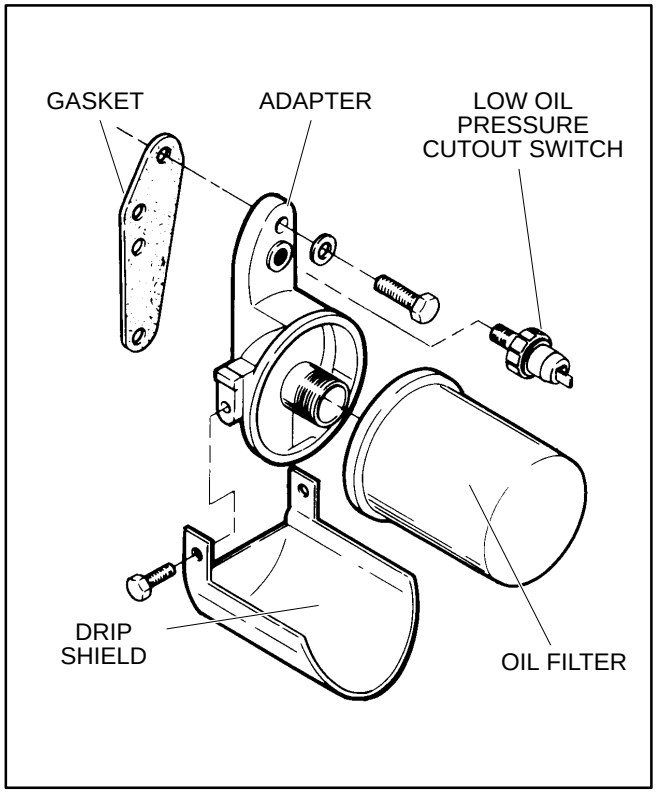


FIGURE 17. OIL FILTER AND PRESSURE SWITCH

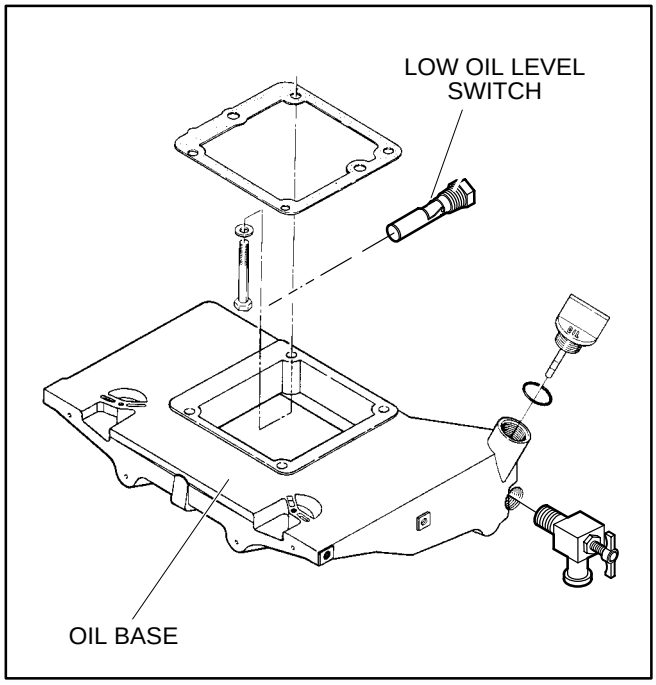


FIGURE 18. OIL BASE AND LEVEL SWITCH

Oil Bypass Valve

The bypass valve is located to the right and behind the gear cover (Figure 19). It controls oil pressure by allowing excess oil to flow back to the crankcase. It is non-adjustable and normally needs no maintenance. If it is suspected that it is the cause of high or low oil pressure, inspect it as follows:

1. Remove the 3/8 capscrew behind the gear cover and under the governor arm.

2. Remove the spring and plunger with a magnetic tool and clean them.

3. Replace the plunger if its diameter is not 0.3105-0.3125 inch (7.89-7.94 mm).

4. Replace the spring if its free length is not approximately 1 inch (25.4 mm) or if it does not take 2.4-2.8 pounds (10.7-12.5 N) to compress it 0.5 inch (12.7 mm).

5. Check the bore and valve seat and clean as necessary.

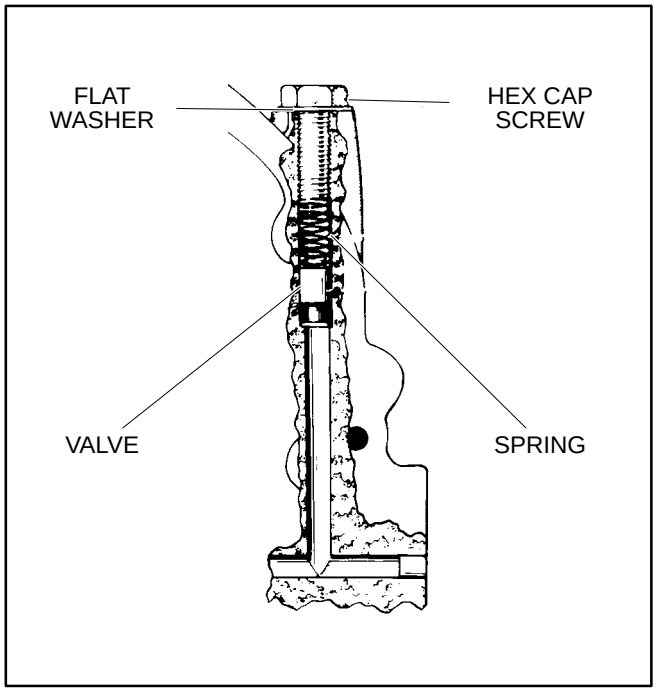


FIGURE 19. OIL BYPASS VALVE

GOVERNOR ROD AND ACTUATOR

See Figure 20. The genset controller operates the throttle by means of the governor rod and actuator to maintain a nearly constant engine speed (frequency) as the electrical load on the genset varies.

Replace the governor actuator if coil resistance is not between 6.5 and 7.5 ohms or if the coil is shorted to ground.

Disconnecting the Governor Rod: Remove the top panel (see COOLING SYSTEM in this section) for access to the governor rod. Unhook the governor rod and spring from the governor actuator arm first. Use both hands so as not to bend the actuator arm. Then unhook the rod and spring from the throttle.

Reconnecting the Governor Rod: Before reconnecting the governor rod check to see that the paint seal on the throttle stop screw on the carburetor has not been broken. If the seal is broken, readjust the throttle stop screw as follows:

1. Disconnect the governor rod from the actuator arm if it has not already been removed.

2. Loosen the throttle stop screw locknut and back the screw out away from the tang on the throttle lever while gently rotating the throttle lever counterclockwise as far as if will go.

3. While holding the throttle lever counterclockwise as far as it will go, turn the stop screw in until it just touches the tang. Then turn the screw an additional 1/8-1/4 turn (clockwise) and set and seal the locknut.

If the throttle stop screw adjustment is okay, reconnect the governor rod as follows:

1. Insert the rod in the spring such that the shorter hook wire is on the throttle side.

2. Hook the rod and spring into the grommet in the throttle lever. (The spring should pull on one side and the rod push on the other side of the grommet when fully assembled.)

3. Pull the governor rod towards the plastic clip on the end of the actuator lever as far as the throttle stop screw permits. Leave the actuator lever in its fully counterclockwise (rest) position. Snap the dogleg on the end of the rod into the slot in the clip that most closely lines up with it. Use both hands so as not to bend the actuator lever.

4. Hook the spring into the slot in the end of the actuator lever. When assembled, the spring hook wires should not wrap around the governor rod.

5. Move the actuator back and forth through its full movement to make certain there is no sticking or binding.

6. After installing the top panel, hook the spark plug cable with the clip inside the panel to keep it from interfering with the governor rod.

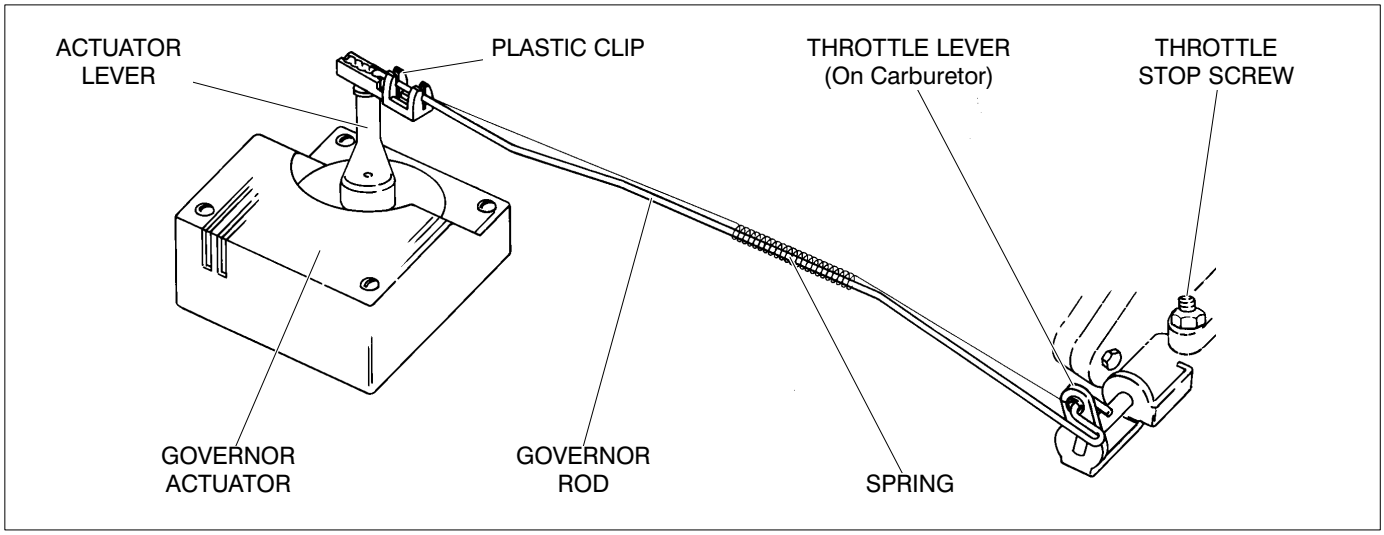


FIGURE 20. GOVERNOR ROD AND ACTUATOR

FUEL SYSTEM

See Figure 21. The carburetor mixes gas and air in the correct proportion for good performance. The governor actuator operates the throttle to maintain a nearly constant engine speed (frequency) as the load varies.

⚠WARNING ***Gaseous fuels are flammable and explosive and can cause severe personal injury or death. Do not smoke if you smell gas or are near fuel tanks or fuel-burning equipment or are in an area sharing ventilation with such equipment. Keep flames, sparks, pilot lights, electrical switches and arc-producing equipment and all other sources of ignition well away. Keep a type ABC fire extinguisher handy.***

NFPA Standard No. 58 requires all persons handling and operating gaseous fuel to be trained in proper handling and operating procedures.

Air Cleaner Assembly

Disassembly:

1. Remove the crankcase breather hose and the gas pressure regulator balance hose (if connected) from the air cleaner housing.

2. Remove the air cleaner housing center capscrew and lift off the housing and air filter.

3. Disconnect the leads connected to the adapter (for the de-icer heater).

4. Remove the three capscrews that secure the air cleaner adapter to the carburetor and lift off the adapter. (One of the screws is inside the throat of the adapter.)

Reassembly: Reassembly is the reverse of disassembly. Use a new gasket between the adapter and the carburetor.

⚠CAUTION ***Take care not to cross-thread the inside adapter mounting screw.***

Carburetor and Intake Manifold Assembly

Disassembly:

1. Remove the air cleaner assembly.

2. Disconnect the gas hose and governor rod from the carburetor.

3. Remove the intake manifold capscrews, and remove the carburetor and intake manifold as an assembly.

4. Remove the two intake manifold gaskets and cover the intake ports to prevent loose parts from accidentally entering the ports.

5. Unbolt the carburetor from the intake manifold. Replace the carburetor if it is malfunctioning. There are no separately replaceable carburetor parts nor service adjustments.

   ⚠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.***

Reassembly: Reassembly is the reverse of disassembly. Use new gaskets between the intake manifold and the engine and between the intake manifold and the carburetor. Do not use sealer on the gaskets. Tighten all fasteners according to *Assembly Torques*.

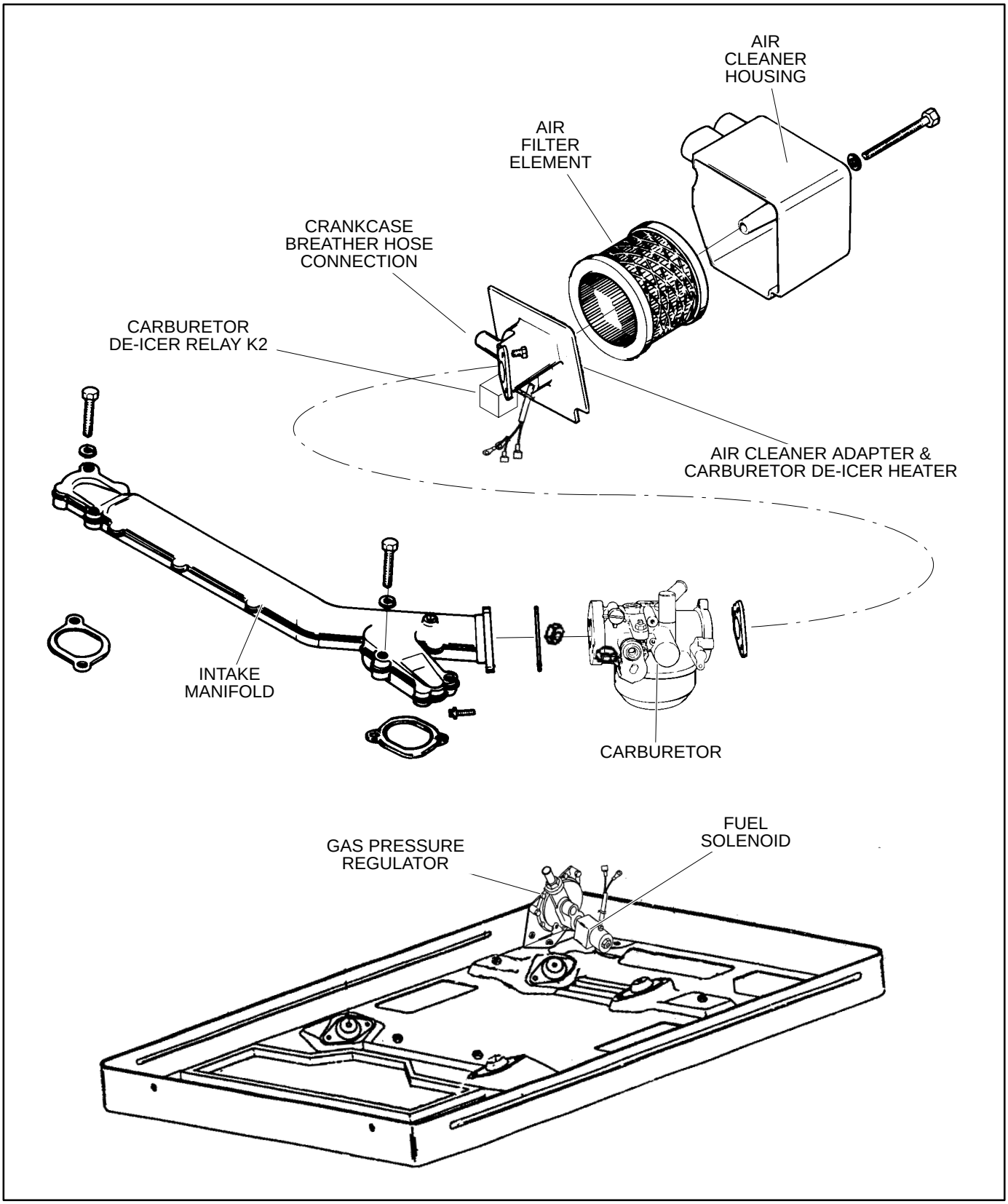


FIGURE 21. THE FUEL SYSTEM COMPONENTS

Carburetor De-icer

The carburetor de-icer is a thermostatically controlled heater assembled as an integral part of the air cleaner adapter (Figure 22). It is powered by the battery charging windings of the generator (B1/B2) at approximately 18 to 20 VAC through relay K2 and fuse F3.

Relay K2 is operated by the de-icer thermostat and is powered off the positive (**+**) terminal of the ignition coil (T1). The relay is mounted on the outside of the adapter assembly.

Replace the carburetor de-icer/air filter adapter assembly if electrical resistance across the black leads is not approximately 1.5 ohms or the thermostat does not close across the white leads at approximately 25° F (-4° C) or open at approximately 40° F (22° C).

Replace relay K2 if there is no electrical continuity across terminals **30** and **87** when the coil is energized across terminals **85** (**+**) and **86** (**-**) with 12 VDC.

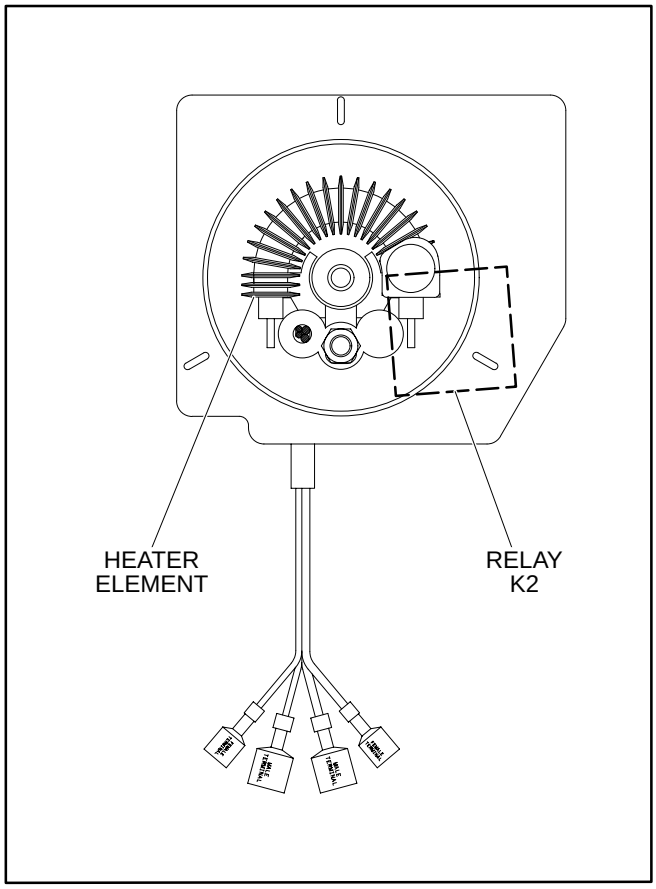


FIGURE 22. DE-ICER HEATER

Demand Regulator/Fuel Solenoid Assembly

The demand regulator and fuel solenoid are joined by a pipe nipple. The assembly is mounted by means of a bracket to the base pan.

Adjusting Gas Supply Pressure

See Figure 23. Gas supply pressure must be maintained at 6-13 inches (152-330 mm) water column (WC) for natural gas and 9-13 inches (229-330 mm) water column for LPG. Adjust the supply pressure as follows:

1. Close the gas supply shutoff valve.
2. Remove the 1/8 inch pipe plug from the regulator test port and connect a manometer calibrated in inches or mm WC having a scale range of at least 14 inches (350 mm).
3. Open the gas shutoff valve and try starting the genset.
4. While the genset is running at no load, check the manometer and adjust the gas supply pressure regulator to obtain 11 inches (279 mm) WC.
5. If the genset will not start, jumper the fuel solenoid to the battery cable connections on the genset so that it stays open (the regulator will keep gas from flowing) and then check and adjust the gas supply pressure.
6. If the genset is operable, check gas supply pressure under full load. If gas pressure drops below the required minimum, the gas supply piping may be too small. On an LPG supply system, the container may be too small to provide the rate of vaporization or it may not have enough fuel.
7. Disconnect any jumpers which may have been used to energize the fuel solenoid and thread in and tighten the pressure test port plug.

Fuel Solenoid Valve Tests

Replace a leaky fuel solenoid valve or one that fails to open.

To test for leakage use a test pressure of at least 11 inches (279 mm) WC and a soap bubble.

To test for opening, jumper the solenoid across the battery cable connections at the genset. The gas supply pressure manometer used for adjusting supply pressure can be used to indicate whether the valve opens.

Demand Regulator Lock-Off Pressure Test

See Figure 23. Determine lock-off pressure as follows:

1. Adjust gas supply pressure and leave the manometer connected to the pressure test port and the fuel solenoid energized (open). If the regulator is being tested on the bench, connect it to a source of air pressure regulated to 11 inches (280 mm) WC.

   ⚠ CAUTION ***When bench testing the regulator, make sure the diaphragm is in a vertical plane (as on the genset) so that the weight of the diaphragm will not cause erroneous lock-off pressure readings.***

2. “T” in two hoses to the end of the pressure balance hose (1/4 inch I. D.). Use one hose to provide the test pressure and the other to measure pressure by connecting it to an inclined manometer calibrated with 0.01 inch (0.1 mm) WC divisions having a range of at least 1 inch (25 mm) WC.

3. Disconnect the gas hose from the hose fitting at the regulator outlet and attach a soap bubble. While reading the pressure indicated by the inclined manometer and watching the soap bubble, blow lightly into the pressure balance hose (this simulates the effect of carburetor venturi vacuum). Regulator lock-off pressure is the minimum pressure that will cause gas to flow through the regulator, as indicated by the expanding soap bubble. (The soap bubble may expand at first due to diaphragm movement, but will stop expanding if gas is not flowing through the regulator.)

   Replace the demand regulator if the lock-off pressure does not fall between 0.10 and 0.25 inch WC (2.5 and 6.4 mm WC).

   ⚠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.***

4. Reconnect the hose to the carburetor, disconnect any jumpers which may have been used to energize the fuel solenoid and thread in and tighten the pressure test port plug.

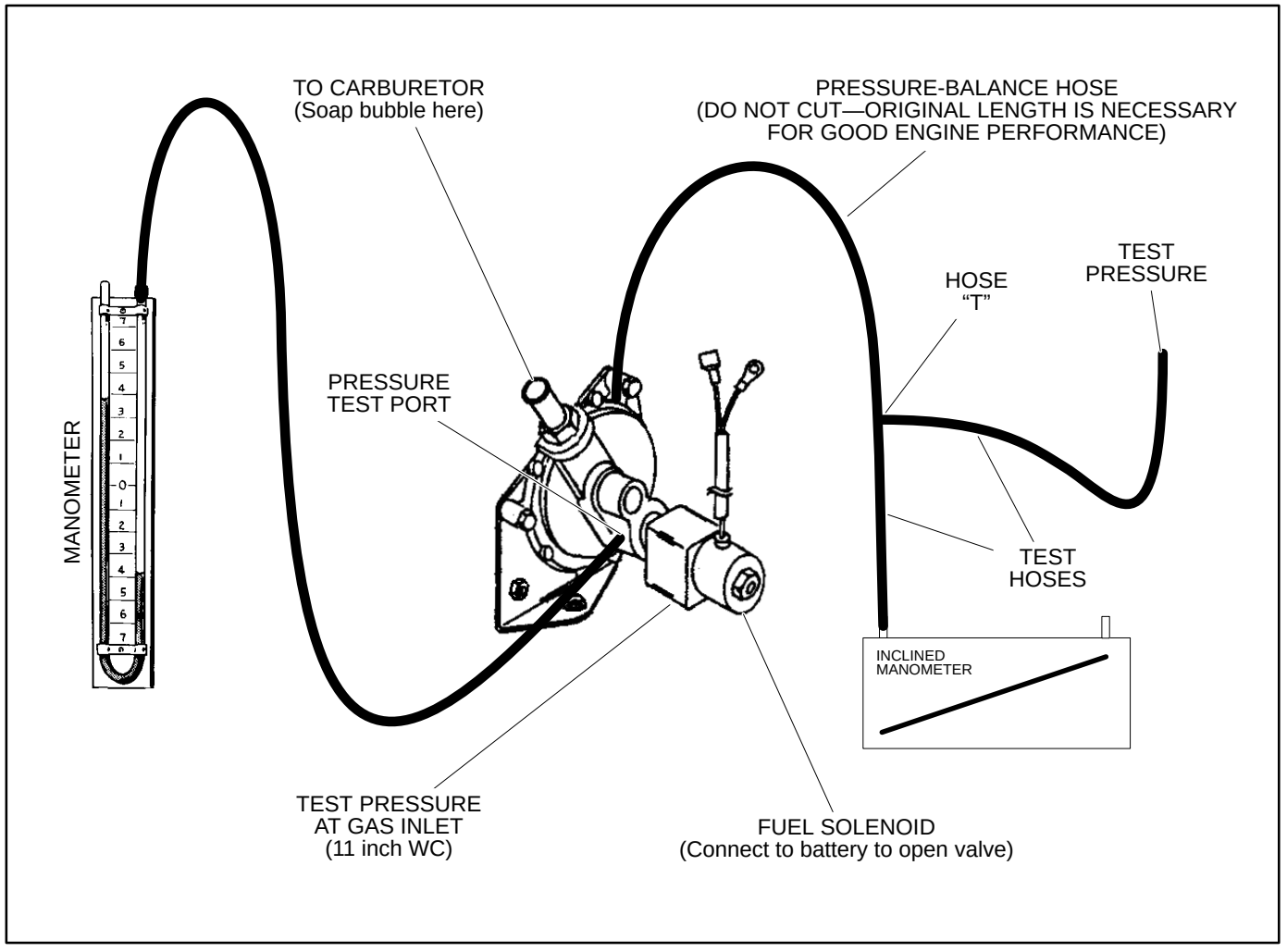


FIGURE 23. APPARATUS FOR GAS SUPPLY PRESSURE AND REGULATOR LOCK-OFF PRESSURE TESTS

BATTERY CHARGER

See Figure 24. The generator is equipped with auxiliary windings **B1-B2** and battery charging voltage regulator **VR2** mounted on the back of the control box. Nominal output is 10 amps.

