DIAGNOSTIC REPAIR MANUAL

GENERAC®

Liquid-Cooled Product

MODELS:

2.4 LITER ENGINE
R-200B CONTROLLER
22KW
27KW
36KW
45KW
60KW

AUTOMATIC STANDBY GENERATORS

SAFETY

Throughout this publication the safety alert symbol (⚠) is used with signal words. 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. PAY CLOSE ATTENTION TO THEM.

⚠ **DANGER! Under this heading will be found special instructions which, if not complied with, will result in personal injury or death.**

⚠ **WARNING! Under this heading will be found special instructions which, if not complied with, could result in personal injury or death.**

⚠ **CAUTION! Under this heading will be found special instructions which, if not complied with, could result in damage to equipment and/or property, and/or might result in minor or moderate injury.**

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.

NOTICE TO USERS OF THIS MANUAL

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

This SERVICE MANUAL is not intended for general public consumers without specialized training and knowledge in servicing generators.

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. 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.

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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SPECIFICATIONS

GENERATOR SPECIFICATIONS

TYPE .... Synchronous
ROTOR INSULATION .... Class H
STATOR INSULATION .... Class H
TOTAL HARMONIC DISTORTION .... <5%
TELEPHONE INTERFERENCE FACTOR (TIF) .... <50
ALTERNATOR OUTPUT LEADS 3 PHASE .... 4 wire
BEARINGS .... Sealed Ball
COUPLING .... Flexible Disc
EXCITATION SYSTEM .... Direct

VOLTAGE REGULATOR:

TYPE .... Electronic
SENSING .... Single Phase
REGULATION .... ± 1%
FEATURES .... V/F Adjustable Voltage and Gain LED Indicators

ENGINE SPECIFICATIONS

MAKE .... Generac
MODEL .... Inline 4
CYLINDERS 4
DISPLACEMENT .... 2.4 Liter
BORE 3.41
STROKE 3.94
COMPRESSION RATIO 8.5:1
INTAKE AIR SYSTEM .... Naturally Aspirated
VALVE SEATS .... Hardened
LIFTER TYPE .... Hydraulic

GOVERNOR SPECIFICATIONS:

TYPE .... Electronic
FREQUENCY REGULATION .... Isochronous
STEADY STATE REGULATION .... ± 0.25
ADJUSTMENTS FOR:
Speed .... Yes
Droop .... Yes

ELECTRICAL SYSTEM:

BATTERY CHARGE ALTERNATOR .... 12V 30 Amp
STATIC BATTERY CHARGER .... 2 Amp
RECOMMENDED BATTERY .... Group 26, 525CCA
SYSTEM VOLTAGE .... 12 Volts

FUEL SYSTEM:

FUEL TYPE .... Natural gas, propane vapor
CARBURETOR .... Down Draft
SECONDARY FUEL REGULATOR .... Standard
FUEL SHUT OFF SOLENOID .... Standard
OPERATING FUEL PRESSURE .... 5” - 14” H_2O

Fuel pressure for a natural gas and liquid propane is 5 in – 14 in of water column at all load ranges, however optimal performance is achieved between 8 – 11 inches of water column.

ENGINE LUBRICATION SYSTEM:

OIL PUMP .... Gear
OIL FILTER .... Full flow spin-on cartridge
CRANKCASE CAPACITY .... 4 Quarts

ENGINE COOLING SYSTEM:

TYPE .... Closed
WATER PUMP .... Belt driven
FAN SPEED 1980
FAN DIAMETER .... 17.75 inches
FAN MODE .... Pusher

SERVICE RECOMMENDATIONS

ENGINE OIL:

The unit has been filled with 15W-20 engine oil at the factory. Use a high-quality detergent oil classified “For Service SJ or latest available.” Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE viscosity rating, based on the ambient temperature range anticipated before the next oil change.

Temperature	Oil Grade (Recommended)
Above 80° F (27° C)	SAE 30W or 15W-40
32° to 80° F (-1° to 27° C)	SAE 20W-20 or 15W-40
Below 32° F (0° C)	SAE 10W or 15W-40

NOTE: Synthetic oil is highly recommended when the generator will be operating in ambient temperatures which regularly exceed 90° F and/or fall below 30° F.

Any attempt to crank or start the engine before it has been properly serviced with the recommended oil may result in an engine failure.

COOLANT:

Use a mixture of half low silicate ethylene glycol base anti-freeze and de-ionized water. Cooling system capacity is about 3.0 U.S. gallons. Use only de-ionized water and only low silicate anti-freeze. If desired, add a high quality rust inhibitor to the recommended coolant mixture. When adding coolant, always add the recommended 50-50 mixture.

Do not use any chromate base rust inhibitor with ethylene glycol base anti-freeze or chromiumhydroxide (“green slime”) forms and will cause overheating. Engines that have been operated with a chromate base rust inhibitor must be chemically cleaned before adding ethylene glycol base anti-freeze. Using any high silicate anti-freeze boosters or additives will also cause overheating. It is also recommended that any soluble oil inhibitor is not used for this equipment.

OPERATING DATA

KW RATING	**22**		
ENGINE SIZE	2.4 Liter Inline 4		
GENERATOR OUTPUT VOLTAGE/KW - 60Hz	**KW**	**AMP**	**CB Size**
120/240V, 1-phase, 1.0 pf	22	92	100
120/208V, 3-phase, 0.8 pf	22	76	80
120/240V, 3-phase, 0.8 pf	22	66	80
GENERATOR LOCKED ROTOR KVA AVAILABLE @ VOLTAGE DIP OF 35% Single phase or 208 3-phase	43		
ENGINE FUEL CONSUMPTION* (Natural Gas) (Propane)	**Natural Gas** (ft^3/hr.)	**Propane** (gal/hr.)	cu ft/hr
Exercise cycle	42	0.44	16
25% of rated load	100	1.0	38
50% of rated load	190	2.0	72
75% of rated load	255	2.7	98
100% of rated load	316	3.3	120
ENGINE COOLING Air flow (inlet air including alternator and combustion air) ft^3/min.	2,400		
System coolant capacity US gal.	2.5		
Heat rejection to coolant BTU/hr.	99,000		
Max. operating air temp. on radiator °C (°F)	60 (150)		
Max. ambient temperature °C (°F)	50 (140)		
COMBUSTION AIR REQUIREMENTS Flow at rated power 60 Hz cfm	68		
SOUND EMISSIONS IN DBA Exercising at 7 meters	61		
Normal operation at 7 meters	70		
EXHAUST Exhaust flow at rated output 60 Hz cfm	165		
Exhaust temp. at muffler outlet °F	900		
ENGINE PARAMETERS Rated synchronous RPM 60 Hz	1800		
HP at rated KW 60 Hz	40		
POWER ADJUSTMENT FOR AMBIENT CONDITIONS Temperature Deration			
3% for every 10 °C above - °C	25		
1.65% for every 10 °F above - °F	77		
Altitude Deration			
1% for every 100 m above - m	183		
3% for every 1000 ft. above - ft.	600		

* Fuel consumption is given at rated maximum continuous power output when using natural gas rated at 1000 Btu per cubic foot and LP gas rated 2520 Btu per cubic foot. Actual fuel consumption obtained may vary depending on such variables as applied load, ambient temperature, engine conditions and other environmental factors.

SPECIFICATIONS

OPERATING DATA

KW RATING	**27**				
ENGINE SIZE	2.4 Liter Inline 4				
GENERATOR OUTPUT VOLTAGE/KW - 60Hz	**KW Nat. Gas**	**AMP**	**KW LPG**	**AMP**	**CB Size (Both)**
120/240V, 1-phase, 1.0 pf	25	104	27	112	125
120/208V, 3-phase, 0.8 pf	25	87	27	94	100
120/240V, 3-phase, 0.8 pf	25	75	27	81	90
GENERATOR LOCKED ROTOR KVA AVAILABLE @ VOLTAGE DIP OF 35% Single phase or 208 3-phase	43				
ENGINE FUEL CONSUMPTION* (Natural Gas) (Propane)	**Natural Gas** (ft^3/hr.)	**Propane** (gal/hr.)		cu ft/hr	
Exercise cycle	42	0.44		16	
25% of rated load	108	1.2		44	
50% of rated load	197	2.2		81	
75% of rated load	287	3.2		118	
100% of rated load	359	4.1		147	
ENGINE COOLING Air flow (inlet air including alternator and combustion air) ft^3/min.	2,400				
System coolant capacity US gal.	2.5				
Heat rejection to coolant BTU/hr.	120,000				
Max. operating air temp. on radiator °C (°F)	60 (150)				
Max. ambient temperature °C (°F)	50 (140)				
COMBUSTION AIR REQUIREMENTS Flow at rated power 60 Hz cfm	68				
SOUND EMISSIONS IN DBA Exercising at 7 meters	62				
Normal operation at 7 meters	75				
EXHAUST Exhaust flow at rated output 60 Hz cfm	130				
Exhaust temp. at muffler outlet °F	900				
ENGINE PARAMETERS Rated synchronous RPM 60 Hz	1800				
HP at rated KW 60 Hz	40				
POWER ADJUSTMENT FOR AMBIENT CONDITIONS Temperature Deration					
3% for every 10 °C above - °C	25				
1.65% for every 10 °F above - °F	77				
Altitude Deration					
1% for every 100 m above - m	183				
3% for every 1000 ft. above - ft.	600				

* Fuel consumption is given at rated maximum continuous power output when using natural gas rated at 1000 Btu per cubic foot and LP gas rated 2520 Btu per cubic foot. Actual fuel consumption obtained may vary depending on such variables as applied load, ambient temperature, engine conditions and other environmental factors.

OPERATING DATA

KW RATING	**36/35**				
ENGINE SIZE	2.4 Liter Inline 4				
GENERATOR OUTPUT VOLTAGE/KW - 60Hz	**KW LPG**	**AMP**	**KW Nat. Gas**	**AMP**	**CB Size (Both)**
120/240V, 1-phase, 1.0 pf	36	150	35	146	175
120/208V, 3-phase, 0.8 pf	36	125	35	121	150
120/240V, 3-phase, 0.8 pf	36	108	35	105	125
277/480V, 3-phase, 0.8 pf	36	54	35	52	60
GENERATOR LOCKED ROTOR KVA AVAILABLE @ VOLTAGE DIP OF 35% Single phase or 208 3-phase	63				
480V 3-phase	84				
ENGINE FUEL CONSUMPTION* (Natural Gas) (Propane)	**Natural Gas** (ft^3/hr.)	**Propane** (gal/hr.)		cu ft/hr	
Exercise cycle	87	0.96		35.2	
25% of rated load	156	1.67		60.8	
50% of rated load	282	3.0		110	
75% of rated load	392	4.2		153	
100% of rated load	503	5.4		196	
ENGINE COOLING Air flow (inlet air including alternator and combustion air) ft^3/min.	2,200				
System coolant capacity US gal.	2.5				
Heat rejection to coolant BTU/hr.	135,000				
Max. operating air temp. on radiator °C (°F)	60 (150)				
Max. ambient temperature °C (°F)	50 (140)				
COMBUSTION AIR REQUIREMENTS Flow at rated power 60 Hz cfm	106				
SOUND EMISSIONS IN DBA Exercising at 7 meters	58				
Normal operation at 7 meters	64				
EXHAUST Exhaust flow at rated output 60 Hz cfm	300				
Exhaust temp. at muffler outlet °F	1075				
ENGINE PARAMETERS Rated synchronous RPM 60 Hz	1800				
HP at rated KW 60 Hz	56				
POWER ADJUSTMENT FOR AMBIENT CONDITIONS Temperature Deration					
3% for every 10 °C above - °C	25				
1.65% for every 10 °F above - °F	77				
Altitude Deration					
1% for every 100 m above - m	915				
3% for every 1000 ft. above - ft.	3000				

* Fuel consumption is given at rated maximum continuous power output when using natural gas rated at 1000 Btu per cubic foot and LP gas rated 2520 Btu per cubic foot. Actual fuel consumption obtained may vary depending on such variables as applied load, ambient temperature, engine conditions and other environmental factors.

OPERATING DATA

KW RATING	**45**		
ENGINE SIZE	2.4 Liter Inline 4		
GENERATOR OUTPUT VOLTAGE/KW - 60Hz	**KW**	**AMP**	**CB Size**
120/240V, 1-phase, 1.0 pf	45	188	200
120/208V, 3-phase, 0.8 pf	45	156	175
120/240V, 3-phase, 0.8 pf	45	135	150
277/480V, 3-phase, 0.8 pf	45	68	80
GENERATOR LOCKED ROTOR KVA AVAILABLE @ VOLTAGE DIP OF 35% Single phase or 208 3-phase	100		
480V 3-phase	110		
ENGINE FUEL CONSUMPTION* (Natural Gas) (Propane)	**Natural Gas** (ft^3/hr.)	**Propane** (gal/hr.)	cu ft/hr
Exercise cycle	102	1.11	40.4
25% of rated load	194	2.12	77.1
50% of rated load	373	4.07	148
75% of rated load	520	5.67	206.3
100% of rated load	720	7.86	286
ENGINE COOLING Air flow (inlet air including alternator and combustion air) ft^3/min.	2,725		
System coolant capacity US gal.	3.0		
Heat rejection to coolant BTU/hr.	173,000		
Max. operating air temp. on radiator °C (°F)	60 (150)		
Max. ambient temperature °C (°F)	50 (140)		
COMBUSTION AIR REQUIREMENTS Flow at rated power 60 Hz cfm	144		
SOUND EMISSIONS IN DBA Exercising at 7 meters	61		
Normal operation at 7 meters	73		
EXHAUST Exhaust flow at rated output 60 Hz cfm	429		
Exhaust temp. at muffler outlet °F	1150		
ENGINE PARAMETERS Rated synchronous RPM 60 Hz	3600		
HP at rated KW 60 Hz	71		
POWER ADJUSTMENT FOR AMBIENT CONDITIONS Temperature Deration			
3% for every 10 °C above - °C	25		
1.65% for every 10 °F above - °F	77		
Altitude Deration			
1% for every 100 m above - m	183		
3% for every 1000 ft. above - ft.	600		

* Fuel consumption is given at rated maximum continuous power output when using natural gas rated at 1000 Btu per cubic foot and LP gas rated 2520 Btu per cubic foot. Actual fuel consumption obtained may vary depending on such variables as applied load, ambient temperature, engine conditions and other environmental factors.

OPERATING DATA

KW RATING	60		
ENGINE SIZE	2.4 Liter Inline 4		
GENERATOR OUTPUT VOLTAGE/KW - 60Hz	**KW**	**AMP**	**CB Size**
120/240V, 1-phase, 1.0 pf	60	250	300
120/208V, 3-phase, 0.8 pf	60	208	250
120/240V, 3-phase, 0.8 pf	60	180	200
277/480V, 3-phase, 0.8 pf	60	90	100
GENERATOR LOCKED ROTOR KVA AVAILABLE @ VOLTAGE DIP OF 35% Single phase or 208 3-phase	120		
480V 3-phase	141		
ENGINE FUEL CONSUMPTION* (Natural Gas) (Propane)	**Natural Gas** (ft^3/hr.)	**Propane** (gal/hr.)	cu ft/hr
Exercise cycle	123	1.34	49.3
25% of rated load	267	2.7	101
50% of rated load	483	5.0	183
75% of rated load	672	7.0	255
100% of rated load	862	9.0	327
ENGINE COOLING Air flow (inlet air including alternator and combustion air) ft^3/min.	3,280		
System coolant capacity US gal.	2.5		
Heat rejection to coolant BTU/hr.	270,000		
Max. operating air temp. on radiator °C (°F)	60 (150)		
Max. ambient temperature °C (°F)	50 (140)		
COMBUSTION AIR REQUIREMENTS Flow at rated power 60 Hz cfm	180		
SOUND EMISSIONS IN DBA Exercising at 7 meters	65		
Normal operation at 7 meters	72		
EXHAUST Exhaust flow at rated output 60 Hz cfm	494		
Exhaust temp. at muffler outlet °F	1,050		
ENGINE PARAMETERS Rated synchronous RPM 60 Hz	3600		
HP at rated KW 60 Hz	94		
POWER ADJUSTMENT FOR AMBIENT CONDITIONS Temperature Deration			
3% for every 10 °C above - °C	25		
1.65% for every 10 °F above - °F	77		
Altitude Deration			
1% for every 100 m above - m	915		
3% for every 1000 ft. above - ft.	3000		

* Fuel consumption is given at rated maximum continuous power output when using natural gas rated at 1000 Btu per cubic foot and LP gas rated 2520 Btu per cubic foot. Actual fuel consumption obtained may vary depending on such variables as applied load, ambient temperature, engine conditions and other environmental factors.

ROTOR/STATOR RESISTANCE TABLES

Rotors	Resistance
22 kW 1-Phase 4 Pole 1800 RPM	6.81 Ohms
22 kW 3-Phase 4 Pole 1800 RPM	6.46 Ohms
27 kW 1-Phase 4 Pole 1800 RPM	7.80 Ohms
27 kW 3-Phase 4 Pole 1800 RPM	7.56 Ohms
36 kW 1-Phase 4 Pole 1800 RPM	8.10 Ohms
36 kW 3-Phase 4 Pole 1800 RPM	8.10 Ohms
45 kW 1-Phase 2 Pole 3600 RPM	4.85 Ohms
45 kW 3-Phase 2 Pole 3600 RPM	4.85 Ohms
60 kW 1-Phase 2 Pole 3600 RPM	5.45 Ohms
60 kW 3-Phase 2 Pole 3600 RPM	5.45 Ohms

Stator	Wires 11 & 22	Wires 33 & 44	Wires 2 & 6
22 kW 1-Phase 120/240	0.0559 Ohms	0.0559 Ohms	0.7647 Ohms
27 kW 1-Phase 120/240	0.0439 Ohms	0.0439 Ohms	0.7151 Ohms
36 kW 1-Phase 120/240	0.0404 Ohms	0.0404 Ohms	0.6335 Ohms
45 kW 1-Phase 120/240	0.0642 Ohms	0.0642 Ohms	0.681 Ohms
60 kW 1-Phase 120/240	0.03905 Ohms	0.03905 Ohms	0.522 Ohms

Stator	Wires S1 & S4	Wires S3 & S6	Wires S2 & S5	Wires 2 & 6
22 kW 3-Phase 120/208	0.0688 Ohms	0.0688 Ohms	0.0688 Ohms	1.2387 Ohms
27 kW 3-Phase 120/208	0.0537 Ohms	0.0537 Ohms	0.0537 Ohms	1.2028 Ohms
36 kW 3-Phase 277/480	0.18135 Ohms	0.18135 Ohms	0.18135 Ohms	1.1525 Ohms
36 kW 3-Phase 120/208	0.0348 Ohms	0.0348 Ohms	0.0348 Ohms	1.1525 Ohms
45 kW 3-Phase 120/208	0.0333 Ohms	0.0333 Ohms	0.0333 Ohms	0.799 Ohms
45 kW 3-Phase 277/480	0.1655 Ohms	0.1655 Ohms	0.1655 Ohms	0.6895 Ohms
60 kW 3-Phase 120/208	0.0195 Ohms	0.0195 Ohms	0.0195 Ohms	0.6705 Ohms
60 kW 3-Phase 277/480	0.09665 Ohms	0.09665 Ohms	0.09665 Ohms	0.6705 Ohms

Stator	Wires S1 & 00	Wires S4 & 00	Wires S3 & S6	Wires S2 & S5	Wires 2 & 6
36 kW 3-Phase 120/240	0.0673 Ohms	0.0673 Ohms	0.13095 Ohms	0.13095 Ohms	1.1525 Ohms
45 kW 3-Phase 120/240	0.0642 Ohms	0.0642 Ohms	0.1248 Ohms	0.1248 Ohms	0.799 Ohms
60 kW 3-Phase 120/240	0.0426 Ohms	0.0426 Ohms	0.0816 Ohms	0.0816 Ohms	0.6705 Ohms

PART 1 GENERAL INFORMATION

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SERVICE ITEM ACCESSIBILITY CHART

SERVICE ITEM	
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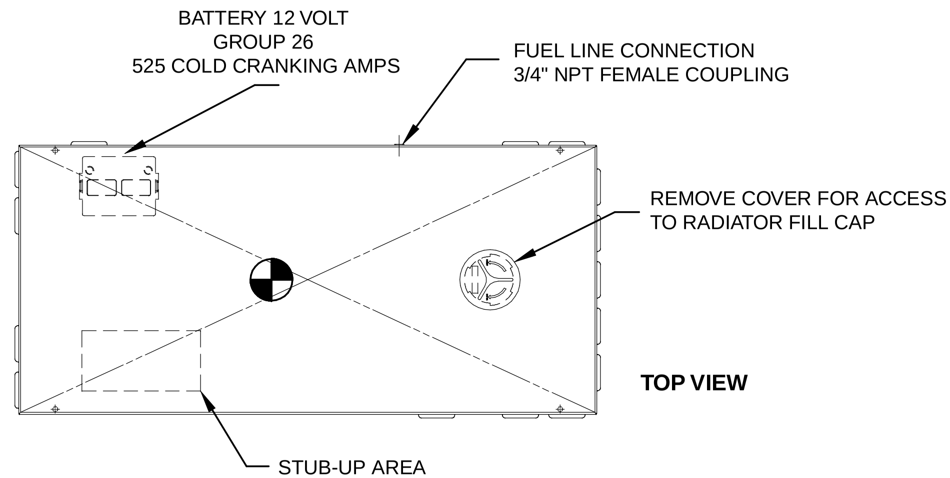
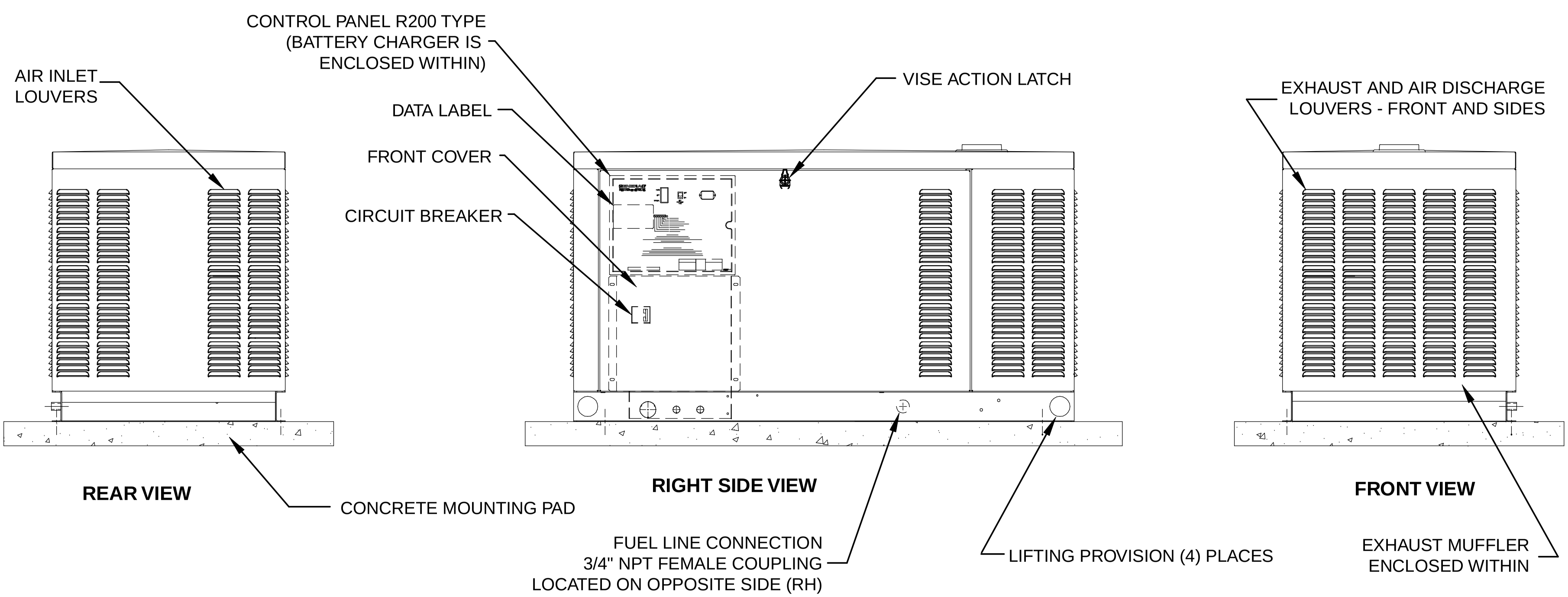
OIL DIP STICK	THRU RIGHT DOOR
OIL FILTER	THRU RIGHT DOOR
OIL DRAIN HOSE	THRU LEFT DOOR
RADIATOR DRAIN HOSE	THRU LEFT DOOR
AIR CLEANER ELEMENT	THRU LEFT DOOR
SPARK PLUGS	THRU LEFT DOOR
MUFFLERS	REMOVE LIFT-OFF ENCLOSURE
FAN BELT	THRU RIGHT DOOR
BATTERY	THRU LEFT DOOR

REFERENCE OWNERS MANUAL FOR PERIODIC REPLACEMENT PART LISTINGS



TOP VIEW



REAR VIEW

RIGHT SIDE VIEW

FRONT VIEW

INTRODUCTION

This Diagnostic Repair Manual has been prepared especially for the purpose of familiarizing service personnel with the testing, troubleshooting and repair of 2.4 Liter R-200B generator systems. Every effort has been expended to ensure that information and instructions in the manual are both accurate and current. However, the manufacturer 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 SECTIONS. Each SECTION consists of two or more SUBSECTIONS.

