SAFETY

Throughout this publication, DANGER, WARNING, and CAUTION blocks are used to alert the mechanic to special instructions concerning a particular service or operation that might be hazardous if performed incorrectly or carelessly. Observe them carefully. Their definitions are as follows:

⚠️ **DANGER!**

After this heading, read instructions that, if not strictly complied with, will result in serious personal injury, including death.

⚠️ **WARNING!**

After this heading, read instructions that, if not strictly complied with, could result in serious personal injury, including death.

⚠️ **CAUTION!**

After this heading, read instructions that, if not strictly complied with, might result in minor or moderate injury.

Four commonly used safety symbols accompany the DANGER, WARNING and CAUTION blocks. The type of information each indicates follows:

⚠️ This symbol points out important safety information that, if not followed, could endanger personal safety and/or property of others.

⚠️ This symbol points out potential explosion hazard.

⚠️ This symbol points out potential fire hazard.

⚠️ This symbol points out potential electrical shock hazard.

These “Safety Alerts” alone cannot eliminate the hazards that they signal. Strict compliance with these special instructions plus “common sense” are major accident prevention measures.

READ THIS MANUAL THOROUGHLY

This SERVICE MANUAL has been written and published by Generac to aid our dealers’ technicians and company service personnel when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products manufactured and marketed by Generac, and that they have been trained in the recommended servicing procedures for these products, including the use of common hand tools and any special Generac tools or tools from other suppliers.

Generac could not possibly know of and advise the service trade of all conceivable procedures by which a service might be performed and of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or tool not recommended by Generac must first satisfy themselves that neither his nor the products safety will be endangered by the service procedure selected.

All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication.

When working on these products, remember that the electrical system and engine ignition system are capable of violent and damaging short circuits or severe electrical shocks. If you intend to perform work where electrical terminals could be grounded or touched, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings of the engine are exposed during service, they should be covered to prevent accidental entry of foreign material. Entry of such materials will result in extensive damage when the engine is started.

During any maintenance procedure, replacement fasteners must have the same measurements and strength as the fasteners that were removed. Metric bolts and nuts have numbers that indicate their strength. Customary bolts use radial lines to indicate strength while most customary nuts do not have strength markings. Mismatched or incorrect fasteners can cause damage, malfunction and possible injury.

**Note:** Special Notes appear in bold type throughout this publication. While not pertaining to safety, they emphasize procedures, circumstances or specifications that require special attention.

REPLACEMENT PARTS

When servicing this equipment, it is extremely important that all components be properly installed and tightened. If improperly installed and tightened, sparks could ignite fuel vapors from fuel system leaks.
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- Generator Identification

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- The VOM
- Measuring AC Voltage
- Measuring DC Voltage
- Measuring AC Frequency
- Measuring Current
- Measuring Resistance
- Electrical Units
- Ohm’s Law

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- Fuel Consumption
- Reconfigure the fuel system

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- User Interface
- Automatic Operation
- Manual Operation

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- Cranking conditions
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- Field Excitation
- AC Power Winding Output

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⚠️ CAUTION!

Caution: Specifications are for reference only, for actual installations always use the most recent version available online. These specifications are subject to change without notice.

<table>
<thead>
<tr>
<th>GENERATOR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>240</td>
</tr>
<tr>
<td>Rated Maximum Load Current (Amps) at 240 Volts (LP)*</td>
<td>29.2</td>
</tr>
<tr>
<td>Main Circuit Breaker</td>
<td>30 Amp</td>
</tr>
<tr>
<td>Transfer Switch Load Center Circuits** 30A, 240V</td>
<td>1</td>
</tr>
<tr>
<td>30A, 240V</td>
<td>1</td>
</tr>
<tr>
<td>20A, 120V</td>
<td>3</td>
</tr>
<tr>
<td>15A, 120V</td>
<td>3</td>
</tr>
<tr>
<td>Phase</td>
<td>1</td>
</tr>
<tr>
<td>Number of Rotor Poles</td>
<td>2</td>
</tr>
<tr>
<td>Rated AC Frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Battery Requirement</td>
<td>Group 26R, 12 Volts and 525 CCA Minimum</td>
</tr>
<tr>
<td>Weight (unit only in lbs.)</td>
<td>225</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Composite</td>
</tr>
</tbody>
</table>

Normal Operating Range: This unit is tested in accordance to UL 2200 standards with an operating temperature of -20 °F (-29 °C) to 122 °F (50 °C). For areas where temperatures fall below 32 °F (0 °C), a cold weather kit is highly recommended. When operated above 77º F (25º C) there may be a decrease in engine power. (Please reference the engine specifications section).

These generators are rated in accordance with UL2200, Safety Standard for Stationary Engine Generator Assemblies; and CSA-C22.2 No. 100-04 Standard for Motors and Generators.

* Natural Gas ratings will depend on specific fuel Btu content. Typical derates are between 10-20% off the LP gas rating.

** Circuits to be moved must be protected by same size breaker. For example, a 15 amp circuit in the main panel must be a 15 amp circuit in the transfer switch.

<table>
<thead>
<tr>
<th>ENGINE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Engine</td>
<td>OHV-432</td>
</tr>
<tr>
<td>Number of Cylinders</td>
<td>1</td>
</tr>
<tr>
<td>Rated Horsepower @ 3,600 rpm*</td>
<td>14.8</td>
</tr>
<tr>
<td>Displacement</td>
<td>432cc</td>
</tr>
<tr>
<td>Cylinder Block</td>
<td>Aluminum w/Cast Iron Sleeve</td>
</tr>
<tr>
<td>Valve Arrangement</td>
<td>Overhead Valves</td>
</tr>
<tr>
<td>Ignition System</td>
<td>Solid-state w/Magneto</td>
</tr>
<tr>
<td>Recommended Spark Plug</td>
<td>RC12YC</td>
</tr>
<tr>
<td>Spark Plug Gap</td>
<td>0.76 mm (0.030 inch)</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>8.2:1</td>
</tr>
<tr>
<td>Starter</td>
<td>12 VDC</td>
</tr>
<tr>
<td>Oil Capacity Including Filter</td>
<td>Approx. 1.1 Qts (1.0L)</td>
</tr>
<tr>
<td>Recommended Oil Filter</td>
<td>Part # 0H9039</td>
</tr>
<tr>
<td>Recommended Air Filter</td>
<td>Part # 0H6104</td>
</tr>
<tr>
<td>Operating RPM</td>
<td>3,600</td>
</tr>
</tbody>
</table>

* Engine power is subject to and limited by such factors as fuel Btu content, ambient temperature and altitude. Engine power decreases about 3.5 percent for each 1,000 feet above sea level; and also will decrease about 1 percent for each 6 C (10 F) above 16 C (60 F) ambient temperature.

Caution: Specifications are for reference only, for actual installations always use the most recent version available online. These specifications are subject to change without notice.
### FUEL CONSUMPTION

<table>
<thead>
<tr>
<th>Unit</th>
<th>Natural Gas*</th>
<th>1/2 Load</th>
<th>Full Load</th>
<th>LP Vapor**</th>
<th>1/2 Load</th>
<th>Full Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/7 kW</td>
<td>66</td>
<td>119</td>
<td>0.82/30</td>
<td>1.47/53</td>
<td>Values given are approximate.</td>
<td></td>
</tr>
</tbody>
</table>

* Natural gas is in cubic feet per hour. **LP is in gallons per hour / cubic feet per hour.
INTRODUCTION

This diagnostic repair manual has been prepared especially for familiarizing service personnel with the testing, troubleshooting and repair of the vertical home standby systems. Every effort has been expended to ensure that the information and instructions in the manual are both accurate and current. However, the manufacture reserves the right to change, alter or otherwise improve the product at any time without prior notification.

The manual has been divided into several PARTS. Each PART has been divided into SUBSECTIONS and each subsection consists of several sub headings.

It is not the manufacturer's intent to provide detailed disassembly and reassembly of the vertical home standby. It is the manufacturer's intent to (a) provide the service technician with an understanding of how the various assemblies and systems work, (b) assist the technician in finding the cause of malfunctions, and (c) effect the expeditious repair of the equipment.

PARTS

Part 1 – Provides the basic understanding of the generator as well as operating instructions for commons tasks.

Part 2 – Provides the basics of the AC alternator design and the AC troubleshooting portion of the manual.

Part 3 – Provides the troubleshooting and diagnostic testing procedure for the 50 amp transfer switch with the EZ Transfer Operator.

Part 4 – Provides the troubleshooting and diagnostic procedure for the engine related problems and the controller.


Part 6 – Illustrates all of the electrical and wiring diagrams for the generator and transfer switch.

GENERATOR IDENTIFICATION

Data Plate

The data plate that is affixed to the generator contains important information pertaining to the unit, including its model number, serial number, amperage rating, and voltage rating. The information from this data plate may be required when requesting information, ordering parts from the factory.

Item Number

Many home standby generators manufactured are to the unique specifications of the buyer. The model number identifies the specific generator set and its unique design specifications.

Serial Number

Used for warranty tracking purposes.

Figure 1. Typical Data Plate
METERS

Devices used to measure electrical properties are called meters. Meters are available that allow one to measure (a) AC voltage, (b) DC voltage, (c) AC frequency, and (d) resistance in ohms. The following apply:

- To measure AC voltage, use an AC voltmeter.
- To measure DC voltage, use a DC voltmeter.
- Use a frequency meter to measure AC frequency in “Hertz” or “cycles per second”.
- Use an ohmmeter to read circuit resistance, in “ohms”.

THE VOM

A meter that will permit both voltage and resistance to be read is the “Volt-Ohm-Milliammeter” or “VOM”.

Some VOMs are of the “analog” type (not shown). These meters display the value being measured by physically deflecting a needle across a graduated scale. The scale used must be interpreted by the user.

“Digital” VOM’s (Figure 2) are also available and are generally very accurate. Digital meters display the measured values directly by converting the values to numbers.

Note: Standard AC voltmeters react to the AVERAGE value of alternating current. When working with AC, the effective value is used. For that reason a different scale is used on an AC voltmeter. The scale is marked with the effective or “rms” value even though the meter actually reacts to the average value. That is why the AC voltmeter will give an Incorrect reading if used to measure direct current (DC).

MEASURING AC VOLTAGE

An accurate AC voltmeter or a VOM may be used to read the generator’s AC output voltage. The following guidelines apply:

1. Always read the generator’s AC output voltage at the unit’s rated operating speed and AC frequency.
2. The generator’s rated AC output voltage is 250 to 254 VAC and is not adjustable.
3. Only an AC voltmeter may be used to measure AC voltage. DO NOT USE A DC VOLTMETER FOR THIS PURPOSE.

Generators produce high and dangerous voltages. Contact with high voltage terminals will result in dangerous and possibly lethal electrical shock.

MEASURING DC VOLTAGE

A DC voltmeter or a VOM may be used to measure DC voltages. Always observe the following rules:

1. Always observe correct DC polarity.
   a. Some VOM’s may be equipped with a polarity switch.
   b. On meters that do not have a polarity switch, DC polarity must be reversed by reversing the test leads.
2. Before reading a DC voltage, always set the meter to a higher voltage scale than the anticipated reading. If in doubt, start at the highest scale and adjust the scale downward until correct readings are obtained.
3. The design of some meters is based on the “current flow” theory while others are based on the “electron flow” theory.
   a. The “current flow” theory assumes that direct current flows from the positive (+) to the negative (-).
   b. The “electron flow” theory assumes that current flows from negative (-) to positive (+).

Note: When testing generators, the “current flow” theory is applied. That is, current is assumed to flow from positive (+) to negative (-).

MEASURING AC FREQUENCY

The generator’s AC output frequency is proportional to Rotor speed. Generators equipped with a 2-pole Rotor must operate at 3600 rpm to supply a frequency of 60 Hertz. Units with 4-pole Rotors must run at 1800 rpm to deliver a 60 Hertz output.
MEASURING CURRENT

Clamp-On

To read the current flow, in AMPERES, a clamp-on ammeter may be used. This type of meter indicates current flow through a conductor by measuring the strength of the magnetic field around that conductor. The meter consists essentially of a current transformer with a split core and a rectifier type instrument connected to the secondary. The primary of the current transformer is the conductor through which the current to be measured flows. The split core allows the instrument to be clamped around the conductor without disconnecting it. Current flowing through a conductor may be measured safely and easily. A line-splitter can be used to measure current in a cord without separating the conductors.

In-Line

Alternatively, to read the current flow in AMPERES, an in-line ammeter may be used. Most Digital Volt Ohm Meters (VOM) will have the capability to measure amperes.

This usually requires the positive meter test lead to be connected to the correct amperes plug, and the meter to be set to the amperes position. Once the meter is properly set up to measure amperes the circuit being measured must be physically broken. The meter will be in-line or in series with the component being measured.

In Figure 5 the control wire to a relay has been removed. The meter is used to connect and supply voltage to the relay to energize it and measure the amperes going to it.

MEASURING RESISTANCE

The Volt-Ohm-Milliammeter may be used to measure the resistance in a circuit. Resistance values can be very valuable when testing coils or windings, such as the Stator and Rotor windings, or checking a wire for an open or grounded condition.

When testing Stator windings, keep in mind that the resistance of these windings is very low. Some meters are not capable of reading such a low resistance and will simply read CONTINUITY. If proper procedures are used, the following conditions can be detected using a VOM:

- A “short-to-ground” condition in any Stator or Rotor winding, or a short to ground on a specific control wire.
- Shorting together of any two parallel Stator windings.
- Shorting together of any two isolated Stator windings.
- An open condition in any Stator or Rotor winding, or an open in a control wire.
Component testing may require a specific resistance value or a test for INFINITY or CONTINUITY. Infinity is an OPEN condition between two electrical points, which would read as no resistance, or OL (Open Line) on a VOM. Continuity is a closed condition between two electrical points, which would be indicated as very low resistance (0.000.000) or “ZERO” on a VOM.

**ELECTRICAL UNITS**

**Ampere**

The rate of electron flow in a circuit is represented by the AMPERE. The ampere is the number of electrons flowing past a given point at a given time. One AMPERE is equal to just slightly more than 6.241x10^18 electrons per second.

With alternating current (AC), the electrons flow first in one direction, then reverse and move in the opposite direction. They will repeat this cycle at regular intervals. A wave diagram, called a “sine wave” shows that current goes from zero to maximum positive value, then reverses and goes from zero to maximum negative value. Two reversals of current flow is called a cycle. The number of cycles per second is called frequency and is usually stated in “Hertz”.

**Volt**

The VOLT is the unit used to measure electrical PRESSURE, or the difference in electrical potential that causes electrons to flow. Very few electrons will flow when voltage is weak. More electrons will flow as voltage becomes stronger. VOLTAGE may be considered to be a state of unbalance and current flow as an attempt to regain balance. One volt is the amount of Electromotive Force (EMF) that will cause a current of 1 ampere to flow through 1 ohm of resistance.

**Ohm**

The OHM is the unit of RESISTANCE. In every circuit there is a natural resistance or opposition to the flow of electrons. When an EMF is applied to a complete circuit, the electrons are forced to flow in a single direction rather than their free or orbiting pattern. The resistance of a conductor depends on (a) its physical makeup, (b) its cross-sectional area, (c) its length, and (d) its temperature. As the conductor’s temperature increases, its resistance increases in direct proportion. One (1) ohm of resistance will permit one (1) ampere of current to flow when one (1) volt of EMF is applied.

**OHM’S LAW**

A definite and exact relationship exists between VOLTS, OHMS and AMPERES. The value of one can be calculated when the value of the other two are known. Ohm’s Law states that in any circuit the current will increase when voltage increases but resistance remains the same, and current will decrease when resistance increases and voltage remains the same.

![Figure 6. Electrical Units](image)

If AMPERES is unknown while VOLTS and OHMS are known, use the following formula:

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

If VOLTS is unknown while AMPERES and OHMS are known, use the following formula:

$$\text{VOLTS} = \text{AMPERES} \times \text{OHMS}$$

If OHMS is unknown but VOLTS and AMPERES are known, use the following:

$$\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

![Figure 7. Ohm’s Law](image)
INTRODUCTION

It is the responsibility of the installer to ensure that the Generator installation was performed properly. A careful inspection must be performed when the installation is complete. All applicable codes, standards, and regulations pertaining to such installations must be strictly complied with. In addition, regulations established by the Occupational Safety and Health Administration (OSHA) must be complied with as well.

Prior to initial startup of the unit, the installer must ensure that the Generator has been properly prepared for use. This includes the following:

• An adequate supply of the correct fuel must be available for Generator operation.
• The engine must be properly serviced with the recommended oil.
• With liquid propane (LP), use only the “vapor withdrawal” system. This type of system uses the vapors formed above the liquid fuel in the storage tank.

The engine has been fitted with a fuel carburetion system that meets the specification of the 1997 California Air Resources Board for tamper-proof dual fuel systems. The unit will run on natural gas or LP, but it has been factory set and tested to run on natural gas. When the change from natural gas to LP is needed, the fuel system needs to be re-configured.

Recommended fuels should have a British Thermal Unit (BTU) content of at least 1,000 BTU’s per cubic feet for natural gas; or at least 2,520 BTU’s per cubic feet for LP. Ask the fuel supplier for the BTU content of the fuel.

Recommended fuel pressures for natural gas and liquid propane vapor (LPV) are as follows:

Note: All pipe sizing, construction and layout must comply with NFPA 54 for natural gas applications and NFPA 58 for liquid propane applications. After installation, verify that the fuel pressure NEVER drops below five (5) inches water column for natural gas or ten (10) inches water column for LPV.