See *Generator* regarding **B1-B2** winding tests.

ENGINE TEMPERATURE SENSOR

The engine temperature sensor is a thermistor device that is bolted to the rear head underneath the air cowling (Figure 25).

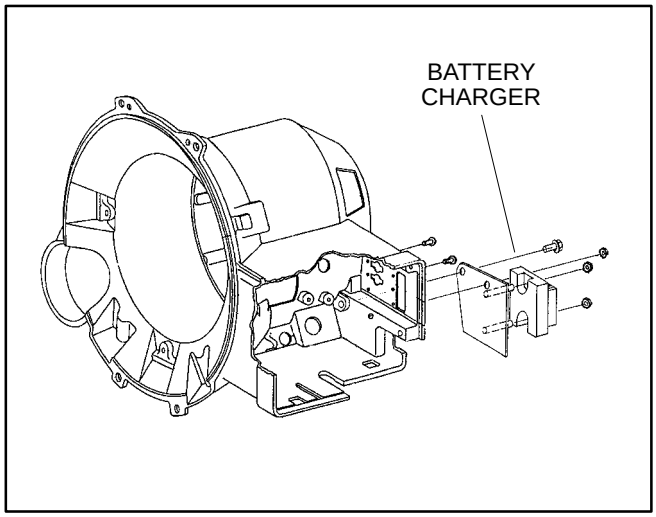


FIGURE 24. BATTERY CHARGER

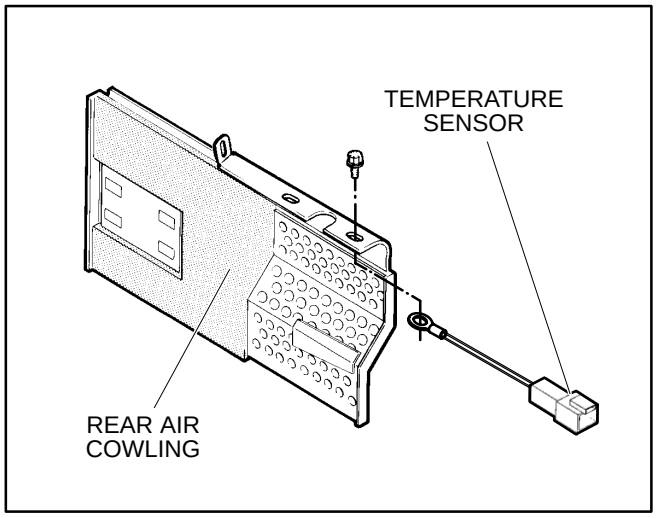


FIGURE 25. ENGINE TEMPERATURE SENSOR

STARTER MOTOR

Starter Removal and Replacement

To remove the starter for service or replacement:

1. Disconnect the negative (**-**) cable from the starting battery.
2. Disconnect all wires and cables from the motor terminals.
3. Remove the two starter mounting bolts and remove the starter.

Replacement is the reverse of removal. Torque the mounting bolts to *Assembly Torques*.

Starter Assembly and Disassembly

See Figure 26. Remove the starter from the genset. Remove the solenoid before disassembling the motor and remount if after assembling the motor. When mounting the solenoid make sure the plunger is hooked by the shift fork. The drive housing, motor frame and end bell are separable after the motor through bolts have been removed. Before loosening the through bolts, however, scratch register lines on the drive housing, motor frame and end bell so that these parts can be easily reassembled the same way relative to each other. While removing the end bell, be prepared to catch the brush springs, which tend to spring loose.

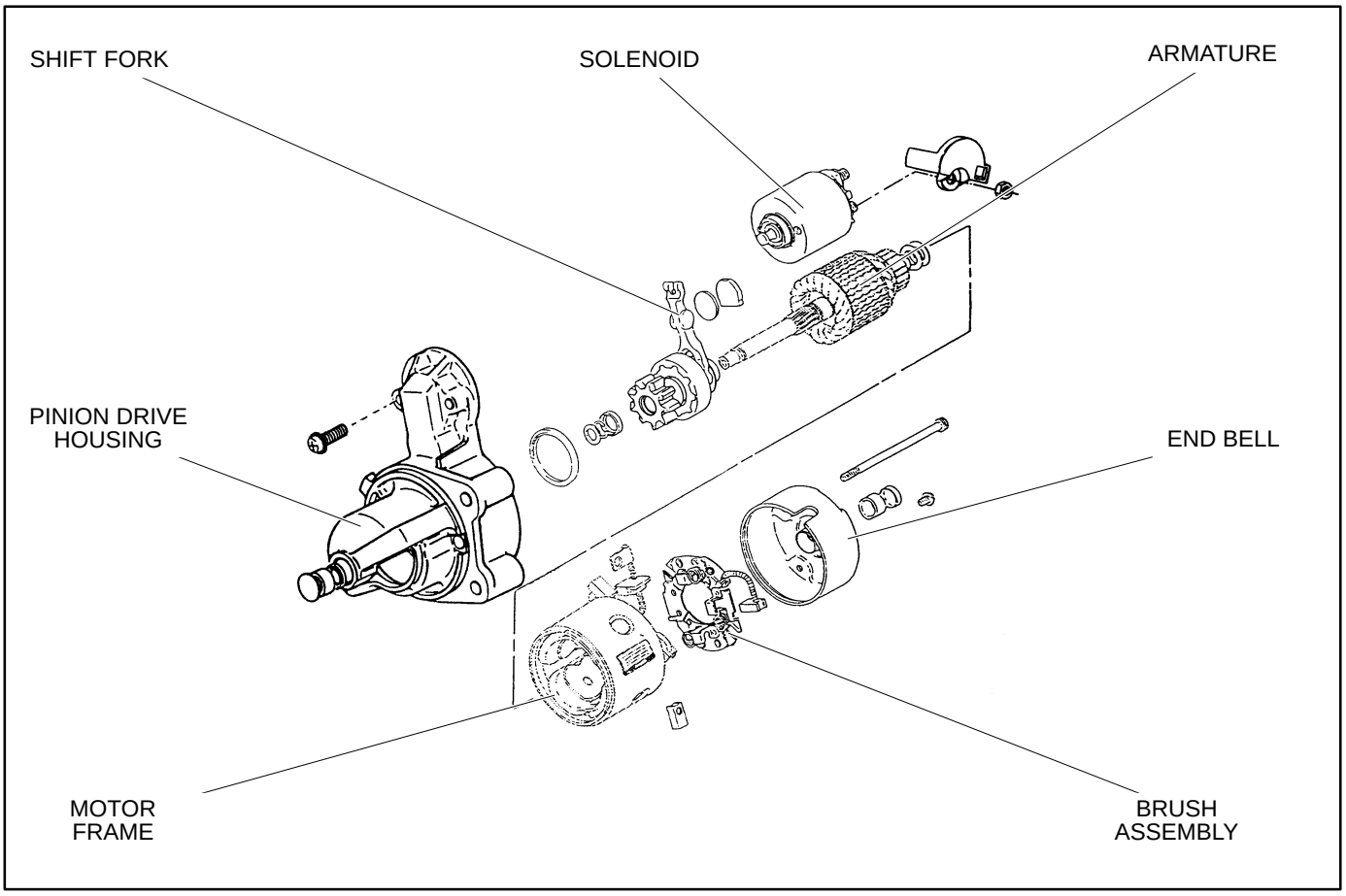


FIGURE 26. SOLENOID SHIFT STARTER

Solenoid

See Figure 27. Before replacing the solenoid, confirm that it is the cause of the starter not working by removing it from the starter assembly and conducting the following tests.

1. Connect **6 volt** battery positive (**+**) to solenoid terminal **S** and battery negative (**-**) to solenoid terminal **M**. The plunger should pull in and hold in strongly. If it does not, replace the solenoid.

2. Connect **6 volt** battery positive (**+**) to solenoid terminal **S** and battery negative (**-**) to the body of the solenoid. Push the plunger in and release it. The plunger should stay in. If it does not, replace the solenoid.

3. Connect **12 volt** battery positive (**+**) to solenoid terminal **M** and battery negative (**-**) to the solenoid body (reversed from normal polarity). Push the plunger in and release it. The plunger should push back out immediately. If it does not, replace the solenoid.

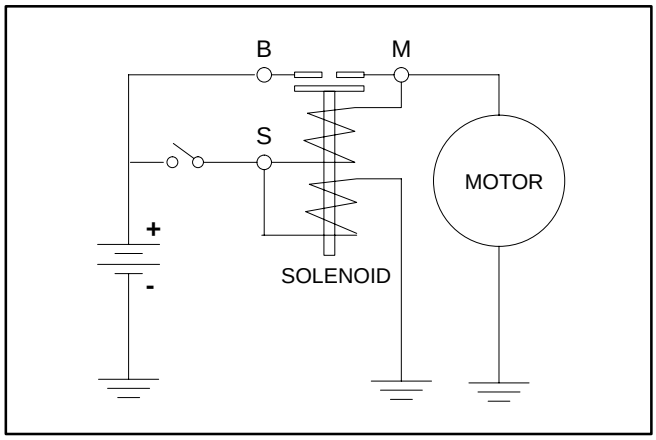


FIGURE 27. SOLENOID-MOTOR CIRCUITS

Armature

Winding Integrity: See Figure 28. Use an ohmmeter to check for electrical continuity between pairs of commutator segments all the way around the commutator. Make sure each segment is checked. Replace the armature if a winding is open (high resistance) at any segment.

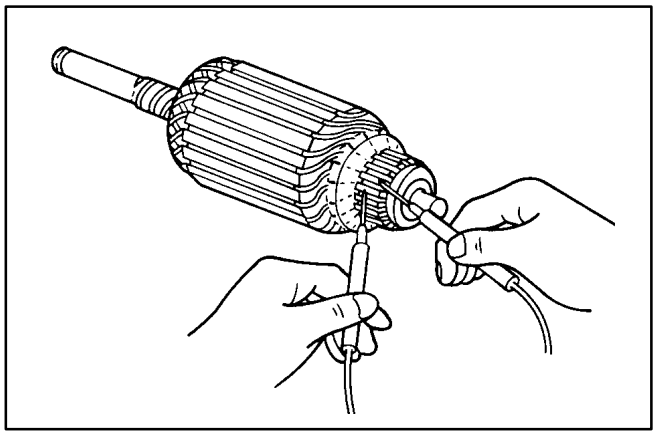


FIGURE 28. CHECKING WINDING INTEGRITY

Winding Insulation: See Figure 29. Use an ohmmeter to check for winding insulation breakdown between the windings and the rotor laminations. Replace the armature if the ohmmeter does not indicate high resistance on its highest scale between any commutator segment and the rotor laminations.

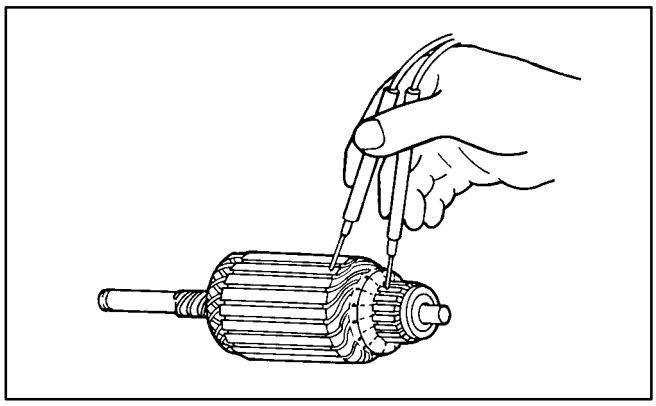


FIGURE 29. CHECKING WINDING INSULATION

Commutator: See Figure 30. Clean the commutator surface with sandpaper. Measure the diameter at several locations around the commutator. Turn the commutator in a lathe if it is not round or has deep pits. Replace the armature if it is necessary to turn the diameter of the commutator to less than 1-1/16 inch (27 mm).

Using a hacksaw blade, undercut the mica between the commutator segments by 1/32 inch and chamfer the edges of the segments slightly.

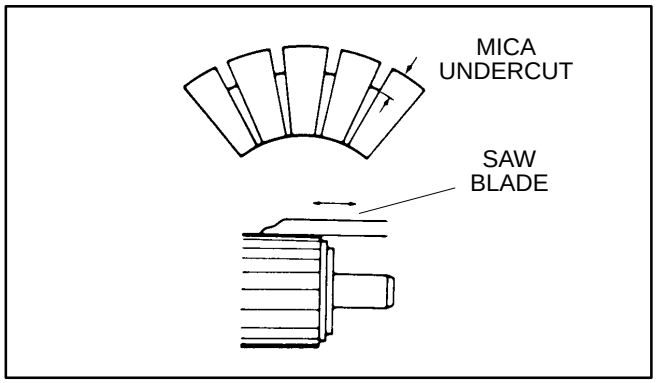


FIGURE 30. COMMUTATOR MICA UNDERCUT

Brush Assembly

Replace the motor frame and brush assembly if any brush is less than 0.43 inch (11 mm) long.

Motor Frame and Stator

See Figure 31. Two of the four brushes are connected directly to the stator windings, one to each pair of windings. The other ends of the two pairs of stator windings are crimped to the motor frame (grounded). To check the integrity of each winding pair, use an ohmmeter to check for continuity between its brush and the motor frame. Replace the motor frame if either winding pair is open (high resistance). (This test will not detect if a single winding of a pair is open. If the windings look burnt or smell bad, it is recommended that the motor frame be replaced.)

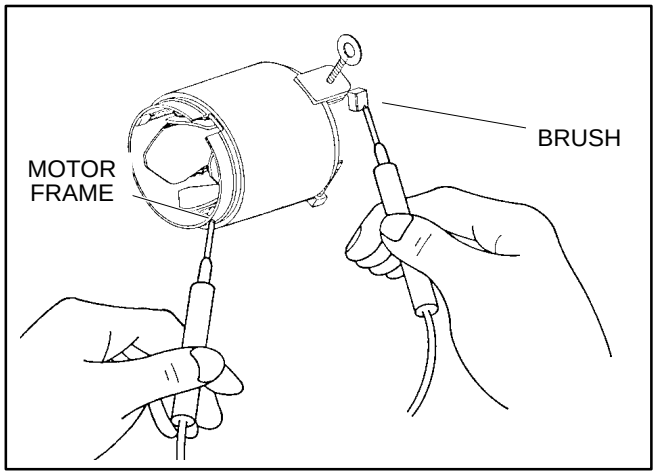


FIGURE 31. CHECKING MOTOR FRAME WINDINGS

Pinion

See Figure 32. Replace the pinion assembly if the pinion teeth and armature shaft splines are worn or damaged. Check the over-running clutch by rotating the pinion clockwise and counterclockwise. Replace the pinion assembly if it does not turn smoothly counterclockwise or lock clockwise.

⚠ CAUTION ***Do not clean the pinion overrunning clutch with any kind of cleaning solution, otherwise it may be damaged.***

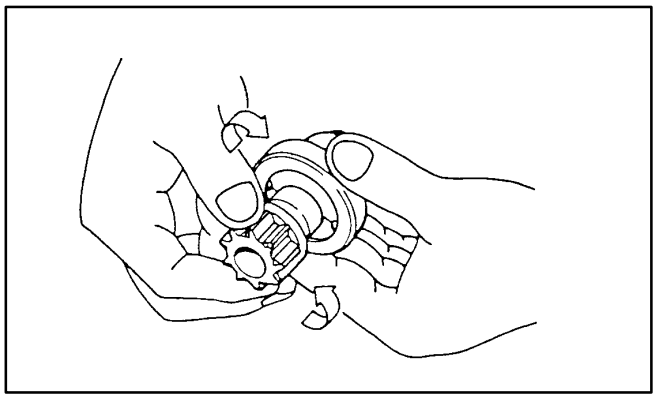


FIGURE 32. CHECKING OPERATION OF THE PINION OVER-RUNNING CLUTCH

Engine Block Assembly

Performing major service on the engine block assembly requires that the genset be removed from the cabinet. See *Preparations*. The generator and all engine subsystems must be removed for complete access to the block assembly.

CYLINDER HEADS

See Figure 33. Remove and clean the cylinder heads as follows when poor engine performance is noticed:

1. Remove the cylinder head bolts by using a 1/2 inch socket wrench. Lift off the cylinder head.

   ⚠ CAUTION ***The heads may warp if they are removed while hot. Wait until the engine has cooled before removing the heads.***

2. After removing the heads clean out all carbon deposits. Be careful not to damage the outer sealing edges where the gaskets fit. The heads are made of aluminum and can be damaged by careless handling.
3. It is a good idea to also remove the valves and clean carbon deposits from the valves and the intake and exhaust ports. See VALVE SYSTEM.
4. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the gaskets rest.
5. Place the heads in position and torque the head bolts in steps of 5 lb-ft (7 N-m) in the numbered sequence shown in Figure 33 up to the specified torque of 15-17 lb-ft (20-23 N-m).
6. Retorque the head bolts before the engine has run a total of 25 hours.

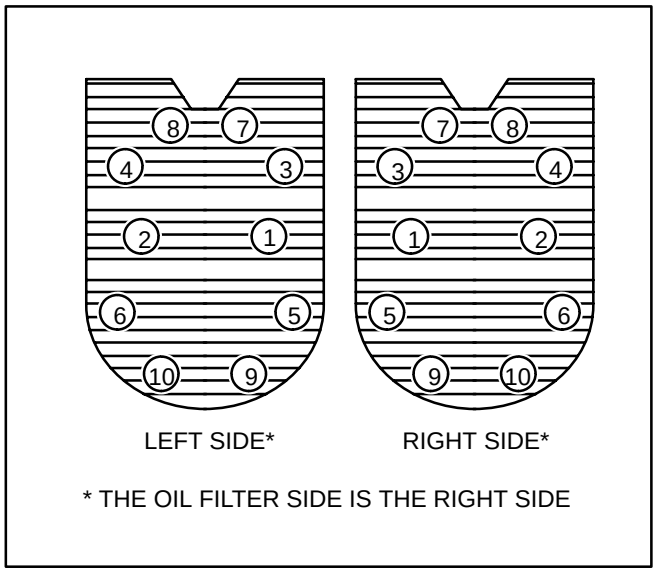


FIGURE 33. CYLINDER HEAD BOLT TORQUE SEQUENCE

VALVE SYSTEM

See Figure 34. This engine has a “side valve” type of valve system layout.

A properly functioning valve system is essential for top engine performance.

See VALVE CLEARANCE (LASH) ADJUSTMENT under *Engine Subsystems* for instructions on how to adjust valve clearance.

Inspecting the Valve System

The valve system is accessible by removing the cylinder heads and the valve covers on top of the engine. Use a valve spring compressor (Figure 35) to remove and replace the valves from the cylinder block. Make sure to first plug the breather hole in the Number 1 cylinder valve box (opposite oil filter side) to prevent the valve keepers from falling into the crankcase.

Valve Face: See Figure 36. Check the valve face for evidence of burning, warping, out-of-roundness and carbon deposits.

Burning and pitting are caused by the valve failing to seat tightly. This condition is often caused by hard carbon particles on the seat. It may also be caused by weak valve springs, insufficient tappet clearance, valve warpage and misalignment.

Warping occurs chiefly in the upper stem because it is exposed to intense heat. Out-of-roundness results from warping when the seat is pounded by a valve whose head is not in line with the stem. If a valve face is burned or warped, or the stem is worn, install a new valve.

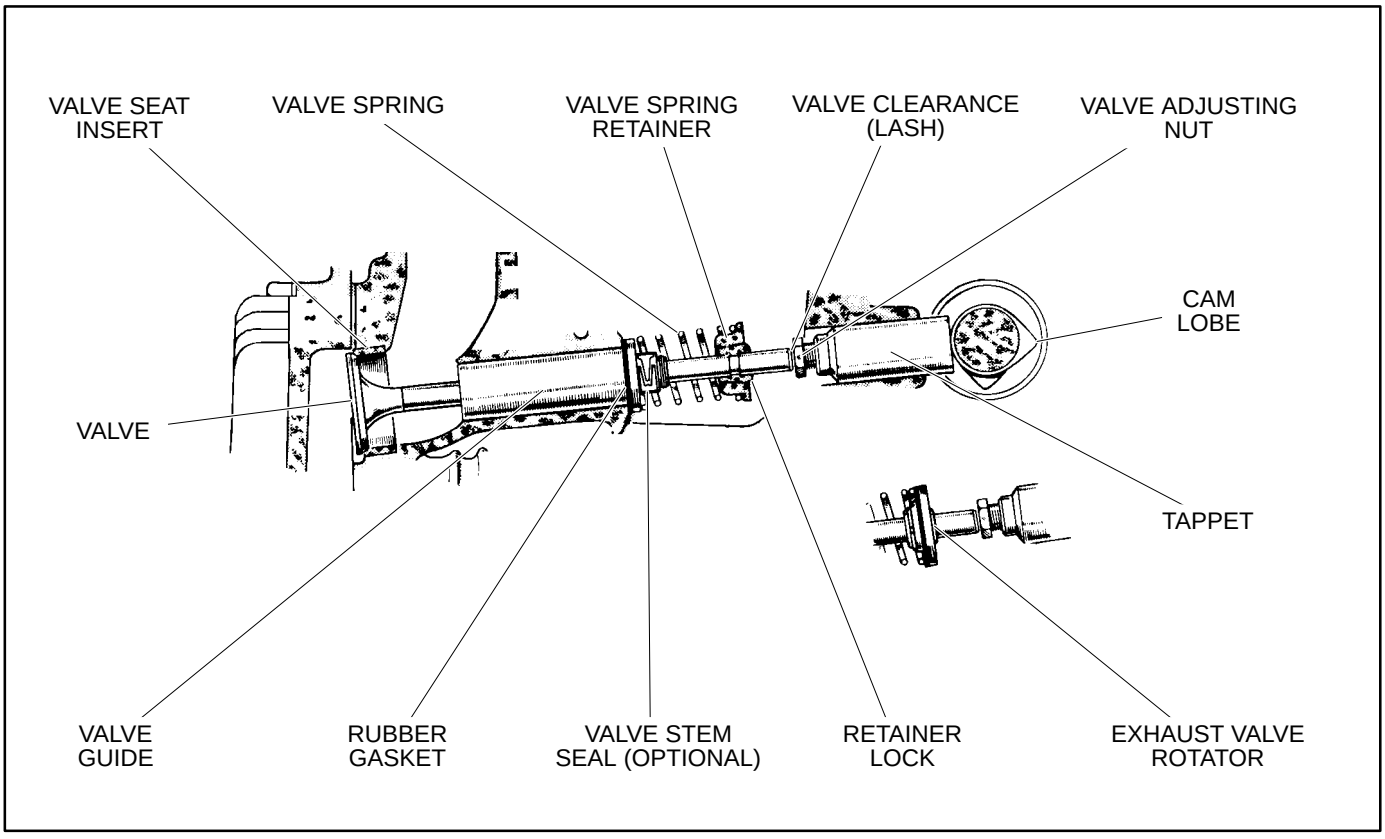


FIGURE 34. VALVE SYSTEM

Excess clearance in the intake guide admits air and oil into the combustion chamber, upsetting carburetion, increasing oil consumption and making heavy carbon deposits. Carbon prevents heat dissipation. Clean metal is a good heat conductor, but carbon insulates and retains heat. This increases combustion chamber temperatures, causing warping and burning.