It is not the manufacturers intent to provide detailed disassembly and reassembly instructions in this manual. It is the manufacturers 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.

TROUBLESHOOTING

Testing and troubleshooting methods covered in this manual are not exhaustive. The manufacturer has not attempted to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis might be performed. The manufacturer has not undertaken any such broad evaluation. 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 product's safety.

Common questions to ask when troubleshooting are:

- What is the generator doing?
- What is the fault that is causing the generator to shut down?
- Is the fault causing the shutdown a symptom of another problem?

  i.e. Set AUTO-OFF-MANUAL switch to the manual position, generator shutdown for a "Flashing Overspeed", but the generator never cranked. If the unit never cranked, then there was never an RPM signal created for the PCB to detect. The "Flashing Overspeed" would be a symptom of a "No Crank" condition.

- What was the generator supposed to do?
- What component controls that function and how does it control that function?

  i.e. Is it a ground signal or a 12VDC signal that controls the component?

- Does the generator have the same fault consistently, and when does it occur?
- If an AUTO operation issue, what was the Green status ready light showing?

  i.e. If the Green LED was flashing then the generator believes that it is in a utility failure. If it is solid then AUTO operations should be working.

TECH TIPS

Look for the (i) to help identify information and service tips that can be helpful along the way in diagnosing the generator.

UNITS WITH LIQUID-COOLED ENGINE

A typical 2.4 Liter R-200B generator with liquid-cooled engine is shown on Page 12.

A DATA PLATE, affixed to the unit, contains important information pertaining to the unit, including its Model Number, Serial Number, kW rating, rated rpm, rated voltage, etc. The information from this data plate may be required when requesting information, ordering parts, etc.

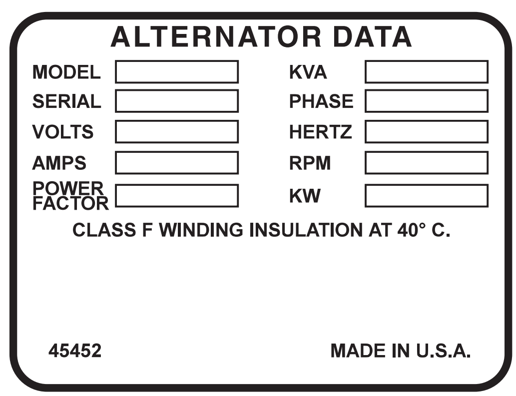


Figure 1. A Typical Data Plate

INTRODUCTION

Information in this section is provided so that the service technician will have a basic knowledge of installation requirements for home standby systems. Problems that arise are often related to poor or unauthorized installation practices.

A typical home standby electric system is shown in Figure 1, below. Installation of such a system includes the following:

- Sizing the generator (key to a good installation).
- Selecting a location.
- Mounting of the generator.
- Grounding the generator.
- Providing a fuel supply.
- Mounting the transfer switch.
- Connecting power source and load lines.
- Connecting system control wiring.
- Post installation tests and adjustments.

SELECTING A LOCATION

Install the generator set as close as possible to the electrical load distribution panel(s) that will be powered by the unit, ensuring that there is proper ventilation for cooling air and exhaust gases. This will reduce wiring and conduit lengths. Wiring and conduit not only add to the cost of the installation, but excessively long wiring runs can result in a voltage drop. Consult NFPA 37 and 70.

Tech Tip: A good rule of thumb is 5 feet clearance on all sides from structures.

MOUNTING THE GENERATOR

Mount the generator set to a concrete slab. The slab should extend past the generator and to a distance of at least twelve (12) inches on all sides. The unit can be retained to the concrete slab with masonry anchor bolts.

GROUNDING THE GENERATOR

The National Electric Code requires that the frame and external electrically conductive parts of the generator be property connected to an approved earth ground. Local electrical codes may also require proper grounding of the unit. For that purpose, a grounding lug is attached to the unit. Grounding may be accomplished by attaching a stranded copper wire of the proper size to the generator's grounding lug and to an earth-driven copper or brass grounding-rod (electrode). Consult with a local electrician for grounding requirements in your area.

THE FUEL SUPPLY

Units with liquid-cooled engines are shipped from the factory to run on natural gas (Figure 2) with the exception of the 60kW unit. The 60kW unit needs to be ordered from the factory to work on a specific fuel. If conversion from one fuel source to another is necessary after the generator has been ordered, a conversion kit is available. Generator sets that are below 60kW can be converted in the field to use LP (propane) gas fuel (Figure 3). Any conversion performed in the field must follow the instructions in the owner's manual or in Section 1.3 of this manual.

LP (propane) gas is usually supplied as a liquid in pressure tanks. Liquid-cooled units require a "vapor withdrawal" type of fuel supply system when LP (pro-

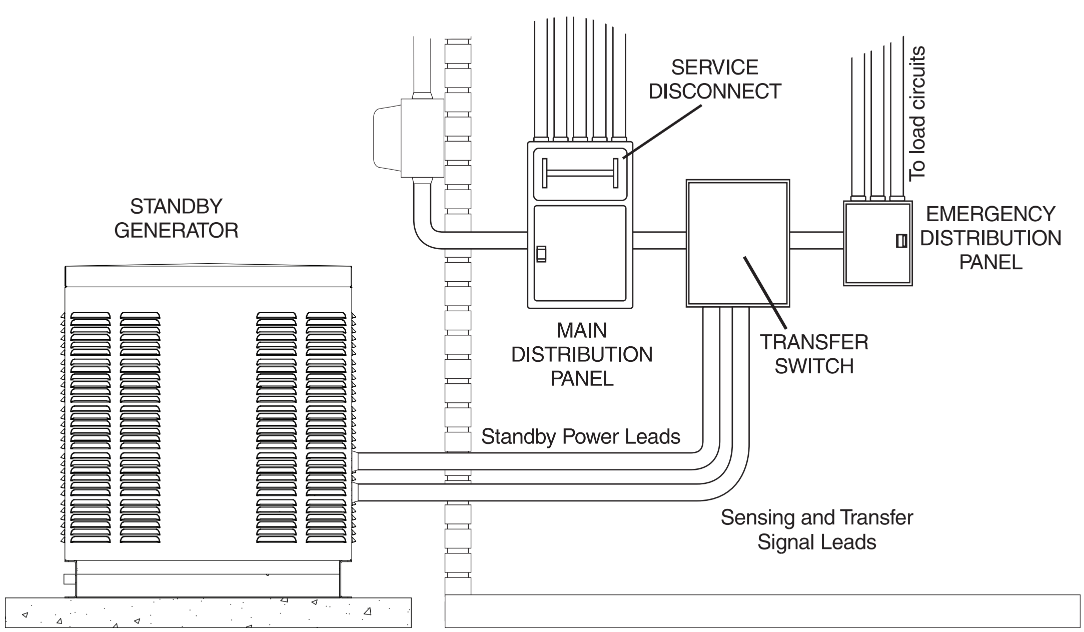


Figure 1. Typical Installation

pane) gas is used. The vapor withdrawal system utilizes the gaseous fuel vapors that form at the top of the supply tank.

The pressure at which LP gas is delivered to the generator's fuel solenoid valve may vary considerably, depending on ambient temperatures. In cold weather, supply pressures may drop to "zero". In warm weather, extremely high gas pressures may be encountered. A primary/secondary supply regulator is required to maintain correct gas supply pressure to the generator demand regulator.

Minimum recommended gaseous fuel pressure at the inlet side of the generator's fuel solenoid valve is 5 inches water column for LP and NG gas (6.38 ounces per square inch). The maximum recommended pressure is 14 inches water column (8.09 ounces per square inch). A primary regulator may be required to ensure that proper fuel supply pressures are maintained.

DANGER: LP and natural gas are both highly explosive. Gaseous fuel lines must be properly purged and tested for leaks before this equipment is placed into service and periodically thereafter. Procedures used in gaseous fuel leakage tests must comply strictly with applicable fuel gas codes. Do not use flame or any source of heat to test for gas leaks. No gas leakage is permitted. LP gas is heavier than air and tends to settle in low areas. Natural gas is lighter than air and tends to settle in high places. Even the slightest spark can ignite these fuels and cause an explosion.

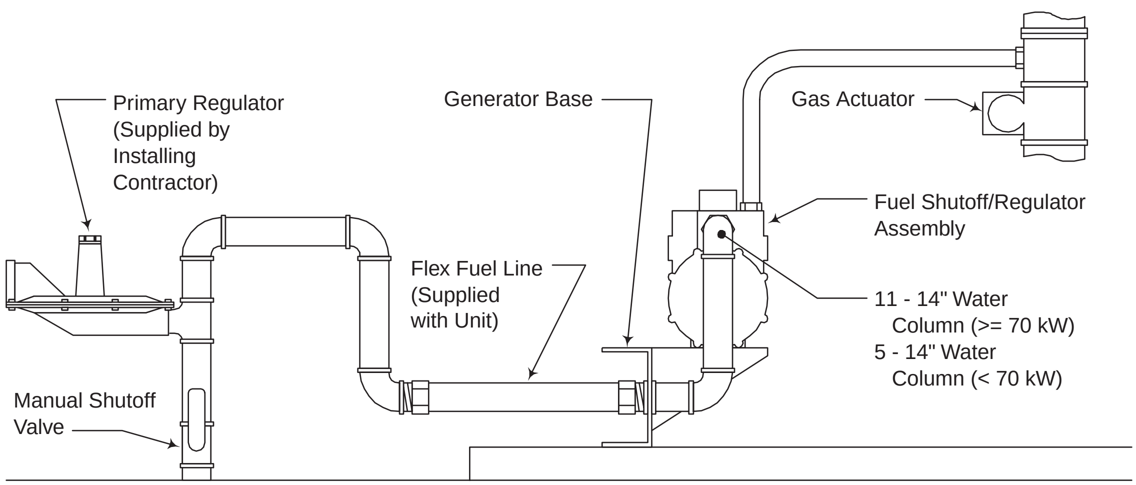


Figure 2. Typical Natural Gas Fuel System (Liquid-Cooled Units)

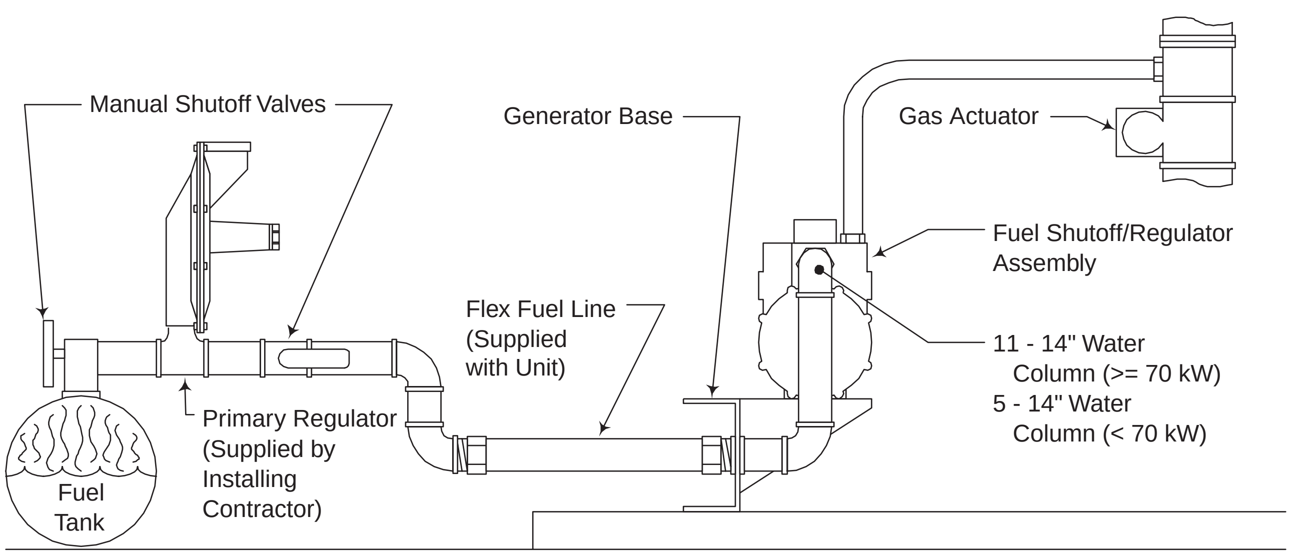


Figure 3. Typical LP Gas Fuel System (Liquid-Cooled Units)

THE TRANSFER SWITCH

A transfer switch is required by electrical code, to prevent electrical feedback between the utility and standby power sources, and to transfer electrical loads from one power supply to another safely.

POWER SOURCE AND LOAD LINES

The utility power supply lines, the standby (generator) supply lines, and electrical load lines must all be connected to the proper terminal lugs in the transfer switch. The following rules apply:

In 1-phase systems with a 2-pole transfer switch, connect the two "Utility" source hot lines to transfer switch Terminal Lugs N1 and N2. Connect the "Standby" source hot lines (E1, E2) to transfer switch Terminal Lugs E1 and E2. Connect the "Load" source lines (T1, T2) to the transfer switch Terminal Lugs T1 and T2. Connect "Utility", "Standby" and "Load" neutral lines to the neutral block in the transfer switch.

SYSTEM CONTROL INTERCONNECTIONS

Home standby generators are equipped with a terminal board identified with the following terminals: (a) 23, (b) 194, (c) 178, (d) 183, (e) N1 and (f) N2. Suitable, approved wiring must be interconnected between identically numbered terminals in the generator and transfer switch. When these four terminals are properly interconnected, dropout of utility source voltage below a preset value will result in automatic generator startup and transfer of electrical loads to the "Standby" source. On restoration of utility source voltage above a preset value will result in retransfer back to that source and generator shutdown. System control wiring must be routed through its own separate conduit.

On units with an RTS type transfer switch, a control board mounted on the standby generator set provides a "7-day exercise" feature. This feature allows the standby generator to start and run once every 7 days, on a day and at a time of day selected.

On units with a GTS type switch the exercise function is controlled via the GTS switch.

The R-type control panel comes with a standard 2 Amp battery charger. This charger, when powered by 120 VAC from the utility distribution panel, will deliver a charging voltage to the battery during non-operating periods to keep the battery charged.

Tech Tip: The 120 VAC input is a separate terminal strip that must be connected in order for the battery charger to work.

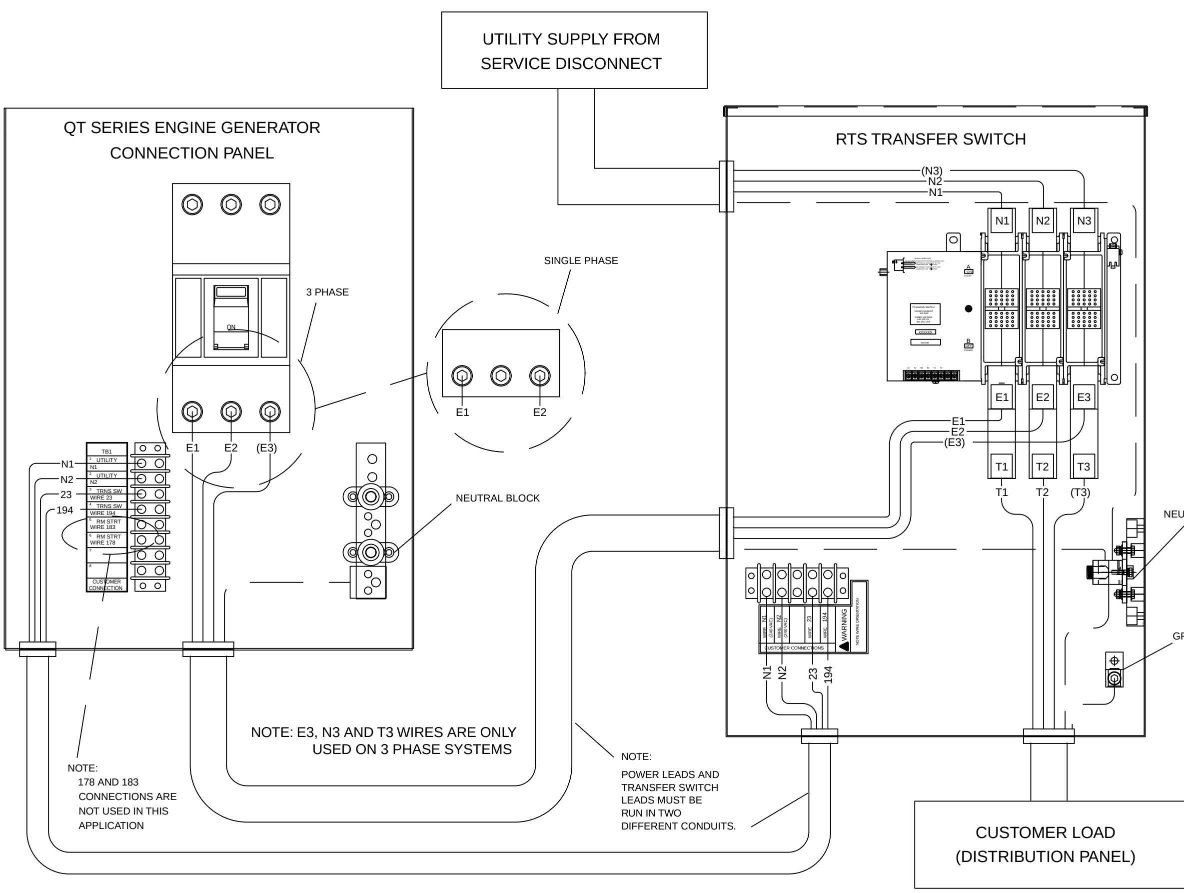


Figure 4. Interconnection Diagram

GENERAL

The installer must ensure that the home standby generator has been properly installed. The system must be inspected carefully following installation. 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.

Prior to initial startup of the unit, the installer must ensure that the engine-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.
- The engine cooling system must be properly serviced with the recommended coolant.

FUEL REQUIREMENTS

Units with liquid-cooled engines are shipped from the factory to run on natural gas with the exception of the 60kW unit. The 60kW unit needs to be ordered from the factory to work on a specific fuel. If conversion from one fuel source to another is necessary after the generator has been ordered, a conversion kit is available. Generator sets that are below 60kW can be converted in the field to use LP (propane) gas fuel.

ALL UNITS:

- When natural gas is used as a fuel, it should be rated at least 1000 BTU's per cubic foot.
- When LP (propane) gas is used as a fuel, it should be rated at 2520 BTU's per cubic foot.

RECONFIGURING THE FUEL SYSTEM

Before the generator can be operated using a LP fuel source, the fuel system, wire harness, and ignition control module must be reconfigured. The steps to reconfigure the generator from a natural gas (NG) to a liquefied petroleum (LP) fuel source are as follows:

FUEL SYSTEM:

1. Turn the main gas supply off and disconnect the battery. The battery may be reconnected after the wire harness has been reconfigured.
2. Remove the mixer fuel hose from the outlet port of the demand regulator (see Figure 1).
3. Disconnect the power wires from the fuel solenoid located on top of the regulator assembly by removing the screw on the front of the connector and pulling the connector forward, away from the solenoid body.
4. Loosen the spring clamp on the small fuel enrichment line and remove the hose from the hose barb.
5. Remove the black pipe assembly from the outlet port of the demand regulator. The solenoid assembly may need to be removed before performing this operation (Figure 1).
6. Remove the NG fuel jet (loosen counter clockwise) from the outlet port.
7. Remove the LP fuel jet (loosen counter clockwise) from the jet keeper port on the side of the regulator housing. Install this jet into the outlet port in the regulator casting.