Prior to installation of the Generator, the installer should consult local fuel suppliers or the fire marshal to check codes and regulations for proper installation. Local codes will mandate correct routing of gaseous fuel line piping around gardens, shrubs and other landscaping to prevent any damage.

Special considerations should be given when installing the unit where local conditions include flooding, tornados, hurricanes, earthquakes and unstable ground for the flexibility and strength of piping and their connections.

Use an approved pipe sealant or joint compound on all threaded fittings.

FUEL CONSUMPTION

<table>
<thead>
<tr>
<th>Unit</th>
<th>Natural Gas*</th>
<th>LP Vapor**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/2 Load</td>
<td>Full Load</td>
</tr>
<tr>
<td>6/7 kW</td>
<td>66</td>
<td>119</td>
</tr>
</tbody>
</table>

* Natural gas is in cubic feet per hour.
**LP is in gallons per hour/cubic feet per hour.
Values given are approximate.

Verify that gas meter is capable of providing enough fuel flow to include household appliances.

Btu Flow Requirements - Natural Gas

BTU flow required for each unit based on 1000 BTU per cubic foot.
• 6kW — 119,000 BTU/Hour (Natural Gas)

RECONFIGURE THE FUEL SYSTEM

Procedure

1. Remove the generator enclosure roof by turning the four quarter turn latches on the roof top. Push down slightly on the latch then turn 90 degrees to release. The latch should pop up as shown.

2. Remove the two side panels of the enclosure by lifting the panels straight up until they are clear.

3. Carefully place the roof and side panels to one side.

4. Locate the fuel throttle assembly mounted to the engine intake.
5. To change the fuel selection, remove the hose clamp and hose from the throttle assembly.

6. Remove the Natural Gas (Larger ID) fuel jet from the fuel inlet.

7. Obtain the fuel jet for Propane (Smaller ID that has been supplied loose with the owners manual).

8. Verify that the O-ring, supplied loose with the owners manual is installed, into the groove of the fuel jet.

9. Insert the Propane fuel jet into the end of the fuel inlet.

10. Reinstall the hose and clamp onto the fuel inlet and secure.

11. Verify the hose has not been kinked in any way.

12. The generator is now ready to run on LP Vapor fuel.

Figure 10.

Figure 11.
CONTROL PANEL

WARNING! With the switch set to AUTO, the engine may crank and start at any time without warning. Such automatic starting occurs when Utility power source voltage drops below a preset level or during the normal exercise cycle. To prevent possible injury that might be caused by such sudden starts, always set the switch to the OFF position and remove the fuse before working on or around the Generator or transfer switch. Then, place a “DO NOT OPERATE” tag on the Generator panel and on the transfer switch.

AUTO-OFF-MANUAL

AUTO – Selecting this switch activates fully automatic system operation. It also allows the unit to automatically start and exercise the engine every seven days at the time chosen by the user.

OFF – This switch position shuts down the engine. This position also prevents automatic operation.

MANUAL – Setting the switch to the MANUAL position will crank and start the engine. Transfer to standby power will not occur unless there is a failure of Utility.

7.5 Amp Fuse

This fuse protects the controller as well as the DC components against overload. If the fuse element has melted open due to an overload, engine cranking and or running will not be possible. Should a fuse replacement become necessary, use only an identical 7.5 amp replacement fuse.

USER INTERFACE

The generator is equipped with an internal exercise timer. Once set, the Generator will start and exercise every seven days, on the day of the week and the time of day specified. During this exercise period, the unit runs for approximately 12 minutes and then shuts down. Transfer of loads to the Generator output does not occur during the exercise cycle unless Utility is lost. Refer to “Setting the exercise time” in Section 1.4.

Note: The exercise will only work with the AUTO-OFF-MANUAL switch in the AUTO position.

AUTOMATIC OPERATION

WARNING!

CAUTION! The Generators Voltage and Frequency must be verified with the Generator Main Line Circuit Breaker (MLCB) OFF or OPEN Prior to selecting Automatic or Manual operation!

To select automatic operation

The following procedure applies only to those installations which utilize an air-cooled generator in conjunction with a transfer switch. Residential transfer switches do not have intelligent circuits of their own. Printed circuit board logic in the controller controls the automatic operation of the transfer switch and the generator.

To select automatic operation when a transfer switch is installed along with a home standby generator, the procedure is as follows.

1. Ensure that the transfer mechanism in the transfer switch is in the “Utility” position. If needed, turn OFF or OPEN the Utility source Main Line Circuit Breaker and manually transfer the breaker to the “Utility” position.

2. CLOSE or turn ON the Utility source Main Line Circuit Breaker and ensure Utility voltage is available to the UTILITY terminals N1 and N2.

3. Actuate the Generator main line circuit breaker (MLCB) to its “Closed” position.

4. Set the Generators AUTO-OFF-MANUAL switch to the AUTO position.

Following the procedure of Steps 1 through 4, a dropout of Utility voltage below a preset level will result in automatic Generator cranking and start-up. Following startup, the transfer switch will actuate to the “Standby” position.

MANUAL OPERATION

Transfer to “Standby” and Manual Startup

To transfer electrical loads to the Generator and to start the generator manually, the procedure is as follows:

1. On the generator, set the AUTO-OFF-MANUAL switch to the OFF position.

2. On the generator, set the main line circuit breaker (MLCB) to the “Open” position.

3. Locate a means of Utility disconnect and set it to the OFF position.

4. Manually actuate the breaker to the “Standby” position in the transfer switch.

5. On the generator, set the AUTO-OFF-MANUAL switch to the MANUAL position.

6. Let the engine warm up and stabilize for a minute or two at no-load. Set the generators MLCB to the “Closed” position. Generator voltage should now be available to the transferred electrical loads.
Re-transfer Back to “Utility” and Manual Shutdown

To shutdown the generator and re-transfer electrical loads back to the “Utility” position, the procedure is as follows:

1. Set the generators MLCB to its OPEN position.
2. Allow the generator to run at no-load for several minutes to cool down.
3. Set the generators AUTO-OFF-MANUAL switch to the OFF position.
4. Locate a means of Utility disconnect and set it to the OFF position.
5. Manually actuate the breaker in the transfer switch to the “Utility” position.
6. Restore Utility voltage to the transfer switch, by the means that was utilized in Step 4.
7. Set the generator’s AUTO-OFF-MANUAL switch to the AUTO position.

With the generator in AUTO, a dropout in Utility voltage below a preset level will result in automatic generator cranking and start-up. Following startup, the transfer switch will actuate to the “Standby” position.
INTRODUCTION

When the generator is installed in conjunction with a transfer switch, either manual or automatic operation is possible.

UTILITY FAILURE

Initial Conditions

The generator is in AUTO, ready to run, and the transfer switch is running on Utility. When Utility fails (below 65% of nominal), a 10 second line interrupt delay time is started. If the Utility is still not present when the timer expires, the engine will crank and start. Once started a five (5) second engine warm-up timer will start.

When the warm-up timer expires the controller will transfer load to the generator. If Utility voltage is restored (above 75% of nominal) at any time between the initiation of the engine start and when the generator is ready to accept load, (five second warm-up time has not elapsed), the controller will complete the start cycle and run the generator through its normal cool down cycle; however the switch will remain in the “Utility” position.

CRANKING

The controller will cyclic crank the engine 5 times as follows:
16 second crank, 7 second rest, 16 second crank, 7 second rest, followed by 3 additional cycles of 7 second crank followed by 7 second rests.

Failure To Start

Failure to start is defined as any of the following occurrences during cranking.

1. Not reaching starter dropout within the specified crank cycle.

Note: Starter dropout is defined as 4 cycles at 1,000 RPM

2. Reaching starter dropout, but not reaching 2200 rpm within 15 seconds. After which the controller will go into a rest cycle of 7 seconds, the continue the rest of the crank cycle.

Note: During a rest cycle the start and fuel outputs are de-energized and the magneto output is shorted to ground.

CRANKING CONDITIONS

The following notes apply during the crank cycle

1. Starter motor will not engage within 5 seconds of the engine shutting down.
2. The fuel output will not be energized with the starter
3. The starter and magneto outputs will be energized together.
4. Once the starter energizes, the controller will begin looking for engine rotation. If it does not see an RPM signal within 3 seconds it will shut down and latch out on “RPM Sensor loss”

LOAD TRANSFER PARAMETERS

The transfer of load when the generator is running is dependent upon the operating mode as follows:

Manual

• No transfer to Standby when Utility is present
• Transfer to Standby will occur if Utility fails (below 65% of nominal) for 10 consecutive seconds.
• Transfer back to Utility when Utility returns for 15 consecutive seconds. The engine will continue to run until removed from the Manual mode.

Auto

• Transfer to standby will occur if Utility fails below (65% of nominal) for 10 consecutive seconds.
• A five second engine warm-up timer will initialize
• Transfer back to the “Utility” position if Utility subsequently returns
• Transfer to the “Standby” position if Utility is still not present.
• Transfer back to Utility once Utility returns (above 75% of nominal) for 15 seconds.
• Transfer back to Utility, if present, if the generator is shut down for any reason (such as the switch turned to the OFF position or a shutdown alarm.)
Exercise

- Exercise will not function if the generator is already running in either AUTO or MANUAL mode.
- During exercise, the controller will only transfer if Utility fails during exercise for 10 seconds, and will follow the steps outline above for AUTO operation.

Utility Restored

The generator is running, switch is in the “Standby” position, running in Utility failure. When the Utility returns (above 75% of nominal), a 15 second return to Utility timer will start. At the completion of this timer, if the Utility supply is still present and acceptable, the controller will transfer the load back to the Utility and run the engine through a one minute cool down period and then shutdown. If Utility fails for three seconds during this cool down period, the controller will transfer load back to the generator and continue to run while monitoring for Utility to return.
INTRODUCTION
Performing proper maintenance on a Generator will ensure proper function during a Utility failure. Once a Generator has failed, it is already too late. Ensuring the proper oil changes and inspections have been completed at the specified times will help keep the Generator reliable.

ENGINE OIL
Modern oils play vital functions in protecting the engine. Lubricating oil acts to reduce friction and wear, cool engine parts, seal combustion chambers, clean engine components, and inhibit corrosion. See Table 1 “Service Schedule” for specific inspection items and interval.

ENGINE OIL RECOMMENDATIONS
All oil should meet minimum American Petroleum Institute (API) Service Class SJ, SL or better. Do not use special additives. Select the oil’s viscosity grade according to the expected operating temperature.

<table>
<thead>
<tr>
<th>SAE Grade</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Above 32º F</td>
</tr>
<tr>
<td>10W-30</td>
<td>Between 40ºF and -10ºF</td>
</tr>
<tr>
<td>Synthetic 5W-30</td>
<td>10ºF and below</td>
</tr>
</tbody>
</table>

AIR FILTER
Air is necessary for successful combustion in the engine. Clean air (almost 100% pure) is critical to engine survival and vital to its performance. There are operational signs when an air filter has become completely plugged. The engine begins to lose power, and fuel consumption increases. Black smoke may blow from the exhaust. Continued operation with a plugged air filter may cause severe damage to the engine.

SPARK PLUGS
Good spark is essential to properly maintaining the engine. Although replacement may not be required, inspection of the plugs during routine maintenance is critical. Always verify that spark plugs are gapped according to the specifications. Improperly gaped spark plugs will effect the operation of the engine.

See Test 65 for diagnosing spark plug related problems. See “Specifications” for specific spark plug gaps.

VISUAL INSPECTION
During all service intervals, a proper visual inspection must be conducted to ensure proper function, airflow, and to prevent fire hazards.

Air inlet and outlet openings in the Generator compartment must be open and unobstructed for continued proper operation. This includes such obstructions as high grass, weeds, brush, leaves, and snow.

CORROSION PROTECTION
Spray engine linkages with a light oil such as WD-40.

CAUTION! Do not spray flammable oils on a hot or running engine.

VALVE CLEARANCE
Proper valve clearance is vital to ensuring longevity of the engine. After the first 6 months of operation, check the engine valve clearance and adjust as necessary. Checking of the engine valve clearance thereafter periodically will increase reliability of the Generator. Refer to Test 70 for Specification and adjustment procedure.

Some symptoms of an engine with valves in need of adjustment are:
- Hard starting
- Smoke out of the exhaust
- Rough running
- Lack of horse power
**BATTERY**

Performing proper battery maintenance at the required intervals will allow for proper starting of the Generator during a power outage. Some common things to look for and check during maintenance are:

- Inspect the battery posts and cables for tightness and corrosion. Tighten and clean as necessary.
- Check the battery fluid level of unsealed batteries and, if necessary, fill with Distilled Water only. Do not use tap water in batteries.
- Have the state of charge and conditions checked. This should be done with an automotive-type battery hydrometer.

*Note: See Test 56 for further testing the state of a battery.*

---

**Table 1. Service Schedule**

<table>
<thead>
<tr>
<th>SYSTEM/COMPONENT</th>
<th>PROCEDURE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel lines and connections*</td>
<td>X</td>
<td>M</td>
</tr>
<tr>
<td>LUBRICATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil level</td>
<td>X</td>
<td>M or 24 hours of continuous operation.</td>
</tr>
<tr>
<td>Oil</td>
<td>X</td>
<td>1Y or 100 hours of operation.**</td>
</tr>
<tr>
<td>Oil filter</td>
<td>X</td>
<td>1Y or 100 hours of operation.**</td>
</tr>
<tr>
<td>COOLING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure louvers</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BATTERY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remove corrosion, ensure dryness</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Clean and tighten battery terminals</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Check charge state</td>
<td>X</td>
<td>R</td>
</tr>
<tr>
<td>Electrolyte level</td>
<td>X</td>
<td>R</td>
</tr>
<tr>
<td>ENGINE AND MOUNTING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air cleaner</td>
<td>X</td>
<td>R</td>
</tr>
<tr>
<td>Spark plug</td>
<td>X</td>
<td>R</td>
</tr>
<tr>
<td>GENERAL CONDITION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration, Noise, Leakage, Temperature*</td>
<td>X</td>
<td>M</td>
</tr>
<tr>
<td>COMPLETE TUNE-UP*</td>
<td>TO BE COMPLETED BY A DEALER</td>
<td>1Y or 200 hours</td>
</tr>
</tbody>
</table>

* Contact the nearest dealer for assistance if necessary.

** Change oil and filter after first eight (8) hours of operation and then every 100 hours thereafter, or 1 year, whichever occurs first. Change sooner when operating under a heavy load or in a dusty or dirty environment or in high ambient temperatures.
INTRODUCTION

This section familiarizes the service technician with the manufacturer recommended procedures for the testing and evaluation of various problems that can occur on the standby generators. It is highly recommended that you read these introductory tips before you attempt to troubleshoot any of the three main generator components: AC Generator, Engine, or the Transfer Switch. The Troubleshooting Flow Charts provide the simplest, quickest, systematic means to troubleshoot the typical problems that might occur during the lifetime of the unit. If you use the flow charts and perform the indicated tests, you will be able to identify the faulty component, which can then be repaired or replaced as necessary.

The test procedures in each section do require a basic knowledge of electricity and electrical safety, hand tool skills, and use of Volt-Ohm-Meters.

RECOMMENDED TOOLS

In addition to the normal hand tools required, some test procedures may require the use of specialized test equipment. At a minimum you must have a meter that measures AC voltage and frequency, and DC voltage and current (digital multi meters (DMM) are recommended); standard meter test leads, a set of piercing probe leads, and a set of pin probe leads for the connector pins. The manufacturer carries a set of acceptable piercing probes (PN 0G7172), or other suppliers piercing probes may be used. Fluke provides a high quality piercing probe, PN AC89, which is highly recommended. The manufacturer also carries a set of flexible pin leads for use with the connector plugs (PN 0J09460SRV).

TROUBLESHOOTING REMINDERS AND TIPS

The most important step in troubleshooting is identifying the actual problem.

The next step is to determine the applicable flow chart to use to help diagnose the problem. Use the flow chart index for the part of the generator you are working with. If it is problem with voltage, use Part 2 – AC Generators; for engine problems use Part 4 – Engine/DC Control; for a problem with the transfer switch, use Part 3 – Transfer Switch. The index for each will help you clarify the problem and the flow chart to use. In each flow chart start at the top and use the test indicated to verify whether a component or control item is working properly or not. At the end of each test follow the “good” or “bad” arrows and perform the next test.

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating a problem, these questions may help identify the problem quicker.

• What is it doing? (low voltage; not cranking; not transferring; etc)
• What should it do? (run and start; transfer; shutdown; etc)
• Does the same thing happen each time?
• When is it happening?
• What could or would cause this?
• What type of test will either prove or disprove the cause of the fault?

CONNECTORS

A number of the tests require the use of a volt-meter and a set of wire piercing probes. When using the piercing probes make sure you use some liquid tape or silicon to coat the insulation where you pierced it; this will keep moisture out and prevent long term corrosion.

It is very easy to damage the female pins in the connectors on the control panel and the C1 connector (Molex connector) which goes to the alternator can.

DO NOT ATTEMPT TO PUSH PROBE TIPS INTO THE FEMALE PINS OF THE MOLEX CONNECTORS; doing so will damage the female pin which will create another problem. Use the piercing probes on the correct wire to check for the appropriate voltages; or use the flexible pin leads, available from the manufacturer (PN 0J09460SRV) to work with the connector plugs.
# PART 2
## AC GENERATORS

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  - Test 16 – Check Voltage and Frequency Under Load ................................. 36
INTRODUCTION

The alternator contained within the generator is a revolving field (rotor) type with a stationary armature (stator), and excitation to the field provided through brushes and slip rings (direct excitation). The generator may be used to supply electrical power for the operation of the 120 and/or 240 VAC, 1-phase, 60 Hz, AC loads.