Unburned carbon residue gums valve stems, causing them to stick in the guide. Deposits of hard carbon with sharp points projecting become white-hot, causing pre-ignition and “pinging”.

Valve Stems and Guides: See Figure 37. Check valve stems and guides for wear. Use a hole gauge to measure the valve guide bore diameter. When valve clearance with the stem exceeds the original clearance by 0.002 inch (0.05 mm), replace either the valve or guide or both, as necessary. Always regrind the seat to make it concentric with the newly installed guide.

Valve Stem Seal: A valve stem seal is used on the intake valve guides. This seal must be replaced each time the valve is removed.

Springs: Check the valve springs for free-height, squareness, end wear and tension. If the spring ends are worn, check the valve spring retainer for wear. Check for height and squareness by placing the spring on a flat surface next to a square. Rotate the spring against the square edge to measure its distortion. Check the spring tension at the installed height in both the valve open and closed positions, using a valve spring tester. Replace a weak, broken, worn or distorted spring.

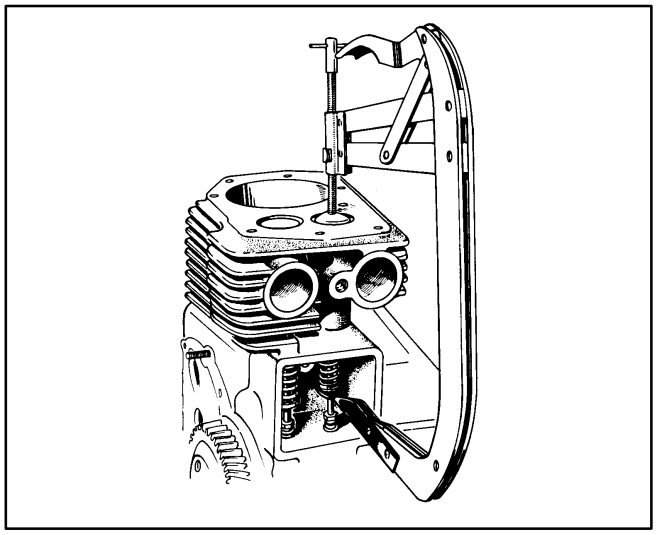


FIGURE 35. VALVE SPRING COMPRESSOR

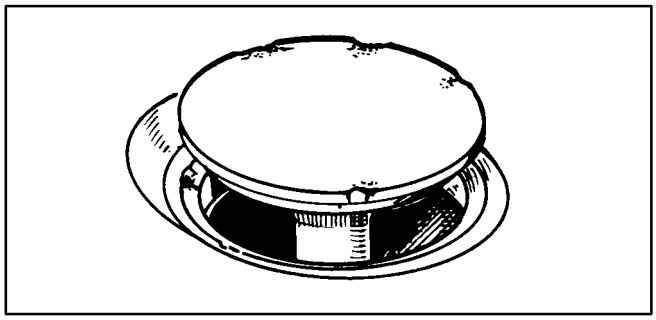


FIGURE 36. BURNED VALVE FACE

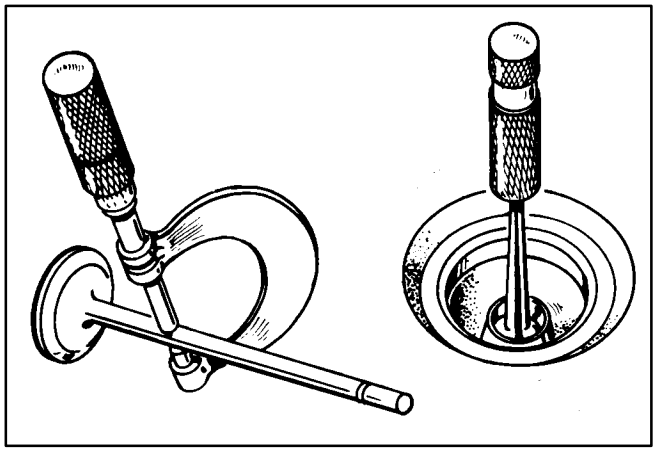


FIGURE 37. VALVE STEM AND VALVE GUIDE BORE DIAMETERS

Reconditioning Valves and Valve Seats

See Figure 38. The interference angle method of valve seating is used on these engines. The valve face angle is 44 degrees. The valve seat angle is 45 degrees. This 1-degree interference angle results in a sharp seating surface between the valve and the top of the valve seat.

The valves must not be hand lapped, because the sharp contact between the valve and the seat will be destroyed. This is especially important where chrome cobalt faced valves and seats are used. Valve faces must be finished to 44 degrees, in a machine.

Each valve must have a minimum of 1/32 inch (0.8 mm) margin (Figure 39). If the valve has less margin than this it will heat up excessively. It will retain this heat during the compression stroke and pre-ignite the mixture, causing loss of power and economy. This valve is also susceptible to warping and breakage.

Not all valves can be reconditioned. A badly warped valve must be replaced, because the amount of grinding required to make it seat correctly removes its margin. To make a valve gas-tight, remove all pitting from the valve face and seat. Deeply pitted or cut valves must be replaced, because grinding removes the margin.

Check each valve for a tight seat. Make several marks at regular intervals across the valve face using machinist's bluing. The marks should rub off uniformly when the valve is rotated a quarter-turn against the seat, indicating even contact all the way around. The line of contact should be at the center of the valve face.

Grind or cut the valve seats at 45 degrees. The seat band should be 1/32-3/64 inch (0.79-1.2 mm) wide. Remove only enough material to ensure proper valve seating. If a valve seat is cracked or loose or does not have enough material left to seat the valve properly, replace the entire block assembly.

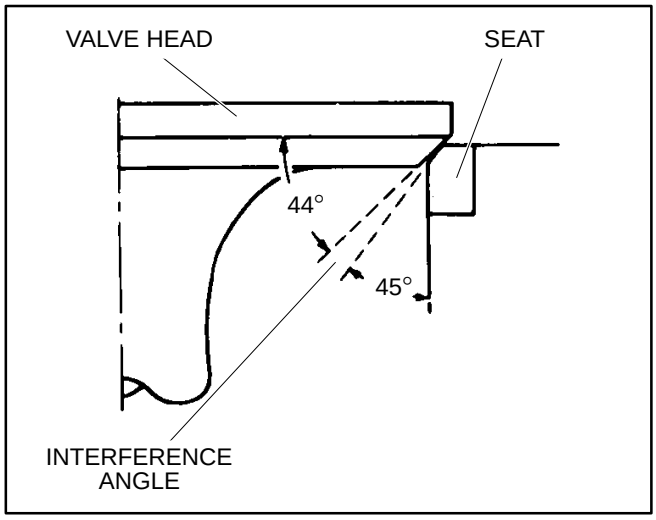


FIGURE 38. VALVE INTERFERENCE ANGLE

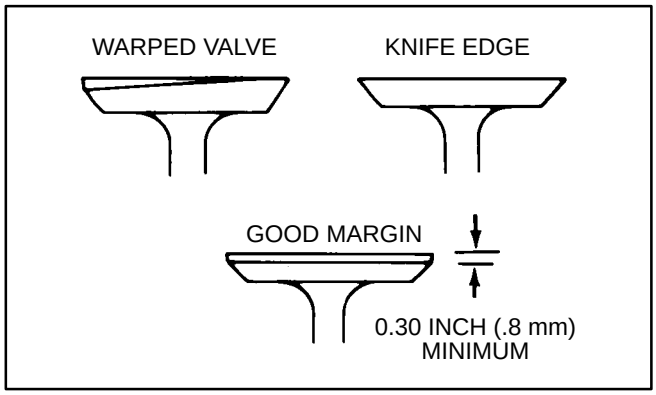


FIGURE 39. VALVE MARGIN

Replacing the Valve Guides

Worn valve stem guides can be replaced from inside the valve chamber. The smaller diameter of the tapered valve guides must face toward the valve head.

Removal:

1. Before removing the valve guides, use an electric drill with a wire brush to remove carbon and other foreign material from the top surface of the guides. Failure to do this may result in damage to the guide bores.

2. Drive the guides out with a hammer and a valve guide driver.

   ⚠ CAUTION ***Driving out the old valve guides can damage the tappet bores. Be careful not to strike the bores with the driver.***

Installation:

1. Run a small polishing rod with crocus cloth through the valve guide holes, to clean out carbon and other foreign materials.

2. Place a new gasket on the intake valve guide and coat the outer edge of each new guide with anhydrous lanolin (available at the drugstore).

3. Place the guide, notch up, in the cylinder block and press it in until the shoulder of the guide rests against the cylinder block (Figure 40).

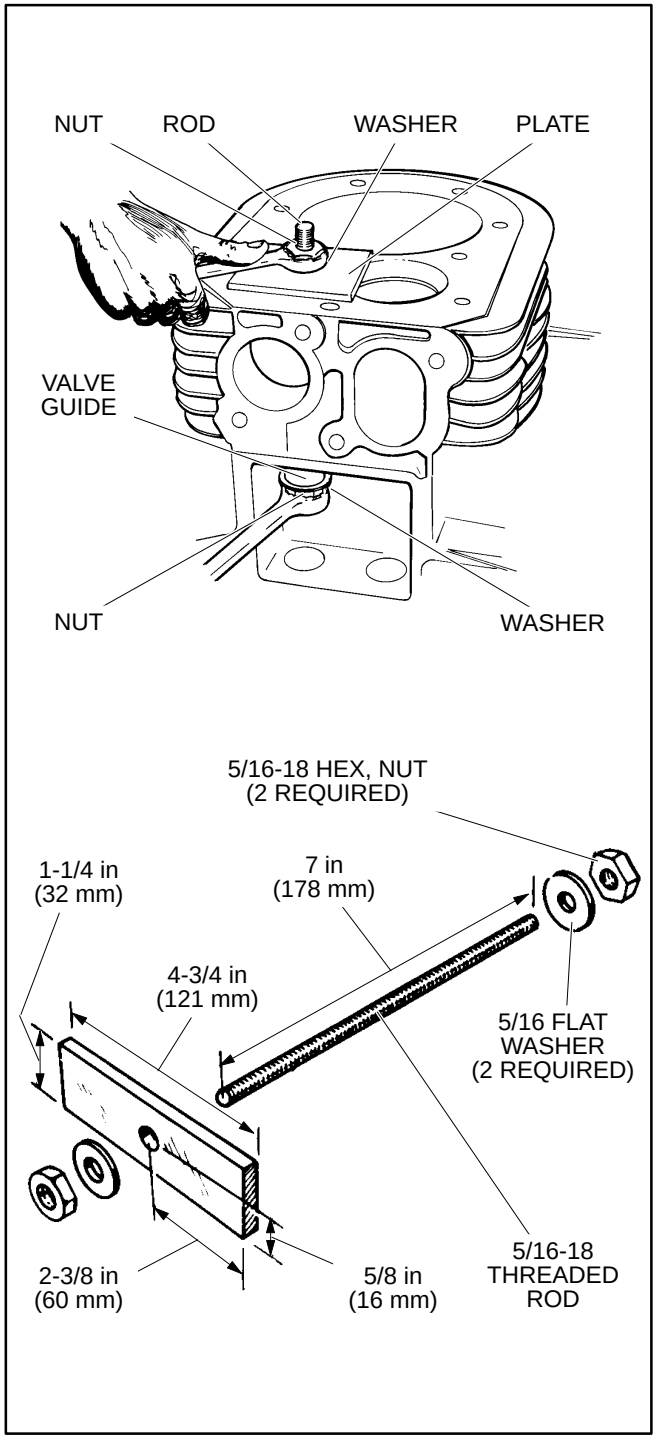


FIGURE 40. SUGGESTED TOOL FOR INSTALLING THE VALVE GUIDES

PISTON ASSEMBLY

The piston assembly consists of the piston, rings, piston pin and connecting rod. Inspect for damage and wear before replacing parts.

Removal and Disassembly

1. Remove the ridge at the top of the cylinder with a ridge reamer before attempting to remove the piston (Figure 41).

   ⚠ CAUTION ***Improper use of a ridge reamer can damage the cylinder bore. Use this tool with extreme care.***

2. Turn the crankshaft until a piston is at the bottom of its stroke.

3. Remove the bearing caps from the connecting rods and push the rods and pistons out the top of the cylinders. Be careful not to scratch the crankpin or the cylinder wall when removing these parts.

4. Mark each piston, rod and bearing cap so that they can be reassembled together in the same cylinder.

5. The pistons are fitted with two compression rings and one oil control ring. Remove these rings from the piston using a piston ring spreader (Figure 42).

6. Remove the piston pin retainer from each side and push the pin out.

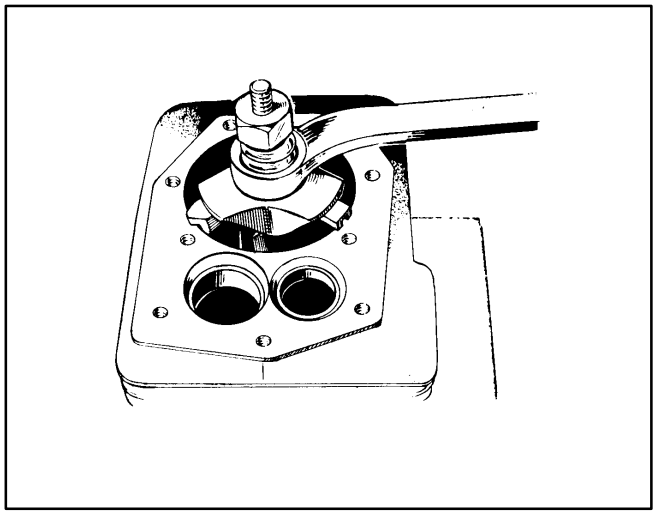


FIGURE 41. CYLINDER RIDGE REAMER

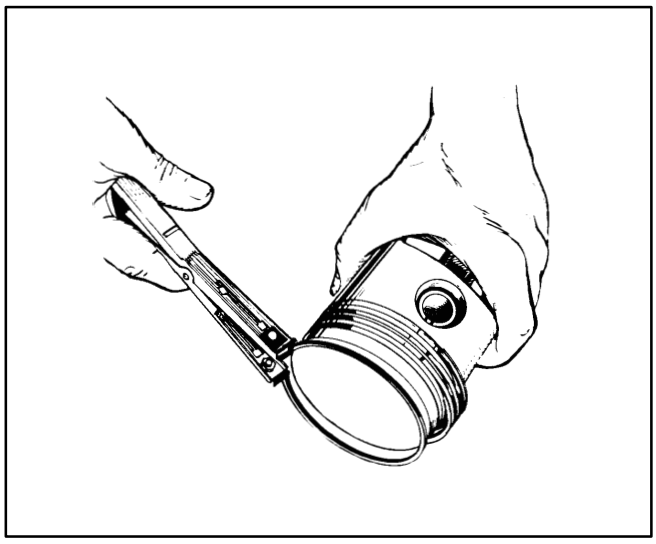


FIGURE 42. PISTON RING SPREADER

7. Remove deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or with the end of a piston ring filed to a sharp point (Figure 43). Take care not to remove metal from the sides of the grooves.

   ⚠ CAUTION ***Caustic cleaning solvents and wire brushes can damage pistons. Use parts cleaning solvent to clean pistons.***

   When cleaning the connecting rods in solvent, make certain to include the rod bore. Blow out all passages with low-pressure compressed air.

Piston and Connecting Rod Inspection

Piston Inspection: Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands, using a new ring and feeler gauge (Figure 44). Replace the piston if the side clearance of the top compression ring is 0.008 inch (0.20 mm) or more.

Improper ring width or excessive ring side clearance can result in ring breakage. New rings in worn ring grooves do not make adequate contact with the cylinder wall (Figure 45).

Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from pre-ignition.

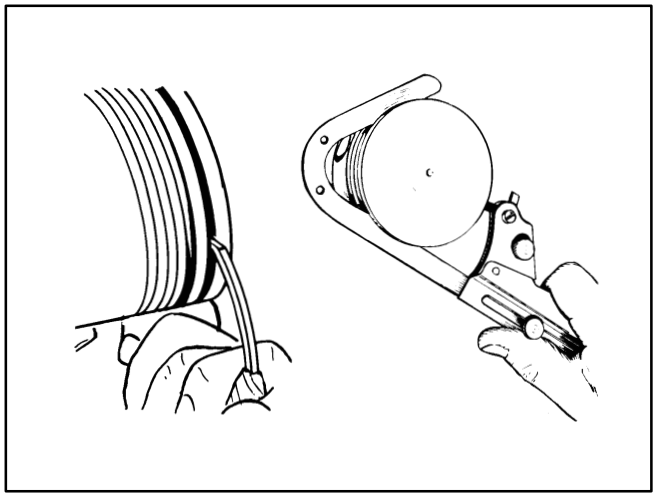


FIGURE 43. PISTON RING GROVE CLEANER

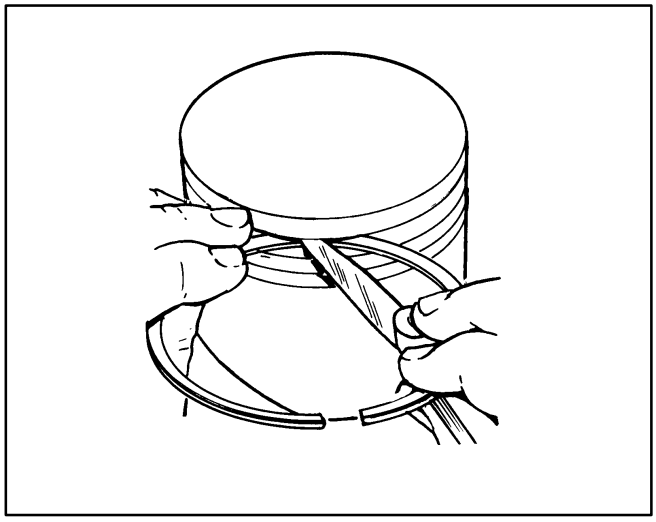


FIGURE 44. CHECKING RING LAND

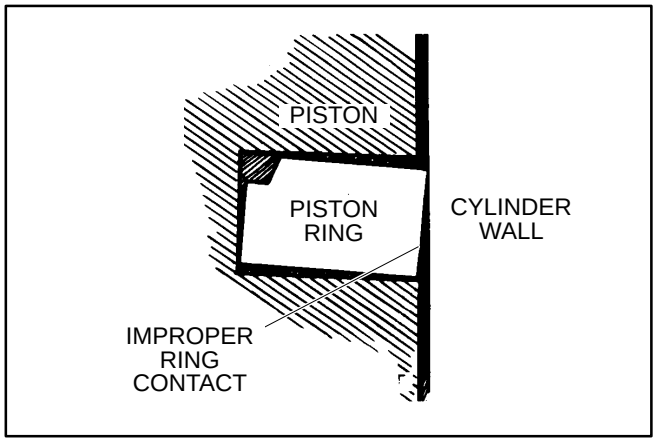


FIGURE 45. NEW RING IN WORN RING GROVE

Connecting Rod Inspection: Replace connecting rod bolts and nuts having damaged threads. Replace connecting rods with deep nicks, signs of fracture, scored bores or bores out of round more than 0.002 inch (0.05 mm).

Use a new piston pin to check the connecting rod for wear. A push-fit clearance is required; this varies from engine to engine. If a new piston pin falls through a dry rod pin bore as a result of its own weight, replace the rod or bushing, as required.

Piston Pin Inspection: Replace piston pins that are cracked, scored, or out of round more than 0.002 inch (0.05 mm).

Bearing Inspection: Inspect bearings for burrs, breaks, pits and wear. Replace bearing inserts which are scored, show fatigue failure, are badly scratched or which have their overlay wiped out,. If a bearings appears serviceable, check for proper clearance.

Piston Clearance

Correct piston tolerances must be maintained. Use a micrometer to measure the piston diameter at the point shown in Figure 46. When the cylinder bore is measured (see CYLINDER BLOCK), subtract the piston diameter from the cylinder bore diameter to obtain the piston-to-cylinder wall clearance. See *Tolerances and Clearances*.

Piston Ring Gap

Before installing new rings on the piston, check the ring gap by placing each ring squarely in its cylinder, at a position corresponding to the bottom of its travel (Figure 47). The gap should be 0.010-0.020 inch (0.25-0.50 mm).

Do not file the ring ends to increase the end gap. If the ring end gap does not meet the specifications, check the correctness of ring and bore sizes. A cylinder bore that is 0.001 inch (0.03 mm) undersize will reduce the end gap 0.003 (0.08 m).

Rings that are 0.010, 0.020, 0.030 and 0.040 inch (0.25, 0.51, 0.76 and 1.02 mm) oversize should be used on corresponding oversize pistons.

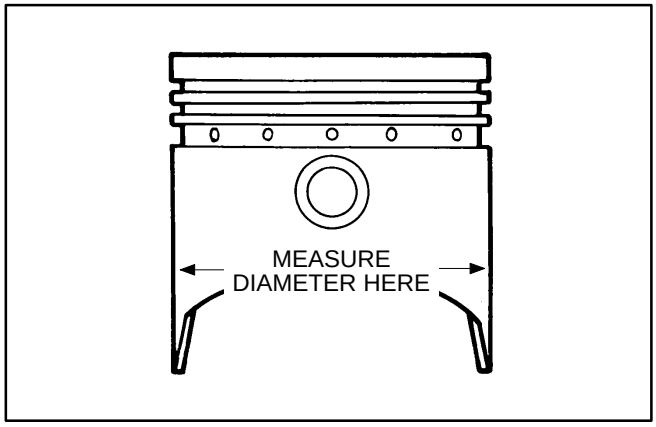


FIGURE 46. MEASURING PISTON DIAMETER

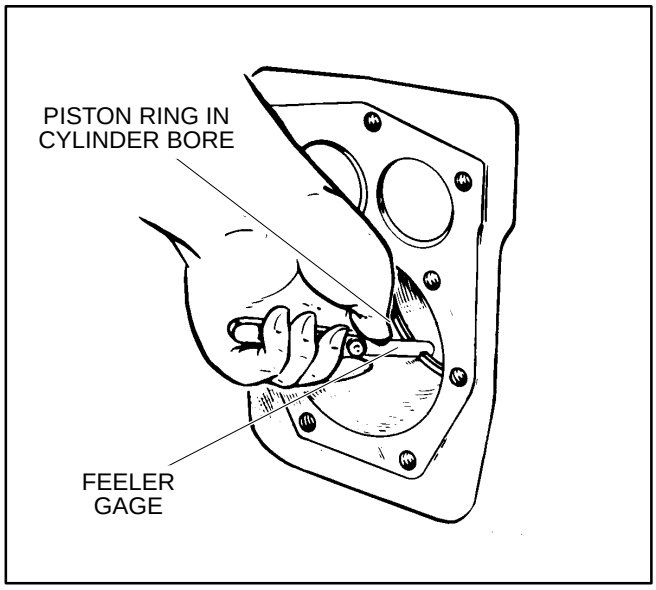


FIGURE 47. CHECKING RING GAP

Piston Assembly

1. Lubricate all parts with clean engine oil.

2. Line up the piston and connecting rod and insert the piston pin. The piston pin is a full-floating type kept in place by a lock ring on each side. Push the lock rings in by thumb pressure or pry them in with a small screwdriver. Make sure they are properly seated.

   ⚠ CAUTION ***Wear safety glasses and hold your thumb over the lock ring to keep it from flying out and getting lost or causing personal injury.***

3. Refer to Figure 48. Use a piston ring spreader to install the piston rings to prevent twisting or excessive expansion. Follow the instructions in the ring kit exactly. Note which ring goes in which groove and which side of the ring is “up”. Also note that the oil control ring is an assembly.

Piston Installation

1. The crankshaft must be in place and should have been serviced already if crankshaft service was required. See CRANKSHAFT.

2. Turn the crankshaft to position the Number 1 rod bearing journal (side opposite oil filter side) at the bottom of its stroke.

3. Lubricate the Number 1 piston assembly and cylinder with engine oil. Compress the rings with a ring compressor as shown in Figure 50. Install the bearing insert in the piston rod.

4. Position the piston and rod assembly in the cylinder block with the connecting rod oil hole up (Figure 49).

5. Tap the piston into the bore with the handle end of the hammer until the connecting rod is seated on the crankshaft journal (Figure 50). If the crankshaft has been reground and/or new rods are being installed, check the bearing clearance with Plasti-gage as instructed below under Rod Bearing Clearance.