NOTE: The jet sizes are stamped on the individual jets. The larger jet size is used for running on NG..

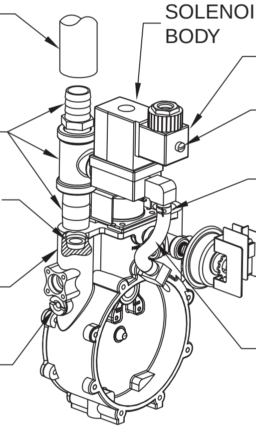


Figure 1. Reconfigure the Fuel System

FUEL SELECT CONNECTOR:

For the 2.4L units with the R-200B controller, this connector is located in the engine harness behind the R-Panel.

Engine timing for Natural Gas (NG) Fuel is selected when this connection is MADE (i.e. the two connector halves are plugged together).

Engine timing for LP Fuel is selected when this connection is LEFT OPEN. When this connector is left open the plugs, located in the R-Panel, should be installed in these connectors to prevent moisture from entering the harness connectors.

CAUTION: Whenever the Generator's Fuel Regulator is converted from one Fuel type to the other, make sure to configure the Fuel Select Connector for the correct Fuel type.

NOTES

VISUAL INSPECTION

When it becomes necessary to test or troubleshoot a generator, it is a good practice to complete a thorough visual inspection. Remove the access covers and look closely for any obvious problems. Look for the following:

- Burned or broken wires, broken wire connectors, damaged mounting brackets, etc.
- Loose or frayed wiring insulation, loose or dirty connections.
- Check that all wiring is well clear of rotating parts.
- Verify that the Generator is properly connected for the correct rated voltage. This is especially important on new installations. See Section 1.2, "AC Connection Systems".
- Look for foreign objects, loose nuts, bolts and other fasteners.
- Clean the area around the generator. Clear away paper, leaves, snow, and other objects that might blow against the generator and obstruct its air openings.

MEASURING VOLTAGES

When troubleshooting and testing the generator set, the technician will be required to measure both AC and DC voltages. Measurement of voltage requires that the user be thoroughly familiar with the meter being used for such tests. Consult the instruction manual for the meter being used.

When measuring voltage, it is best to connect the meter test leads to the terminals being tested while the generator is shut down or while power to those terminals is turned off.

DANGER: Power voltages generated by this equipment are extremely high and dangerous. Use extreme care when measuring power voltages such as generator AC output voltage. Contact with live terminals and conductors may result in harmful and possibly lethal electrical shock. Do not attempt to read power voltages while standing on wet or damp ground, or while hands or feet are wet. Stay well clear of high voltage power terminals. Connect meter test leads to terminals and leads while the generator is shut down or when the power supply to such leads and terminals is turned off. The use of insulative rubber mats is recommended. Take power voltage readings only while standing on such insulative mats.

MEASURING CURRENT

Alternating current (AC) can be measured with a clamp-on ammeter. Most clamp-on ammeters will not measure direct current (DC). Load current readings should never exceed the generator's data plate rating for continuous operation. However, momentary surges in load current may be encountered when starting electric motors.

On 1-phase generators, the data plate generally lists rated line-to-line and line-to-neutral current.

MEASURING RESISTANCE

The resistance (in ohms) of generator stator and rotor windings can be measured using an ohmmeter or an accurate volt-ohm-milliammeter (VOM).

The resistance of some windings is extremely low. Some readings are so low that a meter capable of reading in the "milliohms" range would be required. Many meters will simply read CONTINUITY. However, a standard volt-ohm-milliammeter (VOM) may be used to test for continuity, or for a shorted or grounded condition.

INSULATION RESISTANCE

The insulation resistance of stator and rotor windings is a measurement of the integrity of the insulating materials that separate the electrical windings from the generator's steel core. This resistance can degrade over time or due to such contaminants as dust, dirt, oil, grease and especially moisture. In most cases, failures of stator and rotor windings are due to a breakdown in the insulation. And, in many cases, a low insulation resistance is caused by moisture that collects while the generator is shut down. When problems are caused by moisture buildup on the windings, they can usually be corrected by drying the windings. Cleaning and drying the windings can usually eliminate dirt and moisture built up in the generator windings.

MEGGERS:

The normal resistance of generator winding insulation is on the order of millions of ohms. This high resistance can be measured with a device called a "megger". The megger is a megohm meter ("meg" stands for million) and a power supply. The power supply voltage varies between megger models and is selectable on some models. The most common power supply voltage is 500 volts. Use of power supplies greater than 500 volts are not recommended on generators.

CAUTION: Before attempting to measure insulation resistance, first disconnect and isolate all leads of the winding to be tested. Electronic components, diodes, surge protectors, relays, voltage regulators, etc., can be destroyed if subjected to high megger voltages.

HI-POT TESTER:

A "Hi-Pot" tester is shown in Figure 1. The model shown is only one of many that are commercially available. The tester shown is equipped with a voltage selector switch that permits the power supply voltage to be selected. It also mounts a breakdown lamp that will illuminate to indicate an insulation breakdown during the test.

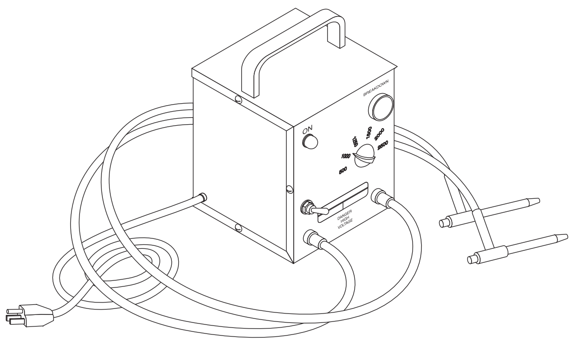


Figure 1. One Type of Hi-Pot Tester

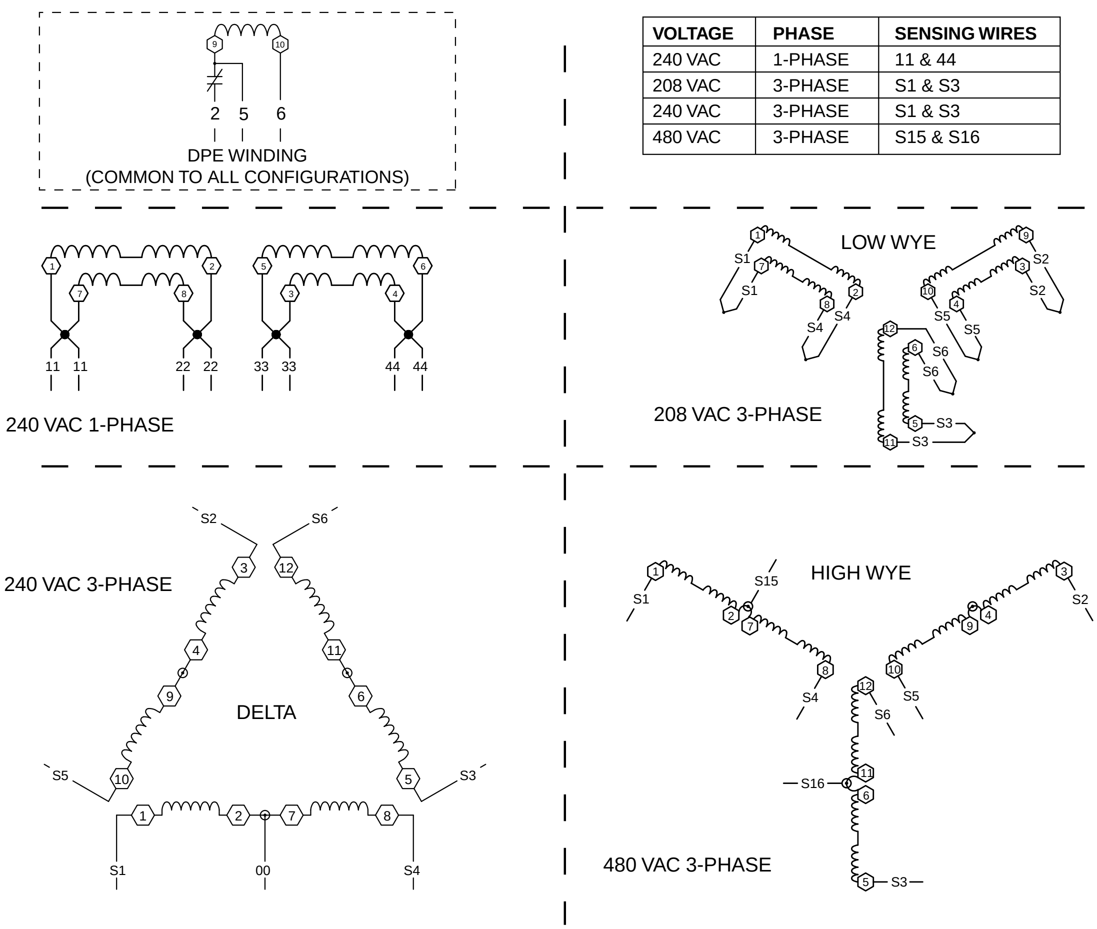
STATOR INSULATION TESTS

GENERAL:

Units with liquid-cooled engine and 1-phase stator windings are equipped with (a) dual stator AC power windings, and (b) an excitation or DPE winding. Stator winding insulation tests consist of (a) testing all windings to ground, (b) testing between isolated windings, and (c) testing between parallel windings. Figure 2 represents the various stator AC output leads on 1 -phase units with liquid-cooled engines.

TEST ALL WINDINGS TO GROUND:

1. Disconnect and isolate all stator leads.
2. Make sure all wire terminal ends are completely isolated from frame ground.
3. Connect the black tester probe to a clean frame ground on the stator can. Test each stator lead by connecting the red test probe of the Hi-Pot tester to the terminal end of each stator lead. Then, proceed as follows:
   a. Turn the Hi- Pot tester switch OFF
   b. Plug the tester cord into a 120 volts AC wall socket and set its voltage selector switch to "500 volts".
   c. Turn the tester switch ON and observe the



VOLTAGE	PHASE	SENSING WIRES
240 VAC	1-PHASE	11 & 44
208 VAC	3-PHASE	S1 & S3
240 VAC	3-PHASE	S1 & S3
480 VAC	3-PHASE	S15 & S16

Figure 2. Stator Winding Leads (Liquid-Cooled Units)

breakdown lamp. After one (1) second, turn the tester switch OFF.

d. Repeat a, b and c for each lead.

If the breakdown lamp turned on during the one (1) second test, clean and dry the stator. Then, repeat the test. If breakdown lamp comes on during the second test, replace the stator assembly.

TEST BETWEEN ISOLATED WINDINGS:

Each winding consists of 2 leads. Use the matrix below as an aid in connecting and testing all windings.

1. Connect red and black probes of the hi-pot according to the matrix.
2. Isolate all lead ends from each other. Be sure that the leads at the other ends of the winding being tested do not touch each other or ground.
3. Set the tester switch to “500 volts”.
4. Turn the tester switch ON and check that the pilot lamp is lighted.
5. Wait one (1) second while observing the tester breakdown lamp. DO NOT EXCEED ONE SECOND. After one (1) second, turn the tester switch OFF.

Example: Connect the red test probe to Stator Lead 2, the black probe to Stator Lead 11. Then, repeat Steps 2, 3 and 4. Repeat for each pair of leads as shown in the matrix.

	1-PHASE	3-PHASE
RED LEAD	2	2
BLACK LEAD	11	S1
RED LEAD	2	2
BLACK LEAD	33	S3
RED LEAD	11	2
BLACK LEAD	33	S5
RED LEAD		S1
BLACK LEAD		S3
RED LEAD		S1
BLACK LEAD		S5
RED LEAD		S3
BLACK LEAD		S5

If the breakdown lamp turned on during any one (1) second test, the stator should be cleaned and dried. After cleaning and drying, repeat the test. If the breakdown lamp turns on during the second test, replace the stator assembly.

TESTING ROTOR INSULATION

Before attempting to test rotor insulation, either the brush leads must be completely removed from the brushes or the brush holders must be completely removed. The rotor must be completely isolated from other components before starting the test.

1. Connect the red tester lead to the positive (+) slip ring (nearest the rotor bearing).
2. Connect the black tester probe to a clean frame ground, such as a clean metal part of the rotor.
3. Turn the tester switch OFF.
4. Plug the tester into a 120 volts AC wall socket and set the voltage switch to “500 volts”.
5. Turn the tester switch ON and make sure the pilot light has turned on.
6. Observe the breakdown lamp, then turn the tester switch OFF. DO NOT APPLY VOLTAGE LONGER THAN ONE (1) SECOND.

If the breakdown lamp came on during the one (1) second test, cleaning and drying of the rotor may be necessary. After cleaning and drying, repeat the insulation breakdown test. If breakdown lamp comes on during the second test, replace the rotor assembly.

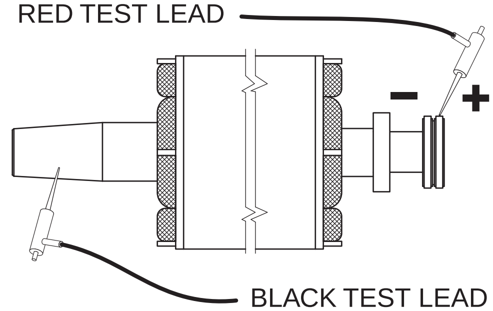


Figure 3. Testing Rotor Insulation

CLEANING THE GENERATOR

Caked or greasy dirt may be loosened with a soft brush or a damp cloth. A vacuum system may be used to clean up loosened dirt. Dust and dirt may also be removed using dry, low-pressure air (25 psi maximum).

CAUTION: Do not use sprayed water to clean the generator. Some of the water will be retained on generator windings and terminals, and may cause very serious problems.

DRYING THE GENERATOR

To dry a generator, proceed as follows:

1. Open the generator main circuit breaker. NO ELECTRICAL LOADS MUST BE APPLIED TO THE GENERATOR WHILE DRYING.
2. Disconnect all Wires No. 4 from TB1 Terminal 3 located in the back wall of the control panel.
3. Provide an external source to blow warm, dry air through the generator interior (around the rotor and stator windings. DO NOT EXCEED 185° F. (85° C.).
4. Start the generator and let it run for 2 or 3 hours.
5. Shut the generator down and repeat the stator and rotor insulation resistance tests.

CONTROL PANEL

GENERAL:

See Figure 1. A typical control panel on units with liquid-cooled engine includes: (a) an auto-off-manual switch, (b) seven LED indicators, (c) a 15 amp fuse, (d) a set exercise switch, and (e) an hourmeter.

AUTO-OFF-MANUAL SWITCH:

Use this switch to (a) select fully automatic operation, (b) to crank and start the engine manually, and (c) to shut the unit down or to prevent automatic startup.

1. AUTO position (RTS type switch):
   a. Select AUTO for fully automatic operation.
   b. When AUTO is selected, circuit board will monitor utility power source voltage.
   c. Should utility voltage drop below a preset level and remain at such a low level for a preset time, circuit board action will initiate engine cranking and startup.
   d. Following engine startup, circuit board action will initiate transfer of electrical loads to the "Standby" source side.
   e. On restoration of utility source voltage above a preset level, circuit board action will initiate retransfer back to the "Utility Source" side.
   f. Following retransfer, circuit board will shut the engine down and will then continue to monitor utility source voltage.
2. AUTO position (GTS type switch):
   a. Select AUTO for fully automatic operation.
   b. When AUTO is selected, circuit board will monitor Wires 183 and 178 for a closed circuit from the GTS transfer switch, also called a 2-wire start signal.
   c. When the GTS switch sees voltage drop below a preset level it will close Wires 183 and 178 in the transfer switch.
   d. When the GTS senses a closed circuit at the circuit board on Wires 183 and 178 it will initiate engine cranking and startup.
   e. Following engine startup, the circuit board will continue to run as long as a closed circuit is present on Wires 178 and 183.
   f. Upon restoration of utility source voltage above a preset level the GTS transfer switch will retransfer the load, cool down the generator, open Wires 178 and 183, and initiate an engine shutdown.
   g. Following shutdown the circuit board will continue to monitor for a closed circuit on Wires 178 and 183.

Tech Tip: When the generator is operating in GTS mode it will only know how to do two things, startup and shutdown. All other Auto operation logic is disabled in this mode including the exercise function. The exercise function will be handled by the transfer switch.

3. OFF Position:
   a. Set the switch to OFF to stop an operating engine.
   b. To prevent an automatic startup from occurring, set the switch to OFF.
4. MANUAL Position:
   a. Set switch to MANUAL to crank and start unit manually.
   b. Engine will crank cyclically and start (same as automatic startup, but without transfer).

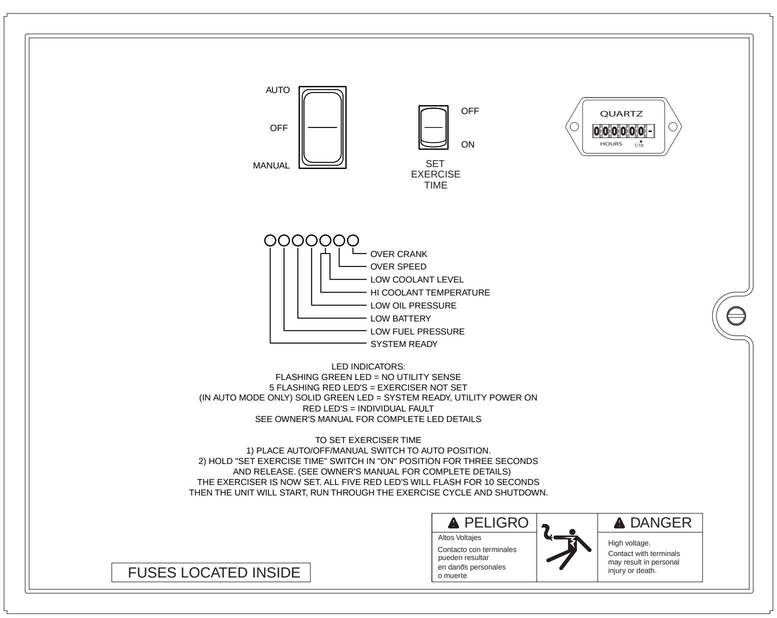


Figure 1. Control Panel

DANGER: When the generator is installed in conjunction with an automatic transfer switch, engine cranking and startup can occur at any time without warning (providing the AUTO-OFF-MANUAL switch is set to AUTO). To prevent automatic startup and possible injury that might be caused by such startup, always set the AUTO-OFF-MANUAL switch to its OFF position before working on or around this equipment.

LED INDICATORS:

The seven LED indicators are labelled as follows (see Figure 1, next page):

System Ready	Green LED
Low Fuel Pressure	Yellow LED
Low Battery	Red LED
Low Oil Pressure	Red LED
Hi Coolant Temp/Low Coolant Level	Red LED
Over Speed/RPM Sensor Loss	Red LED
Over Crank	Red LED

15 AMP FUSE:

This fuse protects the DC control system, including the control board, against overload. If the fuse has blown, engine cranking and running will not be possible. Should fuse replacement become necessary, use only an identical 15 amp replacement fuse.

THE SET EXERCISE SWITCH:

Use this switch to select the time and day for system exercise.

TO SELECT AUTOMATIC OPERATION

The following procedure applies to those installations in which the standby generator is installed in conjunction with a transfer switch. RTS transfer switches do not have an intelligence circuit of their own. Instead, automatic operation on transfer switch and generator combinations is controlled by a control circuit board housed in the generator.

To select automatic operation when a transfer switch is installed along with a standby generator, proceed as follows:

1. Check that the transfer switch main contacts are at their “Utility” position, i.e., the load is connected to the utility power supply. If necessary, manually actuate the switch main contacts to their “Utility” source side. See Part 3 of this manual for instructions.
2. Check that utility source voltage is available to transfer switch Terminal Lugs N1 and N2 (2-pole, 1-phase transfer switches).
3. Set the generator’s AUTO-OFF-MANUAL switch to its AUTO position.
4. Actuate the generator’s main line circuit breaker to its ON or “Closed” position.

With the preceding Steps 1 through 4 completed, a dropout in utility supply voltage below a preset level will result in automatic generator cranking and start-up. Following startup, the transfer switch will be actuated to its “Standby” source side, i.e., loads powered by the standby generator.

MANUAL TRANSFER TO “STANDBY” AND MANUAL STARTUP

To transfer electrical loads to the “Standby” (generator) source and start the generator manually, proceed as follows:

1. On the generator panel, set the AUTO-OFF-MANUAL switch to OFF.
2. On the generator, set the main line circuit breaker to it’s OFF or “Open” position.
3. Turn OFF the utility power supply to the transfer switch, using whatever means provided (such as a utility-source line circuit breaker).
4. Manually actuate the transfer switch main contacts to their “Standby” position, i.e., loads connected to the “Standby” power source side.
5. On the generator panel, set the AUTO-OFF-MANUAL switch to MANUAL. The engine should crank and start.
6. Let the engine warm up and stabilize for a minute or two at no-load.
7. Set the generator’s main line circuit breaker to its ON or “Closed” position. The generator now powers the electrical loads.

MANUAL SHUTDOWN AND RETRANSFER BACK TO “UTILITY”

To shut the generator down and retransfer electrical loads back to the “Utility” position, proceed as follows:

1. Set the generator’s main line circuit breaker to its OFF or “Open” position.
2. Let the generator run at no-load for a few minutes, to cool.
3. Set the generator’s AUTO-OFF-MANUAL switch to OFF. Wait for the engine to come to a complete stop.
4. Turn OFF the “Utility” power supply to the transfer switch using whatever means provided (such as a “Utility” source main line circuit breaker)
5. Manually actuate the transfer switch to its “Utility” power source side, i.e., “Load” connected to the “Utility” source.
6. Turn ON the “Utility” power supply to the transfer switch, using whatever means provided.
7. Set the generator’s AUTO-OFF-MANUAL switch to AUTO.

EXERCISE FEATURE

The 2.4 liter standby generator with an R-200B control panel will start and exercise once every seven (7) days, on a day and at a time of day selected by the owner or operator. The set exercise time switch is provided to select the day and time of day for system exercise. On units with a GTS type switch exercise is controlled via the GTS switch.

NORMAL EXERCISE MODE:

To select this mode, place DIP switch position 3 in the ON position.

In Normal Exercise Mode the generators will exercise at their normal running speed.