ENGINE-GENERATOR DRIVE SYSTEM

The air-cooled engine is directly coupled to the rotor internally. Both the engine and the rotor operate at 3600 rpm to provide a 60 Hz AC output.

ALTERNATOR ASSEMBLY

The standard alternator consists of three basic components; a rotor, stator, and brush assembly. The rotor assembly provides the magnetic field which will induce a voltage into the stator assembly. The brush assembly provides the electrical connection to the rotor, which allows for excitation voltage and current to create the needed magnetic field.

Rotor

Operating the 2-pole rotor at 3600 rpm will supply 60 Hz AC. The term “2-pole” means the rotor has a single north and a single south magnetic pole. Held in place with a single through bolt, the tapered rotor shaft mounts to the tapered crankshaft of the engine. As the rotor rotates its lines of magnetic flux cut across the stator windings and induce a voltage into the stator windings. The rotor shaft has a positive and negative slip ring, with the positive slip ring nearest the lower bearing carrier. The bearing is pressed onto the end of the rotor shaft.

Stator

The stator houses a dual power winding and an excitation winding. Coming from the stator there are eight stator leads as shown in Figure 15.

An adapter molded into the engine block and a rear-bearing carrier support the stator can. Four stator bolts connect the rear bearing carrier and the stator can to the engine.

BRUSH HOLDER AND BRUSHES

Attached to the lower bearing carrier, the brush holder and brushes allow for electrical connection to the rotor. Positive and negative brushes are retained in the brush holder, with the positive brush riding on the slip ring nearest the rotor bearing. The Red wire connects to the positive brush and the Black Wire to the negative brush. The rotor windings receive rectified and regulated field excitation voltage (DC) through the Red and Black Wires. The current flow creates a magnetic field around the rotor having a flux concentration that is proportional to the amount of current flow on the Red and Black Wires.

Figure 14. Rotor

Figure 15. Stator Leads

Figure 16. Brush Holder and Brushes
OTHER AC GENERATOR COMPONENTS

Located within the generator control panel enclosure are the voltage regulator and the main line circuit breaker.

Voltage Regulator

Unregulated AC output from the stator excitation winding is delivered to the regulator’s DPE circuit through the two Blue wires and C1-1 and C1-2. The voltage regulator rectifies that voltage and, based on stator AC power winding sensing, regulates it. The rectified and regulated field excitation current is then delivered to the rotor windings from the positive (+) Red Wire and negative (-) Black Wire (originates as White Wire from regulator and changes to Black at the C1 connector). Stator AC power winding “sensing” is delivered to the regulator through the Green and White Wires.

Main Line Circuit Breaker

The main line circuit breaker protects the generator against electrical overload. Refer to “Specifications” section for the specific amperage ratings.

![Diagram of Main Line Circuit Breaker](image-url)

*Figure 17. Main Line Circuit Breaker*
Section 2.2
Operational Analysis

**STARTUP**
When the engine is started, permanent magnets embedded in the rotor induce a voltage into (a) the stator AC power windings, (b) the stator excitation or DPE windings. In an “on-speed” (engine cranking) condition, this magnetism is capable of creating approximately one to three volts AC.

**ON-SPEED OPERATION**
As the engine accelerates, the voltage that is induced into the stator windings increases rapidly, due to the increasing speed at which the rotor operates.

**FIELD EXCITATION**
An AC voltage is induced into the stator excitation (DPE) windings. The DPE winding circuit is delivered to the voltage regulator through the two Blue Wires and C1-1 and C1-2. Unregulated alternating current flows from the winding to the regulator. The voltage regulator “senses” AC power winding output voltage and frequency through the Green and White Wires.

The regulator changes the AC from the excitation winding to DC Field Excitation. In addition, based on the AC sensing wires, it regulates the flow of direct current to the rotor. The rectified and regulated current flow from the regulator is delivered to the rotor windings through the (+) Red Wire and the positive brush and slip ring. This excitation voltage flows through the rotor windings and through the negative (-) slip ring and brush on the negative (-) Black Wire.

The greater the current flow through the rotor windings, the more concentrated the lines of flux around the rotor become. The more concentrated the lines of flux around the rotor that cut across the stationary stator windings, the greater the voltage that is induced into the stator windings.

Initially, the AC power winding voltage sensed by the regulator is low. The regulator reacts by increasing the flow of field excitation voltage to the rotor until voltage increases to a desired level. The regulator then maintains the desired voltage. For example, if voltage exceeds the desired level, the regulator will decrease the flow of field excitation voltage. Conversely, if voltage drops below the desired level, the regulator responds by increasing the flow of excitation current.

**AC POWER WINDING OUTPUT**
A regulated voltage is induced into the stator AC power windings. When electrical loads are connected across the AC power windings to complete the circuit, current can flow in the circuit.

![Figure 18. Operating Diagram](image-url)
INTRODUCTION
Use the “Flow Charts” in conjunction with the detailed instructions in Section 2.4. Test numbers used in the flow charts correspond to the numbered tests in Section 2.4. The first step in using the flow charts is to identify the correct problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

Problem 1 – Generator Produces Zero Voltage or Residual Voltage

TEST 1 – CHECK MAIN CIRCUIT BREAKER
ON
RESET TO "ON" OR REPLACE IF BAD
REPLACE VOLTAGE REGULATOR
GOOD
BAD
PERFORM INSULATION RESISTANCE TEST
REPLACE STATOR ONLY
BAD
GOOD
TEST 2 – TEST STATOR
BAD
GOOD
TEST 4 – PERFORM FIXED EXCITATION / ROTOR AMP DRAW
TEST 6 – RESISTANCE CHECK OF ROTOR CIRCUIT
BAD
GOOD
TEST 7 – CHECK BRUSHES & SLIP RINGS
GOOD
REPLACE ROTOR ONLY
GOOD
TEST 9 – TEST STATOR
BAD
GOOD
TEST 10 – TEST ROTOR ASSEMBLY
BAD
GOOD
PERFORM INSULATION RESISTANCE TEST
REPLACE ROTOR AND STATOR
CHECK VOM FUSES
REPAIR OR REPLACE FUSES
GOOD
Problem 1 – Generator Produces Zero Voltage or Residual Voltage (Continued)

Problem 2 – Generator Produces Low Voltage at No-Load
Problem 3 – Generator Produces High Voltage at No-Load

1. Test 11 – Check AC Output Voltage
   - High
   - VOLTAGE AND FREQUENCY O.K.
   - STOP TESTS

2. Test 12 – Check AC Output Frequency
   - Frequency O.K., BUT VOLTAGE HIGH
   - Test 14 – Adjust Voltage Regulator
   - Frequency O.K., BUT VOLTAGE IS STILL HIGH
   - REPLACE DEFECTIVE VOLTAGE REGULATOR

3. Frequency O.K., BUT VOLTAGE HIGH
   - Test 13 – Adjust Engine Governor
   - Frequency O.K., BUT VOLTAGE HIGH
   - STOP TESTS

Problem 4 - Voltage and Frequency Drop Excessively When Loads Are Applied

1. Test 16 – Check Voltage and Frequency Under Load
   - Both Low
   - GOOD
     - DISCONTINUE TESTING

2. Test 15 – Check for Overload Condition
   - Overloaded
     - REDUCE LOADS TO UNIT’S RATED CAPACITY
   - Test 9 – Check Stator AC Power Windings
     - GOOD
       - TEST 9 – CHECK STATOR AC POWER WINDINGS
       - BAD
         - REPAIR OR REPLACE

   - Not Overloaded
     - GOOD
       - TEST 13 – CHECK AND ADJUST ENGINE GOVERNOR
       - GOOD
         - ENGINE CONDITION GOOD
         - LOOK FOR A SHORTED CONDITION IN A CONNECTED LOAD OR IN ONE OF THE LOAD CIRCUITS

   - BOTH LOW
     - GOOD
       - DISCONTINUE TESTING
**INTRODUCTION**

This section familiarizes the service technician with acceptable procedure for the testing and evaluation of various problems that can occur on the standby generators with air-cooled engines. Use this section in conjunction with Section 2.3, “Troubleshooting Flow Charts.” The numbered tests in this section correspond with those of Section 2.3.

Some test procedures in this section may require the use of specialized test equipment, meters or tools. Most tests can be performed with an inexpensive Volt-Ohm-Milliammeter (VOM). An AC frequency meter is required where frequency readings must be taken. To measure AC loads it is acceptable to use a clamp-on ammeter.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the products safety.

**SAFETY**

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

**AC TROUBLESHOOTING**

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem asking some of these questions may help identify the problem quicker.

- What is the generator supposed to do?
- What fault (Alarm) is shutting the generator down?
- Is the fault a symptom of another problem?
- Does the generator have the same fault consistently?
- When does the fault occur?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

**TEST 1 – CHECK MAIN CIRCUIT BREAKER**

**Discussion**

Often the most obvious cause of a problem is overlooked. If the generator main line circuit breaker is set to OFF or “Open”, no electrical power will be supplied to electrical loads. If loads are not receiving power, perhaps the main circuit breaker is open or has failed.

**Procedure**

The generator main circuit breaker is located in the external customer connection box. If loads are not receiving power, make sure the breaker is set to “On” or “Closed”.

If you suspect the breaker may have failed, it can be tested as follows (see Figure 19):

1. Set a Volt-Ohm-Milliammeter (VOM) to its “R x 1” scale and zero the meter.
2. With the generator shut down, disconnect all wires from the main circuit breaker terminals, to prevent interaction.
3. With the generator shut down, connect one VOM test probe to the Blue Wire 11 terminal of the breaker and the other test probe to the Wire E1 terminal.
4. Set the breaker to its “On” or “Closed” position. The VOM should read CONTINUITY.
5. Set the breaker to its OFF or “Open” position and the VOM should indicate INFINITY.
6. Repeat Steps 4 and 5 with the VOM test probes connected across the breaker’s Black Wire terminal and the E2 terminal.

**Results**

1. If the circuit breaker tests good, refer back to flow chart.
2. If the breaker tests bad, it should be replaced.

![Figure 19. Generator Main Circuit Breaker Test Points](image)

**TEST 4 – FIXED EXCITATION / ROTOR AMP DRAW TEST**

**Discussion**

Supplying a fixed DC current to the rotor will induce a magnetic field in the rotor. With the generator running, this should create a proportional voltage output from the stator windings.
Procedure

1. Locate and disconnect the Red Wire and the Black Wire from the voltage regulator.
2. Set a Volt-Ohm-Meter (VOM) to measure resistance.
3. Connect one meter test lead to the Red brush wire and connect the other meter test lead to the Black brush wire. Measure and record the resistance.
4. Set VOM to measure DC voltage.
5. Connect one meter test lead to the positive post of the battery and the other meter test lead to the negative post of the battery. Measure and record the voltage indicated.
6. Using a jumper wire similar to Figure 20, connect a jumper wire to the disconnected female connector Red Wire and the positive post of the battery.
7. Using a jumper wire similar to Figure 20, connect a jumper wire to the disconnected female connector Black Wire and the negative post of the battery.
8. Disconnect the C1 connector from the voltage regulator.
9. Set a VOM to measure AC voltage.
10. Connect meter test leads across C1 Terminals Points 1 (Blue Wire) and 2 (Blue Wire). Refer to Figure 21
11. Set the AUTO-OFF-MANUAL switch to the MANUAL position.
12. Once the engine reaches rated speed, measure and record the voltage.
13. Set the AUTO-OFF-MANUAL switch to the OFF position.
14. Connect meter test leads across points 3 (Green Wire) and 4 (White Wire). Refer to Figure 21
15. Set the AUTO-OFF-MANUAL switch to the MANUAL position.
16. Once the engine reaches rated speed, measure and record the voltage.
17. Set the AUTO-OFF-MANUAL switch to the OFF position.

Results:

<table>
<thead>
<tr>
<th>Results:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue and Blue</td>
<td>Above 20 VAC</td>
<td>Above 20 VAC</td>
<td>Below 50 VAC</td>
<td>Zero or Residual Volts</td>
<td>Below 20 VAC</td>
<td>Below 50 VAC</td>
<td>Above 20 VAC</td>
<td>Below 20 VAC</td>
</tr>
<tr>
<td>White and Green</td>
<td>Above 20 VAC</td>
<td>Below 20 VAC</td>
<td>Above 50 VAC</td>
<td>Zero or Residual Volts</td>
<td>Below 20 VAC</td>
<td>Below 50 VAC</td>
<td>Above 20 VAC</td>
<td>Below 20 VAC</td>
</tr>
<tr>
<td>Static Rotor Amp Draw</td>
<td>0.22 - 0.46</td>
<td>0.22 - 0.46</td>
<td>0.22 - 0.46</td>
<td>Zero Current Draw</td>
<td>Above 1 Amp</td>
<td>0.22 - 0.46</td>
<td>Zero Current Draw</td>
<td>0.22 - 0.46</td>
</tr>
<tr>
<td>Running Rotor Amp Draw</td>
<td>0.22 - 0.46</td>
<td>0.22 - 0.46</td>
<td>0.22 - 0.46</td>
<td>Zero Current Draw</td>
<td>Above 1 Amp</td>
<td>0.22 - 0.46</td>
<td>Zero Current Draw</td>
<td>Above 1 Amp</td>
</tr>
</tbody>
</table>

Note: Actual values measured may vary by as much as .5 amps, depending on the type and quality of meter used, the condition of the unit, and how good the connection is between the test leads and test points.

MATCH RESULTS WITH LETTER AND REFER TO FLOW CHART IN SECTION 2.3 “Problem 1”
Section 2.4
Diagnostic Tests

21. Set the AUTO-OFF-MANUAL switch to the MANUAL position.

22. Measure and record the running DC amperage.

23. Set the AUTO-OFF-MANUAL switch to the OFF position and reconnect the wires to the voltage regulator.

Table 3. Test 4 Results Worksheet

<table>
<thead>
<tr>
<th>Test Point</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor Resistance</td>
<td>Ohms</td>
</tr>
<tr>
<td>Battery Voltage</td>
<td>VDC</td>
</tr>
<tr>
<td>Blue to Blue Voltage</td>
<td>VAC</td>
</tr>
<tr>
<td>White and Blue Voltage</td>
<td>VAC</td>
</tr>
<tr>
<td>Static Rotor Amp Draw</td>
<td>Amps</td>
</tr>
<tr>
<td>Running Rotor Amp Draw</td>
<td>Amps</td>
</tr>
</tbody>
</table>

Results

1. Using the values recorded in the above procedures, compare the results to Table 2 "Test 4 Results – Fixed Excitation Test". Determine the appropriate lettered column to use and refer back to the flow chart. The rotor amp draws are a calculated amp draw and actual amperage readings may vary depending on the resistance of the rotor and battery voltage.

Note: To calculate rotor amp draw take the battery voltage applied, divided by the actual resistance reading of the rotor. Rotor resistance can be measured between the RED and BLACK wires going to the voltage regulator.

12.9VDC
50 Ohms x 0.258 DC Amps

TEST 6 – RESISTANCE CHECK OF ROTOR CIRCUIT

Procedure

1. Locate and disconnect the Red and Black wires from the voltage regulator.
2. Set a Volt-Ohm-Milliammeter (VOM) to measure resistance.
3. Connect meter test leads across the female Red and Black wires at connector disconnected in Step 1. Measure and record the resistance.

Results

1. If the VOM indicate a resistance of approximately 40 ohms ± 20 ohms, verify rotor amp draw.

TEST 7 – CHECK BRUSHES AND SLIP RINGS

Discussion

The brushes and slip rings function to provide an electrical connection for excitation current from the stationary components to the rotating rotor. Made of a special long lasting material, brushes seldom wear out or fail. However, slip rings can develop a tarnish or film that can inhibit or offer a resistance to the flow of current. Such a non-conducting film usually develops during non-operating periods. Broken or disconnected wiring can also cause loss of excitation current to the rotor.

Procedure

1. Disassemble the Generator until the brushes and slip rings are exposed. Refer to Section 5.1 "Major Disassembly."
2. Inspect the brush wires and verify they are secured and properly connected.
3. Inspect the brush assembly for excessive wear, or damage.
4. Inspect the rotor slip rings. If their appearance is dull or tarnished, polish with a fine grade abrasive material.

⚠️ WARNING!

Do not use metallic grit to polish slip rings. This may cause irreversible damage to the rotor.

5. The Black Wire, located on the negative brush terminal, provides an electrical connection to the voltage regulator. To test this wire for an OPEN condition, remove the Black Wire from the brush assembly.
6. Set Volt-Ohm-Milliammeter (VOM) to measure resistance.
7. Connect one meter test lead to the Black Wire at the brush assembly and connect the other meter test lead to the Black Wire at the voltage regulator.
   • If the VOM indicated INFINITY, repair or replace the Black Wire between the negative slip ring and the voltage regulator.
   • If the VOM indicated CONTINUITY, continue to Step 8.
8. Disconnect the Red Wire from the brushes.
9. Connect one meter test lead to the Red Wire disconnected at the brushes and the other meter test lead to the Red Wire disconnected at the voltage regulator.
   • If the VOM indicated INFINITY, repair or replace the Black Wire between the negative slip ring and the voltage regulator.
   • If the VOM indicated CONTINUITY, continue to Step 8.
10. Disconnect the Red Wire from the brushes.