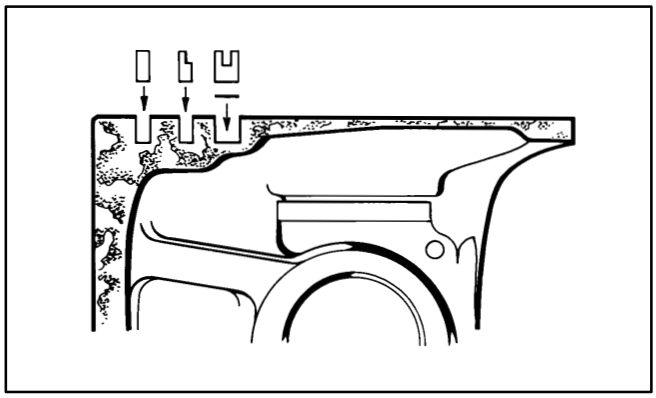


FIGURE 48. PISTON RINGS

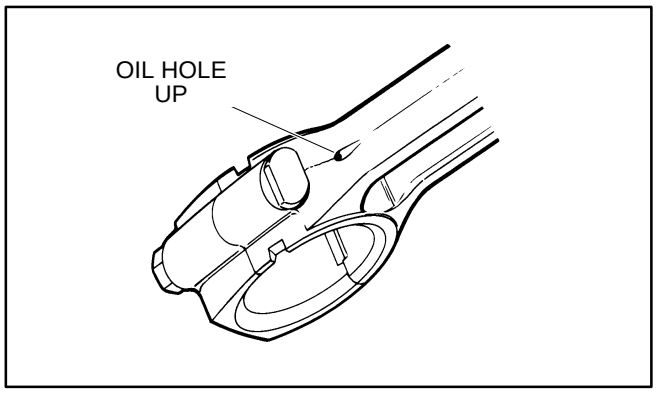


FIGURE 49. CONNECTING ROD OIL HOLE

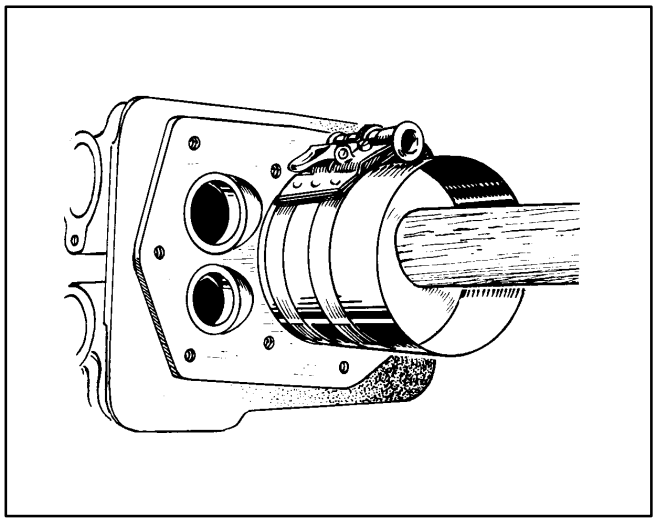


FIGURE 50. INSERTING PISTON

6. Install the rod bearing cap as follows:

   A. Lubricate the cap bolts with engine oil and torque to 5 lb-ft (7 N-m).

   B. Strike the cap/rod joint using a hardwood block and a leather or plastic mallet to remove any misalignment (Figure 51).

   C. Torque the cap bolts to 14 lb-ft (19 N-m). Recheck the torque on each bolt after both bolts have been torqued.

   ⚠ CAUTION ***Failure to align the rod and cap can result in high engine oil temperature and failure of the rod.***

7. Install the other piston assembly and crank the engine by hand to see that all bearings are free.

Connecting Rod Bearing Clearance

1. Wipe all parts clean of oil and grease.

2. Select Plasti-gage that corresponds to the connecting rod bearing clearance specification (0.0020-0.0033 inch [0.051-0.084 mm]). Place the piece of Plasti-gage across the full width of the bearing cap, about 1/4 inch (6 mm) off-center (Figure 52).

3. Install the rod bearing cap (Step 6, Piston Installation). Do not let the crankshaft rotate or the Plasti-gage will smear.

4. Remove the bearing cap, leaving the Plasti-gage on the part it sticks to. Check the widest part of the flattened Plasti-gage with the graduations on the envelope to determine the bearing clearance.

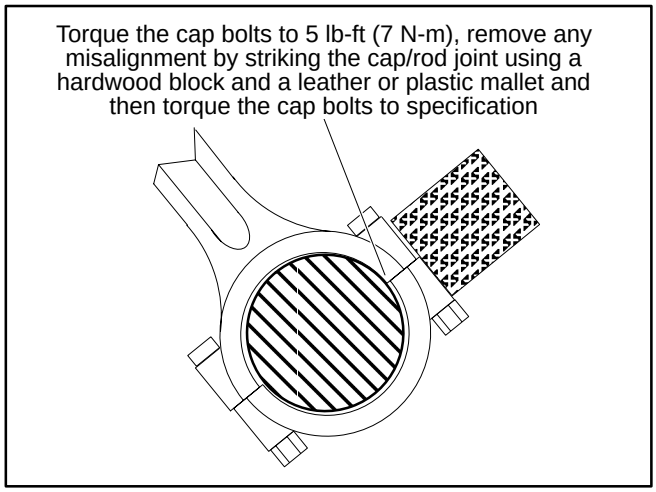


FIGURE 51. ALIGNING CONNECTING ROD CAP

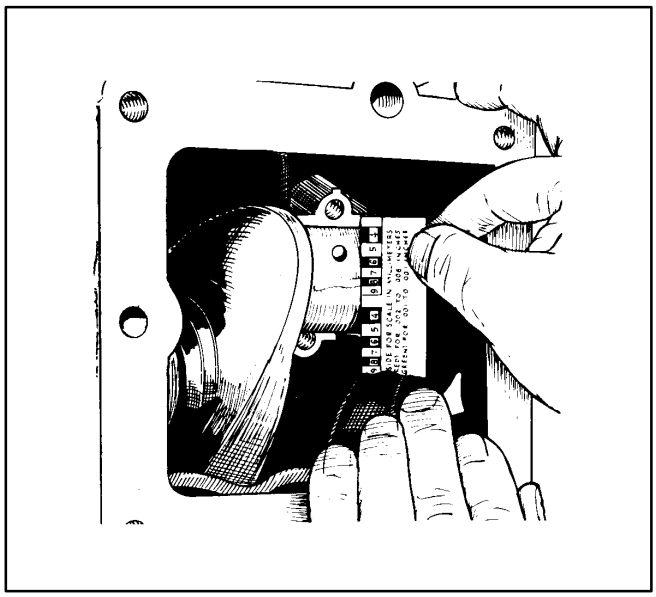


FIGURE 52. USING PLASTI-GAGE

TIMING GEARS AND CAMSHAFT

The camshaft and its timing gear are not separately replaceable. Also, if it is necessary to replace a timing gear, the gears should be replaced as a pair.

Removal

1. Remove the cooling blower and gear cover (Figure 53).
2. Remove the valve tappets so that the camshaft can be withdrawn.
3. Remove the snap ring and washer in front of the crankshaft timing gear.
4. Withdraw the camshaft.
5. Remove the oil pump.
6. Remove the crankshaft timing gear. Use a gear puller and ring bolted to the gear with 1/4-20x1 inch Grade 8 bolts (lesser grade bolts will snap off) (Figure 54), or the shoulder bolts and flywheel puller which are available.

Installation

1. Install the camshaft bearings. See CAMSHAFT BEARINGS.
2. Install the crankshaft. See CRANKSHAFT.
3. Preheat the crankshaft gear to 325° F (168° C).
4. Make sure the key is in place in the crankshaft and then tap the gear down to the shoulder on the crankshaft.
5. Install the camshaft, making sure the thrust bearing is in place between the gear and the block and that the “0” marks on the timing gears line up (Figure 54).
6. Install the oil pump assembly.
7. Install the retainer washer and snap ring in front of the crankshaft timing gear.
8. Replace the crankshaft oil seal in the gear cover and install the gear cover. See OIL SEALS.

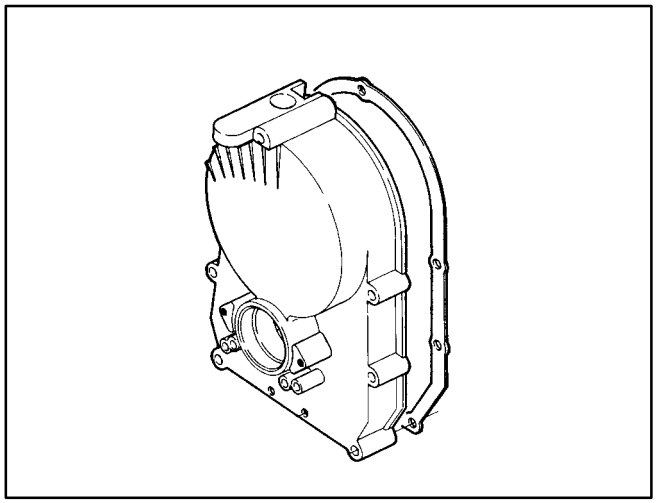


FIGURE 53. GEAR COVER AND GASKET

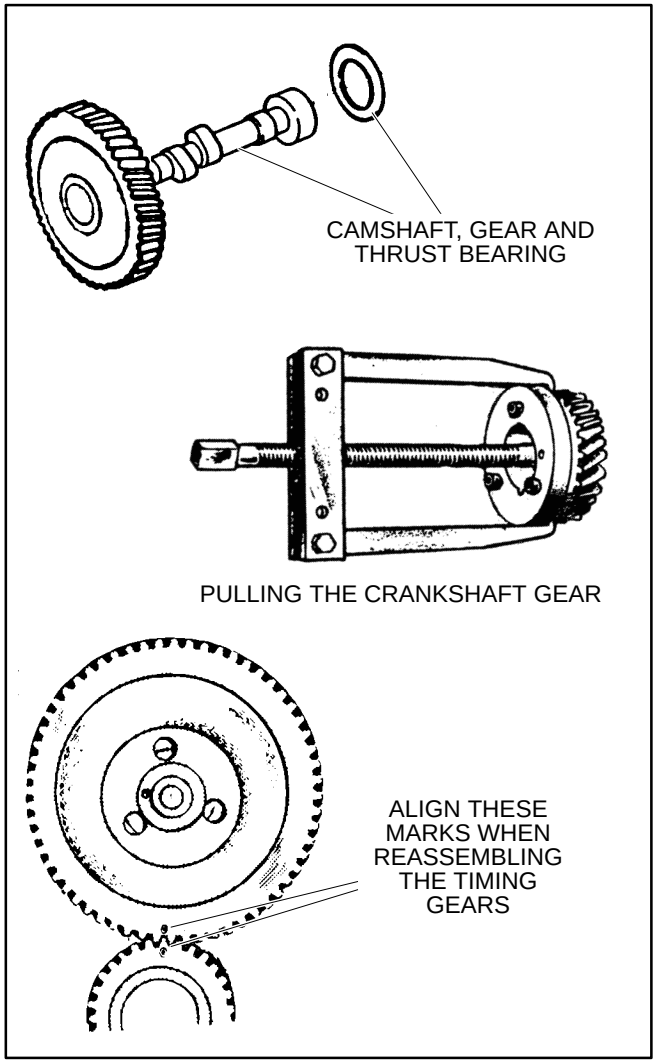


FIGURE 54. TIMING GEARS AND CAMSHAFT

OIL PUMP ASSEMBLY

See Figure 55. The oil pump is mounted behind the gear cover and is driven by the crankshaft gear. The pump discharges into a crankcase passage leading to the front main bearing via the oil filter. A groove in the front main bearing allows oil to cross over to a passage leading to the front camshaft bearing. A crossover tube carries oil to the rear main bearing. The connecting rod journals are lubricated through drilled passages from the main journals. The oil overflow from the bypass valve lubricates the camshaft drive gears.

Replace the oil pump if the crossover tube is tight and the oil bypass valve is functioning properly but the oil pressure is below specification. The gasket and pick-up screen are the only individually replaceable parts. Oil the pump generously when reassembling it so that it will prime faster when the engine is first started.

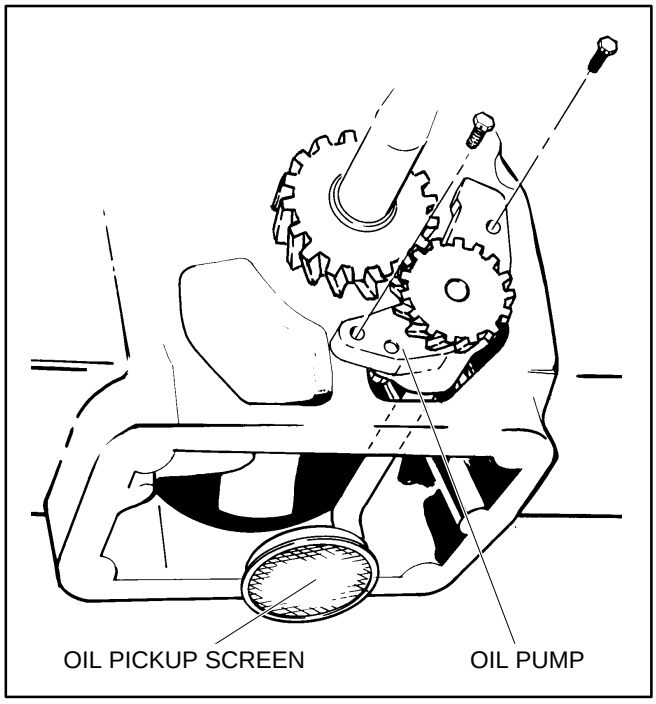


FIGURE 55. OIL PUMP ASSEMBLY

CRANKSHAFT

Removal

1. Remove the piston assemblies if they have not already been removed.

2. Remove the gear cover and crankshaft timing gear. See TIMING GEARS AND CAMSHAFT.

3. Remove the rear bearing plate. See MAIN BEARINGS.

4. Turn the crankshaft so that the crank throw lines up with the notch in the crankcase and carefully slide the crankshaft out.

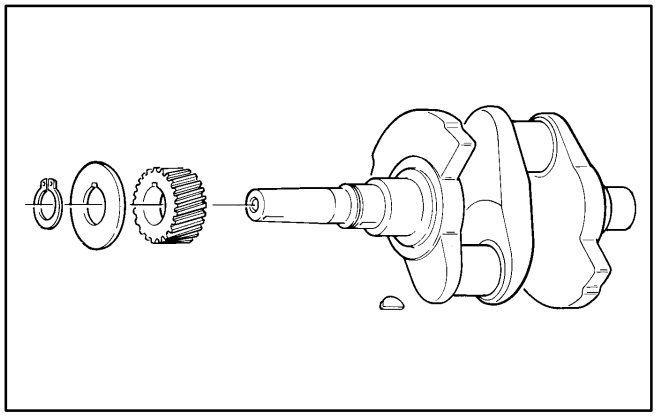


FIGURE 56. CRANKSHAFT AND TIMING GEAR

Inspection

Inspect the rod and main bearing journals. Replace the crankshaft or regrind the journals to the next undersize if the journals are worn or scored and cannot be smoothed by polishing. Make sure to clean out the drilled oil passages in the crankshaft.

Installation

1. Replace the main bearings in the block and rear bearing plate, if necessary. See MAIN BEARINGS.

2. Reinstall the original front thrust bearing if it is still usable or has not been replaced by the combination thrust/shell bearing (Figure 58). The flat side goes against the block and the notches should clear the lock pins. Liberally oil the thrust and shell bearing surfaces.
3. Orient the crankshaft so that the crank throw lines up with the notch in the crankcase and insert the crankshaft in the front bearing. Make sure the front thrust bearing does not slip out of place.
4. Grease the lips of the rear oil seal (mounted in the bearing plate) and insert the oil seal driver to keep the lips spread as the crankshaft passes through.
5. Place the rear thrust bearing and shim on the rear bearing plate with the shim between the bearing and the bearing plate. The flat side of the bearing goes against the shim and the shim and bearing notches should clear the lock pins. (Figure 59). Liberally oil the thrust and shell bearing surfaces.
6. Place the bearing plate gasket in position on the block, making sure the oil hole on the back of the block is exposed.
7. Mount the rear bearing plate making sure the thrust bearing does not slip out of place. To check crankshaft end play, secure the bearing plate with only two mounting bolts (on opposite sides) and tighten them to the specified torque (see *Assembly Torques*).
8. Remove the oil seal driver.
9. Lightly tap the front of the crankshaft with a plastic-faced hammer to take up the crankshaft endplay. Check end play with a feeler gauge at the location shown (Figure 57). The endplay should be 0.006-0.012 inch (0.15-0.30 mm). Add or remove shims as necessary.
10. When crankshaft end play is within specifications, tighten all mounting screws to the specified torque. The crankshaft should turn freely by hand.

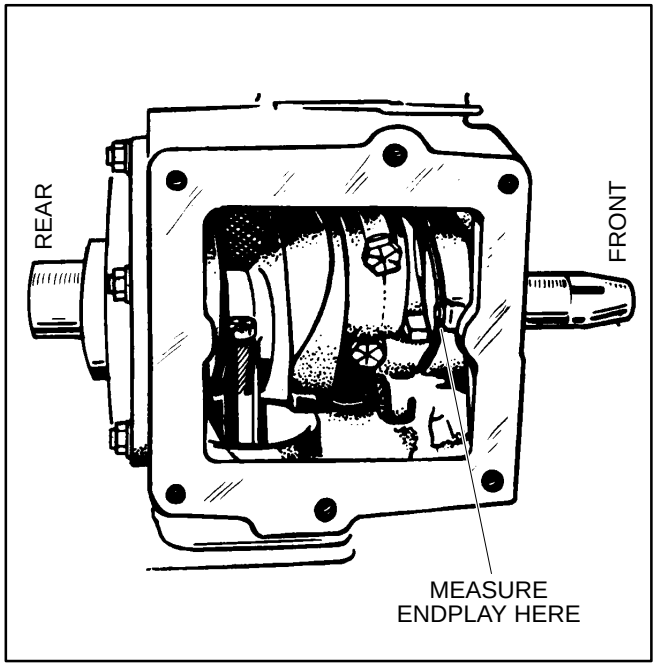


FIGURE 57. CRANKSHAFT ENDPLAY

MAIN BEARINGS

Use the special drivers available to drive out the old bearings and drive in the new. Support the engine casting so as not to cause distortion or damage to the bore or casting.

Crankshaft bearings are available in standard size and in 0.002, 0.010, 0.020 and 0.030 inch undersizes.

Front Bearing: See Figure 58. Use Loctite brand Bearing Mount or equivalent when installing the front bearing in its bore in the block. Use the towelette furnished with the bearing kit to clean the outside of the bearing and its bore in the block. Apply the Loctite to the outside of the bearing and to the mating surface of the bore in the block. Allow three to four minutes for drying.

⚠WARNING ***Skin contact with the Locktite towelette and inhalation of its vapors can be harmful. Use protective gloves and make sure the work area is well ventilated.***

Use the special driver available to drive the bearing into its bore in the block. Make sure that the oil holes in bearing and bore will line up so that the passage is at least half open and that the notches in the thrust bearing will clear the lock pins in the block. Push the driver in until it is stopped by its flange. Wipe off any excess Loctite and allow one hour for hardening at room temperature.

Note: Original bearings consist of separate thrust and shell bearings, front and rear. Replacement front bearings have one-piece thrust/shell construction. Install the front bearing without shims. Adjust crankshaft end play with shims behind the rear thrust bearing only. See CRANKSHAFT.

Rear Bearing: See Figure 59. Use the special driver available to drive the rear main bearing into the bearing plate. Make sure the oil holes in bearing and bore will line up so that the passage is at least 1/2 open. Push the driver in until it is stopped by its flange.

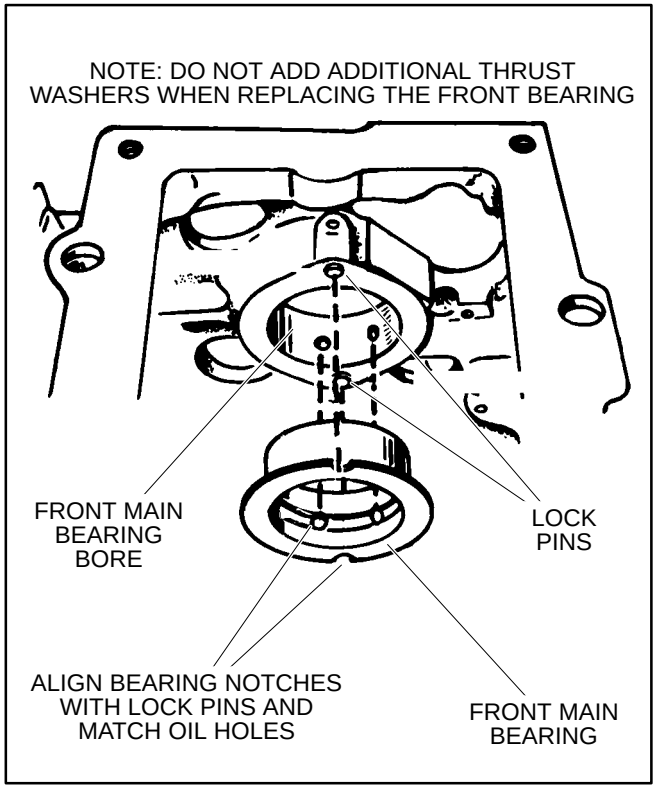


FIGURE 58. FRONT CRANKSHAFT BEARING

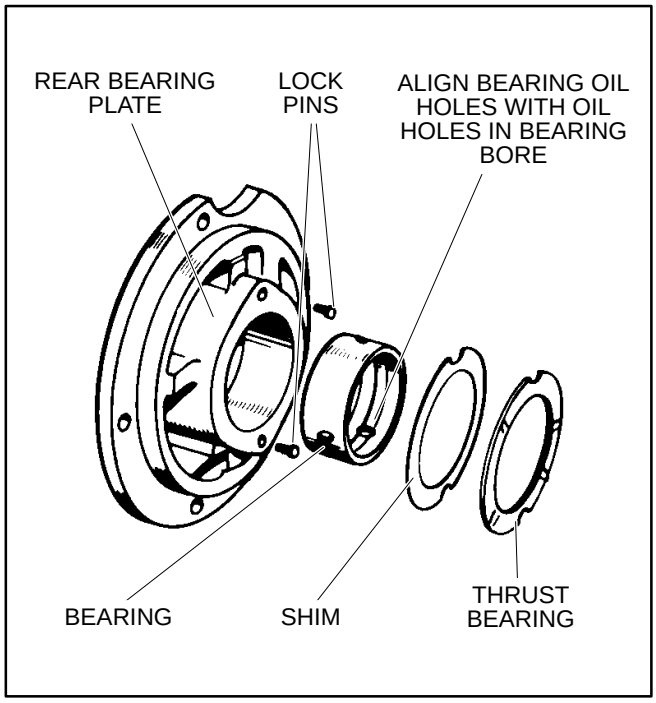


FIGURE 59. REAR CRANKSHAFT BEARING

CRANKSHAFT OIL SEALS

See Figures 60 and 61. The front crankshaft oil seal is located in the gear cover and the rear seal in the rear main bearing plate. Push the old seals out with the oil seal removal tool available and clean the bearing plate and gear cover bores of all old sealing compound before installing the new seals.

Use the appropriate installer to drive in the oil seal from the outside of the bearing plate or gear cover. Drive the tool in until it bottoms so that the seal is located correctly. Note the orientation of the seal lip and the location dimensions.

Coat the oil seal lips with grease to make it easier to push the end of the crankshaft through without damaging the lips and to provide initial lubrication until engine oil reaches the seal.

Rear Oil Seal: Leave the installer in place in the rear oil seal while mounting the bearing plate to keep the oil seal lips spread as the crankshaft passes through. Refer to CRANKSHAFT for the procedure for mounting the bearing plate.

Front Oil Seal: Take care that the oil seal lip does not bear down on the sharp edges of the crankshaft keyway while installing the gearcase. Refer to TIMING GEARS AND CAMSHAFT for installing the gear cover.