The R-200B controller will start and run the generator once every seven (7) days for approximately 12 minutes. If the utility fails during the exercise period, this exercise period is aborted and the R-200B Controller transfers the load to the generator output, assumes automatic operation and continues to run until the utility is returned.

The weekly exercise cycle is set as follows:

1. Place the AUTO-OFF-MANUAL switch in the AUTO position.
2. Press and hold the “Set Exercise Time” switch for five (5) seconds and then release.

At this time all five (5) red LED's will flash for 10 seconds, then the engine will start and run for it's 12 minute exercise period, then shut down. The generator will now start and run each week at approximately the same time.

If battery power to the R-200B Controller is lost, the weekly exercise time setting will be lost. This is indicated by all five (5) red LED's continually flashing in ATS mode. In this state the generator will still start and run in MANUAL mode, or automatically start and run if utility voltage is lost while in AUTO mode, but it will NOT perform a weekly exercise cycle.

In the event of a failure while running in this mode, the five (5) red LED's will stop flashing, the individual fault LED will turn on and the engine will be shut down. Once the AUTO-OFF-MANUAL switch is switched to OFF, the individual fault LED will turn off and the five (5) red LED's will begin flashing to show that the exercise mode has not yet been set.

LOW SPEED EXERCISE:

To select this mode place DIP switch position 3 in the OFF position.

In Low Speed Exercise mode, 3600 rpm generators will exercise at 1800 rpm. 1800 rpm generators will exercise at 1400 rpm in this mode.

If the utility fails during the low speed exercise period, a 10 second timer will start. If the utility returns to a normal operating level, during this 10 second time interval the low speed exercise operation will continue.

If the utility is still not present (i.e. utility voltage less than 60% of nominal) when the above 10 second timer expires then the low speed exercise mode is terminated and the engine will ramp up to its normal running speed within five (5) seconds. If the utility returns during the five (5) second ramp-up period the generator will terminate the exercise mode. If the utility is still not present, once the generator is up to its normal running speed, then the controller will transfer the load to the generator. When the utility returns the generator will shutdown.

If battery power to the R-200B Controller is lost, the weekly exercise time setting will be lost. This is indicated by all 5 red LED's continually flashing in ATS mode. In this state the generator will still start and run in MANUAL mode, or automatically start and run if utility voltage is lost while in AUTO mode, but it will NOT perform a weekly exercise cycle.

In the event of a failure while running in this mode, the five (5) red LED's will stop flashing, the individual fault LED will turn on and the engine will be shut down. Once the AUTO-OFF-MANUAL switch is switched to OFF, the individual fault LED will turn off and the five (5) red LED's will begin flashing to show that the exercise mode has not yet been set.

DANGER: The generator will crank and start when the set exercise time switch is set to “ON”. Do not actuate the switch to “ON” until after reading the instructions in Section 1.6.

INTRODUCTION

When the R-200B control panel is installed in conjunction with an RTS transfer switch, either manual or automatic operation is possible. Manual transfer and engine startup, as well as manual shutdown and retransfer are covered in section 1.6. Selection of fully automatic operation is also discussed in this section. This section will provide a step-by-step description of the sequence of events that will occur during automatic operation of the system.

On units with a GTS type switch sensing and exercise are performed at the transfer switch.

AUTOMATIC OPERATING SEQUENCES

PHASE 1 – UTILITY VOLTAGE AVAILABLE:

With utility source voltage available to the transfer switch, that source voltage is sensed by a control board in the generator panel and the circuit board takes no action.

Electrical loads are powered by the “Utility” source and the AUTO-OFF-MANUAL switch is set to AUTO.

PHASE 2 – UTILITY VOLTAGE DROPOUT:

If a dropout in utility source voltage should occur below about 60 percent of the nominal utility source voltage, a 15 second timer on the control board will start timing. This timer is required to prevent false generator starts that might be caused by transient utility voltage dips.

PHASE 3 – ENGINE CRANKING:

When the control board’s 15 second timer has finished timing and if utility source voltage is still below 60 percent of the nominal source voltage, control board action will energize a crank relay and a run relay. Both of these relays are mounted in the control cabinet.

Control board action will hold the crank relay energized for about 7-9 seconds. The relay will then be de-energized for about 7-9 seconds, energized again for 7-9 seconds, and so on. When the crank relay energizes the engine will crank, when it is de-energized, engine cranking will stop. This cyclic action of crank/rest, crank/rest, etc., will continue until either (a) the engine starts, or (b) until ninety (90) seconds have elapsed.

If the engine has not started within ninety (90) seconds, cranking will terminate and shutdown will occur. On liquid-cooled engine units, LED indicators on the generator panel will illuminate.

If the engine starts, cranking will terminate when generator AC output frequency reaches approximately 30 Hz.

PHASE 4 – ENGINE STARTUP AND RUNNING:

The control board senses that the engine is running by receiving a speed frequency signal from the generator magnetic pickup.

When generator AC frequency reaches approximately 30 Hz, an engine warm-up timer on the control board turns on. That timer will run for about fifteen (15) seconds. At the same time, an engine minimum run timer will turn on.

The engine warm-up timer lets the engine warm-up and stabilize before transfer to the “Standby” source can occur.

Tech Tip: The engine can be shut down manually at any time, by setting the AUTO-OFF-MANUAL switch to OFF.

PHASE 5 – TRANSFER TO “STANDBY”:

When the control board’s engine warm-up timer has timed out, control board action completes a transfer relay circuit to ground. The transfer relay is housed in the transfer switch enclosure.

The transfer relay energizes and transfer of loads to the “Standby” power source occurs. Loads are now powered by standby generator AC output.

PHASE 6 – “UTILITY” POWER RESTORED:

When utility source voltage is restored above about 80 percent of the nominal supply voltage, a fifteen (15) second timer on the control board starts timing. If utility voltage remains sufficiently high at the end of fifteen (15) seconds, a “retransfer time delay” will start timing and will time for about six (6) seconds.

PHASE 7 – RETRANSFER BACK TO “UTILITY”:

When the retransfer time delay has finished timing, control board action will open a circuit to a transfer relay (housed in the transfer switch). The transfer relay will then de-energize and retransfer back to the “Utility” source will occur. Loads are now powered by “Utility” source power. On retransfer, an “engine cool-down timer” starts timing and will run for about one (1) minute.

PHASE 8 – GENERATOR SHUTDOWN:

When the engine cool-down timer has finished timing, and if the minimum run timer has timed out, engine shutdown will occur.

AUTOMATIC OPERATING SEQUENCES CHART

SEQ.	CONDITION	ACTION	SENSOR, TIMER OR OTHER
1	“Utility” source voltage is available.	No action	Voltage Dropout Sensor on control board.
2	“Utility” voltage dropout below 60% of rate voltage occurs.	A 6-second timer on control board turns on.	Voltage Dropout Sensor and 6-second timer on control board.
3	“Utility” voltage is still low after 6 seconds.	Control board action energizes a crank relay and a run relay. The engine cranks for 7-9 seconds, rests for 7-9 seconds, and so on until engine starts. See Note 1	Control board crank and run relays.
4	“Utility” voltage still low and the engine has started.	Control board’s “Engine Warm-Up Timer” turns on.	Engine Warm-up Timer (15 Seconds)
5	Engine running and “engine warm-up timer” times out.	Control board action energizes a transfer relay in transfer switch and transfer to “Standby” occurs.	Control board's “Voltage Pickup Sensor” continues to seek an acceptable “Utility” voltage.
6	Engine running and load is powered by “Standby” power	No further action	Control’s board's “Voltage Pickup Sensor” continues to seek an acceptable “Utility” voltage.
7	“Utility” source voltage is restored about 80% of rated source voltage.	Control board’s “Voltage Pickup Sensor” reacts and a “return to utility timer” turns on.	Voltage Pickup Sensor (80%) Return to Utility Timer (10 seconds)
8	“Utility” voltage still high after 6 seconds.	“Return to Utility Timer” times out.	Return to Utility Timer
9	“Utility” voltage still normal.	Control board action opens the transfer relay circuit to ground. Transfer relay de-energizes and retransfer to “Utility” occurs.	Control board transfer relay circuit.
10	Engine still running, loads are powered by “Utility” source.	Control board’s “Engine Cool Down Timer” starts running.	Control Board’s Engine Cool Down Timer (1 Minute)
11		After 1 minute, “Engine Cool Down Timer” has expired.	Engine Cool Down Timer and Control board Run Relay
12	Engine is shutdown, loads are powered by “Utility” source. Return to Sequence 1.	No action	Voltage Dropout Sensor on control board.

Note1: In Sequence 4, if engine has not started in 90 seconds cranking will end and shutdown will occur.

AMP STYLE CONNECTOR

Wires can be removed from the Amp style connector if a couple steps are followed. Lift the tabs at the end of the connector and gently slide the connector face forward, photo shows forward position. Use caution when lifting tabs to prevent breakage.

A stop will keep the face from sliding off the connector body. Do not completely remove the face because it is extremely difficult to put it back on a populated connector. If you find you have to replace the face on a populated connector it is imperative to match the wire lugs with the connector face to prevent damage to the lugs.

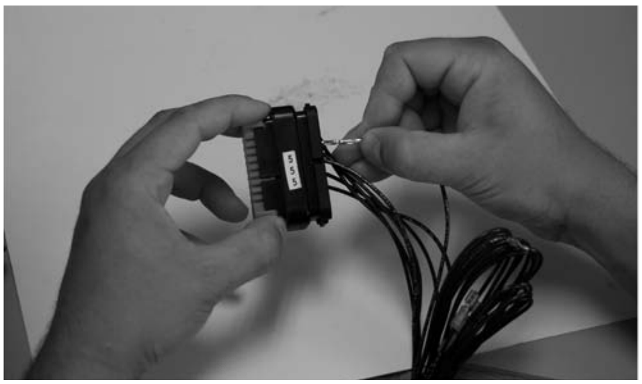


Figure 1.

The wire to be removed should be pushed, rotated, and pulled. The rotating action releases the wire from the lock. When replacing the wire, insert the wire into the appropriate location and push until it locks and push the face of the connector back until it locks. Gently tug the inserted wire and inspect. The lug will be just below the face of the connector if inserted fully and can be seen through the face of the connector.

METER TEST LEADS

Testing should be done paying close attention to not damage either style of connector plug. Many types of test leads and probes are available. Two possible sources are *www.digikey.com* or *www.fluke.com*. Slim test leads work well. Inserting the slim test lead from the back of the connector is preferable. If the harness is plugged together when testing is done, piercing probes or a breakout box or test cable can be used. When using piercing probes to test a live circuit, be careful not to short leads and tape pierced portion of the insulation when finished. A breakout box or testing cable can also be constructed to test the circuit. The circuit between the two connectors is completed via the breakout box or test cable. The testing is done at the breakout box or test cable to prevent any damage to generator connectors.

Figure 2.

SERVICE MAINTENANCE INTERVAL INFORMATION:

The various service maintenance intervals are designated by interval numbers as follows:

1. An early inspection of the generator set to insure it is ready to operate when required and to identify any potential problem areas.
   a. Performed monthly or following each 10 hours of operation of the unit and requires approximately 0.5 man hours per unit to complete.
   b. This inspection may be performed by the end user providing the following safety steps are taken to prevent the engine from starting automatically without warning:

To prevent injury, perform the following steps in the order indicated before starting any maintenance:

- Disable the generator set from starting and/or connecting to the load by setting the control panel AUTO-OFF-MANUAL switch to the “OFF” position.
- Remove the control panel fuse.
- Turn off the battery charger.
- Remove the negative battery cable.

Warning: Connectors should not be powered. The battery charger must be turned off BEFORE removing the battery cable to prevent an over current condition from burning out sensitive control panel components and circuits.

Following all maintenance, reverse these steps to insure the unit is returned to standby setup for normal operation when required.

2. A wear-in service inspection of the generator set to insure it is ready to operate and carry the load when required, and to identify any potential problem areas.
   a. Performed ONLY ONCE following the first three months or the first 30 hours of operation after purchase of the unit and requires approximately 2.5 man-hours per unit to complete.
   b. This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.
3. An operational inspection of the generator set to insure it is ready to operate and carry the load when required, and to identify any potential problem areas.
   a. Performed semi-annually or following each 50 hours of operation of the unit and requires approximately 1.5 man-hours per unit to complete.
   b. This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.
4. A mid-level inspection of the generator set to insure it is ready to operate and carry the load when required, and to identify any potential problem areas.
   a. Performed annually or following each 100 hours of operation of the unit and requires approximately 4.0 man-hours per unit to complete.
   b. This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.
5. A comprehensive inspection of the generator set to insure it is properly serviced and ready to operate and carry the load when required, and to identify any potential problem areas.
   a. Performed annually or following each 250 hours of operation of the unit and requires approximately 8.0 man-hours per unit to complete.
   b. This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.

Warning: Before working on the Stationary Emergency Generator, ensure the following:

- The AUTO-OFF-MANUAL switch is in the OFF position.
- The 15A fuse has been removed from the control box.
- The 120VAC supply to the battery charger is switched OFF.
- The negative battery cable has been removed.

<u>EVERY THREE MONTHS:</u>

1. Check battery condition.
2. Inspect and test fuel system.
3. Check transfer switch.
4. Inspect exhaust system.
5. Check engine ignition system.
6. Check fan belts.

<u>ONCE EVERY SIX MONTHS:</u>

1. Test Engine Safety Devices (low oil pressure, low coolant level, high coolant temperature).

<u>ONCE ANNUALLY:</u>

1. Test engine governor; adjust or repair, if needed.
2. Clean, inspect generator.
3. Flush cooling system.
4. Clean/re-gap spark plugs or replace as necessary.

FIRST 30 OPERATING HOURS:

1. Change engine “break-in” oil and filter.

FIRST 100 OPERATING HOURS:

1. Change engine oil and oil filter. After initial change, service engine oil and filter at 100 operating hours or six months, whichever comes first.
2. Re-torque cylinder head.
3. Re-torque intake and exhaust manifold.

EVERY 500 OPERATING HOURS:

1. Service air filter.
2. Check starter.
3. Check engine DC alternator.

BATTERY MAINTENANCE AND HANDLING RECOMMENDATIONS:

It is important that all labeling on the battery is carefully read, understood and complied with. The format of the following labels and symbols is common to most brands of lead acid batteries (see Figure 1).

DANGER: Lead-acid batteries contain a sulfuric acid electrolyte, which is a highly corrosive poison and will produce gas when recharged and explode if ignited. When working with batteries, you need to wear glasses, have plenty of ventilation, remove your jewelry, and exercise caution. Do NOT allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce chlorine gas that can KILL you! Please follow the manufacturer's instructions for testing, installing, discharging, charging, equalizing and maintaining batteries.

For non-sealed wet batteries (with filler caps), if the electrolyte levels are low, allow the battery to cool to room temperature first and then add only distilled, deionized or de-mineralized water to the level indicated by the battery manufacturer or to within 1/4 to 3/8 inch (6 to 10 mm) below the bottom of the filler tubes (vent wells or splash barrels). Avoid overfilling, especially in hot weather, because the heat will cause the electrolyte to expand and overflow.

Typical Battery Labelling

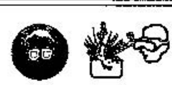
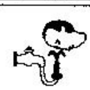
	Explosive gases		Read relevant instructions
	Eye protection must be WORN.		Keep away from children
	No smoking or naked flames.		Do not dispose of as household waste.
	Corrosive acid		Recycle (via recognized disposal system).
	Flush eyes immediately when contacted with acid		Electrical current may cause injury to personnel
	Caution/important notice.		

Figure 1. – Battery Labelling

TO BE PERFORMED EVERY 6 MONTHS:

Safety precautions need to be taken.

- Wear rubber gloves and an apron that are specific for handling batteries containing sulfuric acid.
- Wear protective eyewear and a full face shield.
- Avoid and prevent any open flame, sparks, or electrical arcs in or near the battery or battery charging area.
- Do not smoke near the battery or battery compartment area.
- Keep tools or other metallic items away from an unprotected battery.
- Never open a battery cell cap with your face directly over the battery cell cap.
- Never wear any jewelry to include; watches, necklaces, rings, dangling jewelry, etc.
- Never use metallic tools to remove the battery caps or cable clamps.
- Never place metallic objects on top a battery.

BATTERY INSPECTION:

- Examine the outside appearance of the battery.
- Look for cracks in the container.
- The top of the battery, posts, and connections should be clean, free of dirt, fluids, and corrosion. If batteries are dirty, refer to the Battery Cleaning section for the proper cleaning procedure.
- Any fluids on or around the battery may be an indication that electrolyte is spilling, leaching, or leaking out.
- Leaking batteries must be replaced.
- Check all battery cables and their connections.
- Battery cables should be intact; broken or frayed cables can be extremely hazardous.
- Replace any cable that looks suspicious.

Figure 2. Clean Battery Terminals

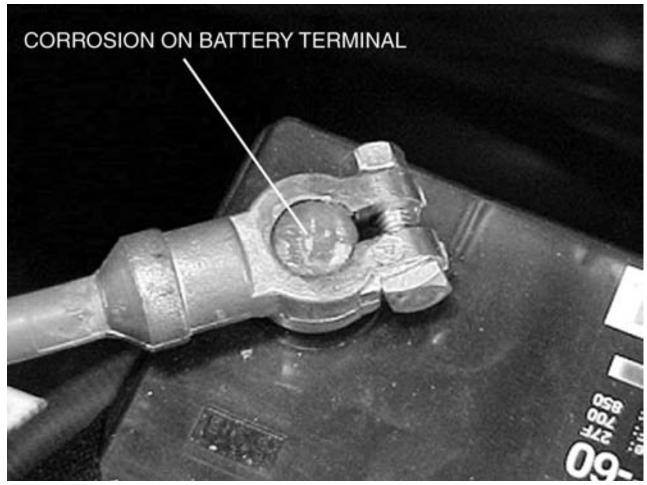


Figure 3. Corroded Terminals

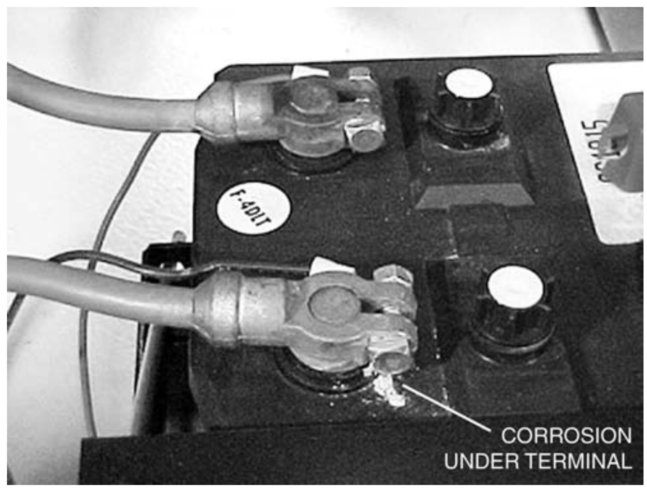


Figure 4. Corrosion Under Terminal

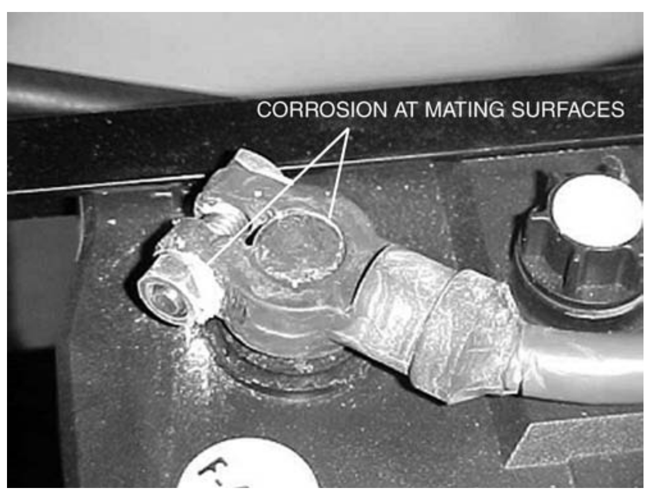


Figure 5. Corrosion at Mating Services

BATTERY CLEANING:

CAUTION: When removing clamps, always loosen and remove the Negative (-) clamp first and the Positive (+) clamp last. When re-installing the clamps, install the Positive (+) clamp first and the Negative (-) clamp last.

- Check that all vent caps are tightly in place.
- Clean the battery top with a cloth or non-conductive brush and a solution of baking soda and water.
- Rinse with water and dry with a clean cloth.
- Clean battery terminals and the inside of cable clamps using a post and clamp cleaner.
- Reconnect the clamps to the terminals and apply a battery terminal corrosion protection to the clamps and terminal area.
- Keep the area around batteries clean and dry.

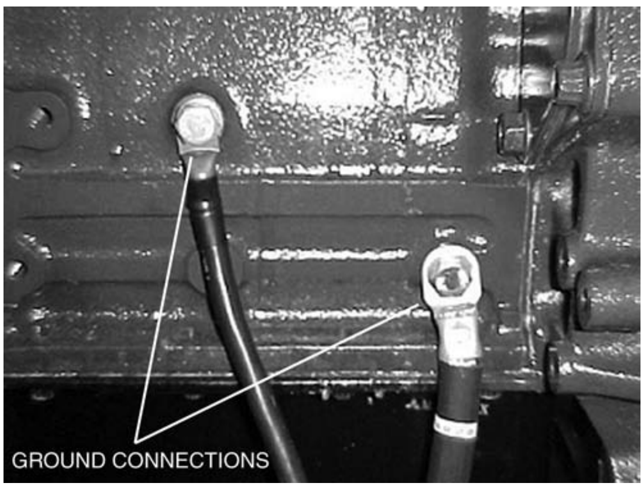


Figure 6. Ground Connections

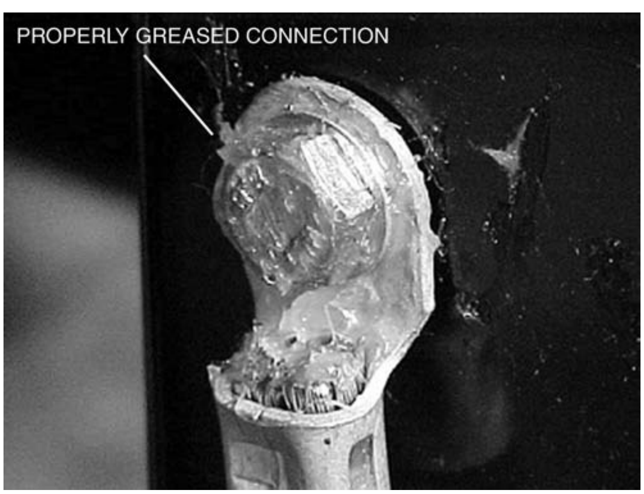


Figure 7. Greased Connection

BATTERY MAINTENANCE:

Check electrolyte level; the minimum level at the top of the plates should be 1/8” below the bottom of the fill well.