Results

1. Repair, replace, or reconnect wires as necessary.
2. Replace any damage slip rings or brush holder.
3. Clean and polish slip rings as required.
TEST 9 – TEST THE STATOR

Discussion
This test will use a Volt-Ohm-Milliammeter (VOM) to test the stator windings for the following faults:

- An OPEN circuit condition
- A “short-to-ground” condition
- A short circuit between windings

Table 7 has been provided to record the results of the following procedure. These results may be required when requesting factory support.

Additional copies of Table 7 can be found in Appendix A “Supplemental Worksheets” at the back of this manual.

Note: It is the recommendation of the factory to perform this test procedure using piercing probes on the wire side of the connector. Testing inside the connector itself can cause damage to the unit resulting in poor or loose connections.

Stator Resistances
- Power Windings
  - White/Blue = .173 Ohms
  - White/Black = .173 Ohms
  - Blue/Black = .346 Ohms
- Sensing Winding
  - Green/White = .064 Ohms
- DPE Winding
  - Blue/Blue = 1.158 Ohms

Procedure: Resistance Test
1. Disconnect the Blue and Black Wires from the main line circuit breaker (MLCB).
2. Disconnect the C1 connector from the voltage regulator.
3. Make sure all of the disconnected leads are isolated from each other and are not touching the frame during the test.
4. Set the VOM to measure resistance.
5. Measure and record the resistance values for each set of windings between the A and B test points as shown in Table 4. Record the results in Table 7.

Table 4. Test Points – Resistance Tests

<table>
<thead>
<tr>
<th>Test Point A</th>
<th>Test Point B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator Lead Blue Wire</td>
<td>Stator Lead Black Wire</td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>C1 Pin 3 (White Wire)</td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>C1 Pin 4 (Green Wire)</td>
</tr>
</tbody>
</table>

Test Windings for a Short to Ground
6. Make sure all stator leads are isolated from each other and are not touching the frame.
7. Measure and record the resistance values for each set of windings between the A and B test points as shown in Table 5. Record the results in Table 7.

Table 5. Test Points – Shorts to Ground

<table>
<thead>
<tr>
<th>Test Point A</th>
<th>Test Point B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator Lead Blue Wire</td>
<td>Ground</td>
</tr>
<tr>
<td>Stator Lead Black Wire</td>
<td>Ground</td>
</tr>
<tr>
<td>C1 Pin 1 Wire 44 (Blue Wire)</td>
<td>Ground</td>
</tr>
<tr>
<td>C1 Pin 4 (Green Wire)</td>
<td>Ground</td>
</tr>
</tbody>
</table>

Test For A Short Circuit Between Windings
8. Measure and record the resistance values for each set of windings between the A and B test points as shown in Table 6. Record the results in Table 7.

Table 6. Test Points – Shorted Condition

<table>
<thead>
<tr>
<th>Test Point A</th>
<th>Test Point B</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Pin 1 (Blue Wire)</td>
<td>Stator Lead Blue Wire</td>
</tr>
</tbody>
</table>

Table 7. Stator Test Results

<table>
<thead>
<tr>
<th>Test Point A</th>
<th>Test Point B</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance Tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>Stator Lead Black Wire</td>
<td></td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>C1 Pin 3 (White Wire)</td>
<td></td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>C1 Pin 4 (Green Wire)</td>
<td></td>
</tr>
<tr>
<td>Shorts to Ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator Lead Blue Wire</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>Stator Lead Black Wire</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>C1 Pin 1 Wire 44 (Blue Wire)</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>C1 Pin 4 (Green Wire)</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>Shorted Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1 Pin 1 (Blue Wire)</td>
<td>Stator Lead Blue Wire</td>
<td></td>
</tr>
</tbody>
</table>

Note: These results may be needed when requesting factory support.

Note: Stator winding resistance values are very low and some VOM’s will not read such a low resistance, and will simply indicate CONTINUITY. The manufacturer recommends a high quality digital type meter capable of reading a very low resistance.
Section 2.4
Diagnostic Tests

Results

1. Resistance Test: If the VOM indicated a very high resistance or INFINITY, the windings are open or partially open.

2. Grounded Condition: Any resistance value other than INFINITY indicates a grounded winding.

3. Shorted Condition: Any resistance value other than INFINITY indicates a shorted winding.

Note: If the winding tests good, perform an insulation resistance test. If the winding fails the insulation resistance test (using a meg-ohm-meter), clean and dry the stator. Then, repeat the insulation resistance test. If the winding fails the second resistance test (after cleaning and drying), replace the stator assembly.

TEST 10 – TEST ROTOR ASSEMBLY

Discussion

A rotor having open windings will cause loss of excitation current flow and as a result generator AC output voltage will drop to “residual” voltage. A “shorted” rotor winding can result in a low voltage condition.

Procedure

1. Remove the brush assembly from the slip rings to prevent interaction.

2. Set a Volt-Ohm-Milliammeter (VOM) to measure resistance.

3. Connect one meter test lead to the positive slip ring (nearest the rotor bearing) and the other test lead to the negative slip ring, measure and record the resistance.

4. Connect one meter test lead to the positive slip ring and connect the other meter test lead to a clean frame ground, measure and record the resistance.

Results

1. If the VOM indicated a resistance of 40 ohms +/- 20 ohms, (GOOD) refer back to flow chart.

2. If the VOM did not indicate a resistance within the allowed tolerances, replace rotor.

3. If the VOM indicated CONTINUITY in Step 4, replace the rotor assembly.

TEST 11 – CHECK AC OUTPUT VOLTAGE

Discussion

A Volt-Ohm-Milliammeter (VOM) may be used to check the generator output voltage. Output voltage may be checked at the unit’s main circuit breaker terminals. Refer to the unit’s DATA PLATE for rated line-to-line and line-to-neutral voltages.

Procedure

1. With the engine shut down, connect the AC voltmeter test leads across the Blue and Black Wire terminals of the generator main circuit breaker. These connections will permit line-to-line voltages to be read.

2. Set the generator main circuit breaker to its OFF or “Open” position. This test will be conducted with the generator running at no-load.

3. Start the generator, let it stabilize and warm up for a minute or two.

4. Take the meter reading. On unit’s having a rated line-to-line voltage of 240 volts, the no-load voltage should be about 242-252 volts AC.

5. Shut the engine down and remove the meter test leads.

Results

1. If zero volts or residual voltage is indicated, proceed to Test 4.

2. If the voltage reading is higher than residual, but is lower than the stated limits, go to Test 12.

3. If a high voltage is indicated, go on to Test 12.

NOTE: “Residual” voltage may be defined as the voltage that is produced by rotor residual magnetism alone. The amount of voltage induced into the stator AC power windings by residual voltage alone will be approximately 2 to 16 volts AC. If a unit is supplying residual voltage only, either DC field excitation voltage is not reaching the rotor or the rotor windings are open and the excitation voltage cannot pass.

TEST 12 – CHECK AC OUTPUT FREQUENCY

Discussion

The generator AC frequency is proportional to the operating speed of the rotor. The 2-pole rotor will supply a 60 Hertz AC frequency at 3600 rpm. The unit’s AC output voltage is proportional to the AC frequency. For example, a unit rated 240 volts (line-to-line) will supply that rated voltage (plus or minus 2 percent) at a frequency of 60 Hertz. If, for any reason, the frequency should drop to 30 Hertz, the line-to-line voltage will drop to a matching voltage of 120 volts AC. Thus, if the AC voltage output is high or low and the AC frequency is correspondingly high or low, the engine speed governor may require adjustment.
Section 2.4
Diagnostic Tests

**TEST 13 – ADJUST ENGINE GOVERNOR**
If both AC frequency and voltage are correspondingly high or low, adjust the engine governor as follows:

1. Loosen the governor clamp bolt (13mm). See Figure 23.
2. Hold the governor lever at its wide open throttle position (clockwise), and rotate the governor shaft clockwise as far as it will go. Then, tighten the governor lever clamp bolt to 70 inch-pounds (8 N-m).
3. Start the generator; let it stabilize and warm up at no-load.
4. Connect a frequency meter across the generators AC output leads.
5. Turn the adjust nut to obtain a frequency reading of 62.5 Hz.

**TEST 14 – ADJUST VOLTAGE REGULATOR**

**Procedure**
1. Remove two screws holding down the voltage regulator (AVR).
2. Leave the C1 connector and the brush connections connected.
3. Set VOM (Volt-Ohm-Meter) to measure AC voltage.
4. Connect meter test leads across the main breaker.
5. Ensure all material is clear of the alternator before proceeding.
6. Set the AUTO-OFF-MANUAL switch to the MANUAL position.
7. Refer to Figure 25 for location of adjustment screw.
8. Adjusting screw clockwise will increase voltage, adjusting counterclockwise will lower the voltage.
9. If no change in voltage while adjusting refer back to flow chart.
10. If voltage is correct, stop testing.

**Results**
1. Refer back to flow chart.
2. If frequency and voltage are both good, tests may be discontinued.

---

**Figure 23. Engine Governor Adjustment Points**

**Figure 24. VOM Test Leads Connected to the main breaker.**

**Figure 25. Voltage Regulator Adjustment Screw**
**TEST 15 – CHECK FOR OVERLOAD CONDITION**

**Discussion**

An “overload” condition is one in which the generator rated wattage/amperage capacity has been exceeded. To test for an overload condition on an installed unit, the best method is to use an ammeter. See “Measuring Current” in Section 1.2.

**Procedure**

Use a clamp-on ammeter to measure load current draw, with the generator running and all normal electrical loads turned on.

**Results**

1. If the unit is overloaded, reduce loads to the unit’s rated capacity.
2. If the unit is not overloaded, but rpm and frequency drop excessively when loads are applied, go to Test 16.

---

**TEST 16 – CHECK VOLTAGE AND FREQUENCY UNDER LOAD**

**Discussion**

It is possible for the generator AC output frequency and voltage to be good at no-load, but they may drop excessively when electrical loads are applied. This condition, in which voltage and frequency drop excessively when loads are applied, can be caused by (a) overloading the generator, (b) loss of engine power, or (c) a shorted condition in the stator windings or in one or more connected loads.

**Procedure**

1. Connect an accurate AC frequency meter and an AC voltmeter across the stator AC power winding leads.
2. Start the engine, let it stabilize and warm-up.
3. Apply electrical loads to the generator equal to the rated capacity of the unit.
4. Check the AC frequency and voltage. Frequency should not drop below approximately 58-59 Hertz. Voltage should not drop below about 230 volts (plus or minus 2 percent).

**Results**

1. If frequency and voltage drop excessively under load, go to Test 15.
2. If frequency and voltage under load are good, discontinue tests.
### PART 3 – Transfer Switch

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Section 3.1
Description and Components

GENERAL

The 50 amp transfer switch is designed to operate in conjunction with all product which utilizes the Wire 194/15B and Wire 23 control systems. Utility voltage and the control panel on the generator controls sequence delays. The AUTO-OFF-MANUAL switch must be in the AUTO position for automatic operation of the transfer switch.

ENCLOSURE

The standard switch enclosure is a National Electrical Manufacturer’s Association (NEMA) UL Type 1.

EZ TRANSFER OPERATOR

The EZ Transfer Operator is a rotary device that actuates the arms that push two standard 2-pole breakers, transferring the load from Utility to Generator. The operator returns to a “Neutral” position so the arms move freely and allow the manual operation of the breakers.

The operator is suited for single-phase applications only, when the single-phase NEUTRAL line is to be connected to a Neutral Lug and is not to be switched.

Internal Components

Three components make up the operator: the servomotor, Limit Switch 1 (LS1), and Limit Switch 2 (LS2). The servomotor is responsible for changing the position of the breakers inside the switch. Both limit switches are responsible for interrupting current flow to the servomotor once the transfer cycle is complete.

FUSE HOLDER

Utility N1 and N2

N1 and N2 provide the Utility voltage-sensing signal to the controller. The controller utilizes the sensing circuit as follows:

- If Utility source voltage should drop below 65% of nominal for ten seconds, the controller’s logic will initiate automatic cranking and startup. The controller will transfer the switch to the Standby position after a five second engine warm-up timer.

Load T1

Wire T1, connected to the Load side of the switch, provides 120 VAC for the battery charging. The charger maintains battery voltage anytime the load terminals have voltage available.
**UTILITY VOLTAGE PRESENT**
When Utility voltage is present, the circuit may be briefly described as:
- Battery voltage is available to B+ (194 or 15B) and B- (Wire 0) from the generator.
- The internal K1 relay is de-energized.
- K1 contacts 11 and 13 are in their normally closed state.
- K1 contacts 8 and 7 are in their normally open state.

**TRANSFER TO STANDBY**
With the Generator running during a Utility failure, the circuit may be described as:
- Battery voltage is available to B+ and B- from the generator.
- A ground has been applied to Terminal XFER (Wire 23) via the generator controller.
- The K1 relay is energized, contacts 11 and 13 open, and 8 and 7 close completing a path for current to flow to the servo motor.
- The servo motor will operate till LS2 is mechanically opened, interrupting the current flow to the servo motor.

**TRANSFER TO UTILITY**
With the Generator running and Utility restored, the circuit may be described as:
- Battery voltage is available to B+ and B- from the generator.
- The return to utility timer has expired and the ground has been removed from the XFER terminal (Wire 23).
- The K1 relay will de-energize, contacts 11 and 13 will close, and 8 and 7 will open completing a path for current to flow to the servo motor.
- The servo motor will operate till LS1 is mechanically opened and LS2 will mechanically close.

---

**Figure 29. EZ Operator Electrical Schematic**
INTRODUCTION

Use the “Flow Charts” in conjunction with the detailed instructions in Section 3.4. Test numbers used in the flow charts correspond to the numbered tests in Section 3.4. The first step in using the flow charts is to identify the correct problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

**Problem 10 – In Automatic Mode, No Transfer to Standby**

![Flowchart for Problem 10]

**Problem 11 – In Automatic Mode, Generator Starts When Loss of Utility Occurs, Generator Shuts Down When Utility Returns But There Is No Retransfer To Utility Power OR Generator Transfers to Standby During Excercise or in Manual Mode**

![Flowchart for Problem 11]
**Problem 12 – Blown F1 or F2 Fuse**

1. Test 32 – Check Fuse F1 & F2
   - Bad
     - Repair or replace wiring
   - Good
     - Inspect/replace controller
     - Finish

2. Test 33 – Check N1 & N2 Wiring
   - Good
     - Good
     - Replace controller
   - Bad
     - Repair or replace wiring

**Problem 13 – Blown T1 Fuse**

1. Test 35 – Check Fuse F3 (T1)
   - Bad
     - Stop testing
   - Good
     - Repair or replace wiring

2. Test 36 – Check T1 Wiring
   - Good
     - Replace controller
   - Bad
     - Repair or replace wiring

**Problem 14 – Unit Starts and Transfer Occurs When Utility Power Is On**

1. Test 38 – Check N1 & N2 Voltage
   - Bad
     - Bad
     - Correct utility source voltage
     - Repair or replace wire N1A/N2A between N1/N2 lugs and fuse holder
     - Repair N1/N2 open wiring between transfer switch and generator
   - Good
     - Repair or replace controller
     - Replace wiring
     - Test 32 – Check Fuse F1 & F2
       - Bad
         - Replace Go to Problem 7
       - Good
         - Test 39 – Check Utility Sense Voltage
           - Bad
             - Repair N1/N2 open wiring between transfer switch and generator
           - Good
             - Test 41 – Check Utility Sensing Voltage at Controller
               - Bad
                 - Repair or replace controller
               - Good
                 - Test 38 – Check N1 and N2 Voltage
                   - Good
                     - Replace or replace controller
                   - Bad
                     - Correct utility source voltage

---

Section 3.3
Troubleshooting Flowcharts

---

Page 42
INTRODUCTION

This section familiarizes the service technician with acceptable procedure for the testing and evaluation of various problems that can occur on pre-packaged transfer switches. Use this section in conjunction with Section 3.3, “Troubleshooting Flow Charts.” The numbered tests in this section correspond with those of Section 3.3.

Some test procedures in this section may require the use of specialized test equipment, meters or tools. Most tests can be performed with an inexpensive volt-ohm-meter (VOM). An AC frequency meter is required, where frequency readings must be taken. To measure AC loads it is acceptable to use a clamp-on ammeter.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the products safety.

SAFETY

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

TRANSFER SWITCH TROUBLESHOOTING

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem asking some of these questions may help identify the problem quicker.

- What is the transfer switch doing?
- What was the transfer switch supposed to do?
- Does the transfer switch have the same fault consistently, and when does it occur?
- Who is controlling it?
- Exactly what is occurring?
- When is it happening?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

TEST 27 – CHECK GENERATOR VOLTAGE AT TRANSFER SWITCH

Procedure

1. Set Volt-Ohm-Milliammeter (VOM) to measure AC voltage
2. With the generator running check generator voltage at the generator’s circuit breaker in the transfer switch. Measure and record the voltage.

Results

1. If the VOM indicated approximately 240 VAC, refer back to flow chart.
2. If the VOM did not indicate the correct AC voltage, investigate the cause of the no AC output.

TEST 28 – TEST TRANSFER OPERATOR

Procedure

1. Using a jumper wire connected to a common ground; connect a ground to the XFER terminal on the operator. Observe the rotation of the operator.
2. Disconnect ground from XFER terminal and observe the rotation of the operator.