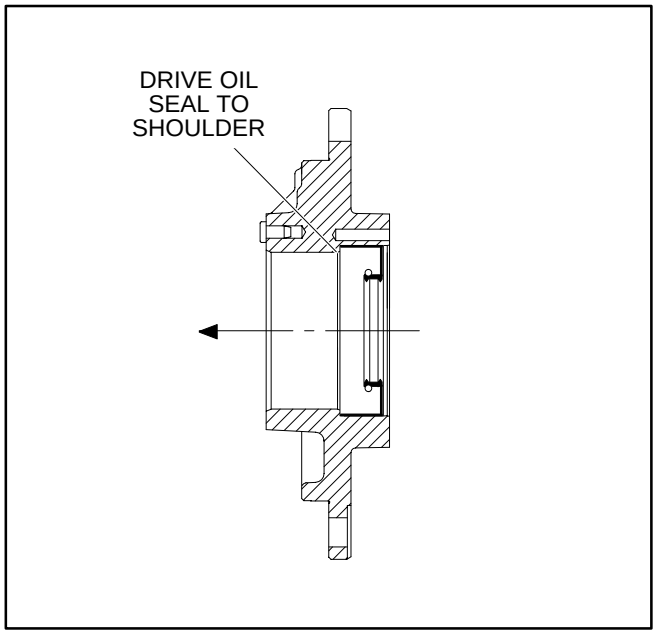


FIGURE 60. BEARING PLATE OIL SEAL

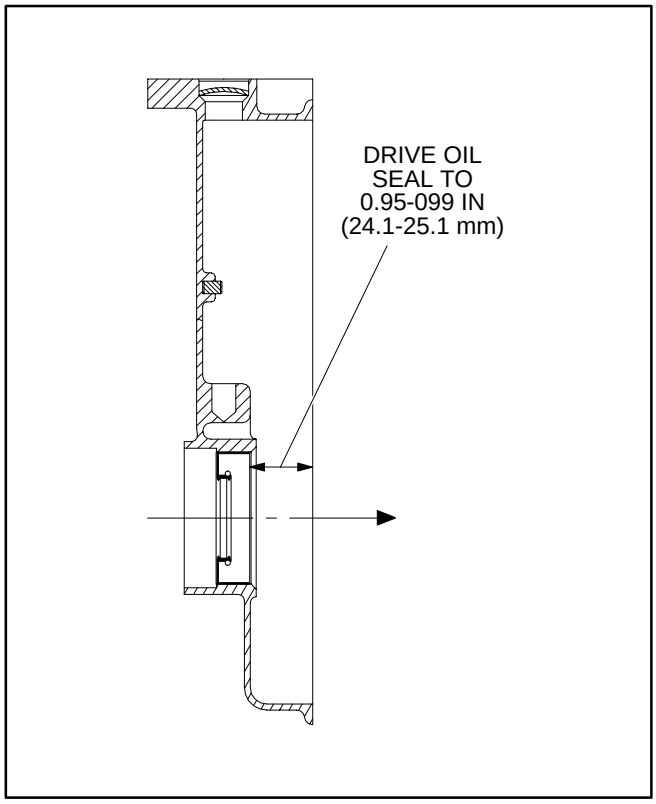


FIGURE 61. GEAR CASE OIL SEAL

CAMSHAFT BEARINGS

To replace camshaft bearings the engine must be completely disassembled. Use the special drivers available to drive out the old bearings and drive in the new. Support the engine casting so as not to cause distortion or damage to the bore or casting.

It should be noted that identical bearings are used for replacing the front and rear camshaft bearings and that they may look different from the old bearings.

Use Loctite brand Bearing Mount or equivalent to install the bearings. Use the towelette furnished with the bearing kit to clean the outside of the bearing and its bore in the block. Apply the Loctite to the outside of the bearing and to the mating surface of the bore in the block. Allow three to four minutes for drying before pressing the bearing into its bore.

⚠WARNING ***Skin contact with the Locktite towelette and inhalation of its vapors can be harmful. Use protective gloves and make sure the work area is well ventilated.***

Front Bearing: See Figure 62. Press the front bearing in so that the oil hole in the bearing lines up with the oil hole in the bore.

Rear Bearing: See Figure 63. Press the rear bearing in so that it is located 1/2 inch (12.7 mm) from the outside edge of the bore. There is no oil hole in the rear bore.

Coat the bearing surfaces with engine oil.

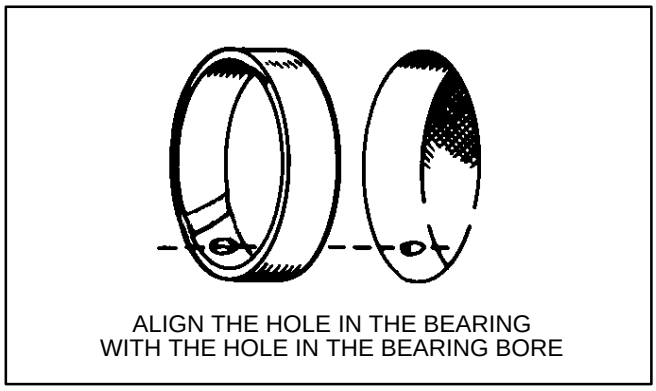


FIGURE 62. FRONT CAMSHAFT BEARING

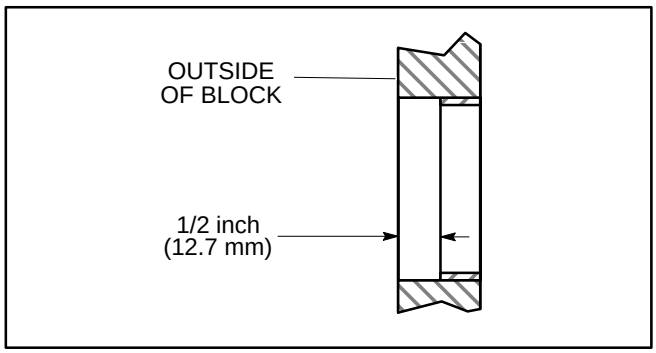


FIGURE 63. REAR CAMSHAFT BEARING

ENGINE BLOCK

The engine block is the main support for all other basic engine parts and subassemblies.

Cleaning

After removing the pistons, crankshaft, cylinder heads, etc., inspect the block for cracks and extreme wear. If it is still serviceable, prepare it for cleaning as follows:

1. Scrape all old gasket material from the block. Remove oil bypass to allow cleaning solution to contact inside of oil passages.
2. Remove grease and scale from the cylinder block by agitating in a bath of commercial cleaning solution or hot soapy washing solution.
3. Rinse the block in clean hot water to remove cleaning solution.

Inspecting the Block

When rebuilding the engine, thoroughly inspect the block for any condition that would make it unfit for further use. This inspection must be made after all parts have been removed and the block has been thoroughly cleaned and dried.

1. Make a thorough check for cracks. Minute cracks may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide (white lead) dissolved in wood alcohol. If cracks are present, the white coating will become discolored at the defective area. (Remove this coating after the test and before reassembly.) Always replace a cracked cylinder block.
2. Inspect all machined surfaces and threaded holes. Carefully remove any nicks or burrs from machined surfaces. Clean out tapped holes and clean up any damaged threads.
3. Check the top of the block for flatness with a straight-edge and a feeler gauge.

Inspecting the Cylinder Bores

Inspect the cylinder bores for scuffs, scratches, and wear. If these conditions exist, the cylinders must be rebored or honed for the next oversize piston.

See Figure 64. If the cylinder bores look good and there are no scuff marks, check the bores for wear and out-of-roundness as follows:

1. Check cylinder bore for taper, out-of-roundness and wear with a cylinder bore gauge, telescope gauge or inside micrometer. These measurements should be taken at four places: the top and bottom of piston ring travel, and parallel and perpendicular to the axis of the crankshaft.

2. Record the measurements taken at the top and bottom of the piston travel as follows:

   A. Measure and record as A the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore where the greatest amount of wear occurs.

   B. Measure and record as B the cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.

   C. Measure and record as C the cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where the greatest amount of wear occurs.

   D. Measure and record as D the cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.

   E. Reading A subtracted from reading B and reading C subtracted from reading D indicates the cylinder taper.

   F. Reading A compared to reading C and reading B compared to reading D indicates whether or not the cylinder is out-of-round. If the out-of-round exceeds 0.003 inch (0.08 mm), the cylinders must be rebored and honed to the next oversize. A reboring machine is used when changing to oversize pistons. The following repair data describes the honing procedure.

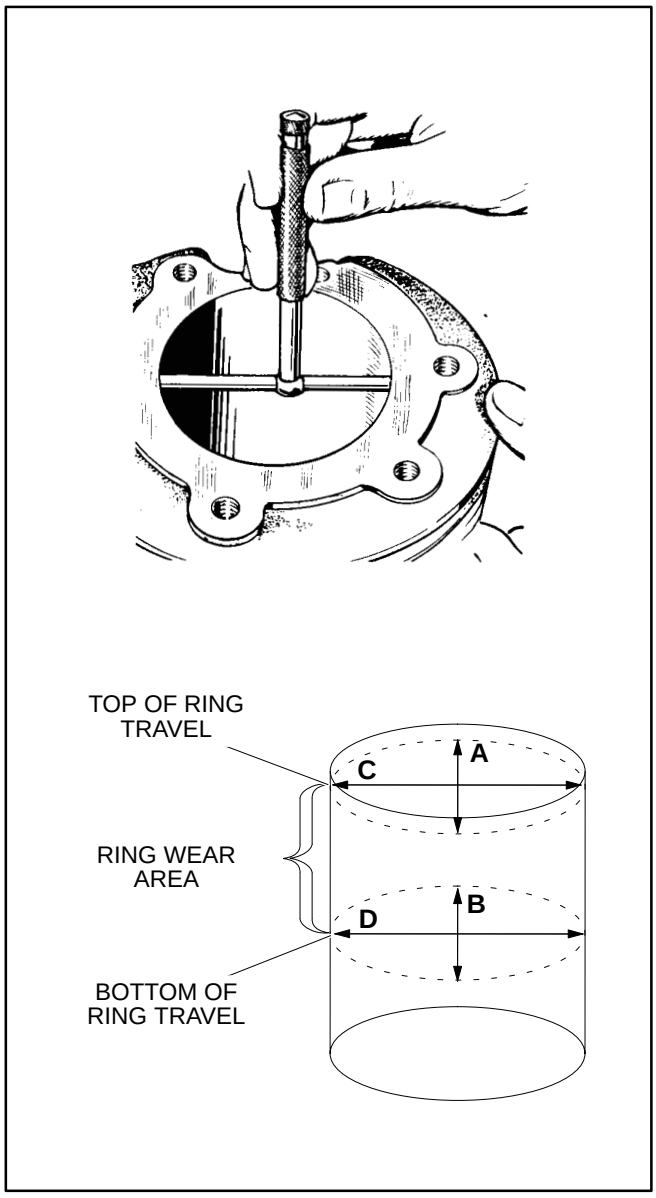


FIGURE 64. MEASURING CYLINDER BORE DIAMETERS

Machining the Cylinder Bores

The available oversize pistons and rings will fit with the required clearance in cylinders machined to the matching oversize (standard bore plus 0.005, 0.010, 0.020, 0.030 and 0.040 inch). There is no need to adjust or to “fit” pistons and rings. Piston and ring size should be checked as described below to confirm that they are correct for the standard bore oversize. Boring and honing must be accurate and remove just enough metal for the smallest oversize possible. The finish hone should leave a 20 to 40 micro-inch crosshatch finish having an included angle of 20 to 25 degrees. The crosshatch finish is necessary for fast piston ring break-in. See Figure 65.

Clean the cylinder bore with hot, soapy water and a brush after machining. A clean white rag will not soil when the cylinder bore is clean. Dry the bores and coat them with oil.

⚠ CAUTION ***Do not use gasoline or commercial cleaning solvents to clean the cylinder bores after honing—they do not remove abrasives.***

Deglazing the Cylinder Bores

Deglaze the cylinder bores for fast piston ring break-in if the bores look good and there is not enough wear, taper and out-of-roundness to warrant machining. Deglazing should not increase the bore diameter, permitting the use of the original pistons (if they are good) with new rings. To deglaze the cylinder bores:

1. Wipe the cylinder bores with a clean cloth that has been dipped in light engine oil.
2. Use a brush-type deglazing tool with coated bristle tips.
3. Drive the tool with a slow-speed drill. Move the tool up and down in the cylinder bores fast enough to obtain the crosshatch pattern shown (Figure 65). Ten to twelve strokes should be sufficient.
4. Clean the cylinder bore with hot, soapy water and a brush after deglazing. A clean white rag will not soil when the cylinder bore is clean. Dry the bores and coat them with oil.

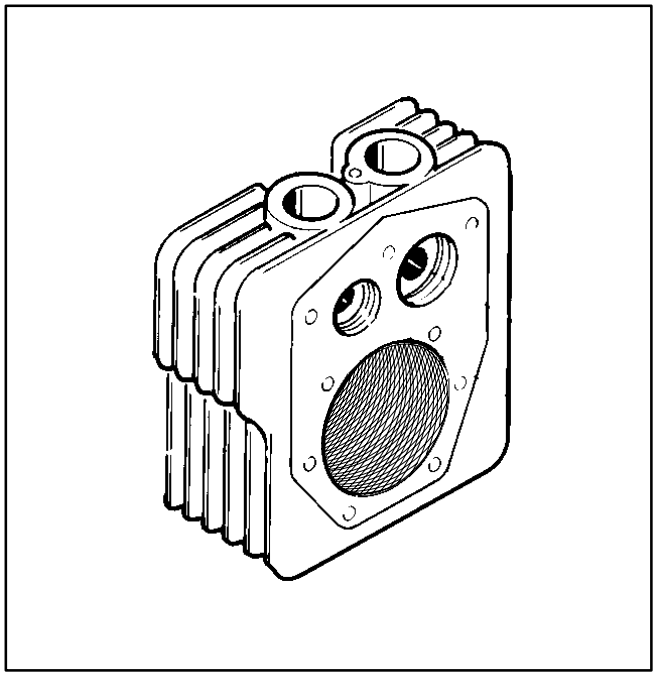


FIGURE 65. CROSSHATCH IN CYLINDER BORE

Generator

The basic generator is a single-phase, 4-pole, revolving-field AC generator with slip rings and auxiliary quadrature and battery charging windings. It is regulated by the microcontrol-based genset controller. The generator rotor and engine crankshaft have a tapered coupling secured by the rotor through-bolt. The other end of the rotor is supported in a sealed, pre-lubricated ball bearing assembly. The cooling blower wheel and starter ring gear are part of the rotor assembly. See Figure 66.

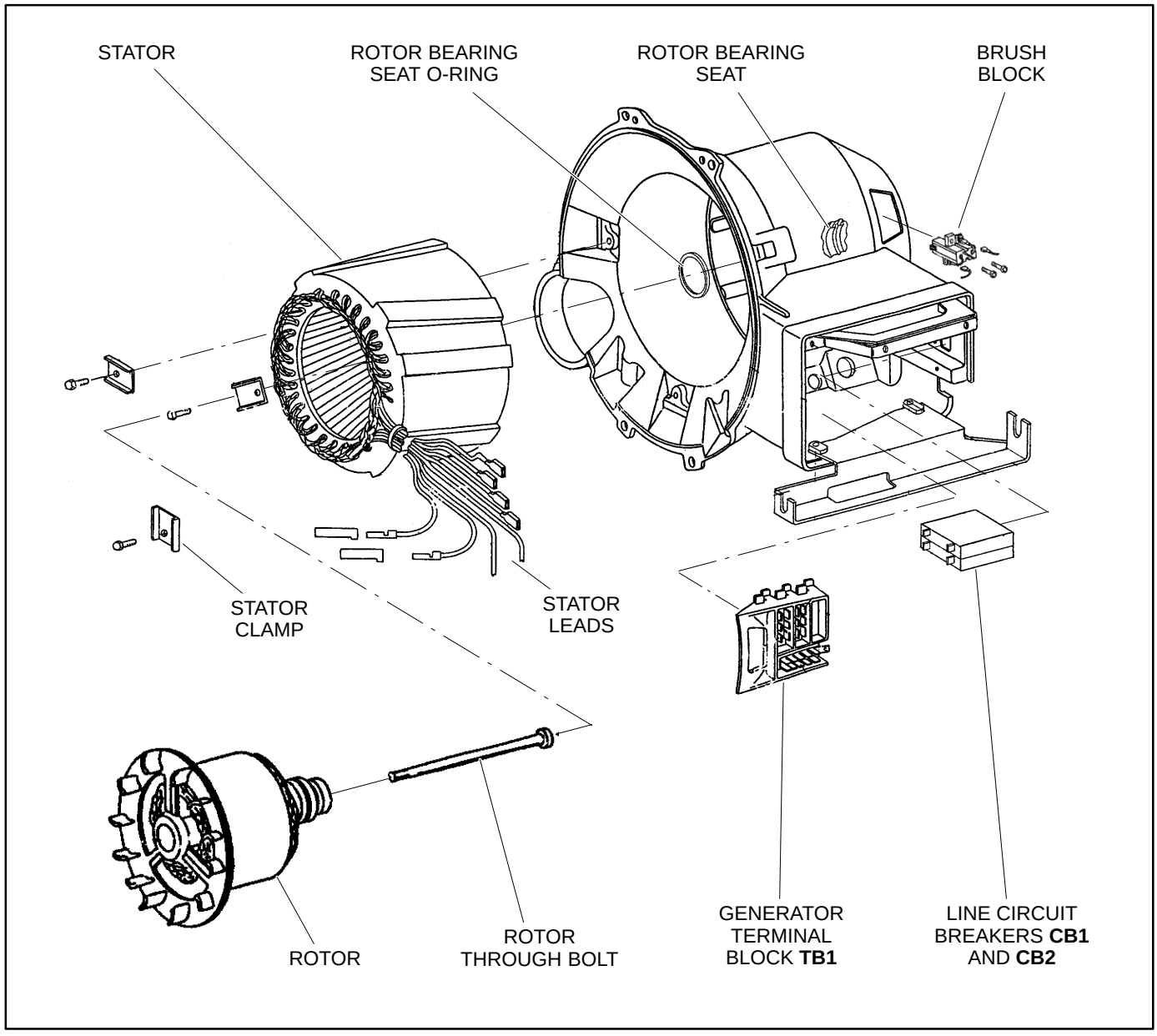


FIGURE 66. AC GENERATOR CONFIGURATION

SERVICING BRUSHES AND SLIP RINGS

Remove the air cleaner and the brush block cover and inspect for burned brushes and grooved or pitted slip rings and other damage. (Turn the rotor with a 3/8 inch allen wrench to inspect all the way around the slip rings.)

If everything looks good, check brush wear with a piece of wire marked off as shown in Figure 67. Replace the brushes and brush springs if the wire can be inserted more than 1 inch (25 mm) into the hole in the brush holder. (Make sure the wire rests on top of the brush and not on part of the brush spring.)

If the slip rings are grooved or pitted try cleaning them up with a commutator stone. If the slip rings need to be replaced, see Removing and Replacing the Slip Ring Assembly under GENERATOR ASSEMBLY/DISASSEMBLY in this section.

To replace the brushes or to clean up the slip rings:

1. Disconnect the leads marked **F1** and **F2** from the brush block terminals.

2. Remove the brush block mounting screws and lift out the brush block assembly.

3. If the slip rings need to be cleaned up, insulate the ends of leads **F1** and **F2**, disconnect all leads from the positive (**+**) terminal of the ignition coil to keep the engine from starting, hold the commutator stone lightly against the slip rings and crank the engine for 3 to 6 seconds. Check the slip rings and repeat the procedure as necessary until the pits and groves have been removed.

4. Replace the brushes and brush springs with new parts. Connect each brush pigtail to the terminal on its side of the insulating divide (Figure 68).

5. Remount the brush block. Center the brushes on the slip rings before tightening the mounting screws.

6. Reconnect the lead marked **F1** to the outboard brush terminal and the lead marked **F2** to the inboard brush terminal and secure the cover and air cleaner.

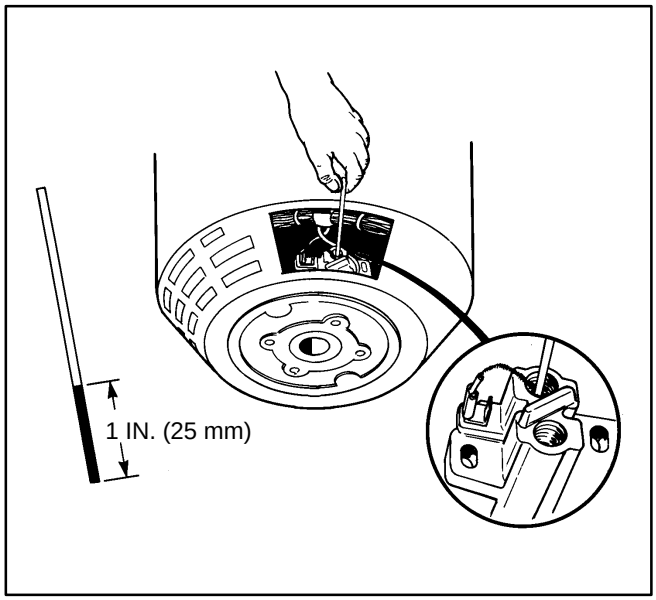


FIGURE 67. CHECKING BRUSH WEAR

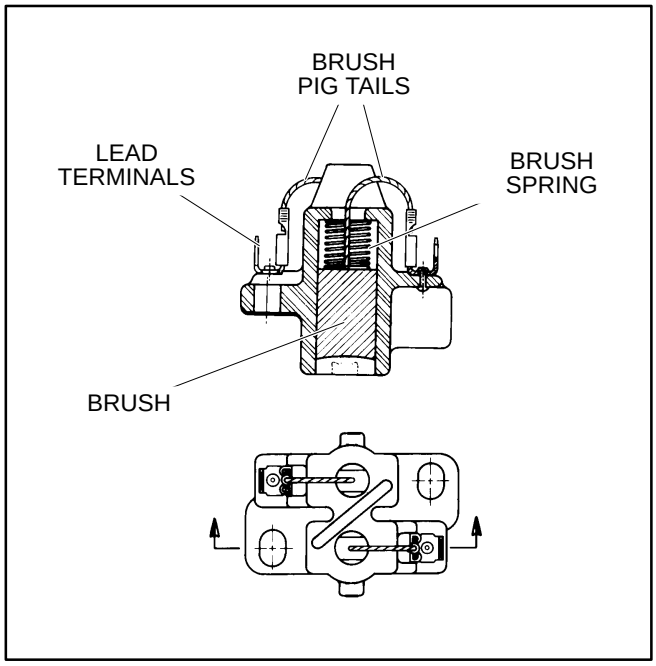


FIGURE 68. BRUSH BLOCK ASSEMBLY

REMOVING/REMOUNTING GENERATOR

Removing The Stator

The following removal procedure leaves the starter motor, battery charger and controller attached to the stator housing.

1. Disconnect the negative (**-**) battery cable *from the battery* and then disconnect the battery cables from the genset.

   ⚠WARNING ***Sparks and high current can cause fire and other damage to the battery, battery cables and equipment if the loose ends of cables connected to the battery touch. Always disconnect the negative (-) battery cable from the battery before disconnecting the battery cables from the genset.***

2. Remove the top panel of the genset housing. See COOLING SYSTEM under *Engine Subsystems*.

3. Disconnect the gas hose and regulator pressure balance hose at the carburetor.

4. Disconnect the crankcase breather hose at the air cleaner adapter.

5. Remove the air cleaner and adapter from the carburetor. See FUEL SYSTEM under *Engine Subsystems*.

6. To keep from damaging the brushes and to keep them from interfering when remounting the stator, either:

   A. Remove the brush block assembly by disconnecting the leads marked **F1** and **F2** from the brush block terminals and then removing the two mounting screws.

   B. Insert a stiff wire into the small hole in the end of the stator housing to hold the brushes up and out of the way (Figure 69). To do this, first pull both brush pigtails to lift the brushes off the slip rings.