If necessary add water to cover the plates. (Use distilled or de-ionized water only.)

Corrosion is caused by one or more of the following:

- Dirty or wet battery tops normally caused from expansion of electrolyte from overfilled cells
- Acid fumes leaking through the vent caps, which could be a sign of overcharging.
- Electrolysis due to the mismatch of metal alloys used in the battery posts and terminals.
- Clean the alternator or charging system to allow better heat transfer and check the alternator belts for cracks and correct tension.
- Replace the battery if the battery case is cracked or leaking.
- Battery Testing can be done in more than one way. The most popular is measurement of specific gravity and battery voltage. To measure specific gravity, use a temperature compensating hydrometer. To measure voltage, use a digital D.C. Voltmeter.
- The battery must first be fully charged. The surface charge must be removed before testing. If the battery has been sitting at least several hours you may begin testing. To remove surface charge the battery must experience a load of 20 amps for 3 plus minutes.

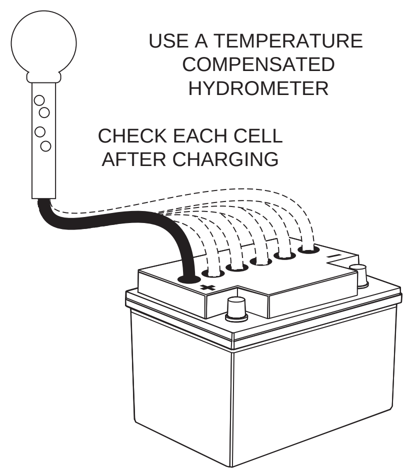


Figure 8. Using a Battery Hydrometer

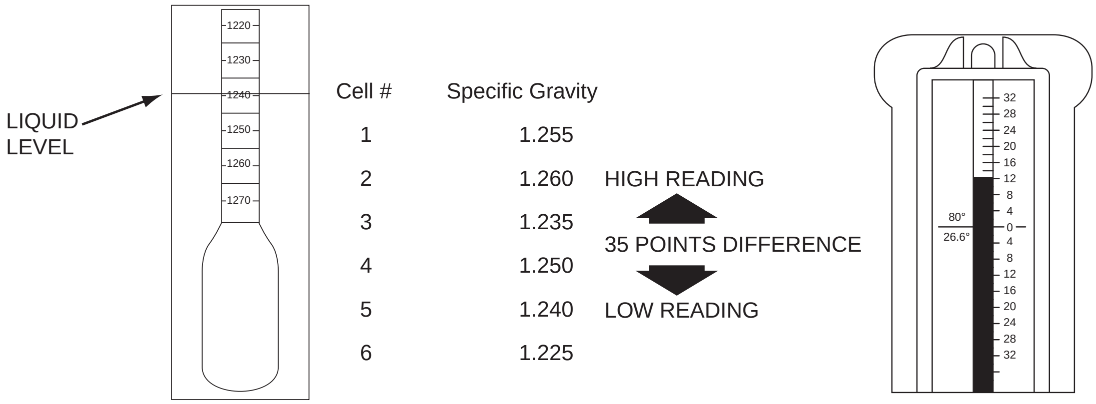


Figure 9. Reading a Battery Hydrometer

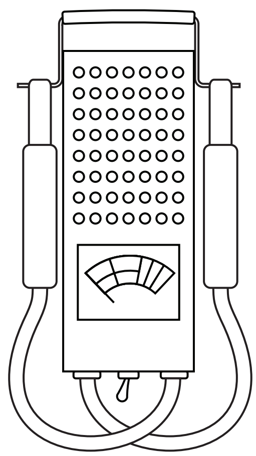


Figure 10. A Typical Battery Load Tester

State of Charge	Specific	Gravity Voltage
100%	1.265	12.7
75%	1.225	12.4
50%	1.190	12.2
25%	1.155	12.0
Discharged	1.120	11.9

Warning: Never add acid to a battery. Always use distilled water.

BELTS

People often wait until they get some indication that their engine needs service – such as a noise or squeal – before calling a service dealer. Although a professional technician should look at the belts and hoses as part of a regular maintenance schedule, basic inspection should be done by the owner. By conducting monthly inspections of the belts, the owner can help prevent premature engine wear and extend the life of the engine.

SERPENTINE BELTS:

Definition: A type of flat rubber drive belt that is used to turn multiple accessories on the front of an engine. It is called a serpentine belt because of the way it snakes around the various pulleys.

Many engines now have a single serpentine drive belt because it eliminates the need for several separate V-belts. A spring-loaded pulley maintains tension on the serpentine belt. This does away with the need to re-tension the belt when it is replaced. Serpentine belts generally last 25% to 50% longer than conventional V-belts.

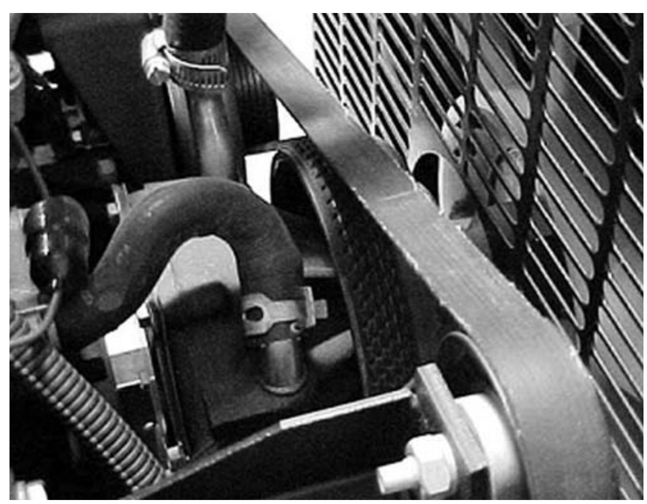


Figure 11. Serpentine Belt

V-BELTS:

V-belts are named for their appearance. They have a relatively narrow outside surface, then get thicker before tapering down. With V-belts, it is common for engines to have multiple belts driving the accessories.

BELT INSPECTION:

- Check the engine's belts before starting the engine, while the engine is still cold. This will help avoid the possibility of an accidental burn from a hot engine component or an injury caused by a moving part of the engine.

- Carefully inspect the belts along their edges and undersides for any signs of wear (see "Visual Signs of Wear" below). These danger signs indicate a belt may need to be replaced or that a belt-driven component may be failing.
- Belt tension should be checked and adjusted on a regular basis. If the belt tension is too tight, it can cause bearings in the accessory components, and even in the engine itself, to wear prematurely. If it is too loose, the belt will slip and squeal, causing the accessory components to work less efficiently. Inadequate tension also will cause the belt to wear excessively. The most accurate way to check tension is with a belt tension gauge, but correct tension can be estimated by pressing on the belt along its longest straight section. If the tension is correct, the belt will only have about 1/2 inch to 1 inch of play.
- Drive belts are necessary to operate the accessory components attached to the engine, such as the alternator, and the water pump. To fully assess the condition of the belts, do a visual inspection and test the belt tension.

VISUAL SIGNS OF WEAR:

GLAZING: The side or contact area of the belt becomes slick and shiny when a loose belt slips in the pulley. The glazed belt can no longer grip adequately and the belt slips even more.

- Cause: When in motion, the belt makes contact with an object in its path such as a flange or bolt. This may be caused by improper belt tension or pulley bearing size. Grease and oil on the pulley can also cause glazing.

Figure 12. Glazed Belt

IMPROPER INSTALL: A belt rib begins separating from the joined strands. If left unattended, the cover will often separate, causing the belt to unravel.

- Cause: Improper belt installation is a common cause of premature failure. One of the outer-most belt ribs is placed outside the pulley groove, causing a belt rib to run without a supporting or aligning pulley groove.

Figure 13. Improper Install

PILLING: The belt's rubber compound wears off and builds up on the drive pulleys (the wheel that is driven by or drives the belt).

- Cause: There are a number of causes, including lack of tension, misalignment, worn pulleys or a combination of these factors. Pilling is found most frequently in diesel engines, but is not isolated to them.

Figure 14. Pilled Belt

CRACKING: Cracks occur because the belt is exposed to heat and stress.

- Cause: With continuous exposure to high temperatures, the stress of bending around the pulley leads to cracking. Cracks begin on the ribs and grow into the cord line. As a rule, if three or more cracks appear in a three-inch section of a belt, eighty percent of the life is gone and the belt should be replaced.

Figure 15. Cracked Belt

CHUNKING: Parts of the belt break off when cracks worsen.

- Cause: Chunking can happen when several cracks in one area move parallel to the cord line. Heat, age and stress are the primary contributors.

Figure 16. Chunking

UNEVEN RIB WEAR: Belt shows damage to the side with the possibility of breaks in the tensile cord or jagged edged ribs. A thumping or grinding noise may also be heard when running.

- Cause: A foreign object in the pulley can cause uneven wear and cut into the belt.

Figure 17. Uneven Rib Wear

MISALIGNMENT: Sidewalls of the belt may appear glazed or the edge-cord may become frayed and ribs removed. A noticeable noise may result. In severe cases, the belt can jump off the pulley.

- Cause: Pulleys out of alignment due to either non-parallel shafts, or incorrect location on shafts. Misalignment forces the belt to kink or twist while running, causing premature wear.

Figure 18. Misalignment

BELT WEAR NOISE INDICATORS:

- Squealing: Squealing is a continuous sound that often occurs when starting the engine after the engine has sat for awhile. It also can occur when a higher strain is put on the engine (such as after increasing the load). Squealing usually indicates belt wear. However, if enough water is splashed onto the drive belts, a squealing noise may be a normal condition associated with slippage due to the belt being wet.
- Slapping: A slapping sound can be caused by a loose belt or a belt misalignment.

AIR FILTERS

Air is necessary for successful combustion in an engine. In fact, for efficient combustion, a modern engine requires several thousand times as much air as it does fuel. Clean air - air almost 100% pure - is critical to engine survival and vital to its performance.

There are operational signs that an air filter has become completely plugged. The engine begins to lose power, and fuel consumption increases. Black smoke may blow from the exhaust stack. Continued operation with a plugged air filter may very well damage the engine.

It is impossible to determine, just by looking, when air filters should be changed. An element that looks relatively clean may be almost totally plugged with ultra-fine particles from exhaust smoke or air pollutants.

On the other hand, a filter that looks dirty may still have many hours of useful life. Remember that until maximum acceptable restriction is reached, the accumulation of dirt in the filter actually adds to its efficiency. Before disposing of old air filters, always inspect them carefully. Their appearance can reveal much about the performance of the entire air-induction system.

- An accumulation of black, oily soot might mean that the air intake is located too close to the exhaust. Consider relocation.
- An accumulation of dirt on the clean side of the filter element might indicate a split in the filter media. Also, determine if the end seal is being bypassed or if a gasket is leaking. Do not attempt to reuse the filter.
- Rust on the filter's metal parts can mean that water is being drawn in with the air. Again, check the location of the intake.

CAUTION: Generac does not recommend the cleaning of air filter elements. Since all contaminants cannot be removed, service intervals become progressively shorter. Further, the cleaning process might damage the filter, leading to engine damage as well.

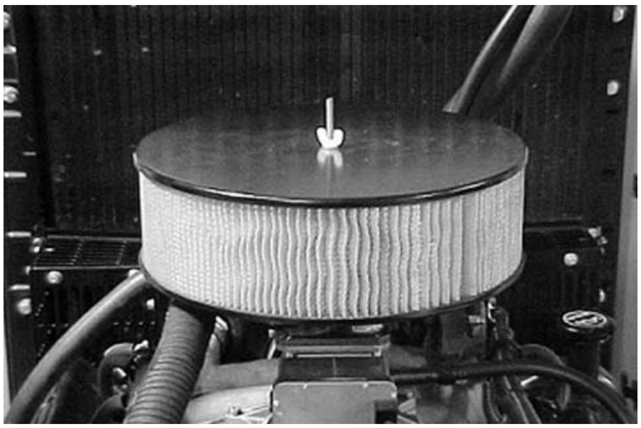


Figure 19. Automotive Type Air Filter

OIL FILTERS

Modern oils play vital functions in protecting engines, especially in a heavy-duty situation. Lubricating oil acts to reduce friction and wear, cool engine parts, seal combustion chambers, clean engine components and inhibit corrosion.

These functions are carried out by special additives in the oil, which complement the action of the oil itself. The protective action of the lubricating oil and its additives are supported and balanced by the work of the lube filter.

Lube filters, particularly those designed for heavy-duty applications, have the sole purpose of keeping damaging contaminants away from sensitive engine parts. Filters trap oil contaminants in two ways: Some particles adhere to filter media as the oil flows through the filter. Such particles attach themselves to the media surface without plugging up the media pores.

Other particles are trapped in the filter media by the pressure of the oil as it flows through the filter. As the oil changes direction in its path through the filter, particles are driven or impinged into the media. Ideally, most of these particles are trapped in the outer portion of the media, leaving inner media surfaces open to continue catching particles that slip through. Eventually, however, media pores will fill up and the filter begins to lose its effectiveness.

When changing the engine oil, always replace the engine oil filter(s).

- Place a container in such a location as to catch the used oil and avoid spills.
- Remove the engine oil drain plug or the remote oil drain plug and allow all of the used engine oil to drain out of the sump.
- Replace the drain plug, do not over tighten.
- Move the container that has the used engine oil in it under the location of the oil filter(s) to catch any spills that occur when the oil filters are removed, or place some oil absorbent mats or rags under the area of the oil filter.
- Remove the used engine oil filter(s), being careful not to spill any oil remaining in the filter(s) and place the filter in a container.

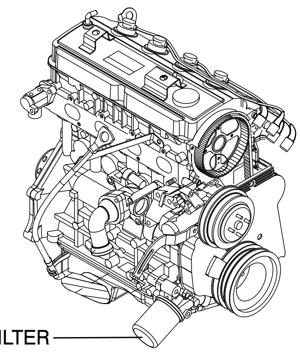


Figure 20. Oil Filter

SPARK

The spark plug is quite simple in theory: It forces electricity to arc across a gap, just like a bolt of lightning. The electricity must be at a very high voltage in order to travel across the gap and create a good spark. Voltage at the spark plug can be anywhere from 5,000 to 100,000 volts, depending on the type of ignition system being used.

The spark plug must have an insulated passageway for this high voltage to travel down to the electrode, where it can jump the gap and, from there, be conducted into the engine block and grounded. The plug also has to withstand the extreme heat and pressure inside the cylinder, and must be designed so that deposits do not build up on the plug.

Spark plugs use a ceramic insert to isolate the high voltage at the electrode, ensuring that the spark happens at the tip of the electrode and not anywhere else on the plug; this insert does double-duty by helping to burn off deposits. Ceramic is a fairly poor heat conductor, so the material gets quite hot during operation. This heat helps to burn off deposits from the electrode.

Some engines require a hot plug. This type of plug is designed with a ceramic insert that has a smaller contact area with the metal part of the plug. This reduces the heat transfer from the ceramic, making it run hotter and thus burn away more deposits. Cold plugs are designed with more contact area, so they run cooler.

<u>RESISTOR PLUGS:</u>

When the spark jumps the spark plug gap it causes a high frequency burst of energy that is known as radio frequency interference (RFI). Placing a resistor within the spark plug suppresses the RFI. Without the resistor plugs in an engine, the RFI could cause interference with the engine/generator's electronics.

HEAT RANGE:

The most basic function of the spark plug is to ignite the air/fuel mixture. Voltage must be supplied by the ignition system to cause a spark to jump across the spark plug's gap and ignite the air/fuel mixture.

To survive the combustion chambers high temperatures and function properly, the spark plug must dissipate the heat that it absorbs. The temperature of the spark plug's firing end must be kept low enough to prevent pre-ignition, but high enough to prevent fouling. It is important to remember that spark plugs do not create heat, but instead they must remove heat. The heat range determines the plug's ability to dissipate the heat from the spark plug to the cylinder head where it is absorbed by the coolant system.

How quickly this heat is transferred is determined by:

- The insulator nose length.
- Insulator nose surface area exposed to the air/fuel mixture.
- The construction of the electrode and the porcelain insulator.

TYPES OF ABNORMAL COMBUSTION:

PRE-IGNITION:

- Defined as: ignition of the air/fuel mixture before the pre-set ignition timing mark.
- Caused by hot spots in the combustion chamber. Can be caused (or amplified) by too hot a spark plug, lean air/fuel mixture, or insufficient engine cooling.
- A change to a colder plug, or a richer fuel mixture may be in order.
- The engine's cooling system may also need to be checked.
- Pre-ignition usually leads to detonation; pre-ignition and detonation are two separate events.

DETONATION:

- The spark plug’s worst enemy.
- Can break insulators or break off ground electrodes.
- Pre-ignition most often leads to detonation.
- Plug tip temperatures can spike to over 3000°F during the combustion process.
- Most frequently caused by hot spots in the combustion chamber.

Hot spots will allow the air/fuel mixture to pre-ignite. As the piston is being forced upward by mechanical action of the connecting rod, the pre-ignited explosion will try to force the piston downward. If the piston can't go up (because of the force of the premature explosion) and it can’t go down (because of the upward motion of the connecting rod), the piston will rattle from side to side. The resulting shock wave causes an audible pinging sound.

- Most of the damage that an engine sustains when “detonating” is from excessive heat.
- The spark plug is damaged by both the elevated temperatures and the accompanying shock wave, or concussion.

MISFIRES:

- A spark plug is said to have misfired when enough voltage has not been delivered to light off all of the fuel present in the combustion chamber at the proper moment of the power stroke.
- A spark plug can deliver a weak spark for a variety of reasons—defective coil, too much compression with incorrect plug gap, dry fouled or wet fouled spark plugs, insufficient ignition timing, etc.
- Slight misfires can cause a loss of performance for obvious reasons (if fuel is not lit, no energy is being created).
- Severe misfires will cause excessive fuel consumption, poor performance, and can lead to engine damage.

FOULING:

- Will occur when spark plug tip temperature is insufficient to burn off carbon, fuel, oil or other deposits.
- Will cause spark to leach to metal shell—no spark across plug gap will cause a misfire.
- Wet-fouled spark plugs must be changed.
- Dry-fouled spark plugs can sometimes be cleaned by bringing engine up to operating temperature.

CHANGING SPARK PLUGS:

- Always change the spark plugs with the engine cold. Grabbing the plug wire by the boot, carefully pull the spark plug wire from the end of the spark plug. Do not pull the wire itself. If the boot sticks, twist the boot left and right and pull the plug wire off. Changing the plugs one at a time is recommended to avoid mixing up the spark plug wires.
- If available, use compressed air to blow any dirt away from the spark plug area. Otherwise, clean off the old plug and the area around it with a rag or small brush. This will help prevent any foreign material from falling into the cylinder when the plug is removed.
- Remove the plug by turning it counterclockwise with a spark plug socket and ratchet. Once loosened, spin it out about three or four turns. Then remove the socket and remove it completely by hand. If the plug can't be reached, slip a piece of 5/16” vacuum line over the spark plug and turn it out with that.
- Take a good look at the cylinder head threads. They should be in good condition, clean, and free of dirt and debris. This new spark plug should freely screw into the cylinder head by hand. Any binding of the plug is an indication that there's a problem. Remove the plug and inspect the threads.
- Insert the plug into the spark plug hole by hand and turn it clockwise until it's snug.
- After installing the plug by hand as far as it will go, firmly tighten it with a spark plug wrench or socket. It is a good idea to use a torque wrench, if one is available, to ensure that the plug is properly seated. Be very careful; do not over tighten the spark plugs. Remember, an accurate torque reading can only be obtained if the spark plug and cylinder head threads are clean and dry.

TROUBLESHOOTING:

Diagnosing spark plugs is really pretty straight forward, based on the appearance of the electrode end of the spark plug. The following illustrations and descriptions should aid in helping diagnose if there is an issue that is affecting the combustion process of the engine.

Normal plug condition: Note the difference in the gaps, the plug on the left has reached the end of it's useful life, also note the grounding electrode coloration, this is how a used spark plug should appear when it is removed. If any plugs do not appear like the plug on the left, contact a service dealer.

Mechanical damage is caused by foreign objects in the combustion chamber or an improper plug reach where it contacts the piston. Even a piece of carbon can do this.

- To solve this, make sure you have the correct length tip spark plug as well as removing any foreign materials in the combustion chamber. In some cases you may have excessive carbon buildup on the backs of the intake valves that will have to be addressed.

Detonation, in cases of severe detonation, insulators may become cracked or chipped. An improper spark plug gap setting will also cause the insulator tip to crack or chip.

- Detonation is tricky ... make sure that you verify correct ignition timing. Next check for an inoperative EGR system (if equipped) as well as proper function of the Knock Sensor (if equipped). Also, you will want to make sure you are using the correct heat range plug.

Overheating, on this symptom you will notice a chalky appearance, white insulator, rapid electrode wear as well as an absence of deposits. The actual shell may also be discolored.

- To cure this you must first verify that the plug is the correct heat range, the ignition timing settings are correct, the air/fuel mixture is not too lean, there are no vacuum leaks and that the EGR valve (if equipped) is functioning properly.

Oil fouled is an oily coating caused by poor oil control. Oil is leaking past worn valve guides, piston rings, or on some engines a possible intake gasket leak and then entering the combustion chamber.

- Check for worn valve guides, intake gasket sealing alignment, as well as worn cylinder walls and piston rings. A leak down test is a good place to start for what is causing this.