Results

1. If the operator transferred to “Standby” when XFER was grounded and re-transferred back to “Utility” when XFER was ungrounded, the operator is functioning correctly.
2. If the operator failed to transfer to either “Standby” or “Utility” positions, refer back to flow chart.

TEST 29 – CHECK 15B/194 CIRCUIT

Procedure

1. Set a Volt-Ohm-Milliammeter (VOM) to measure DC voltage.
2. Connect one meter test lead to BAT + and connect the other meter test lead to BAT - on the operator. Measure and record the voltage.
   a. If the VOM indicated battery voltage, replace transfer operator.
   b. If the VOM did not indicate battery voltage, proceed to Step 3.
3. Connect one meter test lead to Wire 15B and the other meter test lead to Wire 0 located on the customer connection block. Measure and record the voltage.
   a. If the VOM indicated battery voltage, repair or replace the wiring between the transfer switch and the generator.
Section 3.4
Diagnostic Tests

b. If the VOM did not indicate battery voltage, proceed to Step 4.

4. Connect one meter test lead to Wire 15B and the other meter test lead to a clean frame ground. Measure and record the voltage.
   a. If the VOM indicated battery voltage, repair or replace Wire 0 in the generator.
   b. If the VOM did not indicate battery voltage, repair or replace Wire 15B in the generator.

Results
Refer back to flow chart.

TEST 30 – CHECK WIRE 23 CIRCUIT

Procedure
1. Set a Volt-Ohm-Milliammeter (VOM) to measure DC voltage
   Note: Generator should not be running for this part of the procedure.
2. Connect one meter test lead to the XFER terminal on the operator and the other meter test lead to the BAT + terminal. Measure and record the voltage.
   a. If the VOM indicated battery voltage and the transfer operator transferred the load to the Generator, Wire 23 circuit is shorted to ground, proceed to Step 3.
   b. If the VOM did not indicate battery voltage, proceed to Step 8
3. Disconnect the customer supplied Wire 23 from the customer connection block in the generator.
4. Connect one meter test lead to Wire 23 on the customer connection block and the other meter test lead to Wire 15B.
   a. If the VOM indicated battery voltage, proceed to Step 5.
   b. If the VOM did not indicate battery voltage, repair or replace the shorted Wire 23 between the switch and the generator.
5. Locate and disconnect the J2 connector from the controller.
6. Set the VOM to measure resistance.
7. Connect one meter test lead to a clean frame ground and the other meter test lead Wire 23 and the customer connection block. Measure and record the resistance.
   a. If the VOM indicated any resistance to ground, repair or replace the wire between the J2 connector and the customer connection block.
   b. If the VOM indicate INFINITY, replace controller.
8. Set VOM to measure DC voltage.
9. Set the AUTO-OFF-MANUAL switch to the AUTO position and simulate a Utility Failure.
10. Once the generator has started and warmed up, connect one meter test lead to the XFER terminal and the other meter test lead to the BAT + terminal in the transfer switch. Measure and record the voltage.
    a. If the VOM indicated battery voltage, stop testing.
    b. If the VOM did not indicate battery voltage, proceed to Step 11.
11. Connect one meter test lead to Wire 23 and the other meter test lead to Wire 15B in the customer connection block. Measure and record the voltage.
    a. If the VOM indicated battery voltage, repair or replace Wire 23 between the transfer switch and the generator.
    b. If the VOM did not indicate battery voltage, proceed to Step 11.
12. Locate and disconnect the J2 connector from the controller.
13. Set VOM to measure resistance.
14. Connect one meter test lead to J2-5 (Wire 23) and the other meter test to Wire 23 connected at the customer connection terminal block.
    a. If the VOM indicated in CONTINUITY, replace controller.
    b. If the VOM indicated INFINITE, repair or replace Wire 23 between the J2 connector and the customer connection terminal block.

Results
Refer back to flow chart.

TEST 32 – CHECK FUSES F1 AND F2

Discussion
Fuses F1 and F2 are connected in series with the N1 and N2 circuits, respectively. A blown fuse will open the applicable circuit and will result in (a) generator startup and transfer to the “Standby”, or (b) failure to re-transfer back to utility source.

Procedure
1. On the generator panel, set the AUTO-OFF-MANUAL switch to the OFF position.
2. Disconnect Utility from the transfer switch.
3. Remove fuse F1 and F2 from the fuse holder. (see Figure 31).
4. Inspect and test fuses for an OPEN condition with a Volt-Ohm-Milliammeter (VOM) set to measure resistance, CONTINUITY should be measured across the fuse.

Results
1. Replace blown fuse(s) as needed.
TEST 33 – CHECK N1 AND N2 WIRING

Discussion
A shorted Wire N1 or N2 to ground can cause fuse F1 or F2 to blow.

Procedure
1. On the generator panel, set the AUTO-OFF-MANUAL switch to OFF.
2. Turn off the utility power supply to the transfer switch, using whatever means provided.
3. Remove fuses F1, F2, and F3 from the fuse holder (see Figure 31).
4. Remove the generator control panel cover. Disconnect the N1/N2 connector that supplies the printed circuit board located in the control panel (see Figure 34).
5. Set VOM to measure resistance.
6. Connect the positive meter test lead to Wire N1 at the terminal block in the control panel.
   a. Connect the negative meter lead to the ground lug. INFINITY should be measured.
   b. Connect the negative meter lead to Wire 23 at the terminal strip. INFINITY should be measured.
   c. Connect the negative meter lead to Wire 15B at the terminal strip. INFINITY should be measured.
   d. Connect the negative meter lead to Wire 0 at the terminal strip. INFINITY should be measured.
   e. Connect the negative meter lead to Wire N2 at the terminal block. INFINITY should be measured.
7. Connect the positive meter test lead to Wire N2 at the terminal block in the control panel.
   a. Connect the negative meter lead to the ground lug. INFINITY should be measured.
   b. Connect the negative meter lead to Wire 23 at the terminal strip. INFINITY should be measured.
   c. Connect the negative meter lead to Wire 15B at the terminal strip. INFINITY should be measured.
   d. Connect the negative meter lead to Wire 0 at the terminal strip. INFINITY should be measured.
   e. Connect the negative meter lead to the neutral connection. INFINITY should be measured.

Results
If a short is indicated in Step 6 or Step 7, repair wiring and re-test.

TEST 35 – CHECK FUSE F3

Discussion
Connected in series with Load Wire T1, F3 provides 120 VAC to the generator to operate the battery charger. A blown fuse will result in a possible dead battery situation.

Procedure
1. On the generator panel, set the AUTO-OFF-MANUAL switch to the OFF position.
2. Disconnect Utility from the transfer switch.
3. Remove fuse F3 from the fuse holder.
4. Inspect and test fuses for an OPEN condition with a Volt-Ohm-Milliammeter (VOM) set to measure resistance, CONTINUITY should be measured across the fuse.

Results
1. Replace blown fuse as needed.

TEST 36 – CHECK T1 WIRING

Discussion
If the T1 wiring is shorted to ground it can cause the F3 fuse to blow.

Procedure
1. Set the AUTO-OFF-MANUAL to the OFF position.
2. Remove F1, F2, and F3 from the fuse holder in the transfer switch.
3. Disconnect the J2 connector and the Utility sensing connector from the controller.
4. Set the Volt-Ohm-Milliammeter (VOM) to measure resistance.
   a. Connect one meter test lead to T1 on the customer connection in the Generator and the other meter lead to ground. Measure and record the resistance.
   b. Connect one meter test lead to T1 on the customer connection in the Generator and the other meter test lead to Wire 194. Measure and record the resistance.
   c. Connect one meter test lead to T1 on the customer connection in the Generator and the other meter test lead to Wire 23. Measure and record the resistance.
   d. Connect one meter test lead to T1 on the customer connection in the Generator and the other meter test lead to Wire N1. Measure and record the resistance.
   e. Connect one meter test lead to T1 on the customer connection in the Generator and the other meter test lead to Wire N2. Measure and record the resistance.

Results
1. If the VOM indicated INFINITY in Steps 4a -4e, replace the controller.
PART 3
TRANSFER SWITCH

Section 3.4
Diagnostic Tests

2. If the VOM indicated CONTINUITY, repair or replace the wiring in the appropriate circuit.

TEST 38 – CHECK N1 AND N2 VOLTAGE

Discussion
Loss of utility source voltage to the generator will initiate a startup and transfer by the generator. Testing at the control panel terminal block will divide the system in two, thereby reducing troubleshooting time.

Procedure
1. Set the AUTO-OFF-MANUAL switch to OFF.
2. Set a VOM to measure AC voltage.
3. See Figure 30. Connect one test lead to Wire N1 at the terminal block in the generator control panel. Connect the other test lead to Wire N2. Utility line-to-line voltage should be measured.

Results
Refer to Flow Chart

TEST 39 – CHECK UTILITY SENSE VOLTAGE

The N1 and N2 terminals in the transfer switch deliver utility voltage “sensing” to the controller. If voltage at the terminals is zero or low, standby generator startup and transfer to the “Standby” source will occur automatically as controlled by the circuit board. A zero or low voltage at these terminals will also prevent retransfer back to the “Utility” source.

Procedure
With utility source voltage available to terminal lugs N1 and N2, use a VOM to test for utility source line-to-line voltage across terminal locations N1 and N2 terminals. Normal line-to-line utility source voltage should be indicated.

TEST 40 – CHECK UTILITY VOLTAGE AT TRANSFER SWITCH

Procedure
1. Set a Volt-Ohm-Milliammeter (VOM) to measure AC voltage.
2. Connect meter test leads across the Utility Disconnect breaker in the transfer switch. Measure and record the voltage.

Results
1. If the VOM indicated approximately 240 VAC, refer back to flow chart.
2. If the VOM did not indicate 240 VAC, verify any additional breakers or wiring are correct.

TEST 41 – CHECK UTILITY SENSING VOLTAGE AT THE CONTROLLER

Discussion
If the generator starts and transfer to STANDBY occurs in the automatic mode when acceptable UTILITY source voltage is available at the terminal block, the next step is to determine if sensing voltage is reaching the controller.

Note: The System Ready LED will flash in AUTO or UTILITY LOST will display on the panel.

Procedure
1. Set the AUTO-OFF-MANUAL switch to OFF.
2. Disconnect the N1/N2 connector from the control panel (see Figure 34).
3. Set a VOM to measure AC voltage.

4. Connect one meter test lead to Wire N1 at the incoming Utility sensing connector. Connect the other meter test lead to Wire N2. Approximately 240 VAC should be measured.

**Results**

1. If voltage was measured in Step 4 and the pin connections are good, replace the circuit board.

2. If voltage was NOT measured in Step 4, repair or replace Wire N1/N2 between connector and terminal block.
PART 4
ENGINE/DC CONTROL

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GENERAL
This section will familiarize the reader with the various components that make up the DC control system. Major DC control system components that will be covered include the following:

- A Terminal Strip / Interconnection Terminal
- A Controller
- An AUTO-OFF-MANUAL Switch
- A 7.5 Amp Fuse

TERMINAL STRIP / INTERCONNECTION TERMINAL
The terminals of this terminal strip are connected to identically numbered terminals on a transfer switch terminal board. The terminal board connects the transfer switch to the controller. The terminal board provides the following connection points:

- N1 (Utility Sensing)
- N2 (Utility Sensing)
- T1 (Battery Charger)
- Wire 194 (Transfer Relay)
- Wire 23 (Transfer Relay)

CONTROLLER
The controller controls all standby electric system operations including (a) engine startup, (b) engine running, (c) automatic transfer, (d) automatic retransfer, and (e) engine shutdown. In addition, the controller performs the following functions:

- Starts and “exercises” the generator once every seven days.
- Provides automatic engine shutdown in the event of low oil pressure, high oil temperature, overspeed, no RPM sense, overcrank, or low battery.

An 18-pin and a 4-pin connector are used to interconnect the controller with the various circuits of the DC systems. Connector pin numbers, associated wires and circuit functions are listed in the CHART on the next page.

If the Utility sensing voltage drops below a preset value, controller action will initiate automatic generator startup and transfer to the “Standby” source side.

The crank relay and fuel solenoid valve are energized by controller action at the same time.

AUTO-OFF-MANUAL SWITCH
This 3-position switch permits the operator to (a) select fully automatic operation, (b) start the generator manually, or (c) stop the engine and prevent automatic startup.

7.5 AMP FUSE
This fuse protects the circuit board against excessive current. If the fuse has blown, engine cranking and operation will not be possible. Should fuse replacement become necessary, use only an identical 7.5 amp replacement fuse.

Battery Charger
The battery charger is an independent part the generator. It has a 120 VAC input and a DC output of 13.4 VDC with a max amperage of 2.5 amps.
### 6/7 kW Connector Pin Descriptions

<table>
<thead>
<tr>
<th>PIN</th>
<th>WIRE</th>
<th>CIRCUIT FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1-1</td>
<td>85</td>
<td>High temperature shutdown: Shutdown occurs when Wire 85 is grounded by contact closure in HTO</td>
</tr>
<tr>
<td>J1-2</td>
<td>86</td>
<td>Low oil pressure shutdown: Shutdown occurs when Wire 86 is grounded by loss of oil pressure to the LOP</td>
</tr>
<tr>
<td>J1-3</td>
<td>13</td>
<td>12 VDC source voltage for the controller</td>
</tr>
<tr>
<td>J1-4</td>
<td>18</td>
<td>Ignition Shutdown: Circuit board action grounds Wire 18 for ignition shutdown.</td>
</tr>
<tr>
<td>J2-1</td>
<td>0</td>
<td>Not Used</td>
</tr>
<tr>
<td>J2-2</td>
<td>0</td>
<td>Not Used</td>
</tr>
<tr>
<td>J2-3</td>
<td>14</td>
<td>12 VDC output for engine run condition. Used for fuel solenoid.</td>
</tr>
<tr>
<td>J2-5</td>
<td>23</td>
<td>Switched to ground for transfer relay operation</td>
</tr>
<tr>
<td>J2-6</td>
<td></td>
<td>NOT USED</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIN</th>
<th>WIRE</th>
<th>CIRCUIT FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>J2-7</td>
<td></td>
<td>NOT USED</td>
</tr>
<tr>
<td>J2-8</td>
<td>15B</td>
<td>Provides an electrical connection for charge current to reach the battery from the battery charger. Provides 12 VDC to the Transfer Relay</td>
</tr>
<tr>
<td>J2-9</td>
<td></td>
<td>NOT USED</td>
</tr>
<tr>
<td>J2-10</td>
<td>0</td>
<td>Common Ground</td>
</tr>
<tr>
<td>J2-11</td>
<td>56</td>
<td>12 VDC output to starter contactor and the choke solenoid.</td>
</tr>
<tr>
<td>J2-15</td>
<td></td>
<td>Used to operate the choke solenoid and is active during cranking only.</td>
</tr>
<tr>
<td>J2-16</td>
<td></td>
<td>NOT USED</td>
</tr>
<tr>
<td>J2-17</td>
<td></td>
<td>NOT USED</td>
</tr>
<tr>
<td>J2-18</td>
<td></td>
<td>NOT USED</td>
</tr>
<tr>
<td>Wired Plug 1</td>
<td>N1</td>
<td>240 VAC sensing for controller.</td>
</tr>
<tr>
<td>Wired Plug 2</td>
<td>N2</td>
<td>240 VAC sensing for controller.</td>
</tr>
</tbody>
</table>
ALARMS

Low Oil Pressure (Shutdown Alarm)
A five (5) second delay on start-up and eight (8) second delay once the engine is running. This switch has normally closed contacts that are held open by engine oil pressure during operation. Should the oil pressure drop below the five (5) PSI range, switch contacts close and the engine shuts down. The unit should not be restarted until oil level is verified.

High Oil Temperature (Shutdown Alarm – Auto Reset)
A 10 second delay on start-up and one (1) second delay before shutdown. Auto reset when the condition clears and restart the engine if a valid start signal is still present.

This switch’s contacts close if the temperature should exceed approximately 124° C (255° F), initiating an engine shutdown. Once the oil temperature drops to a safe level the switch’s contacts open again.

Over Crank (Shutdown Alarm)
This occurs if the engine has not started within the specified crank cycle. (See Section 1.5 “Automatic Operation”)

Over Speed (Shutdown Alarm)
4320 RPM for three (3) seconds or 4500 RPM immediately. This feature protects the generator from damage by shutting it down if it happens to run faster than the preset limit. This protection also prevents the generator from supplying an output that could potentially damage appliances connected to the generator circuit.

RPM Sensor Loss (Shutdown Alarm)
During cranking, if the controller does not see a valid RPM signal within three (3) seconds, it will shut down and lock out on RPM sensor loss. While engine is running, if RPM signal is lost for two (2) seconds the controller will shut the engine down, wait 15 seconds, then re-crank the engine. If no RPM signal is detected within the first three (3) seconds of cranking, the controller will shut the engine down and latch out on RPM sensor loss. If the RPM signal is detected, the engine will start and run normally. If the RPM signal is subsequently lost again, the controller will try one more re-crank attempt before latching out and displaying the RPM sensor failure message.

CLEAR ALARMS
Clear alarms by setting the AUTO/OFF/MANUAL switch to the OFF position.

WARNINGS
Second Priority (Non-latching) Displayed on the control panel. Warnings automatically clear when the monitored condition goes away. Warnings cannot cause shutdowns.