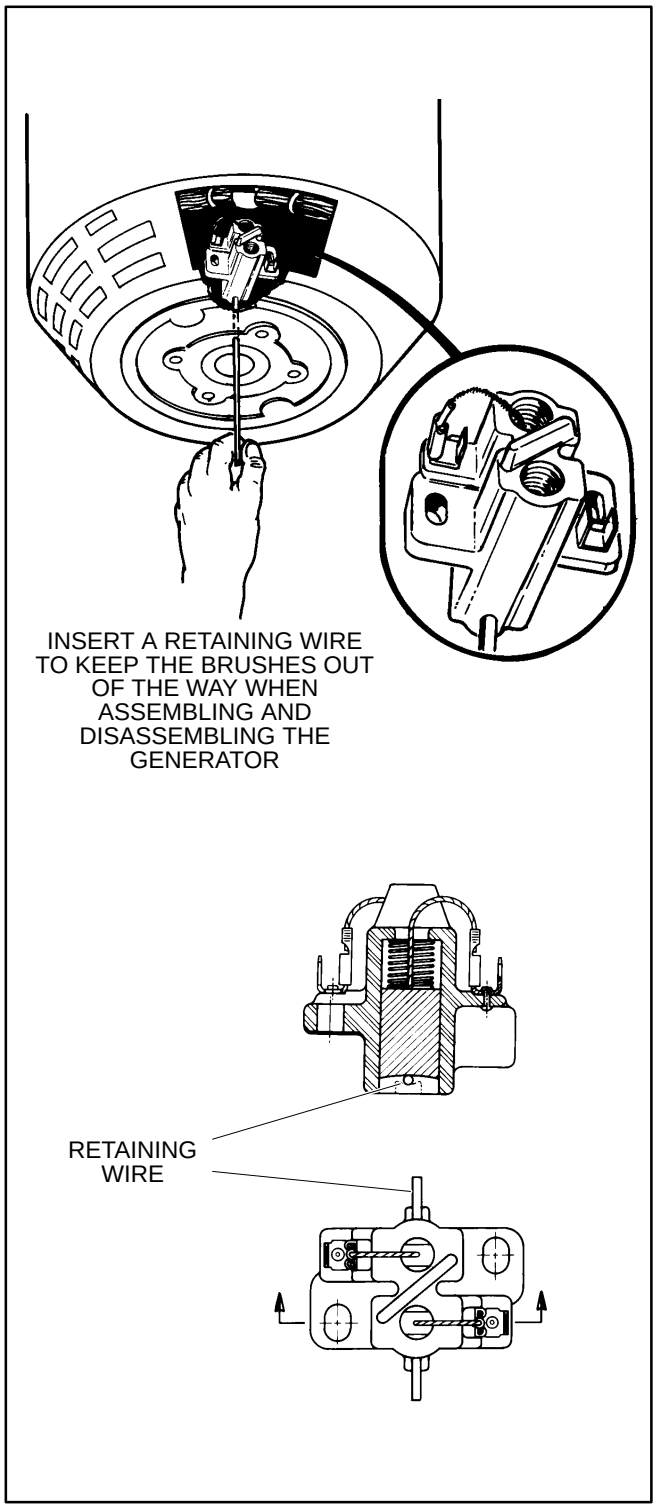


FIGURE 69. BRUSH BLOCK ASSEMBLY

7. Disconnect wiring to the following components:

   A. AC output

   B. Low oil pressure switch

   C. Low oil level switch

   D. High engine temperature sensor

   E. Fuel solenoid

   F. Governor actuator

   G. Carburetor de-icer

   H. Ignition B+ terminal

   I. Base pan (ground strap)

   J. Remote control, cabinet interface and alarms (4 sealed connectors).

8. Remove the two generator vibration isolator center-bolts (Figure 70) and place a piece of “two-by-four” lumber under the engine-generator adapter to support the engine.

9. Remove the four stator housing bolts and pull the housing straight back taking care not to scrape stator windings.

⚠ CAUTION ***Careless handling can damage the insulation on the stator windings.***

Removing the Stator from the Housing

To remove the stator from the generator housing:

1. Turn the stator up as shown in Figure 71.

2. Disconnect all the stator leads and pull them from the control box.

3. Remove the three stator clamps.

4. Lift the stator straight up and out of the housing.

⚠ CAUTION ***Careless handling can damage the insulation on the stator windings.***

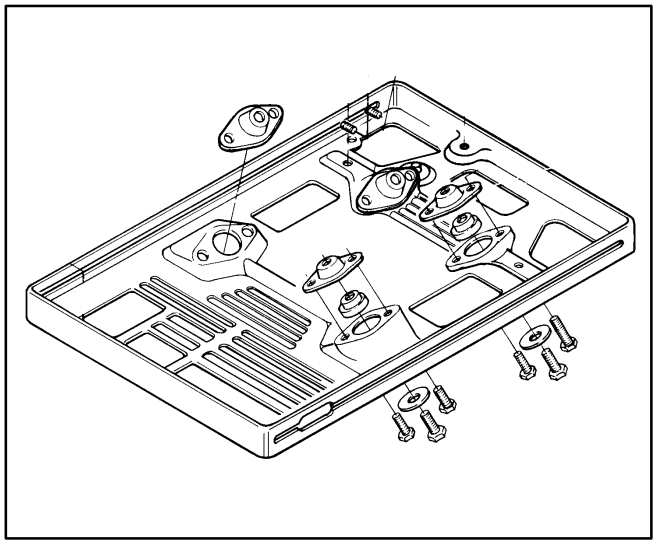


FIGURE 70. GENSET VIBRATION ISOLATORS

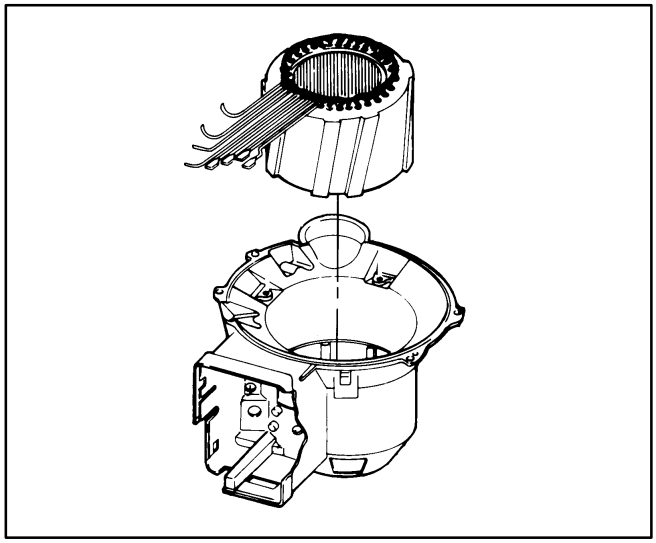


FIGURE 71. REMOVING THE STATOR FROM THE HOUSING

Removing the Rotor

1. Remove the rotor through bolt using a 3/8 inch allen wrench and rubber mallet.
2. Thread in the rotor removal rod (headless bolt, Figure 72) and turn it with a screwdriver until it bottoms. Thread in and tighten a 9/16-12x1-3/4 bolt against the rod until the rotor breaks loose from the crankshaft.
3. If necessary, replace the bearing and the slip ring assembly as instructed in this subsection.

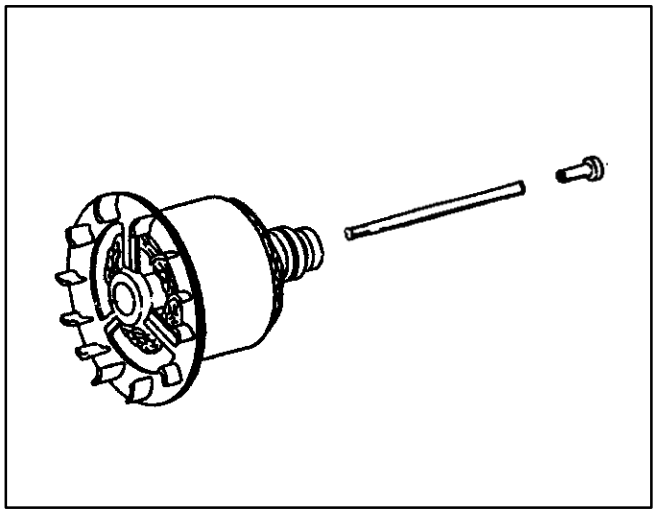


FIGURE 72. ROTOR REMOVAL TOOL

Remounting the Rotor

Replace the bearing and the slip ring assembly, if necessary, as instructed in this section. Use the rotor removal tool to guide the rotor on. Torque the through bolt to *Assembly Torques*.

Reassembling the Stator and Housing

Make sure the stator leads line up with the exit hole in the housing while lowering the stator into the housing. Connect the leads according to the appropriate connection diagram in Figure 81.

Remounting the Stator Housing

Remounting is the reverse of removal. Note the following:

1. Mount the rotor.
2. Reassemble the stator and housing if they have been taken apart.
3. Make sure the brush block assembly has been removed or that the wire is holding both brushes up and out of the way.
4. Make sure the bearing O-ring is in place in the housing bearing bore.
5. Make sure the lock washers go under the bolt heads of the generator housing mounting bolts.
6. Locate the large flat washers at the locations noted when disassembling the vibration isolators (Step 8 under Removal).

7. Torque the generator housing, rotor through-bolt and vibration isolator center-bolts to *Assembly Torques*.

8. Make sure to secure the ground strap to the drip tray using one EIT (external and internal toothed) lock washer on each side of the strap terminal for a good electrical connection.

9. Reconnect or reassemble all other parts that were disconnected or removed.

10. Install the brush block assembly if it was removed. If it was left in place, pull the brush pig tails and remove the retaining wire. If necessary, loosen the brush block mounting screws, align the brush block so that the brushes are centered on the slip rings and retighten the mounting screws.

11. Connect the lead marked **F1** to the outboard brush terminal and the lead marked **F2** to the inboard brush terminal and snap the cover on.

Removing and Replacing the Rotor Bearing

Use a gear puller to remove the bearing from the rotor shaft if it or the slip ring assembly is to be replaced, otherwise leave it in place. If the bearing is to be reused, make sure the fingers of the gear puller bear on the inner race of the bearing only.

⚠ CAUTION ***The bearing will be damaged and become unusable if force is applied to the outer race either when pulling it off or pressing it on.***

Replace the bearing as follows:

1. Replace the slip ring assembly first, if necessary.

2. Press the bearing on with a press, making sure to bear down on the inner race only.

Removing and Replacing the Slip Ring Assembly

Unsolder the two rotor leads from the slip ring assembly and pull the slip ring assembly off with a gear puller. Tape the key to the shaft to keep from loosing it if a new assembly is not going to be installed right away.

Press on a new slip ring assembly with a press, making sure the key is in place and the assembly is aligned with the key. Solder the two rotor leads to the solder terminals on the slip ring assembly.

TESTING THE GENERATOR

Testing the Rotor

It is possible to test the rotor without removing it from the generator by removing the brush block assembly.

Testing for a Grounded Winding: A digital ohmmeter is recommended for this test. Select the highest resistance scale on the meter and touch one test probe to the rotor shaft and the other to either slip ring as shown in Figure 73. Replace the rotor assembly if the meter does not indicate an open circuit to ground (the same high resistance as when the meter probes are separated by an air gap).

Testing Winding Resistance: A digital ohmmeter is recommended for measuring rotor winding resistance. Select the best scale for measuring a 20 to 25 ohm value. Touch the test probes to the slip rings as shown in Figure 74.

If the meter indicates a high resistance, first check the connection between the slip rings and the rotor leads and resolder if necessary. Replace the rotor assembly if the connections are good but the winding does not meet the resistance specification in Table 3.

Testing the Stator

These tests can be done by disconnecting all the **Tx** winding leads from terminal block **TB1** and the **Bx** and **Qx** winding leads from their connectors. The stator has winding lead pairs **T1-T2**, **T3-T4**, **B1-B2** and **Q1-Q2**. Alternatively, a plug-in tester is available for conducting stator winding tests.

Testing for a Grounded Winding: A digital ohmmeter is recommended for this test. Select the highest scale on the meter. Test each lead as shown in Figure 75. Replace the stator assembly if any reading is low indicating a breakdown in the winding insulation.

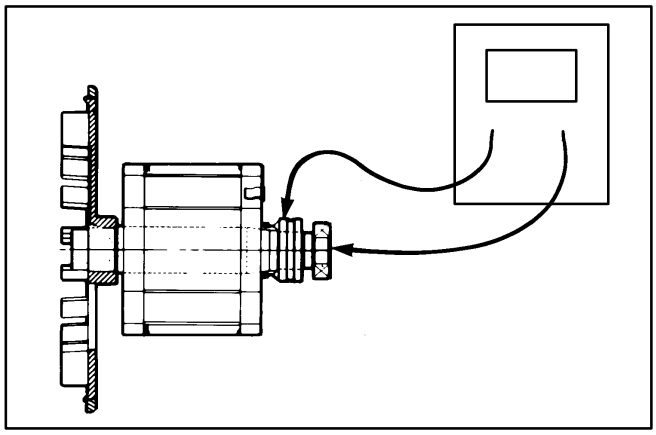


FIGURE 73. ROTOR INSULATION RESISTANCE

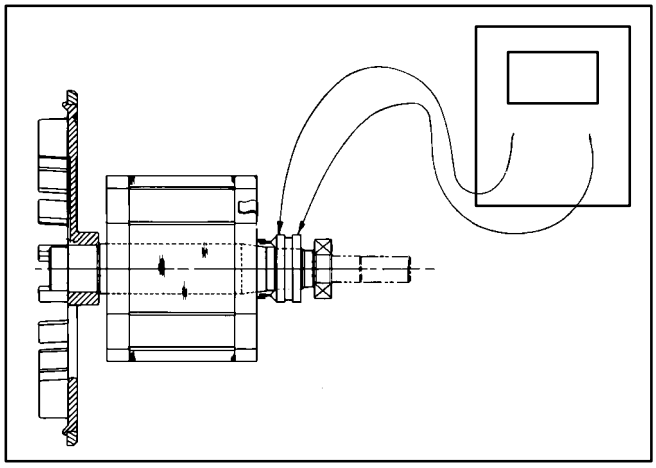


FIGURE 74. ROTOR WINDING RESISTANCE

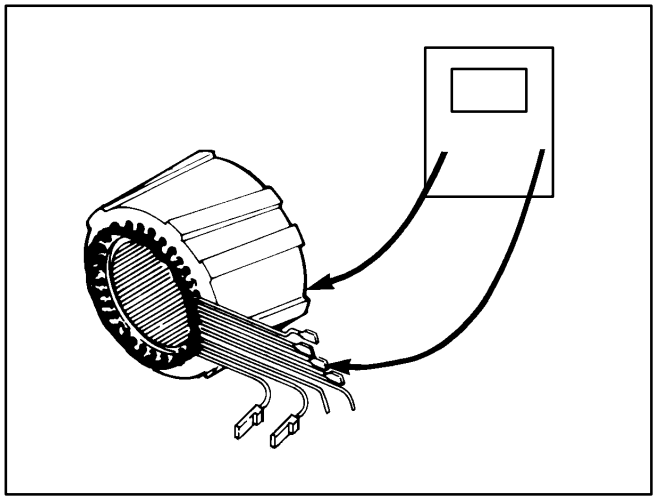


FIGURE 75. STATOR INSULATION RESISTANCE

Testing Winding Resistance: A digital ohmmeter can be used to determine if a stator winding is open, as shown in Figure 76. A Wheatstone (Kelvin) bridge should be used to measure stator winding resistance. Replace the stator assembly if any winding is open or does not meet the resistance specification in Table 3.

TABLE 3. GENERATOR WINDING SPECIFICATIONS

WINDING RESISTANCES* (OHMS)			
T1-T2, T3-T4	B1-B2	Q1-Q2	ROTOR WINDING
0.327	0.058	2.089	22.5
* - Approximate values: ±10% at 68° F (20° C)			

TESTING FOR FIELD VOLTAGE

To check the field voltage, remove the brush block cover and connect a DC voltmeter to the brush block terminals. See Figure 68 (p. 67). Connect the positive lead to the **B+** (outboard) terminal and the negative lead to the **B-** (inboard) terminal.

Start the genset and allow it to stabilize. Measure the field voltage with no load applied and then with full load applied. Both readings should fall between 25 and 100 volts DC and be stable at constant load. If not, see *Troubleshooting.*

GENERATOR RECONNECTIONS

When it is necessary to reconnect a generator, remove the control panel and reconnect the leads at terminal block **TB1** and circuit breakers **CB1** and **CB2** as shown in the appropriate diagram in Figure 81. It should be noted that other leads are also connected to terminal block **TB1** in the control box and that they should be reconnected as marked, if inadvertently disconnected.

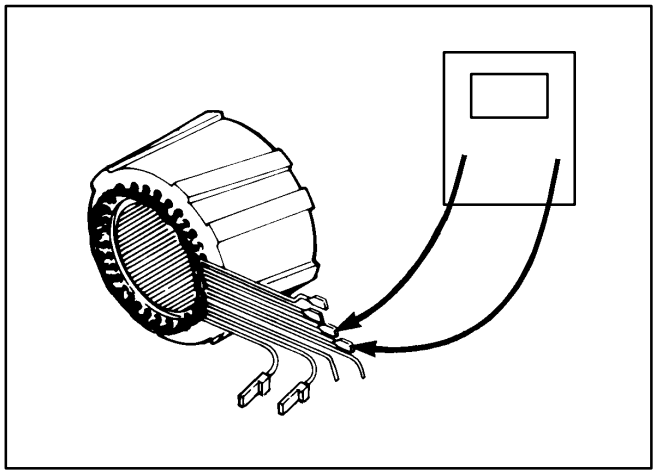


FIGURE 76. STATOR WINDING CONTINUITY

Genset Controller

The genset controller is a fully potted assembly with leads and connectors and is mounted by four screws to the generator control box. To remove the controller, remove the two top screws, loosen the two bottom screws and tip the controller out, disconnecting all the leads and connectors. See Figure 77.

The controller uses two microcontrollers with embedded software. One microcontroller supports the traditional functions of genset control along with voltage regulation and extensive diagnostics (see *Troubleshooting*). The other controller supports serial communications with external systems. Figure 78 is a block diagram of controller inputs and outputs.

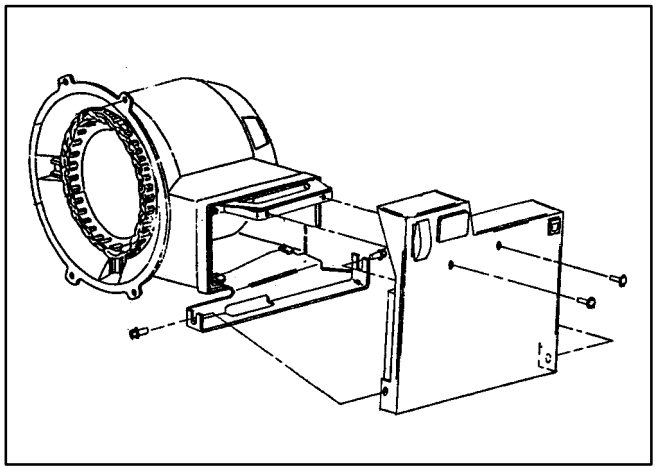


FIGURE 77. CONTROLLER MOUNTING

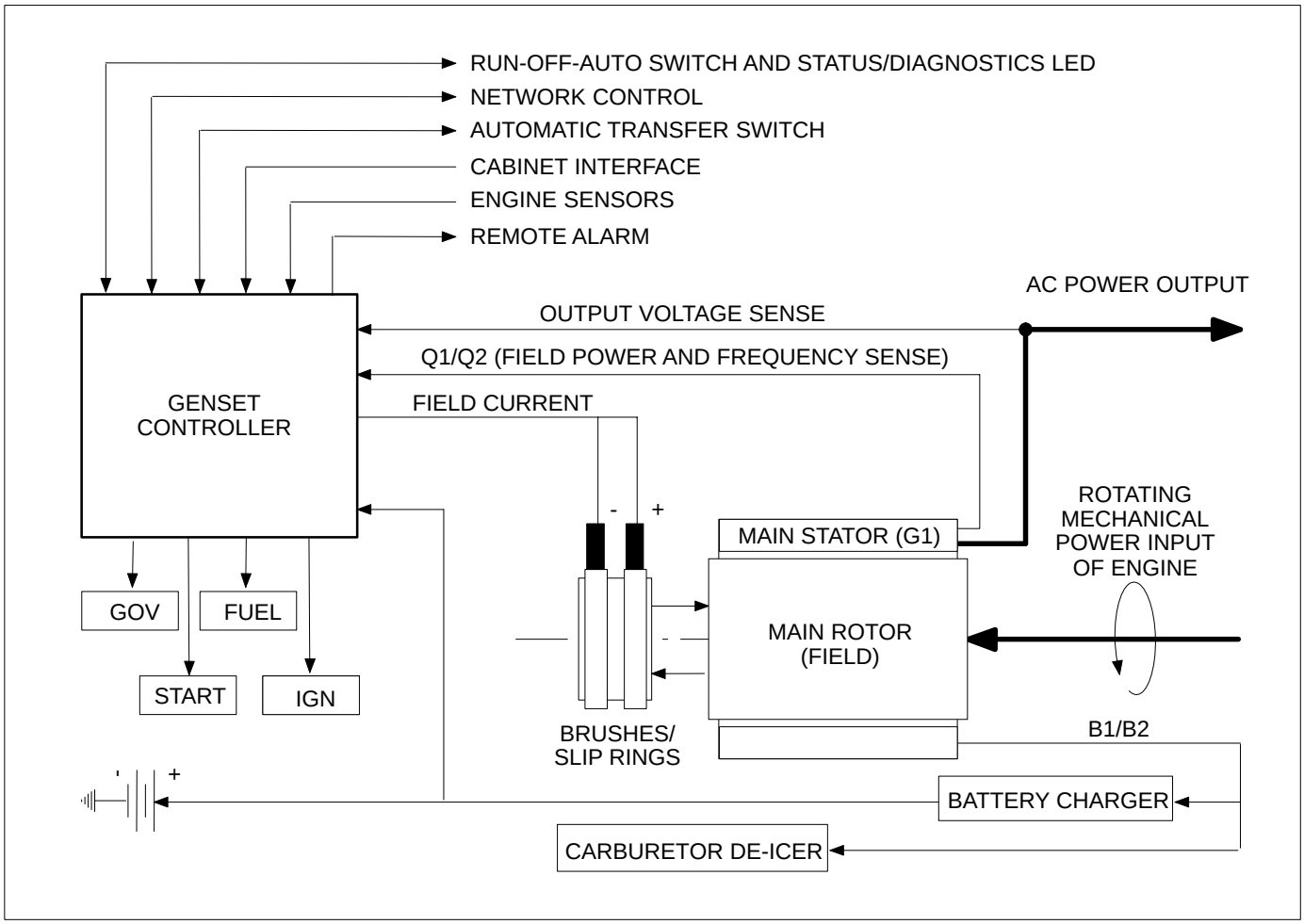


FIGURE 78. GENSET CONTROLLER INPUTS AND OUTPUTS

Figure 79 shows the controller assembly and its wiring connectors. Also:

- Figure 80 (p. 87) shows the wiring digram
- Figure 82 (p. 89) shows the engine wiring harness
- Figure 83 (p. 90) shows the carburetor de-icer and battery charger wiring harness
- Figure 84 (p. 91) shows typical automatic transfer switch connections.

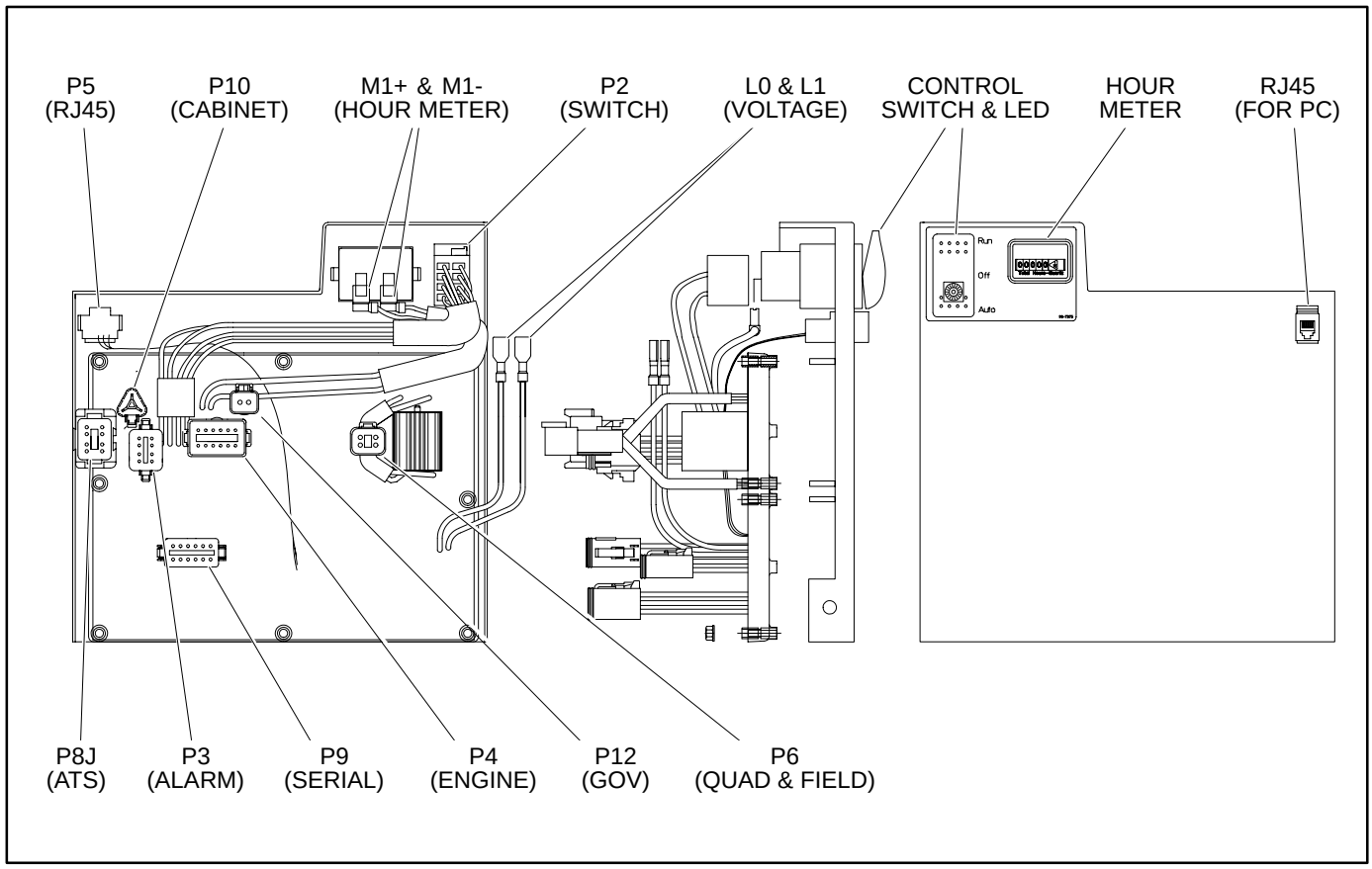


FIGURE 79. CONTROLLER ASSEMBLY AND CONNECTORS

Troubleshooting

Proper maintenance and use of the genset—maintaining oil level, keeping battery connections clean and tight, not overloading the genset—will prevent most shutdowns.