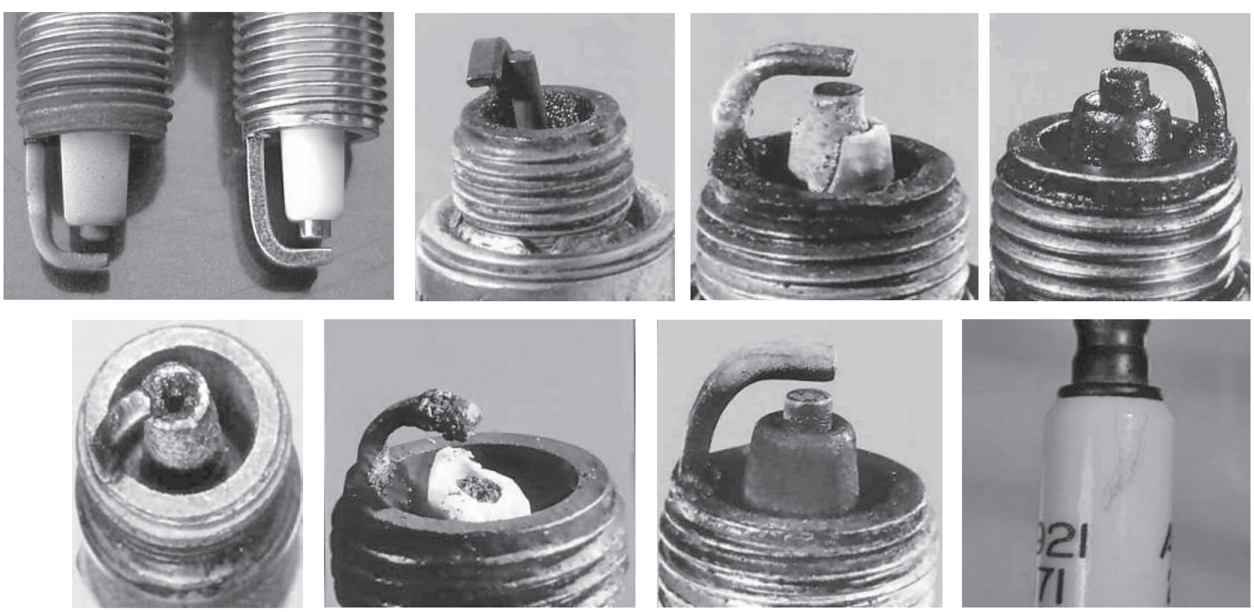
Initial pre-ignition will usually look as a melted center electrode and/or ground electrode.

- Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber.

Sustained pre-ignition, well this will be pretty obvious ... melted and/or missing center and/or ground electrodes as well as a destroyed insulator.

- Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber. After you see this, you'd better look

NORMAL | MECHANICAL DAMAGE | DETONATION | OIL FOULED



INITIAL PRE-IGNITION | SUSTAINED PRE-IGNITION | CARBON FOULED | CRACKED

Figure 21. Plug Conditions

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for possible internal engine damage as well (pistons, cylinder walls, valves, rings, etc.).

Carbon fouled is a very common visual condition on engines. Soft, black, sooty, dry-looking carbon. This indicates a rich mixture, weak ignition or wrong heat range plug (too cold).

- You will first need to verify plug heat range. Check choke as well as choke pull-off (if equipped) for proper function and adjustment. As a general rule on all computer-controlled engines, you need to also make sure that all input signals to the ignition module are working and accurate. This includes, but is not limited to, all temperature and pressure sensors as well as the system components. Lastly on all engines, check for vacuum leaks and weak spark or low voltage output.

Cracked or broken insulator, this is typically a result of improper installation or careless handling of the spark plug and should be replaced.

HOSES

Hoses are used on many components of every engine. They carry liquids (coolant) and gases (LPG, and natural gas).

HOSE INSPECTION:

Cold Engine Inspection

- Check for small leaks before you start the engine, while your engine is still cold. If your engine is operated when it is low on coolant, serious engine damage may occur. Replace the hose as soon as possible.
- Firmly squeeze the radiator hose. A hose that feels very hard or makes a "crunch" as it is squeezed is deteriorating and should be replaced. You also should replace hoses that are extremely soft, sticky or oil-soaked, as they are likely to fail.

Warm Engine Inspection

- Look carefully at all the hoses to spot any swollen areas. Such areas indicate weak spots.
- Inspect around hose ends for dampness, deposits or buildup of dried coolant. These could indicate that a "cold leak" is present. A cold leak is usually a very minor leak that occurs after the engine has cooled down, and expansion and contraction of components has occurred. All coolant leaks should be addressed as soon as you notice them. Over time, these leaks will get worse and could lead to an expensive repair. An inexpensive gasket or a simple tightening of a hose clamp may be all that is needed to avoid an expensive repair.

When to Replace Your Hoses

- When you replace a water pump
- When you replace a thermostat
- Every four years of service
- Anytime you notice damage or leakage

VISUAL SIGNS OF WEAR:

CRACKING:

Cracking is caused by heat and age, exposure to ozone, etc.

- Cause: Increased ozone, caused by pollution, attacks bonds in certain rubber compounds. Tiny cracks occur primarily where the hose is stressed-at curves, bends and clamping locations. These cracks allow airborne contaminants to invade and weaken the hose.

OIL DAMAGED:

Damaged hose is soft, gooey, or spongy to the touch. Bulges and swelling are readily apparent.

- Cause: Oil reacts chemically with hose compounds to weaken the structure of molecular bonds. This causes the hose to soften, swell, and separate by layers, leading to certain failure. Oil can attack both external and internal surfaces of the hose.

Figure 22. Oil Damage

HEAT DAMAGE:

Heat damage can occur internally and may not be easily detected by physical appearance. Swelling is one sure external sign of internal damage. External heat damage is often easier to detect since it can result in hardened and cracked hose covers.

- Cause: Overheating can cause reinforcement fibers within a hose to deteriorate. Engine heat, low coolant levels and/or temperature spikes all contribute to hose damage.

Figure 23. Heat Damage

LEAKAGE:

Moisture, seepage or drips form on or around clamps or connectors.

- Cause: Other than insufficient clamp torque, leakage is usually caused by the deteriorated condition of the hose and/or connector.

Figure 24. Leakage

COOLANT:

The great importance of engine coolant to trouble-free engine operation is poorly understood. Maintenance managers and industry experts estimate that over 40% of a heavy-duty engine's downtime is related to coolant system problems, virtually all of which is preventable with proper preventative maintenance!

The coolant removes excess heat from the engine. Without coolant, the engine metals would quickly soften and deform, resulting in catastrophic damage. In addition, since water is corrosive to engine metals, the coolant has to contain anti-corrosive protective chemicals to prevent rust and other damage that weakens the engine parts or radiator. There are many metals to protect: aluminum, steel, cast iron, copper, brass and solder.

Furthermore, the coolant must not attack the rubber hoses or gaskets in the engine. Of course, it must provide antifreeze and anti-boil protection. Antifreeze is actually a treatment for the water that is used to cool an engine. The water is very important, as it is the primary part of the coolant that removes the heat. The antifreeze treats the water to prevent rust, corrosion, hose failures, radiator failures, liner pitting and a host of other possible problems.

The industry has agreed that most antifreeze/coolants are formulated to be mixed half-and-half with water. This is important, because even in such diverse climates as Minneapolis or Phoenix, 50% antifreeze should be used to insure that an engine is properly protected. In extremely cold climates, it is permissible to increase the antifreeze to a maximum of 70%. Most people don't realize that above that, the freeze point actually gets warmer! The maximum antifreeze protection with EG (ethylene glycol) based antifreezes is -86 degrees F when 70% EG based antifreeze is mixed with 30% water.

GENERAL CONSIDERATIONS:

In most cases, local drinking water is just fine for use with EG based antifreeze (well water or really hard water is not recommended). At every oil change, check the coolant to insure it is still at a 50/50 mixture with a test strip or refractometer.

Use a mixture of half low silicate, ethylene glycol base antifreeze or propylene glycol base antifreeze and half soft water, or use pre-mix antifreeze. Use only soft water or de-ionized water and only low silicate antifreeze.

Do not use water that has been softened using a water softener filled with either salts or chlorides. If desired, add a high quality rust inhibitor to the recommended coolant mixture.

Use only heavy-duty or all-duty formulation (fully formulated) coolants. Any high quality heavy-duty ethylene glycol antifreeze can be mixed with any other high quality heavy-duty ethylene glycol antifreeze, and any high quality heavy-duty propylene glycol antifreeze can be mixed with any other high quality heavy-duty propylene glycol antifreeze regardless of the color or brand of the antifreezes.

When changing from ethylene glycol based antifreeze to propylene glycol based antifreeze or vise versa, be sure that the engine and cooling system is thoroughly flushed of all remaining coolant and other contaminants.

INTRODUCTION

There are two generators currently in the 2.4L family that are equipped with turbochargers; the 36kW which runs at 1800 rpm and the 60kW which runs at 3600 rpm. This section is provided to help familiarize you with how a turbocharger works and symptoms of a faulty turbocharger and the appropriate solutions.

WORKING PRINCIPAL:

A turbocharger is a small radial fan pump driven by the energy of the exhaust gases of an engine. A turbocharger consists of a turbine and a compressor on a shared shaft. The turbine section of a turbocharger is a heat engine in itself. It converts the heat energy from the exhaust to power, which then drives the compressor, compressing ambient air and delivering it to the air intake manifold of the engine at higher pressure, resulting in a greater mass of air entering each cylinder. Compressed air is routed through a charge air cooler before introduction to the intake manifold. Because a turbocharger is a heat engine, and is converting otherwise wasted exhaust heat to power, it compresses the inlet air to the engine more efficiently than a supercharger.

The objective of a turbocharger is the same as a supercharger; to improve upon the size-to-output efficiency of an engine by solving one of its cardinal limitations. A naturally aspirated automobile engine uses only the downward stroke of a piston to create an area of low pressure in order to draw air into the cylinder through the intake valves. Because the pressure in the atmosphere is no more than 1 atm (approximately 14.7 psi), there ultimately will be a limit to the pressure difference across the intake valves and thus the amount of airflow entering the combustion chamber. This ability to fill the cylinder with air is its volumetric efficiency. Because the turbocharger increases the pressure at the point where air is entering the cylinder, a greater mass of air (oxygen) will be forced in as the inlet manifold pressure increases. The additional oxygen makes it possible to add more fuel, increasing the power and torque output of the engine.

Because the pressure in the cylinder must not go too high to avoid detonation and physical damage, the intake pressure must be controlled by controlling the rotational speed of the turbocharger. The control function is performed by a waste gate, which routes some of the exhaust flow away from the exhaust turbine. This controls shaft speed and regulates air pressure in the intake manifold.

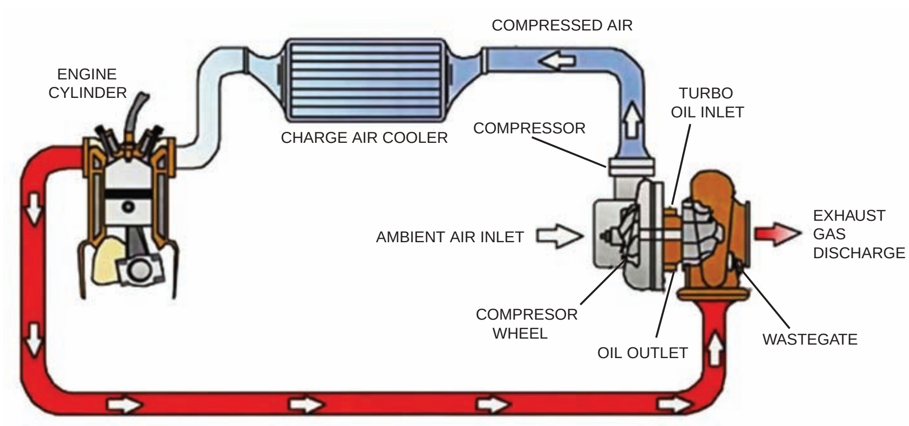

Figure 1. Turbocharger Flow Diagram

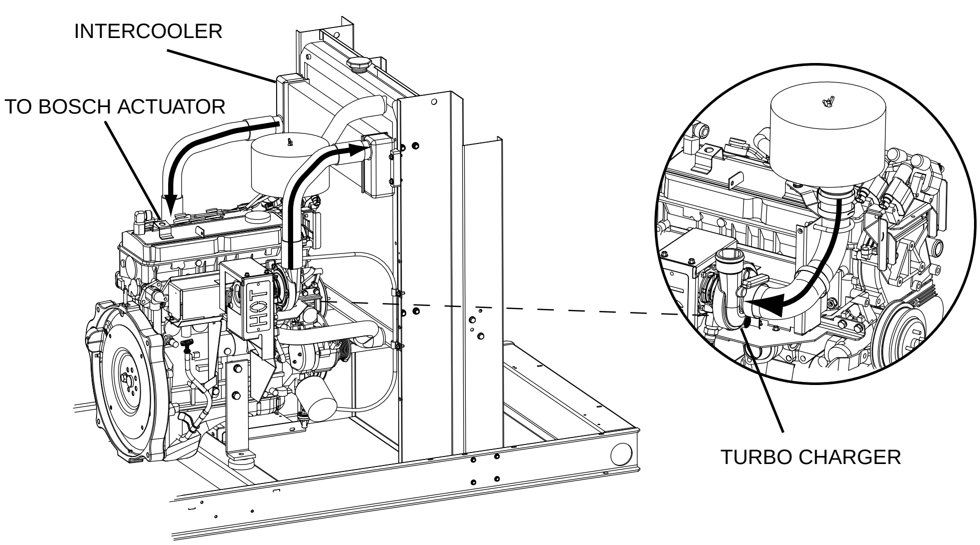

Figure 2. 2.4 Liter Turbocharger

TURBOCHARGER TROUBLESHOOTING

Engine Lacks Power	Black Exhaust Smoke	Excessive Engine Oil Consumption	Blue Exhaust Smoke	Turbocharger noisy	Cyclic sound from turbocharger	Oil Leak from compressor seal	Oil Leak from Turbine Seal	Cause	Remedy
X						X		Clogged air filter element	Replace element according to engine manufacturers recommendations
				X		X		Obstructed air intake duct to turbo compressor	Remove obstruction or replace damaged parts as required
X				X				Obstructed air outlet duct from compressor to intake manifold	Remove obstruction or replace damaged parts as required
X				X				Obstructed intake manifold	Refer to engine manufacturers manual & remove obstruction
				X				Air leak in duct from air cleaner to compressor	Correct leak by replacing seals or tightening fasteners as required
X	X	X	X	X				Air leak in duct from compressor to intake manifold	Correct leak by replacing seals or tightening fasteners as required
X	X	X	X	X				Air leak at intake manifold to engine joint	Refer to engine manufacturers manual & replace gaskets or tighten fasteners as required
X	X	X	X	X		X		Obstruction in exhaust manifold	Refer to engine manufacturers manual & remove obstruction
X	X			X		X		Obstruction in muffler or exhaust stack	Remove obstruction or replace faulty components as required
X	X			X		X		Gas leak in exhaust manifold to engine joint	Refer to engine manufacturers manual & replace gaskets or tighten fasteners as required
X	X			X		X		Gas leak in turbine inlet to exhaust manifold joint	Replace gasket or tighten fasteners as required
				X				Gas leak in ducting after the turbine outlet	Refer to engine manufacturers manual & repair leak
	X	X				X	X	Obstructed turbocharger oil drain line	Remove obstruction or replace line as required
	X	X				X	X	Obstructed engine crankcase vent	Refer to engine manufacturers manual , clear obstruction
	X	X				X	X	Turbocharger center housing sludged or coked	Change engine oil & oil filter, overhaul or replace turbo as required
X	X							Fuel injection pump or fuel injectors incorrectly adjusted	Refer to engine manufacturers manual - replace or adjust faulty components(s) as required
X	X							Engine camshaft timing incorrect	Refer to engine manufacturers manual & replace worn parts
X	X	X	X			X	X	Worn engine piston rings or liners (blowby)	Refer to engine manufacturers manual & repair engine as required
X	X	X	X			X	X	Internal engine problem (valves, pistons)	Refer to engine manufacturers manual & repair engine as required
X	X	X	X	X	X	X	X	Dirt caked on compressor wheel and/or diffuser vanes	Clean using a Non-Caustic cleaner & Soft Brush. Find & correct source of unfiltered air & change engine oil & oil filter
X	X	X	X	X	X	X	X	Damaged turbocharger	Analyze failed turbocharger, find & correct cause of failure, overhaul or replace turbocharger as required

NOTES

PART 2
LIQUID-COOLED AC GENERATORS

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INTRODUCTION

This section covers the major components of the AC generator proper, i.e., those generator assemblies that provide for the production of AC electrical power.

The single bearing rotor (revolving field) is driven by a 2.4 liter, liquid-cooled gas engine. The rotor is coupled to the engine flywheel, by means of a flexible coupling and a fan and ring gear assembly, so the engine crankshaft and rotor operate at the same speed.

Major components of the AC generator are shown in Figure 2 on the next page. These components are (a) a flexible coupling, (b) fan and ring gear, (c) rotor, (d) engine adaptor, (e) stator assembly, (f) rear bearing carrier, and (g) a rear bearing carrier cover.

ENGINE ADAPTOR

The engine adaptor is bolted to the engine and supports the engine end of the AC generator.

FLEXIBLE DISK

A flexible disk bolts to the engine flywheel and to the fan and ring gear assembly. The disk maintains proper alignment between the engine and generator parts.

FAN AND RING GEAR ASSEMBLY

The fan and ring gear assembly are retained to the flexible disk which, in turn, is retained to the engine flywheel. The fan draws cooling air into the generator interior through slots in a rear bearing carrier cover, then expels the heated air outward through a screen on the engine adaptor. The ring gear teeth mate with teeth on a starter motor pinion gear, when the engine is cranked.

ROTOR ASSEMBLY

The rotor assembly on units rated 1800 rpm is a 4-pole type, having two north magnetic poles and two south magnetic poles. On units rated 3600 rpm the rotor is a 2-pole type with one north pole and one south pole.

The rear end of the rotor is bolted and keyed to the fan and ring gear. A ball bearing has been pressed onto the rotor's front shaft, which is retained, in a machined bore in the rear bearing carrier.

A positive (+) and a negative (-) slip ring is provided on the rotor shaft that retains the ball bearing. Brushes will ride on these slip rings.

The combination of slip rings and brushes allow rotor excitation current to be transmitted from stationary components into the rotating rotor windings. The positive (+) slip ring is the one nearest the rotor bearing.

REAR BEARING CARRIER

The rear bearing carrier supports the front of the generator. Mounting feet at the carrier bottom permit the carrier to be bolted to the generator's mounting base. A machined bore, in the center of the carrier, accepts the rotor bearing. Bosses allow for the retention of brush holders. Long stator bolts pass through holes in the carrier's outer periphery, to sandwich and retain the stator can between the carrier and the engine adaptor. A rear bearing carrier gasket helps prevent dust from entering the bearing area.

STATOR ASSEMBLY

The stator can is sandwiched between the blower housing and the rear bearing carrier, and retained in that position by four (4) stator bolts.

REAR BEARING CARRIER PLATE

This plate is retained to the rear bearing carrier by four (4) capscrews, lockwashers and flatwashers. The plate provides slotted air inlet openings for the passage of cooling and ventilating air into the generator.

BRUSH HOLDERS AND BRUSHES

Brushes are retained in a brush holder which is retained to drilled and threaded bosses on the rear bearing carrier. In most cases, two brush holders are used having two brushes per holder. Brush holders are precisely positioned so that one of the two brushes slides on a positive (+) slip ring, the other on a negative (-) slip ring. The positive (+) brush and slip ring are nearest the rotor bearing. The positive (+) side of the DC excitation circuit (Wire No. 4, red) connects to the positive (+) brush; the negative (-) or grounded side (Wire No. 1) to the negative (-) brush. Brushes and brush holders are illustrated in Figure 1.

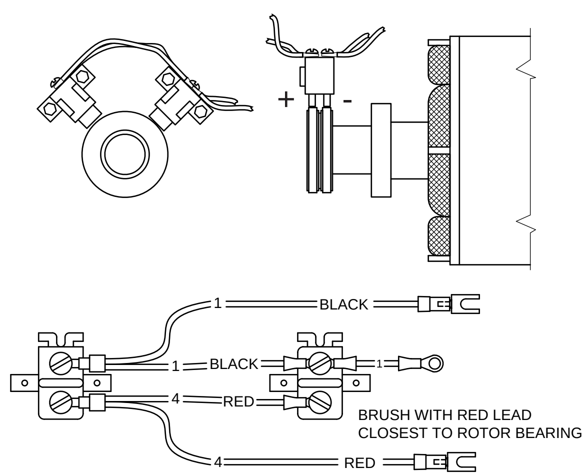


Figure 1. Brush Holders and Brushes

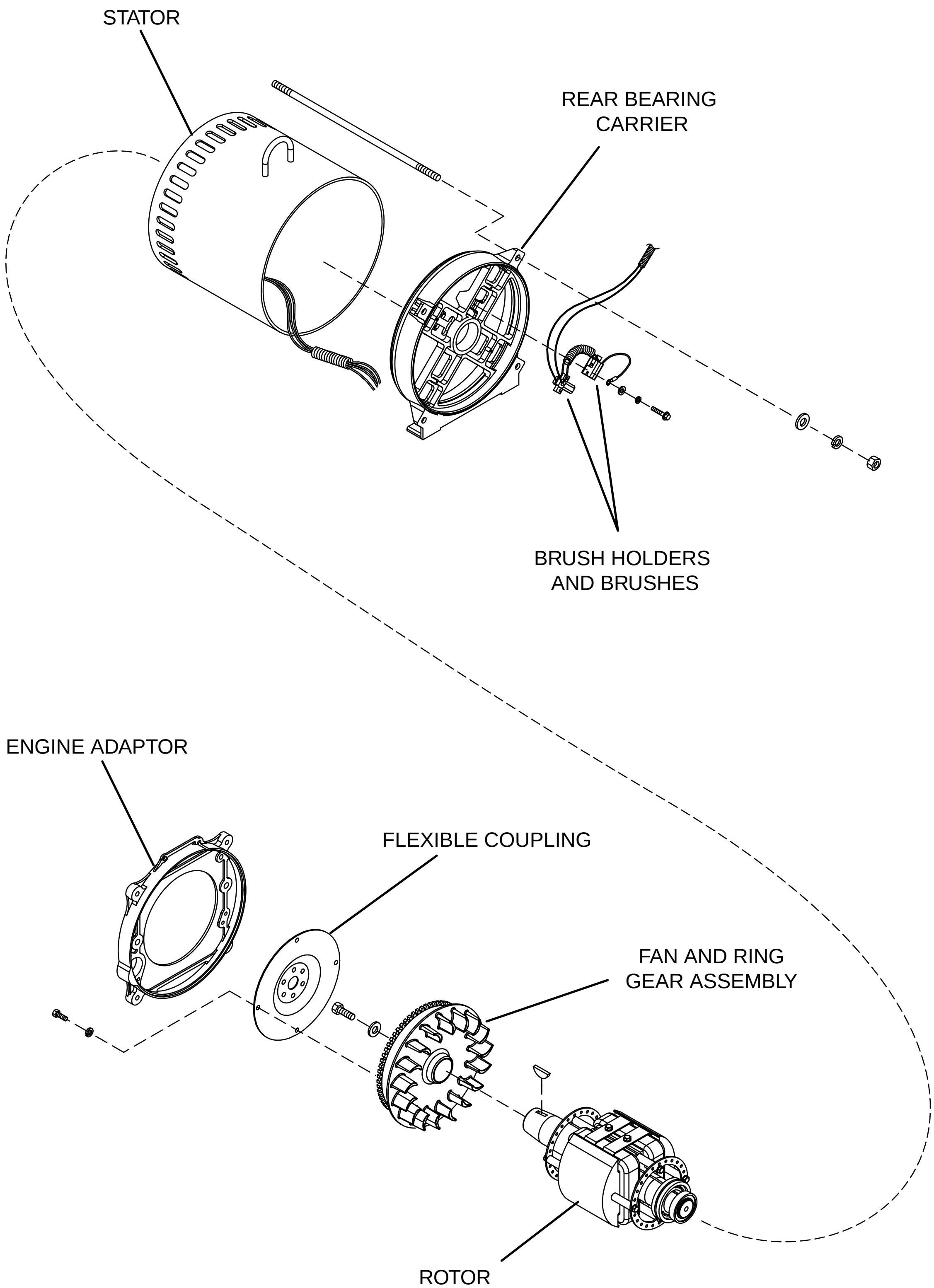


Figure 2. Generator Major Components

THE EXCITATION CIRCUIT

AC output from the stator excitation (DPE) winding is delivered to the voltage regulator, via a thermal protector (TP), Wire No. 2, an excitation circuit breaker (CB2), Wire No. 162, and Wire No. 6. This is "unregulated" excitation current.