Low Battery
The controller monitors battery voltage and illuminates an LED warning if the battery voltage falls below 11.9 volts for one (1) minute. Warning is automatically cleared if the battery voltage rises above 12.4 volts. Battery voltage is not monitored during the crank cycle.
Section 4.3
Operational Analysis

UTILITY SOURCE AVAILABLE

Utility voltage is available to the transfer switch terminals N1/N2 and the transfer switch in the normal utility position.

Utility sensing voltage is delivered to the controller via wires N1/N2 from a transfer switch. This voltage is 240VAC sensing voltage only for the controller. T1 is 120 VAC supply for power to the battery charger.

Battery output voltage is delivered to the controller via wire 13 when the battery is installed.
**UTILITY FAILURE AND ENGINE CRANKING**

When the utility sensing voltage drops out the controller will start a 10 second timer. If the voltage does not return fully or is below 60 percent of normal the generator will start to crank.

The controller action delivers 12 VDC to the starter contactor via wire 56. When the starter contactor energizes, it delivers battery voltage to the starter motor and the engine will crank.

Wire 56 also delivers 12 VDC to the choke solenoid. The controller action grounds wire 90 to actuate the choke solenoid cyclically during cranking. The controller action will remove wire 90 from ground during normal running operation.

The controller delivers 12 VDC to the fuel solenoid during cranking and will continue to during normal running operation.

As the engine cranks a magnet on the flywheel induces a high voltage into the engines ignition magneto (IM). A spark is produced that jumps the spark plug gap.

During cranking residual magnetism from the rotor induces a voltage into the stator (blue) excitation wires and the (green and white) sensing wires. Voltage from the excitation wires power up the voltage regulator.
Section 4.3
Operational Analysis

UTILITY FAILURE AND ENGINE RUNNING

The generator is running, the controller’s engine warm up timer is timing out and the generator is producing AC voltage.

12 VDC is delivered to the actuator motor (in the EZ Transfer Operator) via wire 15B. This 12 VDC circuit is completed back to the controller via wire 23. When the engine warm up time expires the controller will take wire 23 to ground to actuate the actuator in the transfer switch to the generator position.

When the utility voltage returns to the controller above 75 percent of normal, the controller will energize a 15 second timer. Once the timer has expired the controller will remove wire 23 from ground, this will actuates the actuator in the transfer switch to the normal utility position.

Once back in the utility the controller will run the generator for 1 minute for its “cool down” cycle then shut down.

With utility available and the generator in the AUTO position the SYSTEM READY light will be solid.
Problem 20 – Engine Will Not Crank When Utility Power Source Fails

<table>
<thead>
<tr>
<th>VERIFY UTILITY SOURCE IS “OFF”</th>
<th>OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td></td>
</tr>
<tr>
<td>TURN “OFF” - RETEST</td>
<td></td>
</tr>
</tbody>
</table>

TEST 52 – CHECK POSITION OF AUTO-OFF-MANUAL SWITCH

SWITCH IS “OFF”

SET TO “AUTO” - RETEST

TEST 53 – TRY A MANUAL START

ENGINE DOES NOT CRANK

ENGINE CRANKS

GO TO PROBLEM 21

REPLACE CONTROLLER ASSEMBLY

Problem 21 – Engine Will Not Crank When AUTO-OFF-MANUAL Switch is Set to “MANUAL”

<table>
<thead>
<tr>
<th>TEST 55 – CHECK 7.5 AMP FUSE</th>
<th>GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAD</td>
<td>REPLACE</td>
</tr>
</tbody>
</table>

TEST 56 – CHECK BATTERY

TEST 57 – CHECK WIRE 56 VOLTAGE

NOTE: If a starting problem is encountered, the engine itself should be thoroughly checked to eliminate it as the cause of starting difficulty. It is a good practice to check the engine for freedom of rotation by removing the spark plugs and turning the crankshaft over slowly by hand, to be sure it rotates freely.

WARNING: DO NOT ROTATE ENGINE WITH ELECTRIC STARTER WITH SPARK PLUGS REMOVED. ARCING AT THE PLUG ENDS MAY IGNITE THE LP OR NG VAPOR EXITING THE SPARK PLUG HOLE.
Section 4.4
Troubleshooting Flowcharts

Problem 22 – Engine Cranks but Won’t Start

- **Test 60 – Check Fuel Supply and Pressure**
  - Good → **Test 61 – Check Controller Wire 14 Output**
  - Bad → **Find and Correct Cause of No Fuel or Low Pressure**

- **Check Air Filter – Replace as Needed**

- **Test 64 – Check for Ignition Spark**
  - Good → **Test 65 – Check Spark Plugs**
  - Bad → **Clean, Regap or Replace**

- **Test 79 – Check Shutdown Wire**
  - Bad → **Repair or Replace Shorted Wire 18 or Controller**

- **Test 62 – Check Fuel Solenoid**
  - Bad → **Replace Fuel Solenoid**

- **Test 63 – Check Choke Solenoid**
  - Bad → **Replace Choke Solenoid**

- **Test 66 – Check Engine Compression**
  - Good → **Replace Fuel Regulator**

- **Test 70 – Check and Adjust Valves**
  - Bad → **Readjust**

- **Test 67 – Check Ignition Magneto**
  - Bad → **Adjust or Replace**

- **Check Flywheel Key**
  - Good → **Contact Technical Service**

**Problem 22**

- Engine Cranks but Won’t Start

**Check**

- Air Filter
- Fuel Supply
- Controller Wires
- Ignition Spark
- Spark Plugs
- Shutdown Wire
- Fuel Solenoid
- Choke Solenoid
- Engine Compression
- Ignition Magneto
- Flywheel Key

**Repair or Replace**

- Shorted Wires
- Controller

**Contact Technical Service**
Problem 24 – Shutdown Alarm/Fault Occurred

- **CHECK FAULT LIGHTS**
  - **OVERCRANK** → PROCEED TO PROBLEM 22

- **HIGH TEMP**
  - **TEST 69 – CHECK HIGH OIL TEMPERATURE SWITCH** → CHECK INSTALLATION FOR PROPER AIRFLOW OR REPLACE DEFECTIVE SWITCH

- **OVERSPEED**
  - **TEST 12 – CHECK AC OUTPUT FREQUENCY** ← BAD → **TEST 13 – CHECK AND ADJUST ENGINE GOVERNOR** ← GOOD → REPAIR LINKAGE IF BINDING.

- **NO RPM SENSE**
  - **ENGINE CRANKS**
    - **TEST 71 – CHECK WIRE 18 CONTINUITY** ← GOOD → **TEST 64 – CHECK FOR IGNITION SPARK** ← GOOD OR BAD → **TEST 79 – CHECK SHUTDOWN WIRE** ← BAD → REPAIR OR REPLACE SHORTED WIRE 18 OR CONTROLLER ← GOOD
    - **ENGINE DOES NOT CRANK** → GO TO PROBLEM 21

- **LOW OIL**
  - **TEST 68 – CHECK OIL PRESSURE SWITCH AND WIRE 86**

- **LOW BATTERY** → PROCEED TO PROBLEMS 27
Problem 25 – 7.5 Amp Fuse (F1) Blown

FUSE BLOWS WHEN PLACED IN “AUTO” OR “MANUAL”

TEST 74 & 75 – CHECK CRANKING AND RUNNING CIRCUITS

Problem 26 – Generator Will Not Exercise

TEST 72 – TEST EXERCISE FUNCTION

Problem 27 – No Battery Charge

TEST 76 – CHECK BATTERY CHARGER SUPPLY VOLTAGE
GOOD
BAD
REPAIR OR REPLACE

TEST 77 – CHECK BATTERY CHARGER OUTPUT VOLTAGE
GOOD
BAD
BAD
REPLACE CHARGER
REPLACE CHARGER

NO BATTERY SUPPLY VOLTAGE

TEST 78 – CHECK WIRE 0/15B
GOOD
BAD
REPLACE PRINTED CONTROLLER
REPAIR OR REPLACE
INTRODUCTION

This section familiarizes the service technician with acceptable procedures for the testing and evaluation of various problems that can occur on the standby generators with air-cooled engines. Use this section in conjunction with Section 4.4, "Troubleshooting Flow Charts." The numbered tests in this section correspond with those of Section 4.4.

Some test procedures in this section may require the use of specialized test equipment, meters or tools. Most tests can be performed with an inexpensive volt-ohm-meter (VOM). An AC frequency meter is required where frequency readings must be taken.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the products safety.

Figure 35 shows the Volt-Ohm-Milliammeter (VOM) in two different states. The left VOM indicates an OPEN circuit or INFINITY. The right VOM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer back to Figure 35 as needed to understand what the meter is indicating about the particular circuit that was tested.

Note: CONTINUITY is equal to .01 ohms of resistance or a dead short.

SAFETY

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

ENGINE/DC TROUBLESHOOTING

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem asking some of these questions may help identify the problem quicker.

- What is the generator doing?
- What is the fault that the generator is shutting down for?
- Is the fault causing the shutdown a symptom of another problem?
- Does the generator have the same fault consistently, and when does it occur?
- What was the generator supposed to do?
- Who is controlling it?
- Exactly what is occurring?
- When is it happening?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

TEST 52 – CHECK POSITION OF AUTO-OFF-MANUAL SWITCH

Discussion

If the standby system is to operate automatically, the generator AUTO-OFF-MANUAL switch must be set to AUTO. That is, the generator will not crank and start on occurrence of a “Utility” power outage unless that switch is at AUTO. In addition, the generator will not exercise every seven (7) days as programmed unless the switch is at AUTO.

Procedure

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

With the AUTO-OFF-MANUAL switch set to AUTO, test automatic operation. Testing of automatic operation can be accomplished by turning off the Utility power supply to the transfer switch. When the utility power is turned off, the
standby generator should crank and start. Following startup, transfer to the standby source should occur. Refer to Section 1.5 in this manual.

Following generator startup and transfer to the standby source, turn ON the utility power supply to the transfer switch. Retransfer back to the “Utility” source should occur. After an “engine cooldown timer” has timed out, generator shutdown should occur.

Results
1. If normal automatic operation is obtained, discontinue tests.
2. If engine does not crank when utility power is turned off, proceed to Problem 20 Flow Chart, Section 4.4.
3. If engine cranks but won’t start, go to Problem 22 in Section 4.4.
4. If engine cranks and starts, but transfer to “Standby” does NOT occur, go to Problem 10 in Section 3.3.
5. If transfer to “Standby” occurs, but retransfer back to “Utility” does NOT occur when utility source voltage is restored, go to Problem 11 in Section 3.3.

**TEST 53 – TRY A MANUAL START**

Discussion
The first step in troubleshooting for an “engine won’t crank” condition is to determine if the problem is peculiar to automatic operations only or if the engine won’t crank manually either.

Procedure
1. On the generator panel, set the AUTO-OFF-MANUAL switch to OFF.
2. Set the generator main line circuit breaker to its OFF (or open) position.
3. Set the generator AUTO-OFF-MANUAL switch to MANUAL.
   a. The engine should crank cyclically through it’s “crank-rest” cycles until it starts.
   b. Let the engine stabilize and warm up for a few minutes after it starts.

Results
1. If the engine cranks manually but does not crank automatically, go to Problem 20, Section 4.4.
2. If the engine does not crank manually, proceed to Problem 21 in Section 4.4.

**TEST 54 – TEST AUTO OPERATIONS**

Discussion
Initial Conditions: The generator is in AUTO, ready to run, and load is being supplied by the utility source. When utility fails (below 65% of nominal), a 10 second (optionally programmable) line interrupt delay time is started. If the utility is still gone when the timer expires, the engine will crank and start. Once started, a five (5) second engine warm-up timer will be initiated. When the warm-up timer expires, the control will transfer the load to the generator. If the utility power is restored (above 75% of nominal) at any time from the initiation of the engine start until the generator is ready to accept a load (5 second warm-up time has not elapsed), the controller will complete the start cycle and run the generator through its normal cool down cycle; however, the load will remain on the utility source.

Procedure
1. Simulate a power failure by disconnecting main breaker.
2. If the generator does not perform the sequence of events listed in the above discussion, replace the controller.

Results
Refer back to flow chart

**TEST 55 – CHECK 7.5 AMP FUSE**

Discussion
The 7.5 amp fuse is located on the generator control console. A blown fuse will prevent battery power from reaching the controller, with the same result as setting the AUTO-OFF-MANUAL switch to OFF.

Procedure
Remove the 7.5 amp fuse (F1) by pushing the fuse.

Results
1. If the fuse if good, refer back to Flow Chart.
2. If the fuse is bad, it should be replaced. Use only an identical 7.5 amp replacement fuse.
3. If fuse continues to blow, proceed to Problem 25 Flow Chart.

**TEST 56 – CHECK BATTERY**

Discussion
Battery power is used to (a) crank the engine and (b) to power the controller. Low or no battery voltage can result in failure of the engine to crank, either manually or during automatic operation. The trickle charger that is included in the generator will not recharge a dead battery.
Section 4.5
Diagnostic Tests

Procedure

A. Inspect Battery Cables:
1. Visually inspect battery cables and battery posts.
2. If cable clamps or terminals are corroded, clean away all corrosion.
3. Install battery cables, making sure all cable clamps are tight. The red battery cable from the starter contactor (SC) must be securely attached to the positive (+) battery post; the black cable from the frame ground stud must be tightly attached to the negative (-) battery post.
4. Disconnect both negative and positive cables.

*Note: Disconnect negative battery cable first.*
5. Using a DC Volt meter, measure DC volts on the battery.

B. Perform a load test on the Battery: (Maintenance Free Battery)
1. Using a lead acid battery load tester test the load capability of the battery.
2. Follow the load tester’s manufacturer’s instructions carefully.

C. Test Battery State of Charge: (Non-Maintenance Free Battery)
1. Use an automotive type battery hydrometer to test battery state of charge.
2. Follow the hydrometer manufacturer’s instructions carefully. Read the specific gravity of the electrolyte fluid in all battery cells.
3. If cells are low, distilled water can be added to refill cell compartment.
4. If the hydrometer does not have a “percentage of charge” scale, compare the reading obtained to the following:
   a. An average reading of 1.260 indicates the battery is 100% charged.
   b. An average reading of 1.230 means the battery is 75% charged.
   c. An average reading of 1.200 means the battery is 50% charged.
   d. An average reading of 1.170 indicates the battery is 25% charged.

Figure 37. A Typical Battery Load Tester

Figure 38. Using a Battery Hydrometer

Figure 39. Reading a Battery Hydrometer
5. Test Battery Condition:
   a. If the difference between the highest and lowest reading cells is greater than 0.050 (50 points), battery condition has deteriorated and the battery should be replaced.
   b. However, if the highest reading cell has a specific gravity of less than 1.230, the test for condition is questionable. Recharge the battery to a 100 percent state of charge, and then repeat the test for condition.

Results

1. Remove the battery and recharge with an automotive battery charger, if necessary.
2. If battery condition is bad, replace with a new battery.

TEST 57 – CHECK WIRE 56 VOLTAGE

Discussion
During an automatic start or when starting manually, a crank relay on the controller should energize. Each time the crank relay energizes, the controller should deliver 12 VDC to the starter contactor (SC), and the engine should crank. This test will verify (a) that the crank relay on the controller is energizing, and (b) that controller action is delivering 12 VDC to the starter contactor.

Procedure

1. Set a VOM to measure DC voltage.
2. Connect the positive (+) test probe of a DC voltmeter (or VOM) to the Wire 56 connector of the starter contactor the starter contactor (SC). Connect the common (-) test probe to frame ground.
3. Observe the meter. Then, set the AUTO-OFF-MANUAL switch to the MANUAL position. The meter should indicate battery voltage. If battery voltage is measured, stop testing and refer back to flow chart.
4. Set a VOM to measure resistance.
   Note: Remove 7.5 amp fuse before disconnecting J1 connector.
5. Remove Wire 56 from the starter contactor. Connect one meter test lead to disconnected Wire 56. Remove the J2 Connector from the controller. Connect the other test lead to J2-11 (Wire 56). CONTINUITY should be measured. If CONTINUITY is not measured, repair or replace Wire 56.

Results

1. If battery voltage is indicated in Step 3 refer back to flow chart.

TEST 58 – TEST STARTER CONTACTOR

Discussion
The starter contactor (SC) must energize and its heavy duty contacts must close or the engine will not crank. This test will determine if the starter contactor is in working order.

Procedure
Carefully inspect the starter motor cable that runs from the battery to the starter motor. Cable connections must be clean and tight. If connections are dirty or corroded, remove the cable and clean cable terminals and terminal studs. Replace any cable that is defective or badly corroded.
Use a DC voltmeter (or a VOM) to perform this test. Test the starter contactor as follows:

1. Connect the positive (+) meter test lead to the starter contactor stud (Test Point 1). Connect the common (-) meter test lead to a clean frame ground. Battery voltage (12 VDC) should be indicated.
2. Connect the positive (+) meter test lead to the starter contactor stud to which the starter motor cable attaches (Test Point 2). Connect the common (-) test lead to frame ground.
   a. No voltage should be indicated initially.
   b. Set the AUTO-OFF-MANUAL switch to MANUAL. The meter should now indicate battery voltage as the starter contactor energizes.

Results

1. If battery voltage was indicated in Step 1, but NOT in Step 2b, replace the starter contactor.
2. If battery voltage was indicated in Step 2b, but the engine did NOT crank, refer back to flow chart.
Section 4.5
Diagnostic Tests

TEST 59 – TEST STARTER MOTOR

Conditions Affecting Starter Motor Performance
1. A binding or seizing condition in the starter motor bearings.
2. A shorted, open or grounded armature.
   a. Shorted armature (wire insulation worn and wires touching one another). Will be indicated by low or no RPM.
   b. Open armature (wire broken) will be indicated by low or no RPM and excessive current draw.
   c. Grounded armature (wire insulation worn and wire touching armature lamination or shaft). Will be indicated by excessive current draw or no RPM.
3. A defective starter motor switch.
4. Broken, damaged or weak magnets.
5. Starter drive dirty or binding.