Table 4 provides troubleshooting guidance for a genset that fails to start or that shut downs. The genset controller has an extensive diagnostic capability and its fault codes are covered in numerical sequence in Table 4. *The code numbers that have been skipped over are not active for this series of gensets.*

STATUS / DIAGNOSTICS LIGHT ON THE GENSET CONTROL SWITCH

The genset controller causes the status/diagnostics light (local) and remote alarm (if provided) to repeatedly blink a fault code if there is a fault shutdown or maintenance or service alert. There are distinct pauses between repetitions of the code blink transmissions.

Single-Digit Fault Code - A single-digit fault code is indicated by a corresponding number of blinks. For example:

Code No. 5 - blink-blink-blink-blink-blink

Two-Digit Fault Code - A two-digit fault code is indicated by two sets of blinks separated by a short pause. The first set corresponds to the tens digit and second to the ones digit. For example:

Code No. 23 - blink-blink-*pause*-blink-blink-blink

Last Fault Indication/Controller Reset - Blinking stops in five minutes but can be restored to indicate the last fault by pushing the control switch to OFF and then returning it to AUTO. *This also resets the controller.*

Last Five Faults - The last five faults can be indicated by pushing the control switch between OFF and AUTO rapidly three times:

OFF-AUT O-OFF-AUT O-OFF-AUT O

The light will display the fault codes in succession, starting with the most recent. There will be a two-second pause between fault codes except that there will be a four-second pause before the fifth most recent fault code.

Code No. 6 (Control Switch Off Alert) will blink if the control switch is left in the **OFF** position more than 5 seconds.

Code No. 7 (Loss of Utility Power Alert) will blink if there is a loss of utility power and the genset is called upon by the automatic transfer switch to make up for the loss of utility power.

CONTROL AND DIAGNOSTICS VIA NETWORK OR PC (LAPTOP)

See your authorized Onan dealer regarding software, hardware and network requirements for control and diagnostics via network or PC.

⚠WARNING ***Automatic startup of the genset while performing maintenance or service can cause severe personal injury or death. Push the control switch to Off and disconnect the negative (-) battery cable from the battery to keep the genset from starting up while working on it.***

TABLE 4. TROUBLESHOOTING

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

NO RESPONSE WHEN THE CONTROL SWITCH IS IN THE RUN POSITION

(The controller is not being power—12VDC)

Corrective Action:

1. Replace **Fuse F1** (B+) if blown. Before starting the genset, reconnect engine harness connector **T1+** to the ignition coil (p. 31) if loose and touching ground.
2. Push the control switch to **AUTO** and try starting the genset with remote network or transfer switch control. Replace control switch **S1** if the genset can be operated remotely but not locally.
3. Reconnect a loose **K1-1** engine harness connector (two) to the positive (**+**) terminal on starter motor solenoid **K1** (p. 14).
4. Clean and tighten the positive (**+**) and negative (**-**) battery cable connections at the battery and at the genset (p. 14).
5. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
6. Lift the controller (p. 74) out of the way and:
   - Reconnect the leads of fuse holder **F1** to the wiring harness.
   - Reconnect engine harness connectors **P2** and **P4** to the controller.
   - Reconnect the engine harness **CONT GND** connectors (two) to **TB1-L0**.
7. Replace fuse holder **F1** if electrical continuity is lacking across the leads with a good fuse installed.
8. Repair or replace the engine harness if electrical continuity is lacking between:
   - Connector **F1** and connector **P4**, pins **2** and **3**.
   - Connector **F1-A/F2-A** and connector **K1-1** (one of two).
   - Connector **CONT GND** and connector **P4-4**.
9. Check for and push back in any loose pins in connector **P2** or **P4**.
10. Replace the controller.

NO POWER WHEN THE GENSET IS RUNNING

(A line circuit breaker or transfer switch is OFF, tripped or malfunctioning)

Corrective Action:

1. Reset or turn ON the line circuit breaker on the genset.
2. Reset or turn ON any other circuit breaker in the power supply system.
3. Check for proper transfer switch function.
4. Check genset AC output connections at the equipment (transfer switch) and reconnect as necessary.
5. Lift the controller (p. 74) out of the way and check wiring connections inside the control box at terminal block **TB1** and line circuit breakers **CB1** and **CB2** and reconnect as necessary according to the genset wiring diagram (p. 87).
6. Attempt to reset the circuit breakers and measure electrical continuity across each set of terminals. Replace a circuit breaker that does not close or that has measurable resistance across the contacts.

TABLE 4. TROUBLESHOOTING (CONT.)

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

HIGH ENGINE TEMPERATURE FAULT SHUTDOWN—CODE NO. 1

(The controller sensed that the engine temperature design limit has been exceeded)

Corrective Action:

1. Check for and remove any objects blocking the air inlet or outlet openings.
2. Reduce the electrical load. (Note that high altitude and high ambient temperature decrease engine cooling capacity.)
3. Clean the engine cooling fins and blower blades. See *Periodic Maintenance.*
4. Replace temperature sender **R2** (p. 43) if there is low electrical resistance across the connector pins at room temperature (shorted).
5. Repair or replace the engine harness if there is electrical continuity between connector **P4-12** and ground.
6. Review the installation and housing design against the specifications and requirements of the Installation Manual.

LOW OIL PRESSURE FAULT SHUTDOWN—CODE NO. 2

(The controller sensed that the low oil pressure cutoff switch did not open within 10 seconds of starting)

Corrective Action:

1. Check engine oil level and add oil as necessary. Repair oil leaks.
2. Drain excess oil. (Excess oil leads to foaming and a consequent loss of oil pressure.)
3. Service a worn lubricating system and/or engine according to *Engine Subsystems* and/or *Engine Block Assembly*.

100 HOUR MAINTENANCE ALERT—CODE NO. 3

(The genset has accumulated another 100 hours of operation since the last maintenance alert)

Corrective Action: Perform the required maintenance according to *Periodic Maintenance*. The alert can only be reset by means of a software command via network or PC. See your authorized Onan dealer.

LOW OIL LEVEL ALERT—CODE NO. 4

(The controller sensed that the low oil level switch was open 1 minute after the genset stopped)

Corrective Action:

1. Check the engine oil level and add oil as necessary. Repair oil leaks.
2. Reconnect the lead to low oil level switch **S4** if not connected.
3. Replace low oil level switch **S4** (p. 35) if the oil level is correct but electrical continuity to ground is lacking.
4. Repair or replace the engine harness if electrical continuity is lacking between connector **S4-1** and connector **P4-11**.

TABLE 4. TROUBLESHOOTING (CONT.)

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

FAILURE TO START FAULT SHUTDOWN—CODE NO. 5

(The engine cranks [five 10 second cranks with 30 second rests] but does not start)

Corrective Action:

1. Open any closed fuel shutoff valve.
2. Fill the LPG fuel tank if less than half full. *On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.*
3. Secure the spark plug cables at the spark plugs and at the ignition coil.
4. Check the governor for binding and service as necessary. Replace the governor actuator if coil resistance is not 6.5 to 7.5 ohms or is shorted to ground. Make sure the governor rod is not hanging up on the spark plug cable (p. 37).
5. Check for proper fuel selection and change if necessary (p. 12).
6. Check the engine air filter and remove any blockage.
7. Check for a blocked exhaust system and service as necessary.
8. Replace the spark plugs and/or spark plug cables.
9. Conduct the ignition system tests and service as necessary (p. 31).
10. Check the gas supply pressure and adjust as necessary (p. 42).
11. Test the fuel solenoid valve and replace if necessary (p. 38).
12. Test the demand pressure regulator and replace if necessary (p. 38).
13. Conduct a cylinder compression test (p. 26) and service the engine if it is worn or malfunctioning.
14. Push back in any loose pins in connector **P4**.
15. Replace the controller.

CONTROL SWITCH OFF ALERT—CODE NO. 6

(The control switch has been in the OFF position more than 5 seconds, preventing remote control)

Corrective Action: Push the control switch to **AUTO** before leaving the site if the genset is to be placed in service.

LOSS OF UTILITY POWER ALERT—CODE NO. 7

(The controller sensed a loss of utility power)

Corrective Action:

1. Verify that the genset is supplying the load.
2. If the utility is available, check for and repair shorted leads between controller connector **P8** and the transfer switch.
3. Check to see that the transfer switch signal circuit makes on loss of utility power (NO).

TABLE 4. TROUBLESHOOTING (CONT.)

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

CABINET FAULT ALERT-CODE NO. 8

(A user-installed cabinet fault sensor switch closed indicating flooding, shear, etc.)

Corrective Action:

1. Service the fault as necessary.
2. Check for and repair shorted leads between controller connector **P10** and the fault switches.
3. Check to see that the leads are connected to the normally open (NO) contacts of the fault switches.

LOW GAS SUPPLY PRESSURE ALERT—CODE NO. 9

(The user-installed pressure switch closed indicating low gas supply pressure)

Corrective Action:

1. Open all shutoff valves in the fuel supply line.
2. Fill the LPG container. *On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.*
3. Check for and repair shorted leads between controller connector **P10** and the pressure switch.
4. Check to see that the leads are connected to the normally open (NO) contacts of the pressure switch.
5. Check the gas supply pressure and adjust as necessary (p. 42).

OVERVOLTAGE FAULT SHUTDOWN—CODE NO. 12

(The controller sensed that voltage was greater than 154 VAC for 3 seconds)

Corrective Action:

1. Lift the controller (p. 74) out of the way and reconnect voltage sense lead **P7-A** to **TB1-L1** and voltage sense lead **P7-B** to **TB1-L0**. Replace the connectors if corroded or damaged.
2. Replace the controller.

TABLE 4. TROUBLESHOOTING (CONT.)

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

UNDERVOLTAGE FAULT SHUTDOWN—CODE NO. 13

(The controller sensed that voltage was less than 90 VAC [L1-L0] for 8 seconds)

Corrective Action:

1. Turn the genset line circuit breaker **OFF**. *If the genset runs without shutting down*, run the genset with fewer connected loads.
2. Service the brushes and slip rings as necessary (p. 67).
3. Lift the controller (p. 74) out of the way and:
   - Reconnect voltage sense lead **P7-A** to **TB1-L1** and voltage sense lead **P7-B** to **TB1-L0**. Replace the connectors if corroded or damaged
   - Check wiring connections inside the control box at terminal block **TB1** and at line circuit breakers **CB1** and **CB2** and reconnect as necessary according to the genset wiring diagram (p. 87).
4. Check power factor. Disconnect loads that cause a power factor of 0.5 or less.
5. Measure voltage across L1-L2. Replace the controller if the voltage is at least 180 VAC but shutdown with Code No. 13 still occurs within 8 seconds.
6. Test the generator field, stator and quadrature windings for opens or shorts. Replace the generator rotor or stator assembly if winding resistance is not as specified in Table 3 (p. 73).

OVERFREQUENCY FAULT SHUTDOWN—CODE NO. 14

(The controller sensed that frequency was greater than 80 Hz [2400 rpm] for 0.16 second)

Corrective Action:

1. Check for governor rod binding and service as necessary (p. 37). Make sure it is not hanging up on the spark plug cable (p. 37).
2. Replace the controller.

TABLE 4. TROUBLESHOOTING (CONT.)

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

UNDERFREQUENCY FAULT SHUTDOWN—CODE NO. 15

(The controller sensed that frequency was less than 53 Hz [1600 rpm] for 8 seconds)

Corrective Action:

1. Turn the genset line circuit breaker **OFF**. *If the genset runs without shutting down*, run the genset with fewer connected loads.
2. Check the governor for binding and service as necessary. Make sure it is not hanging up on the spark plug cable (p. 37).
3. Replace Fuse **F3** (carburetor de-icer) if blown.
4. Reconnect any carburetor de-icer leads that may be loose.
5. Fill the LPG fuel tank if less than half full. *On cold days the LPG container may have to be kept at least half full to provide the rate of vaporization required to keep up with genset fuel demand. LPG with more than 2.5 percent butane will not vaporize below 32° F (0° C). Use HD-5 grade LPG.*
6. Secure the spark plug cables at the spark plugs and at the ignition coil.
7. Check for proper fuel selection and change if necessary (p. 12).
8. Check the engine air filter and remove any blockage.
9. Check for a blocked exhaust system and service as necessary.
10. Replace the spark plugs and/or spark plug cables.
11. Conduct the ignition system tests and service as necessary (p. 31).
12. Service the carburetor de-icer as necessary (p. 40).
13. Check the gas supply pressure and adjust as necessary (p. 42).
14. Test the demand pressure regulator and replace if necessary (p. 38).
15. Conduct a cylinder compression test (p. 26) and service the engine if it is worn or malfunctioning.

ENGINE ACCESSORY FAULT SHUTDOWN—CODE NO. 17

(The controller sensed an accessory overload)

Corrective Action:

1. Disconnect any customer-connected load(s) from **T1+** on the ignition coil.
2. Replace the ignition coil (T1) if primary coil resistance is less than 3 ohms (p. 33).
3. Replace the fuel solenoid (E3) if coil resistance is less than 10 ohms (p. 39).
4. Replace the carburetor de-icer relay (K2) if coil resistance is less than 80 ohms.

GOVERNOR ACTUATOR FAULT SHUTDOWN—CODE NO. 19

(The controller sensed an overload in the governor actuator circuit)

Corrective Action:

1. Replace the governor actuator if coil resistance is less than 6.5 ohms (p. 37).

TABLE 4. TROUBLESHOOTING (CONT.)

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

LOW OIL PRESSURE CUTOFF SWITCH FAULT ALERT—CODE NO. 23

(The controller sensed that the switch did not close within 1 minute after the genset stopped)

Corrective Action:

1. Reconnect the low oil pressure switch lead if loose (touching ground).
2. Repair or replace the engine harness if the pressure switch lead is pinched and grounded.
3. Replace low oil pressure switch **S2** (p. 35).

TEMPERATURE SENDER FAULT ALERT—CODE NO. 24

(The controller did not sense a temperature change during the first 5 minutes of operation)

Corrective Action: (Note that under this condition the controller will limit genset output to 3.5 kW.)

1. Reconnect the temperature sender lead to the engine harness if loose.
2. Repair or replace the engine harness if electrical continuity is lacking between connector **P14-1** and connector **P4-12** or between connector **P14-2** and the **ENG GND** connector.
3. Replace temperature sender **R2** (p. 43).

HIGH ENGINE TEMPERATURE ALERT—CODE NO. 34

(The controller senses that engine temperature is close to the design limit)

Corrective Action:

1. Check for and remove any objects blocking the air inlet or outlet openings.
2. Reduce the electrical load. (Note that high altitude and high ambient temperature decrease engine cooling capacity.)
3. Clean the engine cooling fins and blower blades. See *Periodic Maintenance.*
4. Replace temperature sender **R2** (p. 43).

CONTROL CARD FAULT SHUTDOWN—CODE NO. 35

(There was a memory error in the controller microcontroller during self-test)

Corrective Action: Replace the genset controller.

INVALID SET CONFIGURATION ALERT—CODE NO. 37

(Set configuration must be programmed for each replacement controller assembly)

Corrective Action: Reconfigure the genset controller. Special software and a PC are required. See your authorized Onan dealer.

TABLE 4. TROUBLESHOOTING (CONT.)

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

WEAK BATTERY ALERT—CODE NO. 39

(The controller sensed that battery voltage was less than 12 volts while the genset was running)

Corrective Action:

1. Clean and tighten the positive (**+**) and negative (**-**) battery cable connections at the battery and at the genset.
2. Recharge or replace the battery. Refer to the battery manufacturer's recommendations.
3. Check for and remove any parasitic loads on the battery.
4. Reconnect the battery charger harness between the generator **B1** and **B2** leads and battery charger **VR2** if loose or missing.
5. Disconnect the battery charger harness from battery charger **VR2** and prepare to measure AC voltage across the connectors while the genset is running.
   - If there is at least 18 VAC across the leads under no-load, replace battery charger **VR2**.
   - If there is no voltage, disconnect the harness from the generator **B1** and **B2** leads.
     - Repair or replace the harness if either lead lacks electrical continuity.
     - Replace the generator stator assembly if the harness is good.

GENERATOR FIELD FAULT SHUTDOWN—CODE NO. 41

(The controller sensed a short in the field circuit while the genset was running)

Corrective Action:

1. Remove the pin used to keep the brushes out of the way while assembling the generator (p. 68).
2. Lift the controller out of the way (p. 74) and check that field leads **F1** and **F2** are not pinched and shorted together. Repair as necessary.
3. Test the generator field winding for a shorted circuit. Replace the generator rotor assembly if winding resistance is not as specified in Table 3 (p. 73).
4. Replace the genset controller.

1000 HOUR SERVICE ALERT—CODE NO. 43

(The genset has accumulated another 1000 hours of operation since the last service alert)

Corrective Action: Perform the required maintenance according to *Periodic Maintenance*. The alert can only be reset by means of a software command via network or PC. See your authorized Onan dealer.

TABLE 4. TROUBLESHOOTING (CONT.)

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

SPEED SENSE FAULT SHUTDOWN—CODE NO. 45

(The controller failed to sense quadrature circuit frequency and voltage)

Corrective Action—engine does not crank:

1. Replace Fuse **F2** if blown. Before starting the genset, reconnect engine harness connector **K1-A** to the starter solenoid coil if loose and touching ground.
2. Reconnect a loose **K1-1** engine harness connector (two) to the positive (**+**) terminal on starter motor solenoid **K1** (p. 14).
3. Lift the controller (p. 74) out of the way and:
   - Reconnect the leads of fuse holder **F2** to the wiring harness.
   - Reconnect the engine harness **CONT GND** connectors (two) to **TB1-L0**.
   - Reconnect any loose relay **K3** engine harness lead (relay terminals 30, 85, 86 and 87).
4. Replace fuse holder **F2** if electrical continuity is lacking across the leads with a good fuse installed.
5. Replace lead **K3-86—CONT GND** if it lacks electrical continuity.
6. Replace relay **K3** if electrical continuity is lacking across terminals **30** and **87** when the coil is energized by 12 VDC across terminals **85** (**-**) and **86** (**+**).
7. Repair or replace the engine harness if electrical continuity is lacking between:
   - Connector **K3-85** and connector **P4-7**.
   - Connector **K3-87** and **K1-A**.
8. Service the starter solenoid/motor assembly as necessary (p. 44).
9. Push the connector **P4-7** pin back in if loose.
10. Replace the controller.

Corrective Action—engine starts but shuts down:

1. Free up the generator brushes if stuck in the brush block and clean up the slip rings (p. 67).
2. Lift the controller out of the way (p. 74) and reconnect generator quadrature leads **Q1** and **Q2** to the controller if disconnected at connector **P6**.
3. Test the generator quadrature winding for an open or shorted circuit. Replace the generator stator assembly if winding resistance is not as specified in Table 3 (p. 73).
4. Replace the genset controller.

LOSS OF BATTERY (B+) ALERT—CODE NO. 46

(The control must be reset after the battery is reconnected—which prevents false genset startup)

Corrective Action: Push the control switch to **OFF** and then to **AUTO** or **RUN**. Clean and tighten the positive (**+**) and negative (**-**) battery cable connections at the battery and at the genset to prevent intermittent connections.

TABLE 4. TROUBLESHOOTING (CONT.)

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

REFERENCE VOLTAGE FAULT SHUTDOWN—CODE NO. 47

(The controller sensed an open or short in the reference voltage circuit)

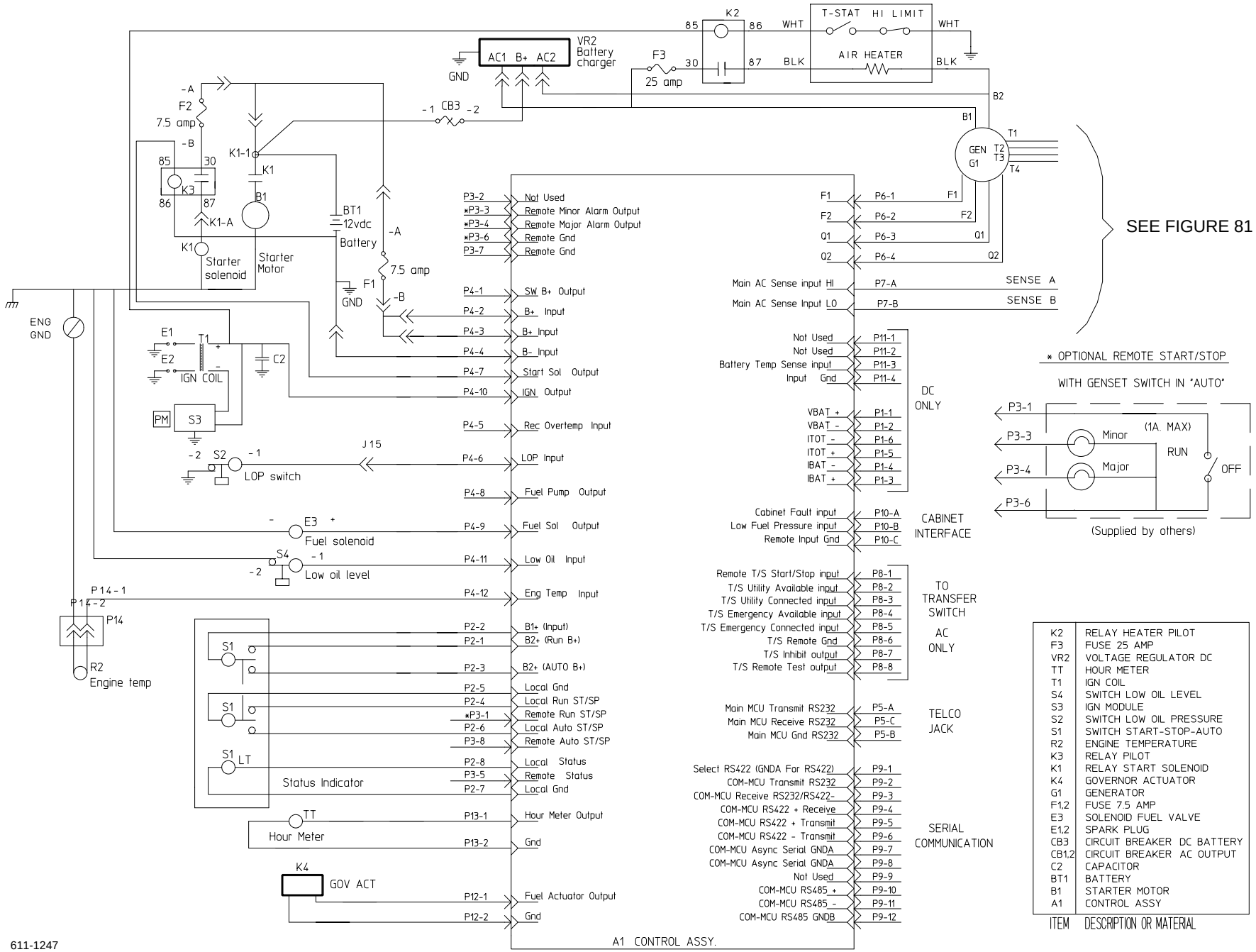
Corrective Action:

1. Lift the controller (p. 74) out of the way and reconnect voltage sense lead **P7-A** to **TB1-L1** and voltage sense lead **P7-B** to **TB1-L0**. Replace the connectors if corroded or damaged.
2. Replace the genset controller.