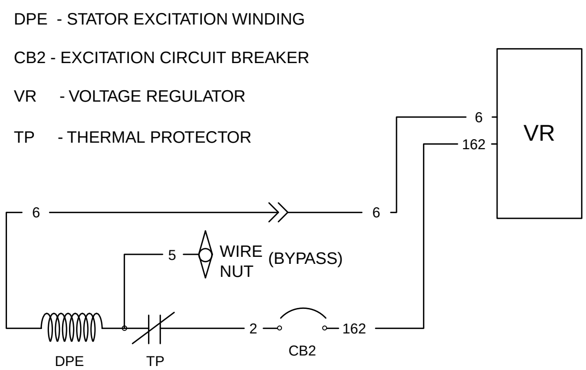


Figure 3. Schematic - Excitation Circuit

THERMAL PROTECTOR:

This normally closed thermal switch protects the stator windings against excessively high internal temperatures. The switch is physically imbedded in the stator windings and electrically connected in series with the DPE winding AC output to the regulator. If internal stator temperatures exceed a safe value, the switch contacts will open and the DPE output to the voltage regulator will be terminated. Without excitation current flow to the rotor, generator AC output voltage will drop to a value commensurate with field boost voltage only.

The thermal protector is self-resetting. That is, when internal stator temperatures drop to a safe value, its contacts will re-close and normal DPE output to the regulator will resume.

Wire No. 5 is a thermal protector "bypass" lead. If the thermal switch has failed in its open position, it can be bypassed. The Wire No. 5 bypass lead is brought out of the stator and has a wire nut on its end.

Note: This is an emergency fix. If bypassing the thermal protector fails, the stator should be replaced.

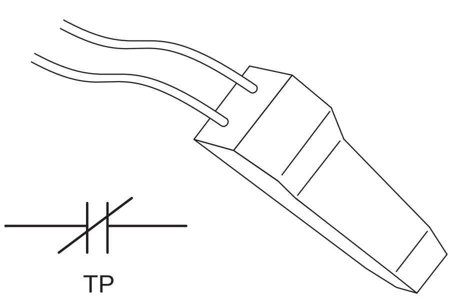


Figure 4. The Thermal Protector

EXCITATION CIRCUIT BREAKER:

This circuit breaker protects the stator from the voltage regulator drawing to much current. If the breaker has tripped open, loss of excitation current will occur. Stator power winding AC output voltage will then drop to a value commensurate with field boost voltage only. The breaker is self-resetting.

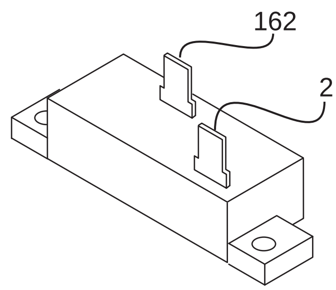


Figure 5. Excitation Circuit Breaker

SENSING WIRES:

These wires deliver stator power winding AC voltage and frequency signals to the voltage regulator. Depending on the voltage and phase of the unit, these wires can be numbered in different ways. In order to properly identify the wires on the unit being serviced, it is essential to know the phase and voltage of the unit. Refer to Figure 6 for proper identification.

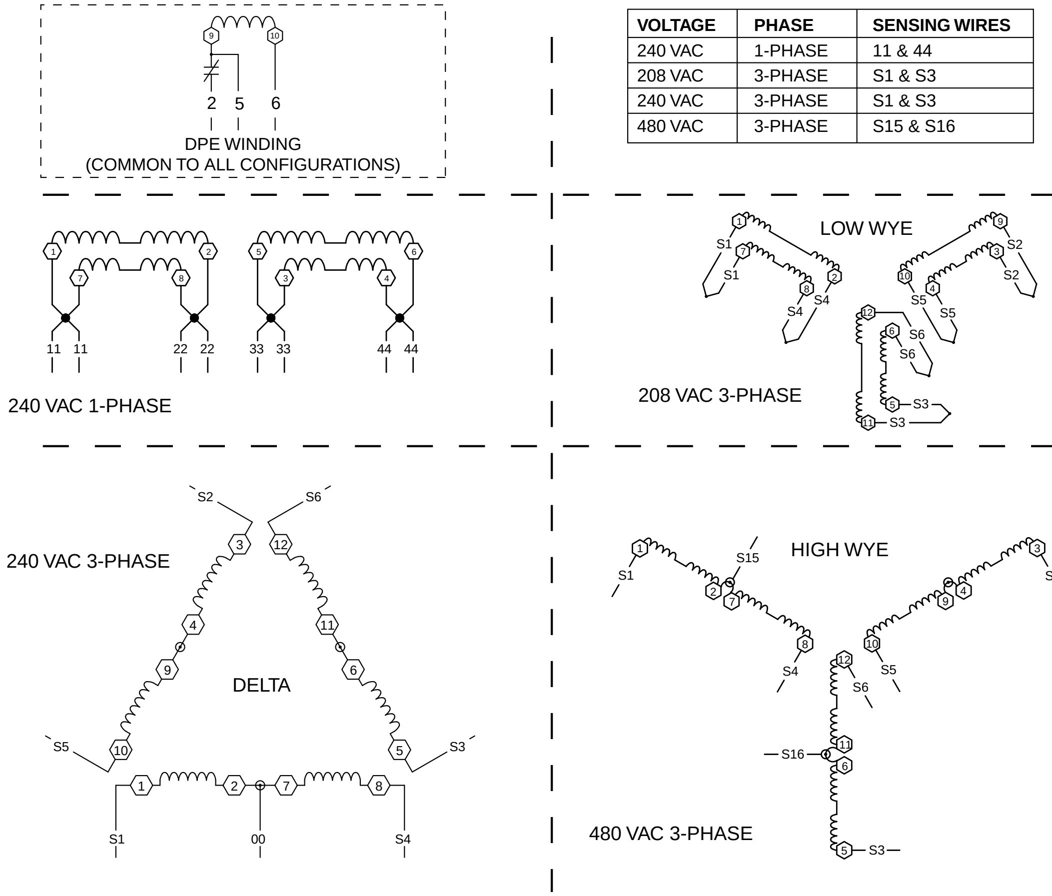
VOLTAGE REGULATOR:

See Figure 7. Unregulated AC output from the stator DPE winding is delivered to the voltage regulator, via Wires 6 and 162. Stator power winding AC voltage and frequency signals are delivered to the regulator, via the sensing wires. The regulator rectifies the DPE output and, based on the sensing lead signals, regulates the DC current output to the brushes via Wires 4 and 0. An LED (light emitting diode) is incorporated on the regulator. The voltage regulator is equipped with three lamps (LED's). These lamps are (a) a red "Regulator" lamp, (b) a yellow "Sensing" lamp, and (c) a green "Excitation" lamp. During normal operation with no faults in the system, all three lamps should be ON.

The voltage regulator is powered by stator excitation (DPE) winding output, with approximately 4 to 8 volts required to turn the regulator on.

The green "Excitation" lamp and the red "Regulator" lamp are both powered by excitation winding output. If excitation winding output is gradually reduced, these two lamps will begin to dim until, at some midpoint voltage and current, the lamps will no longer glow visibly. Depending on the specific generator model, excitation (DPE) voltage may be about 40-240 VAC RMS.

The yellow "Sensing" lamp is powered by sensing input to the regulator from the stator AC power windings. The brightness of this lamp will depend on the available sensing voltage. Sensing input to the regulator is approximately 190-240 VAC RMS, depending on the specific generator.



VOLTAGE	PHASE	SENSING WIRES
240 VAC	1-PHASE	11 & 44
208 VAC	3-PHASE	S1 & S3
240 VAC	3-PHASE	S1 & S3
480 VAC	3-PHASE	S15 & S16

Figure 6. Stator Winding Leads (Liquid-Cooled Units)

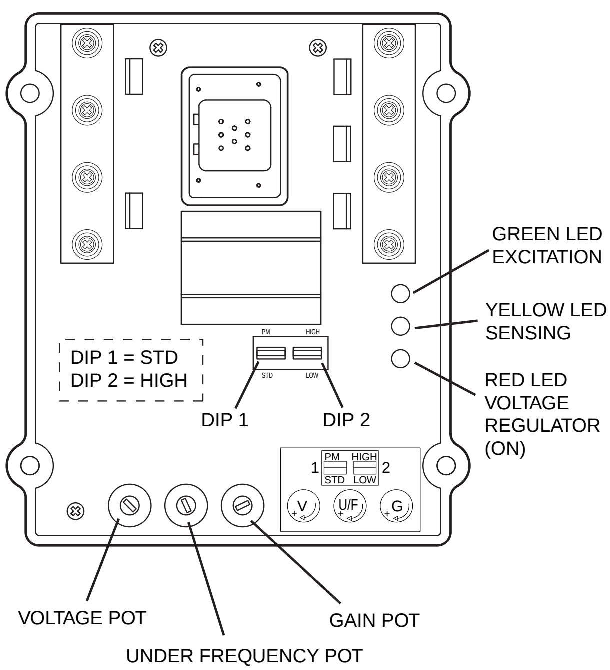


Figure 7. Voltage Regulator

The following factors apply to voltage regulator operation:

1. The voltage regulator will shut down on occurrence of any one or more of the following conditions:
   a. Loss of sensing voltage to the regulator.
   b. Loss of excitation (DPE) voltage input to the regulator.
   c. Loss of circuit reference.

NOTE: The term "circuit reference" refers to voltage regulator settings. The regulator "regulates" excitation (DPE) winding current flow to the rotor (field) in order to maintain a sensing voltage that is commensurate with a preset "reference" voltage. That is, the regulator seeks to maintain a sensing (actual) voltage that is the same as a "reference" voltage. Regulator "reference" volt age is adjustable within a 20 percent range at the regulator.

2. During generator operation, all three lamps (LED's) should be ON.
   a. "Regulator" lamp ON indicates the regulator is operating normally.
   b. "Sensing" lamp ON indicates that sensing voltage is available to the regulator.
   c. "Excitation" lamp ON indicates that unregulated excitation (DPE) current is available to the regulator.

3. If the red “Regulator” lamp goes OUT, a voltage regulator fault exists or the regulator has shut down due to occurrence of one or more shutdown conditions.
   a. Expect to see a generator AC output voltage that is commensurate with rotor residual magnetism plus the magnetism produced by field boost.
   b. Residual plus field boost magnetism will provide approximately one-half the unit's rated voltage.
4. If the green “Excitation” lamp goes out, loss of excitation (DPE) winding output to the regulator has occurred.
   a. Loss of excitation (DPE) output to the regulator will result in regulator shutdown and the red “Regulator” lamp will also turn on.
   b. If the red “Regulator” and the green “Excitation” lamps are both OUT, look for an AC output voltage that is commensurate with residual plus field boost magnetism.
5. If the yellow “Sensing” lamp goes out, loss of sensing to the regulator has occurred.
   a. Loss of sensing may cause the regulator to shutdown.
   b. On regulator shutdown, both the “Regulator” and the “Sensing” lamps will be OUT.
   c. Look for a generator output voltage that is the result of residual plus field boost magnetism.
6. If all three of the lamps go out, look for a fault that can cause both sensing and excitation to fail.
   a. Look for faulty slip rings, brushes, rotor, etc.
   b. Look for a fault in the regulator to rotor circuit.
7. If the red “Regulator” lamp is flashing, “Stability” probably requires adjustment. An open condition in the sensing leads to the regulator (see Sensing Wires in this section) tends to create a “full field” condition. This occurs because the regulator tries to bring the sensing voltage up to an equal value with the “reference” voltage setting, by increasing regulated excitation current to the rotor. However, regulator shutdown occurs on loss of sensing voltage. This, in turn, causes loss of excitation current to the rotor. The generator's AC output voltage will then become commensurate with rotor residual magnetism plus field boost magnetism, about one-half rated voltage. If the yellow LED goes OUT, sensing signals to the regulator have been lost. The following rules apply:

- Loss of sensing can be caused by an “open” circuit condition in sensing the leads. Thus, if the yellow LED is out, it may be assumed that an open circuit exists in the sensing circuit.
- Loss of sensing to the regulator will usually result in a “full field” condition and resultant high voltage output from stator AC power winding. The maximum voltage that regulator action can deliver is limited by a “clamming” action on the part of the regulator.
- A complete open circuit condition in the stator AC power windings will cause loss of sensing voltage and frequency. However, this will result in a zero voltage output from the stator windings.

Based on the “sensing” signals, the regulator delivers direct current (DC) to the rotor, via Wire 4 and the positive (+) brush and slip ring. This regulated current flows through the rotor and to frame ground, via the negative (-) slip ring and brush and Wire 1. The following apply:

- The concentration of magnetic flux lines around the rotor will be proportional to the regulated excitation current flow through the rotor plus any residual magnetism.
- An increase in excitation current flow through the rotor windings will increase the concentration of “magnetic flux” lines around the rotor which, in turn, will increase the AC voltage induced into the stator AC power windings.

FIELD BOOST

See Figure 8. The system provides a “field boost” feature. Field boost, in effect, “flashes the field” whenever the engine is cranking or running to ensure an early “pickup voltage” in the stator windings.

Manual and automatic cranking is initiated by the PCB board action, when the board energizes the run relay (RL2). The relay is energized; battery voltage is delivered across its closed contacts and to the rotor, via a field boost resistor (R4), field boost diode (BR1), and Wire No. 4.

Tech Tip: If the diode fails in a matter that the diodes are no longer blocking voltage, regulated DC voltage from the regulator could be delivered to the Wire 14 circuit damaging components that are connected on that circuit.

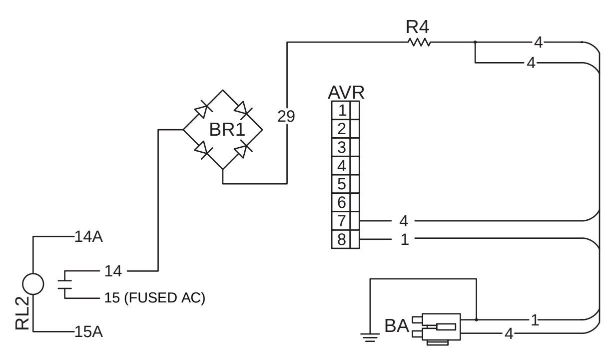


Figure 8. The Field Boost Circuit

MAGNETISM

Although magnetism is invisible, some of the effects it produces can be clearly seen. The behavior patterns of magnetism have been studied. It is the application of these behavior patterns that has led to the development of generators, motors, relays, transformers, coils, etc.

Magnetism can be used to produce electricity. Conversely, electricity can produce magnetism. Because of the relationship between magnetism and electricity, a study of one should include a study of the other.

The following facts are known about magnetism:

- Lines of magnetic force called "flux", are directed away from the north pole of a magnet, travel in a loop, and re-enter the magnet at its south pole.
- Lines of flux form definite patterns which vary in density according to the strength of the magnet.
- Lines of flux never cross one another.
- The area surrounding a magnet in which its lines of magnetic flux can be felt is called a "magnetic field".

ELECTROMAGNETISM

Current carrying electrical conductors are surrounded by a magnetic field which is at right angles to the conductor. When current flow through the conductor increases, the number of lines of flux increase proportionally. That is, the strength of the magnetic field increases when current flow increases. The magnetic field is distributed along the entire length of the conductor.

ELECTROMAGNETIC INDUCTION

When a conductor is moved so that it passes through a magnetic field, an electromotive force (EMF or voltage) is created in the conductor. If the magnetic field is moved so that it cuts across the conductor, an EMF or voltage will also be created in the conductor. This is the basic principle that allows a generator to produce electricity.

Figure 3 shows a simple revolving field generator. A permanent magnet rotates so that its lines of flux cut across a coil of wires called a stator. As the north pole of the magnet passes the stator windings, a voltage is induced into the stator and current will flow in one direction through the light bulb (called the "load"). As the north pole passes the stator, voltage and current will drop to zero. When the magnet's south pole pass the stator, current flow increases in the opposite direction. Magnet rotation causes this cycle to continue, with current flow reversing direction at the passage of each north and south pole. This constant reversal of current is called "alternating current" or "AC".

The flow of electrical current through a conductor in one direction followed by its reversal and flow in the opposite direction is called a "cycle" or "1 Hertz".

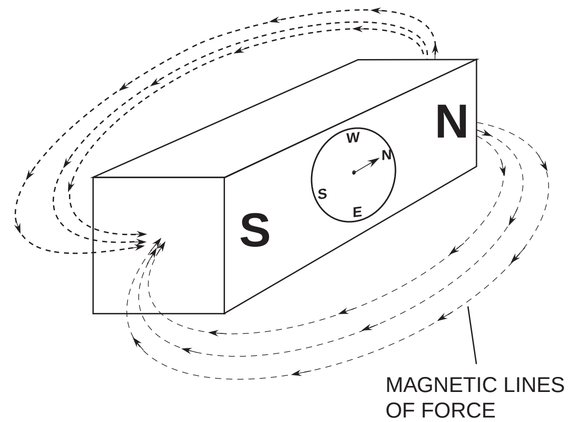


Figure 1. Magnetic Lines of Flux

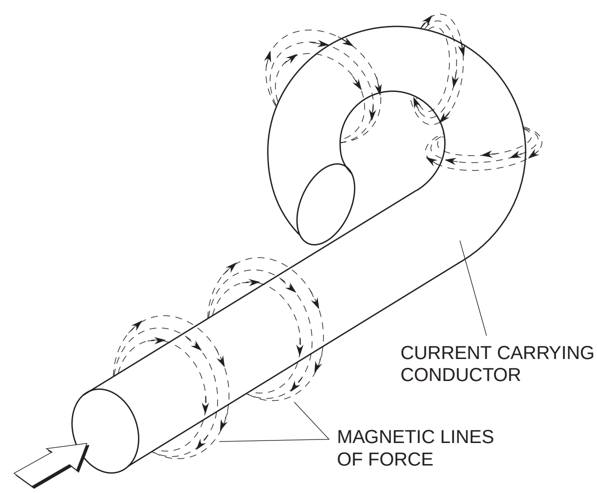


Figure 2 - Magnetism Around a Conductor

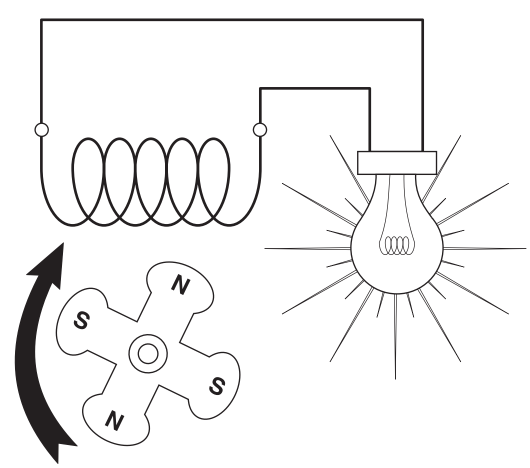


Figure 3 - A Simple Revolving Field Generator

OPERATION

STARTUP:

When the engine is started, residual plus field boost magnetism from the rotor induces a voltage into the stator AC power windings and the stator excitation or DPE windings. In an "on-speed" condition, residual plus field boost magnetism are capable of creating approximately one-half the unit's rated voltage.

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 completed to the voltage regulator, via Wire 2, excitation circuit breaker, Wire 162, and Wire 6. Unregulated alternating current can flow from the winding to the regulator.

If excitation voltage is present at the voltage regulator, the green excitation LED will be lit.

The voltage regulator "senses" AC power winding output voltage and frequency via the stator sensing wires.

The regulator changes the AC from the excitation winding to DC. In addition, based on the sensing signals, 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, via Wire 4, and the positive brush and slip ring. This excitation current flows through the rotor windings and is directed to ground through the negative (-) slip ring and brush, and Wire 1. 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 excitation current 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 excitation current. 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. The regulated AC power winding output voltage will be in direct proportion to the AC frequency. For example, on units rated 120/240 volts at 60 Hz, the regulator will try to maintain 240 volts (line-to-line) at 60 Hz. This type of regulation system provides greatly improved motor starting capability over other types of systems.