Discussion
Test 57 verified that the controller is delivering DC voltage to the starter contactor (SC). Test 58 verified the operation of the starter contactor (SC). Another possible cause of an “engine won’t crank” problem is a failure of the starter motor.

Procedure
The battery should have been checked prior to this test and should be fully charged.

Set a VOM to measure DC voltage (12 VDC). Connect the meter positive (+) test lead to the starter contactor stud which has the small jumper wire connected to the starter. Connect the common (-) test lead to the starter motor frame.

Set the AUTO-OFF MANUAL Switch to its “MANUAL” position and observe the meter. Meter should indicate battery voltage, starter motor should operate and engine should crank.

Results
1. If battery voltage is indicated on the meter but starter motor did NOT operate, remove and bench test the starter motor (see following test).
2. If battery voltage was indicated and the starter motor tried to engage (pinion engaged), but engine did NOT crank, check for mechanical binding of the engine or rotor.

If engine turns over slightly, go to Test 70 “Check and Adjust Valves.”

Checking The Pinion

When the starter motor is activated, the pinion gear should move and engage the flywheel ring gear. If the pinion does not move normally, inspect the pinion for binding or sticking.

Tools For Starter Performance Test
The following equipment may be used to complete a performance test of the starter motor:
• A clamp-on ammeter.
• A tachometer capable of reading up to 10,000 rpm.
• A fully charged 12 volt battery.

Measuring Current
To read the current flow, in AMPERES, a clamp-on ammeter may be used. This type of meter indicates current flow through a conductor by measuring the strength of the magnetic field around that conductor.
Section 4.5
Diagnostic Tests

Remove Starter Motor
It is recommended that the starter motor be removed from the engine when testing starter motor performance. Assemble starter to test bracket and clamp test bracket in vise, Figure 46.

Testing Starter Motor
1. A fully charged 12 volt battery is required.
2. Connect jumper cables and clamp-on ammeter as shown in Figure 46.

Note: The starter motor will activate immediately once the cables are connected
3. With the starter motor activated (jump the terminal on the starter contactor to battery voltage), note the reading on the clamp-on ammeter and on the tachometer (rpm).

Remove Starter Motor
It is recommended that the starter motor be removed from the engine when testing starter motor performance. Assemble starter to test bracket and clamp test bracket in vise, Figure 46.

Testing Starter Motor
1. A fully charged 12 volt battery is required.
2. Connect jumper cables and clamp-on ammeter as shown in Figure 46.

Note: The starter motor will activate immediately once the cables are connected
3. With the starter motor activated (jump the terminal on the starter contactor to battery voltage), note the reading on the clamp-on ammeter and on the tachometer (rpm).

Tachometer
A tachometer is available from your parts source. The tachometer measures from 800 to 50,000 rpm, (see Figure 44).

Test Bracket
A starter motor test bracket may be made as shown in Figure 45. A growler or armature tester is available from an automobile diagnostic service supplier.

Note: Take the reading after the ammeter and tachometer are stabilized, approximately 2-4 seconds.
4. A starter motor in good condition will be within the following specifications:

<table>
<thead>
<tr>
<th>Minimum rpm</th>
<th>4500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Amps</td>
<td>9</td>
</tr>
</tbody>
</table>

TEST 60 – CHECK FUEL SUPPLY AND PRESSURE

Discussion
The air-cooled generator was factory tested and adjusted using natural gas as a fuel. If desired, LP (propane) gas may be used. However, when converting to propane, some minor adjustments are required. The following facts apply:

• An adequate gas supply and sufficient fuel pressure must be available or the engine will not start.
• Minimum recommended gaseous fuel pressure at the generator fuel inlet connection is 5 inches water column for natural gas (NG) or 10 inches water column for LP gas.
Section 4.5
Diagnostic Tests

- Maximum gaseous fuel pressure at the generator fuel inlet connection is 7 inches water column for natural gas or 12 inches water column for LP gas.
- When propane gas is used, only a “vapor withdrawal” system may be used. This type of system utilizes the gas that forms above the liquid fuel. The vapor pressure must be high enough to ensure engine operation.
- The gaseous fuel system must be properly tested for leaks following installation and periodically thereafter. No leakage is permitted. Leak test methods must comply strictly with gas codes.

⚠️ DANGER! Gaseous fuels are highly explosive. Do not use flame or heat to test the fuel system for leaks. Natural gas is lighter than air, and tends to settle in high places. LP (propane) gas is heavier than air, and tends to settle in low areas. Even the slightest spark can ignite these gases and cause an explosion.

Procedure

A water manometer or a gauge that is calibrated in “ounces per square inch” may be used to measure the fuel pressure. Fuel pressure at the inlet side of the fuel solenoid valve should be between 5-7 inches water column for natural gas (NG) or 10-12 inches water column for LP gas.

1. See Figure 47 for the gas pressure test point on the fuel regulator. The fuel pressure can be checked at Port 1.
2. With the manometer connected properly, crank the engine. Nominal fuel pressure should be measured. If pressure is not measured while cranking refer back to flow chart.

Note: Where a primary regulator is used to establish fuel inlet pressure, adjustment of that regulator is usually the responsibility of the fuel supplier or the fuel supply system installer.

Results

1. If fuel supply and pressure are adequate, but engine will not start refer back to flow chart.
2. If generator starts but runs rough or lacks power, repeat the above procedure with the generator running and under load. The fuel system must be able to maintain 10-12 inches water column at all load requirements for propane, and 5-7 inches water column for natural gas. If proper fuel supply and pressure is maintained, refer to Problem 18 Flow Chart.

TEST 61 – CHECK CIRCUIT BOARD WIRE 14 OUTPUT

Discussion

During any crank cycle, the controller’s crank relay and run relay both energize simultaneously. When the run relay energizes, it’s contacts close and 12 VDC is delivered to Wire 14 and to a fuel solenoid. The solenoid energizes open to allow fuel flow to the engine. This test will determine if the controller is working properly.

Procedure

1. Set AUTO-OFF-MANUAL switch to OFF.
2. Set a VOM to measure DC voltage.
3. Disconnect Wire 14 from the fuel solenoid.
4. Connect the positive test lead to disconnected Wire 14 and the negative test lead to a clean frame ground.
5. Set the AUTO-OFF-MANUAL switch to the MANUAL position.
6. Battery voltage should be measured. If battery voltage is measured, refer back to flow chart.
7. Disconnect the J2 connector from controller.
8. Set VOM to measure resistance.
9. Connect the positive test lead to disconnected Wire 14 and the negative test lead to J2 Pin 3 (Wire 14).
10. CONTINUITY should be measured. If CONTINUITY is not measured, repair or replace Wire 14 between J2 Pin 3 and the fuel solenoid.

Results

Refer to flow chart.
TEST 62 – CHECK FUEL SOLENOID

Discussion

In Test 61, if battery voltage was delivered to Wire 14, the fuel solenoid should have energized open. This test will verify whether or not the fuel solenoid is operating.

Fuel Solenoid FS1 Nominal Resistance – 14-16 ohms.

Procedure

1. Install a manometer to Port 2 on the fuel regulator. See Figure 47.
2. Set the AUTO-OFF-MANUAL Switch to MANUAL.
3. Proper gas pressure should be measured during cranking. If gas pressure is measured, the fuel solenoid is operating. If gas pressure is not measured, repair or replace the fuel solenoid.

Results

Refer to flow chart.

TEST 63 – CHECK CHOKE SOLENOID

Discussion

The automatic choke cycles open and closed during cranking and remains de-energized in the open position during running.

Procedure

1. Turn off the fuel supply to the generator.
2. Set the AUTO-OFF-MANUAL Switch to the MANUAL position.
3. While cranking the choke solenoid should energize and pull the choke plate closed and release back to the open position as the solenoid cycles during cranking. If the choke solenoid does not cycle, verify that the choke can be manually closed. There should be no binding or interference.

Results

1. If battery voltage was not measured in Step 7 and wire continuity is good, replace the controller.
2. If Choke Solenoid coil resistance is not measured in Step 9, replace the Choke Solenoid.
3. If battery voltage was not measured in Step 4, replace the controller.

TEST 64 – CHECK FOR IGNITION SPARK

Discussion

If the engine cranks but will not start, perhaps an ignition system failure has occurred. A special “spark tester” is required to check for ignition spark.

Procedure

1. Remove spark plug lead from the spark plug.
2. Attach the clamp of the spark tester to the engine cylinder head.
3. Attach the spark plug lead to the spark tester terminal.
Section 4.5  
Diagnostic Tests

4. Crank the engine while observing the spark tester. If spark jumps the tester gap, you may assume the engine ignition system is operating satisfactorily.

**NOTE:** The engine flywheel must rotate at 350 rpm (or higher) to obtain a good test of the solid state ignition system.

To determine if an engine miss is ignition related, connect the spark tester in series with the spark plug wire and the spark plug (Figure 51). Then, crank and start the engine. A spark miss will be readily apparent. If spark jumps the spark tester gap regularly but the engine miss continues, the problem is in the spark plug or in the fuel system.

**TEST 65 – CHECK SPARK PLUGS**

**Discussion**

If the engine will not start and Test 64 indicated good ignition spark, perhaps the spark plug(s) are fouled or otherwise damaged. Engine miss may also be caused by defective spark plug(s).

**Procedure**

1. Remove spark plugs and clean with a penknife or use a wire brush and solvent.
2. Replace any spark plug having burned electrodes or cracked porcelain.
3. Set gap on new or used spark plugs to 0.76 mm (0.030 inch).

**Results**

1. Clean, re-gap or replace spark plugs as necessary.
2. If spark plugs are good, refer back to flow chart.
NORMAL MISFIRES

PRE-IGNITION DETONATION

TEST 66 – CHECK ENGINE / CYLINDER LEAK DOWN TEST / COMPRESSION TEST

Introduction
Performing the following test procedures will accurately diagnose some of the most common problems:

- Will not start
- Lack of power
- Runs Rough
- Vibration
- Overheating
- High Oil Consumption

*CYLINDER LEAK DOWN TEST*

Discussion
The Cylinder Leak Down Tester checks the sealing (compression) ability of the engine by measuring air leakage from the combustion chamber. Compression loss can present many different symptoms. This test is designed to detect the section of the engine where the fault lies before disassembling the engine. Figure 55 represents a standard Tester available on the market.

Note: Refer to Manufacturer’s instructions for variations of this procedure.

Procedure
1. Remove the spark plug from the front cylinder.
2. Gain access to the flywheel. Remove the valve cover.
3. Rotate the engine crankshaft until the piston reaches top dead center (TDC). In this position, both the intake and exhaust valves will be closed. If the engine is not properly position at TDC the results of the test may be inaccurate at diagnosing a problem.
4. Lock the flywheel at top dead center.
5. Attach cylinder leak down tester adapter to spark plug hole.
6. Connect an air source of 90 PSI to the cylinder leak down tester.
7. Adjust the regulated pressure on the gauge to 80 PSI.
8. Read the right hand gauge on the tester for cylinder pressure. A leakage of 20 percent is normally acceptable. Use good judgment, and listen for air escaping at the carburetor (air intake), the exhaust, and the crankcase breather. This will determine where the fault lies.
9. Repeat Step 1 through 8 on remaining cylinder.

Results
- Air escapes at the carburetor (air intake) – check intake valve
- Air escapes through the exhaust – check exhaust valve
- Air escapes through the breather – check piston rings
- Air escapes from the cylinder head – the head gasket should be replaced.

*CHECK COMPRESSION*

Discussion
Lost or reduced engine compression can result in a failure of the engine to start, or a rough operation. One or more of the following will usually cause loss of compression:
Section 4.5
Diagnostic Tests

• Blown or leaking cylinder head gasket
• Improperly seated or sticking-valves
• Worn piston rings or cylinder. (This will also result in a high oil consumption)

The minimum allowable compression pressure for a cold engine is 60 PSI. Compression values are difficult to obtain accurately without special equipment. For this reason, compression values are not published for the larger engines. However, testing has proven that an accurate indication of compression in the cylinder can be obtained by using the following procedure.

**Note:** Refer to Manufacturer’s instructions for variations of this procedure.

**Procedure**

1. Remove the spark plug.
2. Insert a compression gauge into the cylinder.
3. Crank the engine until there is no further increase in pressure.
4. Record the highest reading obtained.
5. Repeat the procedure for the remaining cylinder and record the highest reading.

**Results**

The minimum allowable compression pressure for a cold engine is 60 PSI. If compression is poor, look for one or more of the following causes:

- Loose cylinder head bolts
- Failed cylinder head gasket
- Burned valves or valve seats
- Insufficient valve clearance
- Warped cylinder head
- Warped valve stem
- Worn or broken piston ring(s)
- Worn or damaged cylinder bore
- Broken connecting rod
- Worn valve seats or valves
- Worn valve guides

**TEST 67 – CHECK IGNITION COIL**

**Discussion**

The ignition system is a solid-state (breakerless) type. The system utilizes a magnet on the engine flywheel to induce a relatively low voltage into an ignition coil assembly. Ignition coil internal components increase the voltage and deliver the resulting high voltage across the spark plug gap.

The ignition coil houses a solid-state circuit that controls ignition timing. Timing is fixed, air gap is non-adjustable and spark advance is automatic.

Major components of the ignition system include (a) the ignition coil assembly, (b) the spark plug, and (c) the engine flywheel.

Solid-state components encapsulated in the ignition coil are not accessible and cannot be serviced. If the coil is defective, the entire assembly must be replaced. The air gap between the coil and the flywheel magnet is fixed and non-adjustable.

The ignition coil assembly (Figure 56) consists of (a) ignition coil, (b) spark plug high tension lead and (c) spark plug boot.

![Figure 56. Ignition Coil](image)

**Procedure**

1. Disconnect Wire 18 at the bullet connector and repeat Test 67.

**Results**

1. If unit was able to produce spark after disconnecting Wire 18 then a short to ground is supplying Wire 18 with a ground that is inhibiting the engine from producing spark.
2. If the Ignition Coil failed to produce spark with Wire 18 disconnected, verify integrity of Wire 18 under cover, then replace ignition coil.

**Note:** Before replacing the Ignition Coil, check the flywheel key.

**Flywheel Key**

In all cases, the flywheel’s taper is locked on the crankshaft taper by the torque of the flywheel nut. A keyway is provided for alignment only and theoretically carries no load.

If the flywheel key becomes sheared or even partially sheared, ignition timing can change. Incorrect timing can result in hard starting or failure to start.

**TEST 68 – CHECK OIL PRESSURE SWITCH AND WIRE 86**

**Discussion**

If the oil pressure switch contacts have failed in their closed position, the engine will probably crank and start. However, shutdown will then occur within about 5 (five) seconds. If the engine cranks and starts, then shuts down almost immediately with a LOP fault light, the cause may be one or more of the following:

- Low engine oil level.
- Low oil pressure.
- A defective oil pressure switch.
Diagnostic Tests

Section 4.5

Procedure

1. Check engine crankcase oil level.
   a. Check engine oil level.
   b. If necessary, add the recommended oil to the dipstick FULL mark. DO NOT OVERFILL ABOVE THE FULL MARK.

2. With oil level correct, try starting the engine.
   a. If engine still cranks and starts, but then shuts down, go to Step 4.
   b. If engine cranks and starts normally, discontinue tests.

3. Do the following:
   a. Disconnect Wire 86 and Wire 0 from the oil pressure switch terminals. Remove the switch and install an oil pressure gauge in its place.
   b. Start the engine while observing the oil pressure reading on gauge.
   c. Note the oil pressure.
      (1) Normal oil pressure is approximately 35-40 psi with engine running. If normal oil pressure is indicated, go to Step 4 of this test.
      (2) If oil pressure is below about 4.5 psi, shut engine down immediately. A problem exists in the engine lubrication system.

   Note: The oil pressure switch is rated at 10 psi for single cylinder engines.

4. Remove the oil pressure gauge and reinstall the oil pressure switch. Do NOT connect Wire 86 or Wire 0 to the switch terminals.
   a. Set a VOM to measure resistance.
   b. Connect the VOM test leads across the switch terminals. With engine shut down, the meter should read CONTINUITY. If INFINITY is measured with the engine shutdown, replace the LOP switch.
   c. Crank and start the engine. The meter should read INFINITY.

5. Set a VOM to measure resistance.
   a. Disconnect the J1 Connector from the controller.
   b. Connect one test lead to Wire 86 (disconnected from LOP). Connect the other test lead to Pin Location 4 (Wire 86) of the J1 Connector at the controller. CONTINUITY should be measured. If CONTINUITY is not measured, repair or replace Wire 86 between the LOP switch and the J1 Connector.
   c. Connect one test lead to Wire 0 (disconnected from LOP). Connect the other test lead to a clean frame ground. CONTINUITY should be measured. If CONTINUITY is NOT measured repair or replace Wire 0 between the LOP and the ground terminal connection on the engine mount.

6. If the LOP switch tests good in Step 5 and oil pressure is good in Step 4 but the unit still shuts down with a LOP fault, check Wire 86 for a short to ground. Set a VOM to measure resistance. Disconnect the J1 Connector from the controller. Remove Wire 86 from the LOP switch. Connect one test lead to Wire 86. Connect the other test lead to a clean frame ground. INFINITY should be measured. If CONTINUITY is measured, repair or replace Wire 86 between the LOP switch and the J1 Connector.