REMOTE SHUTDOWN—CODE NO. 48

(The remote controller shut down the genset)

Corrective Action: Reset the controller by means of the remote controller (via network or PC) or by pushing the control switch on the genset to **OFF** and then back to **AUTO**. See an authorized Onan dealer.



611-1247

FIGURE 80. WIRING DIAGRAM

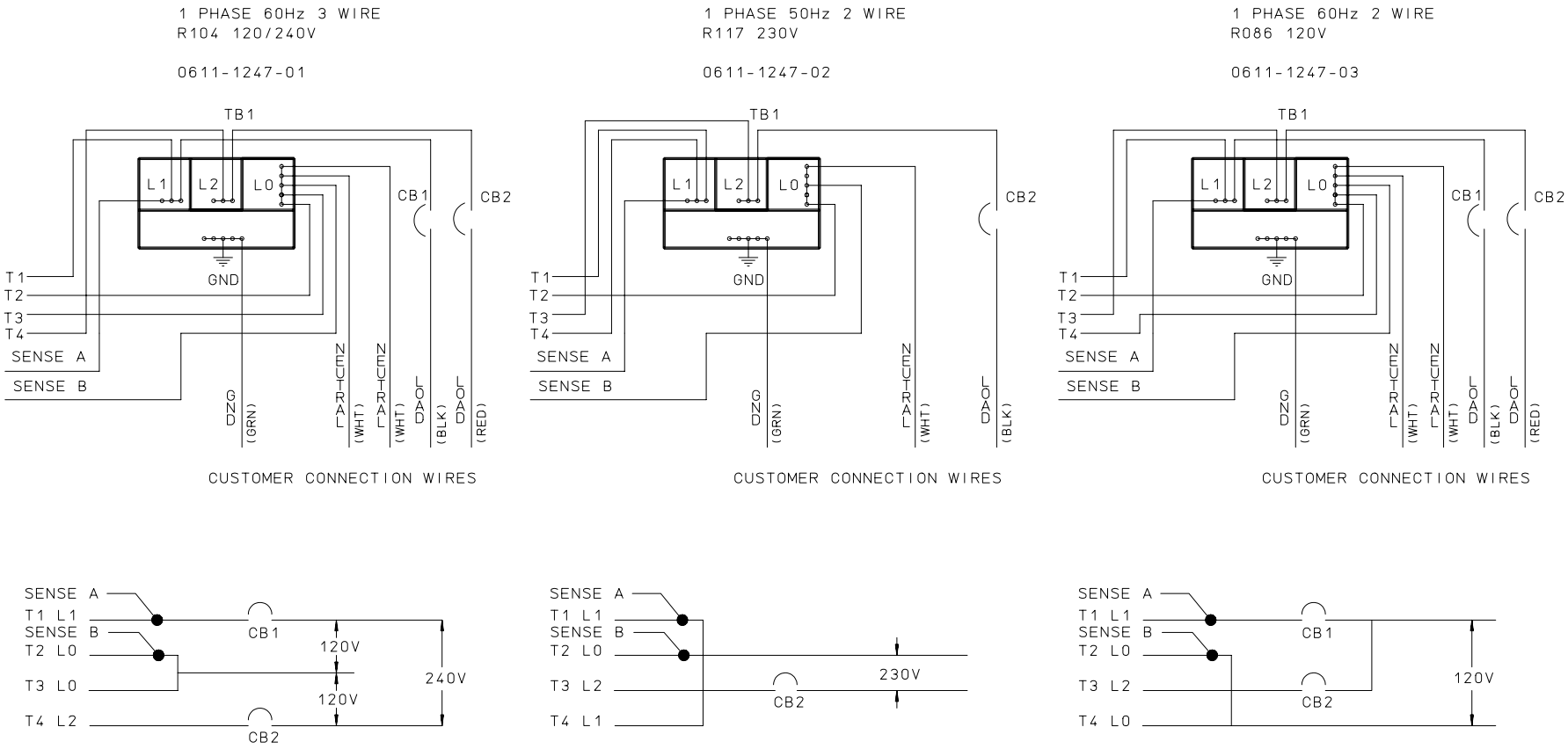
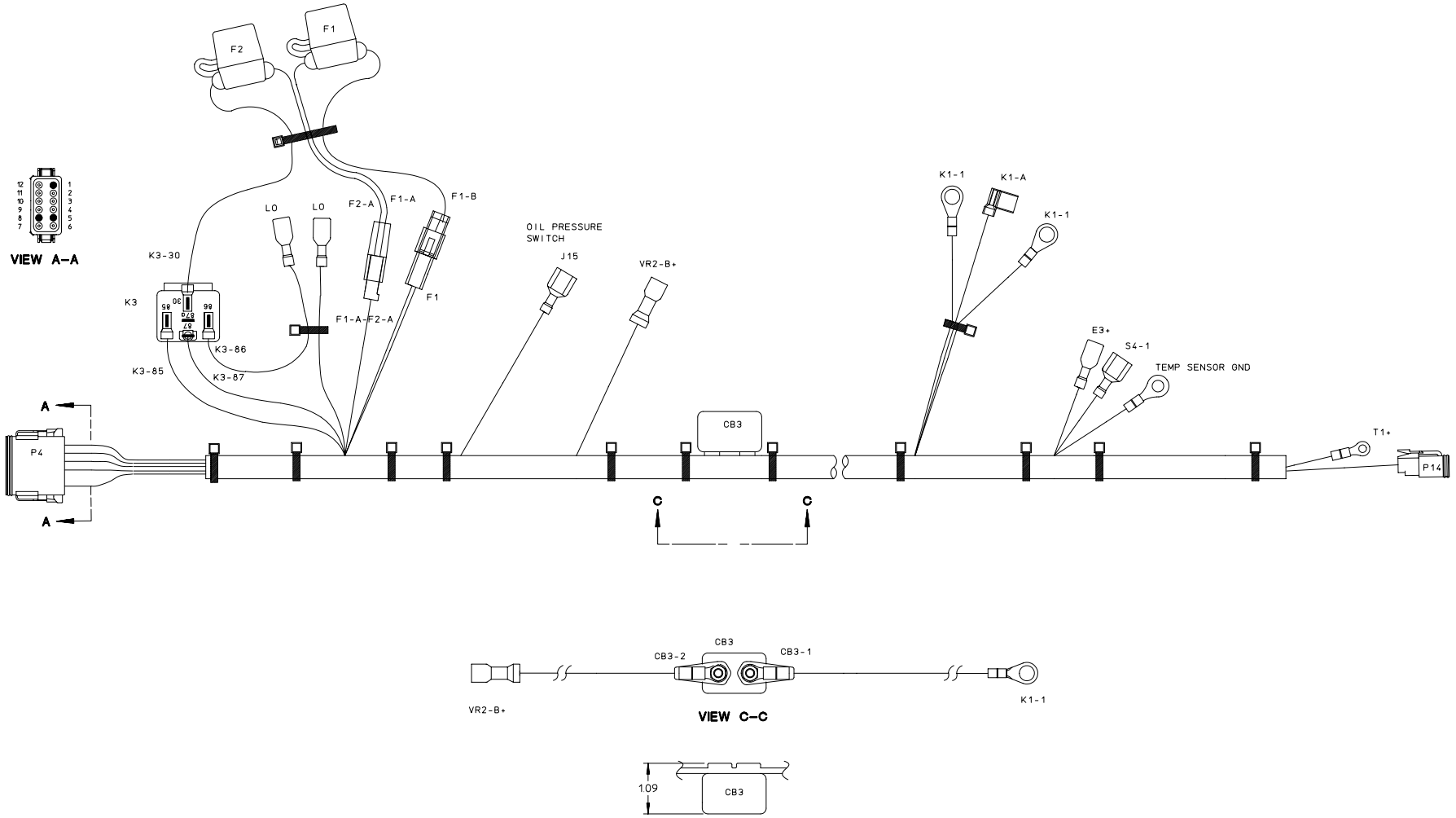
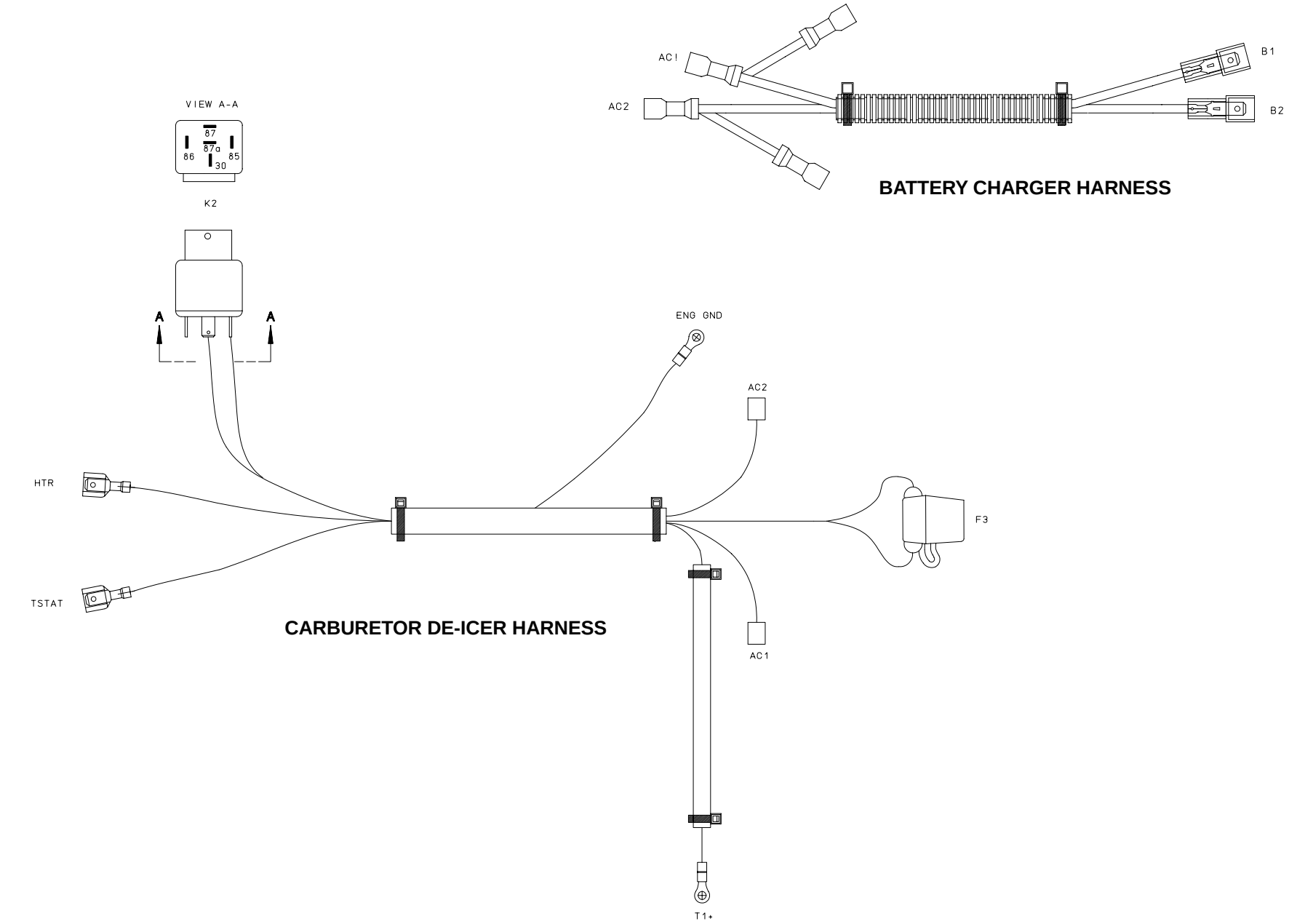


FIGURE 81. GENERATOR RECONNECTION DIAGRAMS



0338-3311

FIGURE 82. ENGINE WIRING HARNESS



0338-3600 & 0338-3431

FIGURE 83. CARBURETOR DE-ICER AND BATTERY CHARGER WIRING HARNESSES

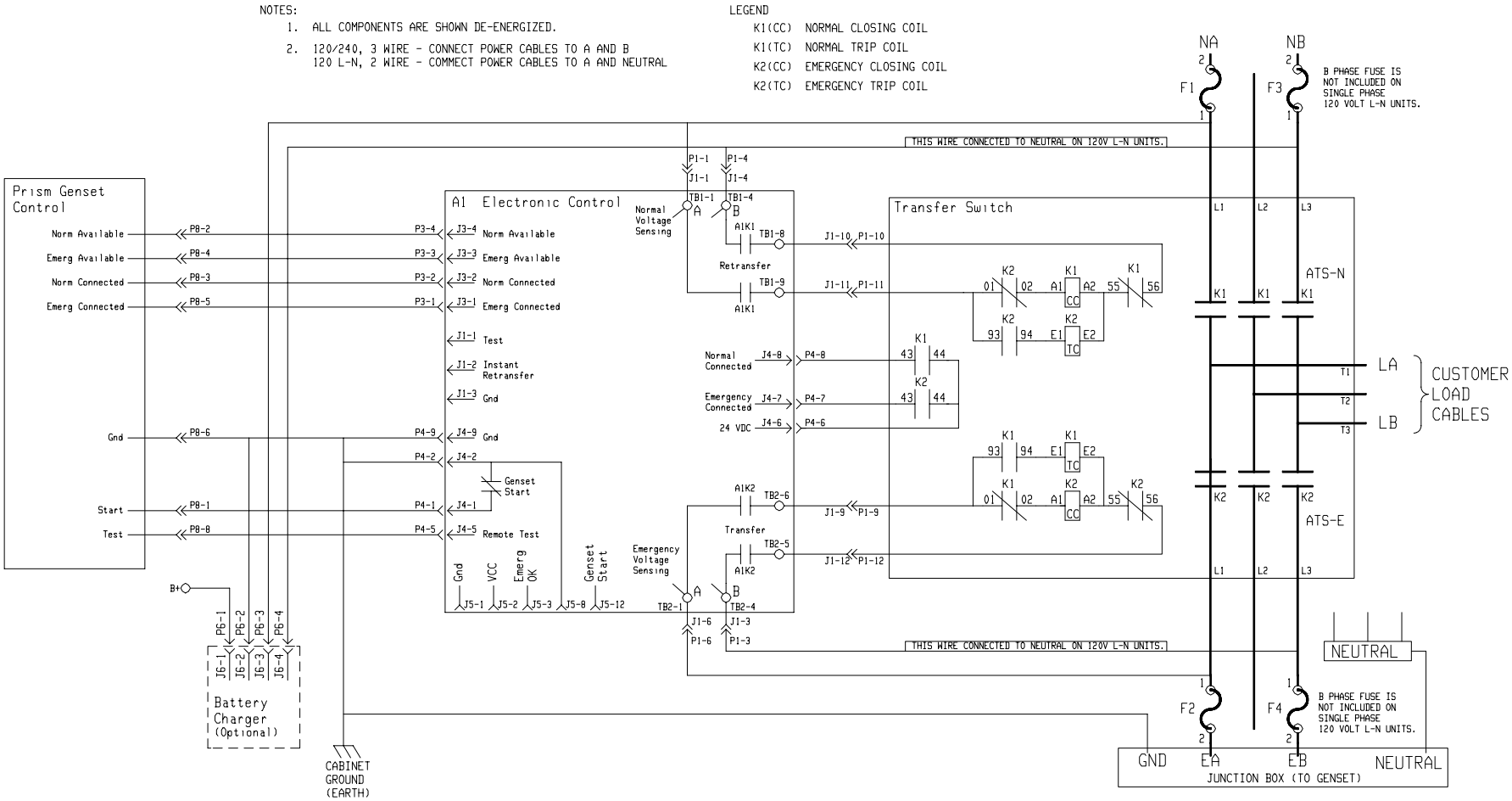
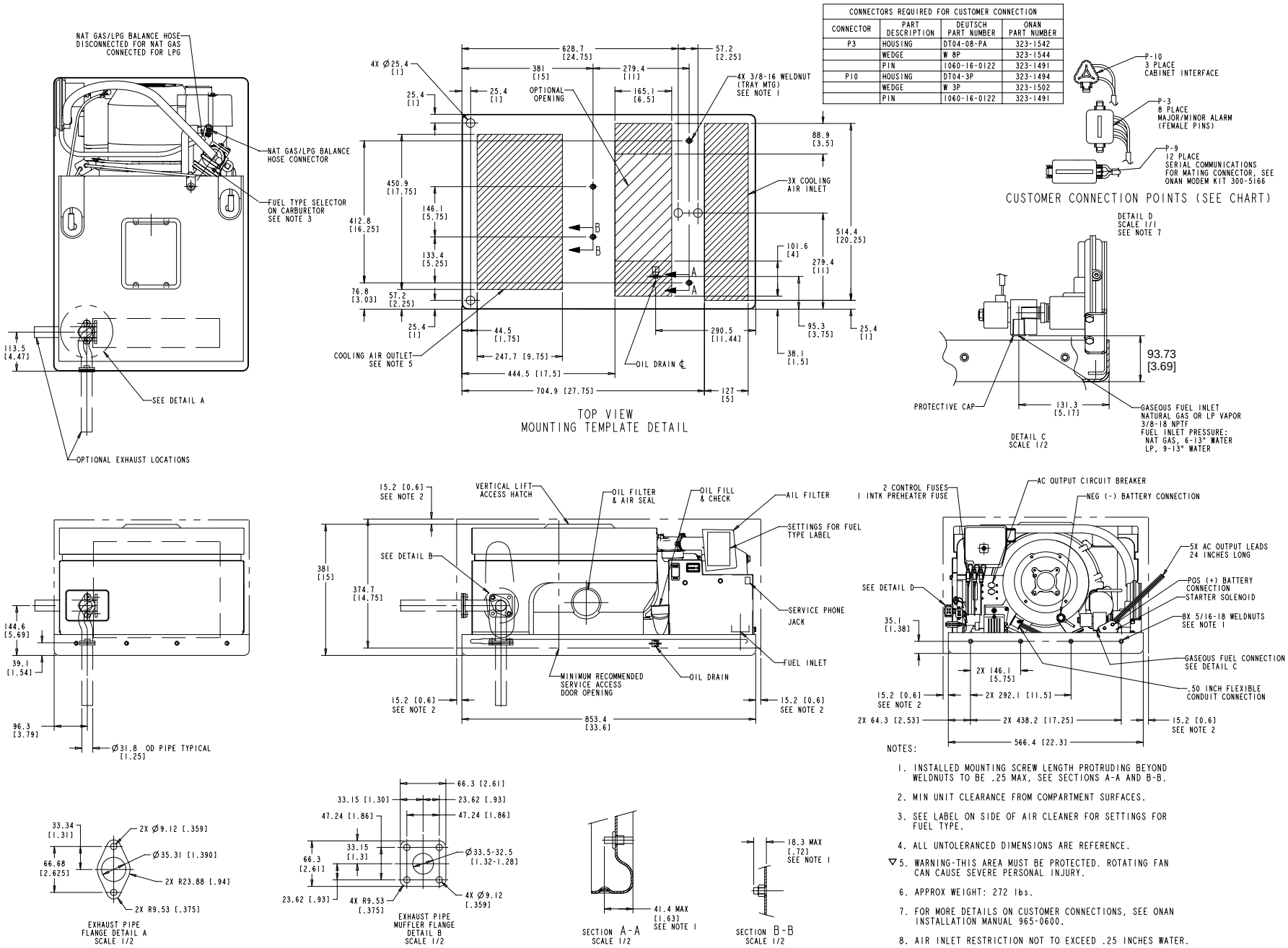


FIGURE 84. TYPICAL AUTOMATIC TRANSFER SWITCH (ATS) CONNECTIONS



NOTES:

1. INSTALLED MOUNTING SCREW LENGTH PROTRUDING BEYOND WELDNUTS TO BE .25 MAX, SEE SECTIONS A-A AND B-B.
2. MIN UNIT CLEARANCE FROM COMPARTMENT SURFACES.
3. SEE LABEL ON SIDE OF AIR CLEANER FOR SETTINGS FOR FUEL TYPE.
4. ALL UNTOLERANCED DIMENSIONS ARE REFERENCE.
5. ▽ WARNING-THIS AREA MUST BE PROTECTED. ROTATING FAN CAN CAUSE SEVERE PERSONAL INJURY.
6. APPROX WEIGHT: 272 lbs.
7. FOR MORE DETAILS ON CUSTOMER CONNECTIONS, SEE ONAN INSTALLATION MANUAL 965-0600.
8. AIR INLET RESTRICTION NOT TO EXCEED .25 INCHES WATER.

FIGURE 85. TYPICAL GENSET OUTLINE DRAWING

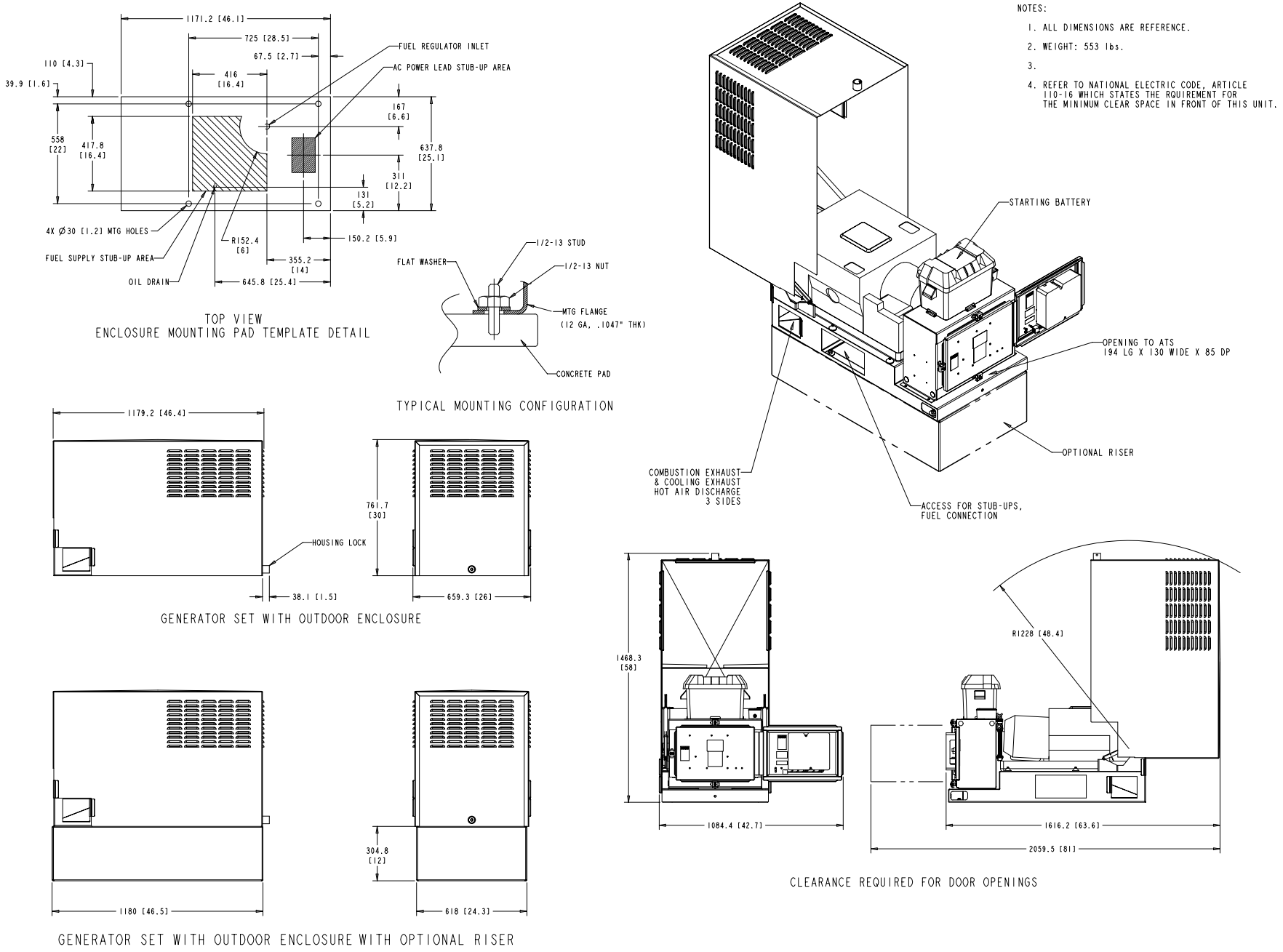


FIGURE 86. TYPICAL GENSET OUTLINE DRAWING WITH ENCLOSURE

Onan

Cummins Power Generation
1400 73rd Avenue N.E.
Minneapolis, MN 55432
763-574-5000
Fax: 763-528-7229