Results

1. Replace switch if it fails the test.

TEST 69 – CHECK HIGH OIL TEMPERATURE SWITCH

Discussion

If the temperature switch contacts have failed in a closed position, the engine will fault out on “OVERTEMP.” If the unit is in an overheated condition, the switch contacts will close at 293° F. This will normally occur from inadequate airflow through the generator.

Procedure

1. Verify that the engine has cooled down (engine block is cool to the touch). This will allow the contacts in the High Oil Temperature Switch to close.
2. Check the installation and area surrounding the generator. There should be at least three feet of clear area around the entire unit. Make sure that there are no obstructions preventing incoming and outgoing air.
3. Disconnect Wire 85 and Wire 0 from the High Oil Temperature Switch.
4. Set a VOM to measure resistance. Connect the test leads across the switch terminals. The meter should read INFINITY.
5. If the switch tested good in Step 4, and a true overtemperature condition has not occurred, check Wire 85 for a short to ground. Remove J1 Connector from the controller. Set the VOM to measure resistance. Connect one test lead to Wire 85 (disconnected from High Oil Temperature Switch). Connect the other test lead to a clean frame ground. INFINITY should be measured.
Section 4.5
Diagnostic Tests

Testing High Oil Temperature Switch

6. Remove the High Oil Temperature Switch.
7. Immerse the sensing tip of the switch in oil as shown in Figure 58, along with a suitable thermometer.
8. Set a VOM to measure resistance. Then, connect the VOM test leads across the switch terminal and the switch body. The meter should read INFINITY.
9. Heat the oil in the container. When the thermometer reads approximately 283°-305° F. (139°-151° C.), the VOM should indicate CONTINUITY.

Results

1. If the switch fails Step 4, or Steps 8-9, replace the switch.
2. If INFINITY was NOT measured in Step 5, repair or replace Wire 85 between the controller and the High Oil Temperature Switch.

Figure 58. Testing the Oil Temperature Switch

TEST 70 – CHECK AND ADJUST VALVES

Discussion

Improperly adjusted valves can cause various engine related problems including, but not limited to, hard starting, rough running and lack of power.

Procedure

1. The engine should be cool before checking. If valve clearance is 0.006"-0.008" (0.15-0.20mm), adjustment is not needed.
2. Remove spark plug wire and position wire away from plug.
3. Remove spark plug.
4. Make sure the piston at TDC, remove the intake screen at the top of the engine to gain access to the flywheel nut. Use a large socket and socket wrench to rotate the nut and hence the engine in a clockwise direction. While watching the piston through the spark plug hole. The piston should move up and down. The piston is at TDC when it is at its highest point of travel.

Figure 59. Valve Train

5. Remove the four screws attaching the valve cover.
6. Loosen the rocker jam nut. Use a wrench to turn the pivot ball stud while checking clearance between the rocker arm and the valve stem with a feeler gauge. Correct clearance is:

   Intake — 0.005-0.007 inch (0.13-0.17 mm)
   Exhaust — 0.007-0.009 inch (0.18-0.22 mm)

   NOTE: Hold the rocker arm jam nut in place as the pivot ball stud is turned.

7. When valve clearance is correct, tighten the rocker arm jam nut. Tighten the jam nut to 70 to 106 in-lbs. torque. After tightening the jam nut, recheck valve clearance to make sure it did not change.
8. Install new valve cover gasket.
9. Re-attach the valve cover.

   NOTE: Start all four screws before tightening or it will not be possible to get all the screws in place. Make sure the valve cover gasket is in place.

10. Install spark plug.
11. Re-attach the spark plug wire to the spark plug.

Results

Adjust valve clearance as necessary, then retest.
TEST 71 – CHECK WIRE 18 CONTINUITY

Discussion
During cranking and running the controller receives a pulse from the ignition magneto via Wire 18. If this signal is not received by the controller the unit will shut down due to no RPM sensing.

Procedure
1. Set a VOM to measure resistance.
2. Remove Wire 18 from the in-line bullet connector. Disconnect the J1 Connector from the controller.
3. Verify the continuity of Wire 18. Connect one meter test lead to Wire 18 removed from the bullet connector. Connect the other meter test lead to Pin Location J1-4. CONTINUITY should be measured. If CONTINUITY is not measured, repair or replace Wire 18 as needed.

Results
Refer to flow chart.

TEST 72 – TEST EXERCISE FUNCTION

Discussion
The following parameters must be met in order for the weekly exercise to occur:
• AUTO-OFF-MANUAL switch set to AUTO.

Procedure
1. Set the AUTO-OFF-MANUAL switch to MANUAL. The generator should start. Set AUTO-OFF-MANUAL switch back to AUTO. Verify that AUTO-OFF-MANUAL switch has been in AUTO for weekly exercise to function.
2. Hold the Set Exercise switch until the generator starts (approximately 10 seconds) and then release. All of the red LEDs will flash for approximately 10 seconds and then stop. The generator will start and run for approximately 12 minutes and then shutdown on it’s own. The exerciser will then be set to start and run at that time of that day each week. If the unit does not start, replace the controller.

Results
1. In all models, if the unit starts in MANUAL, but fails to exercise without any ALARMS present, replace the controller.

TEST 73 – TEST CRANKING AND RUNNING CIRCUITS

Discussion
This test will check all of the circuits that are “Hot” with battery voltage and which could cause the Main Fuse to blow. Refer to Table 8 throughout the procedure for the known resistance values of components.

Figure 60 shows the Volt-Ohm-Milliammeter (VOM) in two different states. The left VOM indicates an OPEN circuit or INFINITY. The right VOM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer back to Figure 60 as needed to understand what the meter is indicating about the particular circuit that was tested.

Note: CONTINUITY is equal to .01 ohms of resistance or a dead short.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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<tr>
<td>Starter Contactor</td>
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<td>Main Fuel Solenoid</td>
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<tr>
<td>Transfer Relay</td>
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<tr>
<td>Choke Solenoid</td>
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Table 8. Components Resistance Values

Figure 60. Open Line vs. Continuity

OPEN LINE “INFINITY”     SHORT “CONTINUITY”     .01Ω

Table 9. Resistance Measurements

<table>
<thead>
<tr>
<th>Test Point</th>
<th>Pin Location</th>
<th>Circuit</th>
<th>Value</th>
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<tr>
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<td>J2 Pin 4</td>
<td>Wire 14</td>
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<td>2</td>
<td>J2 Pin 11</td>
<td>Wire 56</td>
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<td>3</td>
<td>J2 Pin 8</td>
<td>Wire 15B</td>
<td>OPEN</td>
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Section 4.5
Diagnostic Tests

Table 10. Test 73 Results

<table>
<thead>
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<th>Circuit</th>
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<tr>
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</tr>
<tr>
<td>3</td>
<td>J2 Pin 8</td>
<td>Wire 15B</td>
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TEST 74 – TEST RUN CIRCUIT

Discussion
Wire 14 provides 12 VDC during cranking and running. If the VOM indicated CONTINUITY in the previous test, one of the possible causes could be a faulty relay or solenoid.

Procedure
1. Set a Volt-Ohm-Milliammeter (VOM) to measure resistance.
2. Disconnect Wire 14 from the fuel solenoid (FS)
3. Connect one meter test lead to the FS terminal from which Wire 14 was removed. Connect the other meter test lead to the ground terminal, measure and record the resistance.

Results
1. If the VOM indicated 16 ohms of resistance in Step 3, a short to ground exists on Wire 14 between the FS and the J2 connector. Repair and replace as needed.
2. If the VOM indicated CONTINUITY in Step 3, replace the FS solenoid.

TEST 75 – TEST CRANK CIRCUIT

Discussion
Wire 56 provides 12 VDC during cranking only. If the VOM indicated CONTINUITY in the previous test, one of the possible causes could be a faulty relay or solenoid.

Procedure
1. Set a Volt-Ohm-Milliammeter (VOM) to measure resistance.
2. Disconnect Wire 56 from the starter contactor (SC) and disconnect the choke solenoid (CS)
3. Connect one meter test lead to the SC terminal from which Wire 56 was removed. Connect the other meter test lead to the ground terminal, measure and record the resistance.
4. Refer to Figure 49 in reference to the CS connector. Connect one meter test lead to Pin 1 and the other meter test lead to Pin 2, measure and record the resistance.

Results
1. If the VOM indicated 4 ohms of resistance in Step 3, a short to ground exists on Wire 56 between the SC and the J2 connector. Repair or replace as needed.
2. If the VOM indicated CONTINUITY in Step 3, replace the SC solenoid.

TEST 76 – CHECK BATTERY CHARGER SUPPLY VOLTAGE

Discussion
The battery charger is supplied with 120 VAC. The output of the battery charger is 13.4 VDC (2.5A).

Procedure
1. Set VOM to measure AC voltage.
2. Measure across points A and B. 120 VAC should be measured.
   a. If 120 VAC is not measured, verify that load source voltage is available, and that the duplex circuit breaker in ON.
   b. If 120 VAC is measured, proceed to Step 3.
3. Measure across points C and D. 120 VAC should be measured.
   a. If 120 VAC is not measured, repair or replace Wire BC LINE or BC 00 between the load center and the generator.
   b. If 120 VAC is measured, refer to Flow Chart.
**TEST 77 – CHECK BATTERY CHARGER OUTPUT VOLTAGE**

**Discussion**
The battery charger is supplied with 120 VAC. The output of the battery charger is 13.4 VDC (2.5A).

**Procedure**
Refer to Figure 62.

1. Set VOM to measure DC voltage.
2. Remove and isolate battery charger black and red leads from generator terminal strip points E and F.
3. Measure across points E and F. Battery supply voltage (12 VDC) should be measured.
   a. If battery voltage is not measured, wait 5 minutes and repeat Step 3. If battery supply voltage is still not available, refer to Flow Chart.
   b. If battery voltage is measured, proceed to Step 4.
4. Reconnect battery charger black and red lead wires previously removed in Step 2.
5. Measure across points E and F. 13.4 VDC should be measured.
   a. If 13.4 VDC is not measured, replace the battery charger.
   b. If 13.4 VDC is measured, the charger is working.

**NOTE:** Battery charger voltage will be higher than battery supply voltage.

**TEST 78 – CHECK WIRE 0/15B**

**Discussion**
In order for the battery charger to function, battery supply voltage must be available to the battery charger.

**Procedure**
Refer to Figure 62.

1. Set VOM to measure DC voltage.
2. Remove and isolate battery charger black and red leads from generator terminal strip points E and F.
3. Measure across points G and H on the terminal strip. 12 VDC should be measured.
   a. If 12 VDC is measured, the charger should be functioning.
   b. If 12 VDC is not measured, proceed to Step 4.
4. Remove Wire 0 and Wire 15B from generator terminal strip locations E and F.
5. Wait five (5) minutes after removing wires.
6. Measure across points E and F on the terminal strip. 12 VDC should be measured.
   a. If 12 VDC is measured, proceed to Step 8.
   b. If 12 VDC is not measured, proceed to Step 7.
7. Measure across point H and ground lug. 12 VDC should be measured.
   a. If 12 VDC is measured, repair or replace Wire 0 between the generator terminal strip and the ground lug.
   b. If 12 VDC is not measured, proceed to Step 8.
8. Set VOM to measure resistance.
9. Connect the meter test leads across the disconnected Wire 0 and Wire 15B. Approximately 200 Ohms should be measured.
   a. If 200 Ohms is measured, proceed to Step 11.
   b. If zero resistance or CONTINUITY is measured, connect the meter test leads across BAT- and XFER on the load center motor.
   c. If zero resistance is measured, a short exists. Replace the load center motor.
   d. If 200 Ohms to INFINITY is measured, repair or replace Wire 15B between the generator and the load center.
10. Disconnect the J2 connector from the controller.
11. Measure across point F and pin location J2-8 of the connector just removed. CONTINUITY should be measured.
   a. If CONTINUITY is not measured, repair or replace Wire 15B between the J2 connector and the terminal strip.
   b. If CONTINUITY is measured and the pin connection looks good, the internal fuse on the controller has failed. Replace the controller.

**TEST 79 – CHECK SHUTDOWN WIRE**

**Discussion**
Circuit board action during shutdown will ground Wire 18. Wire 18 is connected to the Ignition Magneto(s). The grounded magneto will not be able to produce spark.
Section 4.5
Diagnostic Tests

Procedure

1. Disconnect Wire 18 at the bullet connector. See Figure 61.

2. Connect a jumper wire from the stud to which Wire 56 is connected on the Starter Contactor (SC) and 12 VDC Wire 15B at TB1 (Customer Connection). The generator will start cranking. As it is cranking, repeat Test 70.

3. If spark now occurs with Wire 18 removed, check for a short to ground. Remove the J1 Connector from the circuit board.

4. Set a VOM to measure resistance. Connect one test lead to Wire 18 (disconnected in Step 1). Connect the other test lead to a clean frame ground. INFINITY should be measured.

5. Reconnect the J1 Connector to the controller.

Results

1. If INFINITY was not measured in Step 4, repair or replace shorted ground Wire 18 between the J1 Connector from the controller to the bullet connector.

2. If INFINITY was measured in Step 4, replace the controller and retest for spark.

3. If ignition spark still has not occurred, proceed to Test 67.
Figure 62. Test 76, 77, and 78 Test Points.
Section 5.1
Major Disassembly

DISASSEMBLY

Tools Required:
- 7mm Socket
- 8mm Socket
- 10mm Socket
- 13mm Socket
- Harmonic Balancer or Steering Wheel Puller
- Replacement Rotor Bolt (Part No. 0H6930)
- Replacement Exhaust Gasket (Part No. 0H8191)

Torque Values
- Stator Bolts: 6 ft-lbs
- Rotor Bolt: 30 ft-lbs

1. Remove lid from the top of the enclosure.

2. Remove the three removable sides of the enclosure. Refer to Figure 64 for the side that will remain during the disassembly.

3. Disconnect and remove the battery.

4. Using a 10mm socket remove the front two enclosures braces.

5. Using an 8mm socket and a 10mm socket remove the three bolts holding the heat shield. Refer to Figures 66 and 67.

Figure 63.

Figure 64.

Figure 65.

Figure 66.
6. Using a 10mm socket remove the three (3) bolts holding the exhaust housing from the engine support and base. Refer to Figure 68 and 69.

7. Using a 10mm socket remove the remaining exhaust enclosure pieces on each side.

8. Disconnect the red and black brush wires.
9. Disconnect the voltage regulator.

10. Disconnect the ground and neutral connections.

11. Using an 8mm socket remove the two bolts supporting the muffler.

12. Disconnect the fuel supply hose from the air box assembly.
13. Disconnect the choke solenoid.

14. Using an 8mm socket remove the remaining bolt.

15. Using a 10mm socket remove the two bolts connecting support to the base.

16. Carefully slide out the support structure from the base and position assembly horizontally.

17. Using a 13mm wrench remove the rotor bolt from the alternator.
Section 5.1
Major Disassembly

18. Install a harmonic balancer or steering wheel puller onto the fan assembly.

19. Using a 13mm socket remove the four stator bolts.
Note: Make a note of the orientation of the brush wire exit passage on the stator. During re-assembly, if the stator is not bolted together with the exit passage in the same location, the brush wires will not be long enough to reconnect to the wire harness.

20. Remove brush assembly using a 7mm socket.

21. Slide the stator assembly off the rotor.

**WARNING!** Do not cut the rotor bolt unless you have a replacement rotor bolt.

22. Rotor Removal: Cut 2.5 inches from the rotor bolt. Slot the end of the bolt to suit a flat blade screwdriver. Slide the rotor bolt back through the rotor and use a screwdriver to screw it into the crankshaft. Use a 55mm M6 x1.00 bolt to screw into rotor. Apply torque to the 55mm M6 x1.00 bolt until taper breaks.
Section 5.1
Major Disassembly

23. For engine replacement remove the four bolts connecting the engine cradle to the engine casting.

Figure 93.
Control Panel

GROUP EV

Exploded View: EV CONTROL PANEL/EXT CONBOX
Drawing No.: 088211

Revision: A
Date: 9/30/10
## Section 5.2
Exploded Views

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Section 5.2
Exploded Views

Enclosure

GROUP EV

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PART 6
ELECTRICAL DATA

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Wiring Diagram ............................................................. 102
Electrical Schematic ....................................................... 103
Electrical Formulas ........................................................ 104
Electrical Schematic – Drawing 0H7182-C

NOTE: ALL Wires 18 AWG
300V UL listed unless
shown otherwise

LEGEND:
BA = BRUSH ASSEMBLY
BC = BATTERY CHARGER
C1 = 4 POLE CONNECTOR
CB = CIRCUIT BREAKER
GND = GROUND
HTO = HIGH TEMPERATURE SWITCH
IN = IGNITION MODULE
LOP = LOW OIL PRESSURE SWITCH
SC = STARTER CONTACTOR
SM = STARTER MOTOR
SP = SPARK PLUG
SP = SPICE INTERCONNECT

AWG SIZE
### Electrical Formulas

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<td>Frequency, RPM</td>
<td>$\frac{2 \times 60 \times \text{Frequency}}{\text{RPM}}$</td>
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$E = \text{VOLTS} \quad I = \text{AMPERES} \quad R = \text{RESISTANCE (OHMS)} \quad PF = \text{POWER FACTOR}$
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Test 9 Stator Results

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