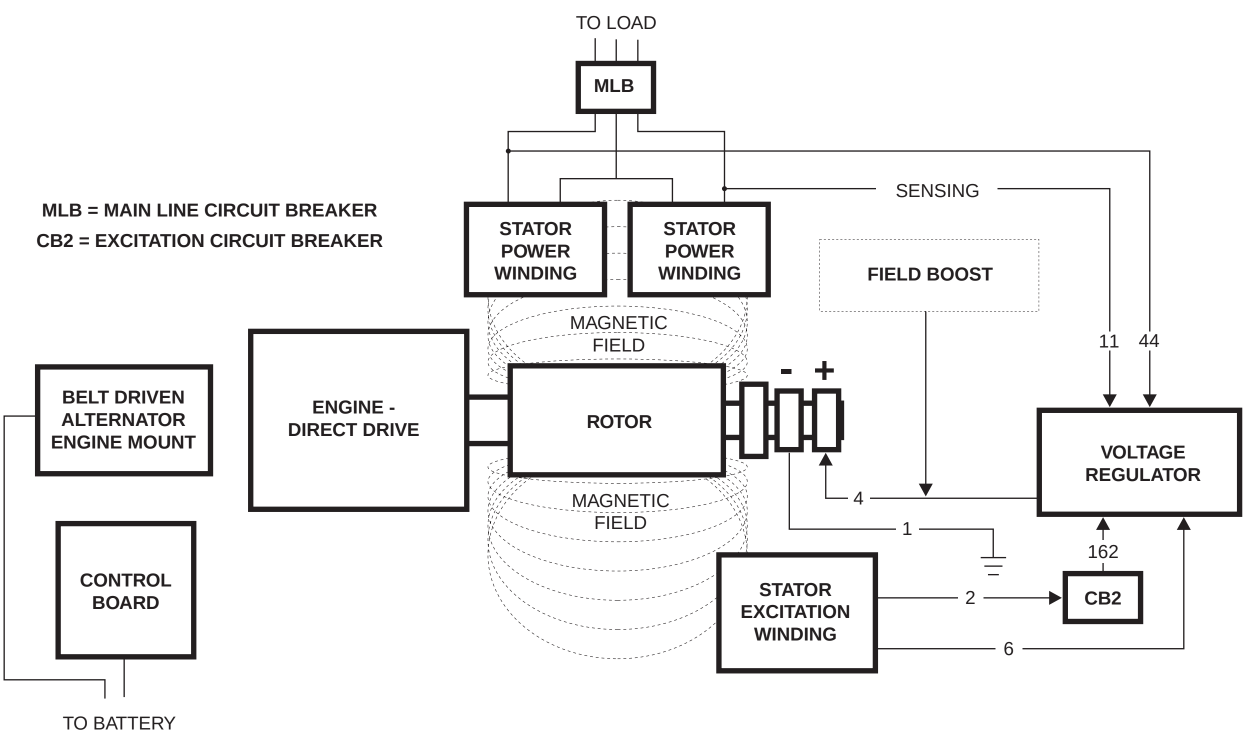
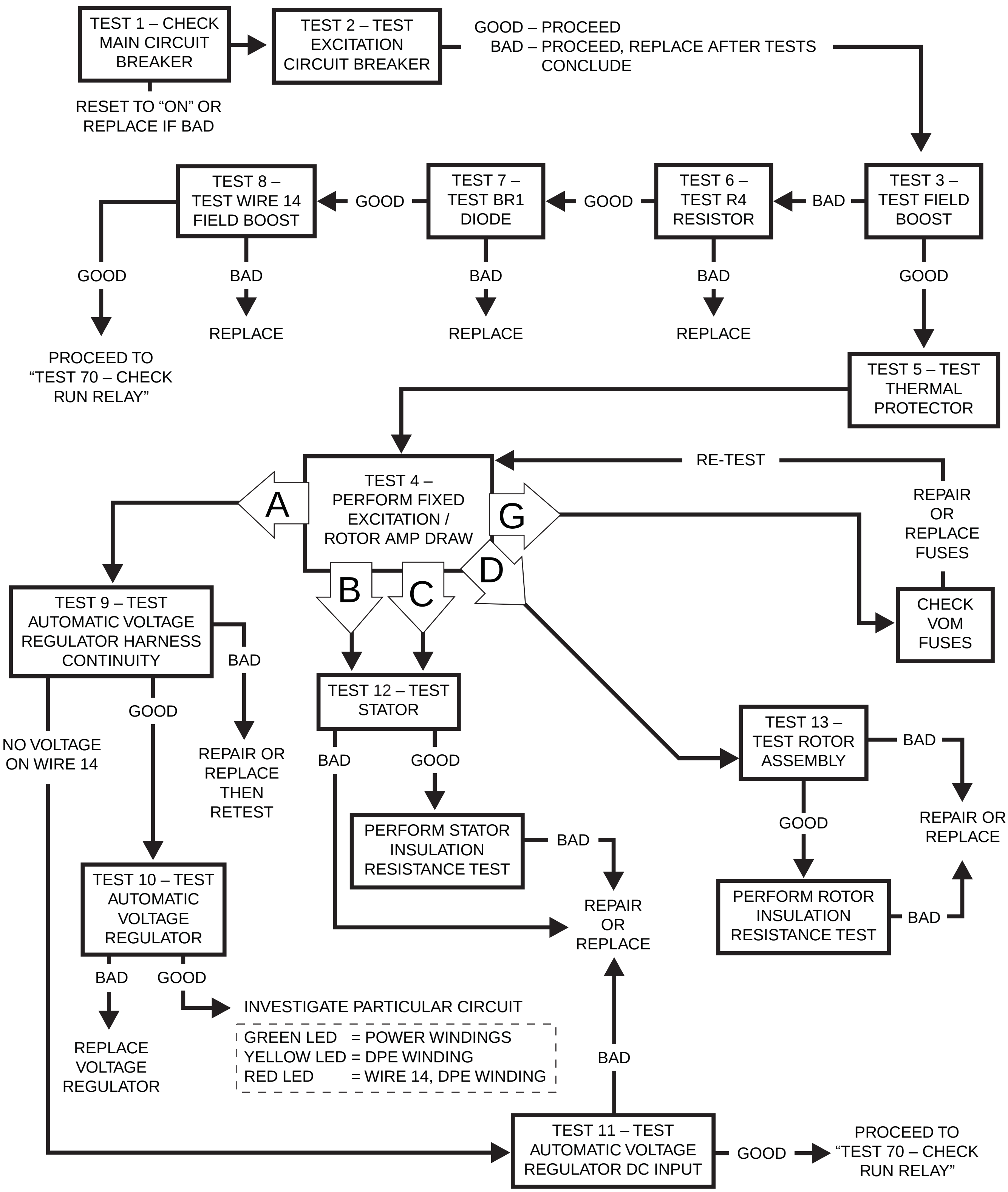


Figure 4. Operating Diagram of AC Generator

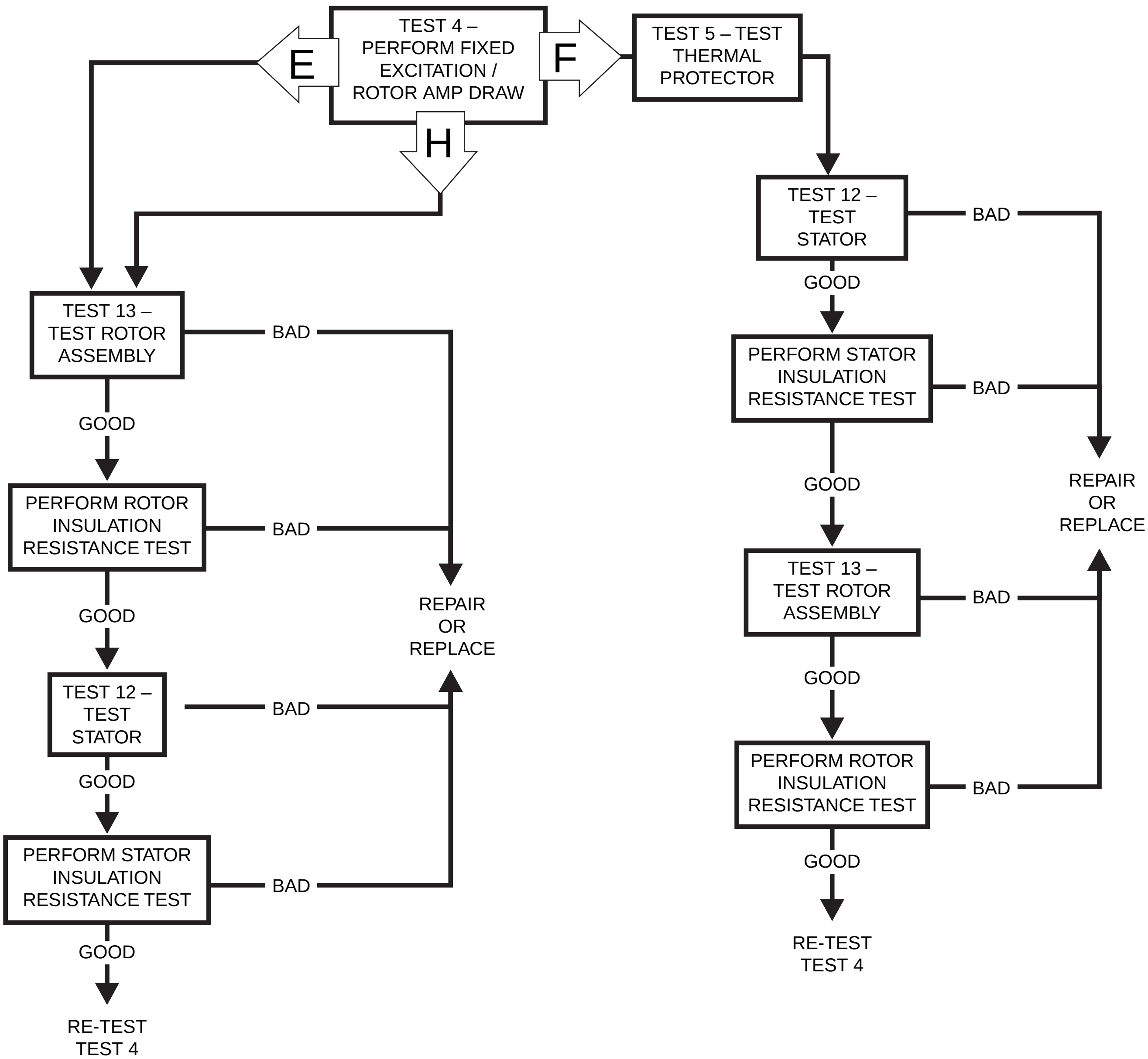
Use the "Flow Charts" in conjunction with the detailed instructions in Section 2.4. Test numbers used in the flow charts correspond to the numbered tests in Section 2.4.

The first step in using the flow charts is to correctly identify the problem. Once that has been done, locate the problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

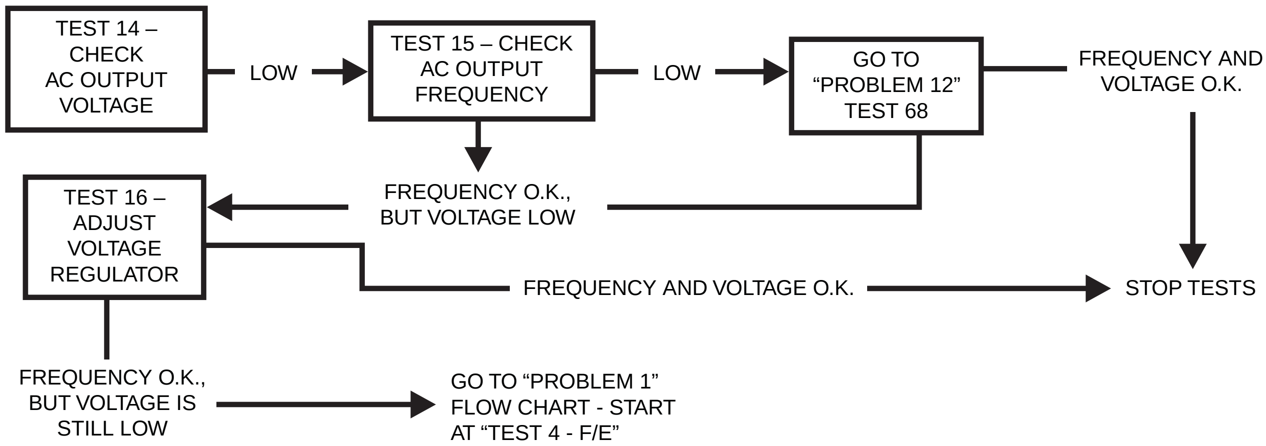
Problem 1 – Generator Produces Zero Voltage or Residual Voltage



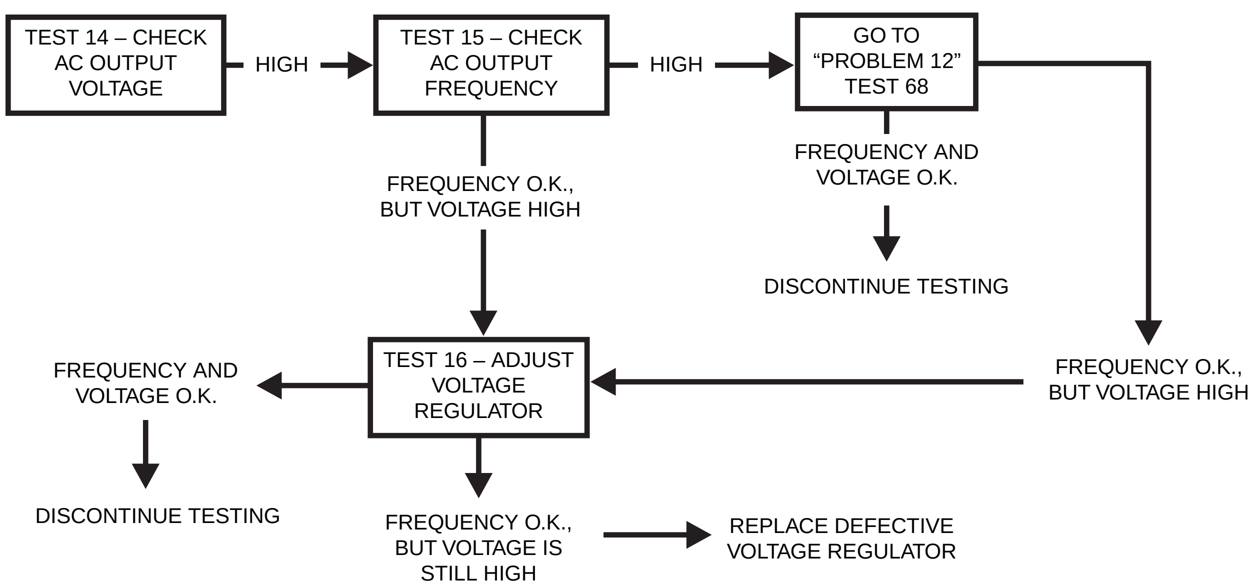
Problem 1 – Generator Produces Zero Voltage or Residual Voltage (Continued)



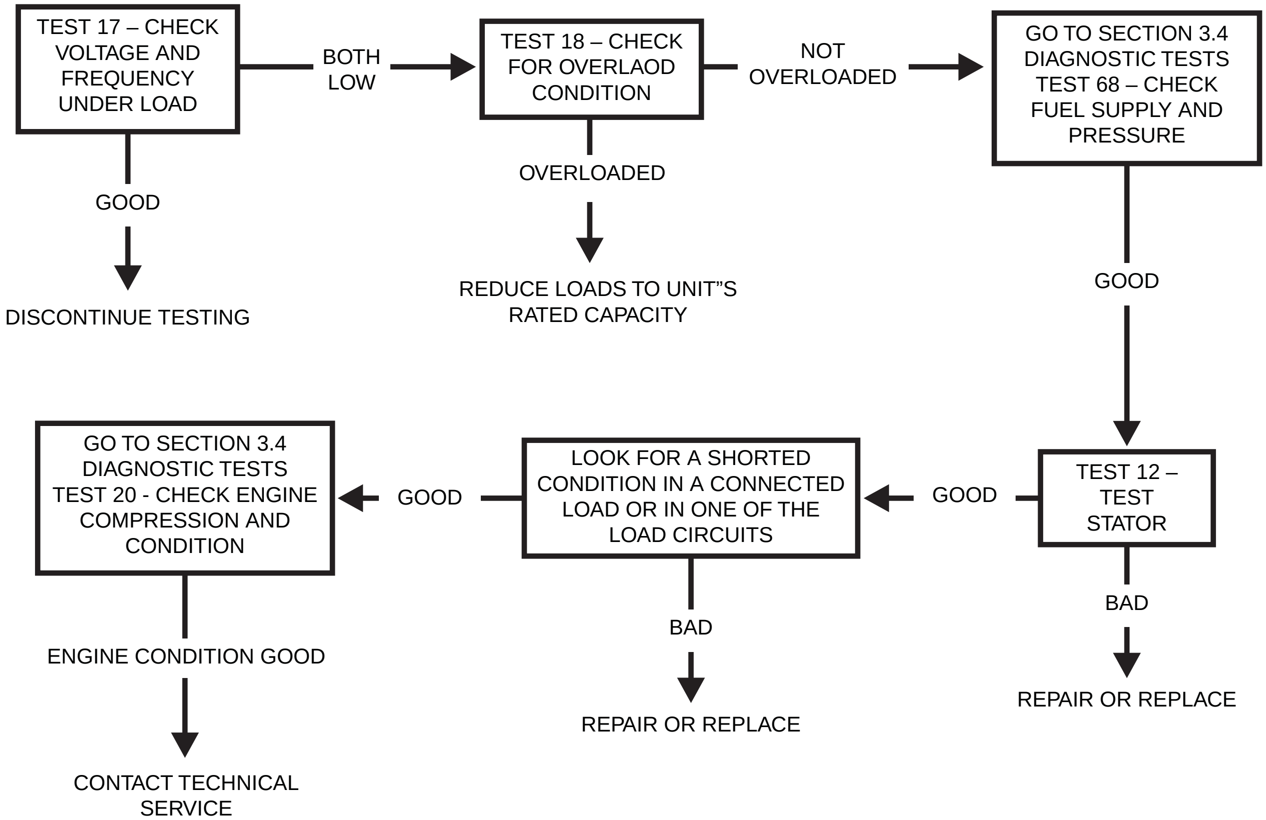
Problem 2 – Generator Produces Low Voltage at No-Load



Problem 3 – Generator Produces High Voltage at No-Load



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



INTRODUCTION

This section is provided to familiarize the service technician with acceptable procedures for the testing and evaluation of various problems that could be encountered on standby generators with liquid-cooled engines. Use this section of the manual in conjunction with Section 2.3, “Troubleshooting Flow Charts”. The numbered tests in this section correspond with those of Section 2.3.

Most tests can be performed with an inexpensive volt-ohm-milliammeter (VOM). An AC frequency meter is required, where frequency readings must be taken. A clamp-on ammeter may be used to measure AC loads on the generator.

Testing and troubleshooting methods covered in this section are not exhaustive. We have not attempted to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis might be performed. We have not undertaken any such broad evaluation. 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 product’s safety.

SAFETY

Service personnel who work on this equipment must be made 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 be ignited 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 don’t understand a component, device or system, do not work on it.

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 on the control panel. 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 1):

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 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. The VOM should indicate infinity.
6. Repeat Steps 4 and 5 with the VOM test probes connected across the breaker’s Wire 44 terminal and the E2 terminal.

RESULTS:

1. If the circuit breaker tests good, go on to Test 2.
2. If the breaker tests bad, it should be replaced.

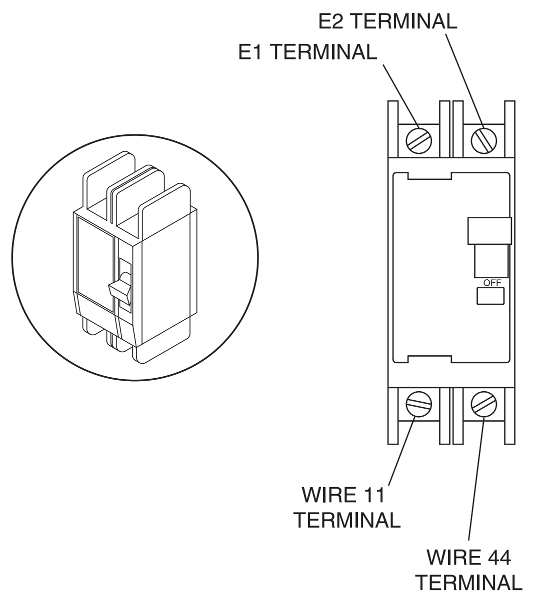


Figure 1. Generator Main Circuit Breaker Test Points

TEST 2 – TEST EXCITATION CIRCUIT BREAKER

DISCUSSION:

Unregulated excitation current is delivered to the voltage regulator from the stator excitation (DPE) winding, via Wire 2, an excitation circuit breaker (CB2), Wire 162, and Wire 6. If the excitation circuit breaker has failed open, excitation current will not be available to the voltage regulator or to the rotor. Stator AC power winding output will then be reduced to a voltage that is the product of residual magnetism alone, plus field boost.

PROCEDURE:

⚠ **Caution! The Excitation Circuit Breaker may be hot.**

1. With the generator shut down, locate the excitation circuit breaker in the control panel. Disconnect wires from the breaker, to prevent interaction.
2. Set VOM to measure resistance (Ω).
3. Connect the VOM test probes across the circuit breaker terminals. The meter should read CONTINUITY.

RESULTS:

1. Replace circuit breaker if defective (meter reads "OPEN"), refer back to flow chart.
2. If circuit breaker is good, refer back to flow chart.

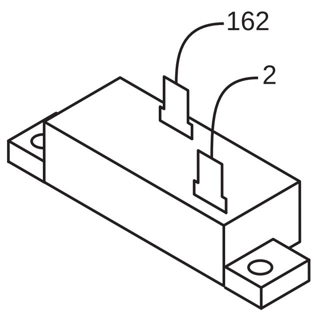


Figure 2. Excitation Circuit Breaker

TEST 3 – TEST FIELD BOOST CIRCUIT

DISCUSSION:

See "Field Boost Circuit" in Section 2.2. Field boost current is required for the rotor only while the engine is cranking or running. Loss of field boost output to the rotor may or may not affect power winding AC output voltage. The following facts apply:

- A small amount of voltage must be induced into the DPE winding to turn the voltage regulator on.
- If rotor residual magnetism is sufficient to induce a voltage into the DPE winding that is high enough to turn the voltage regulator on, regulator excitation current will be supplied even if field boost has failed. Normal AC output voltage will then be supplied.
- If rotor residual magnetism has been lost or is not sufficient to turn the regulator on, and field boost has also been lost, excitation current will not be supplied to the rotor. Generator AC output voltage will then drop to zero or nearly zero.

PROCEDURE:

1. Disconnect the connector from the voltage regulator.
2. Disconnect the Wire 4 that runs to the brush assembly on Terminal 3 of TB1. Figure 3 on the following page shows the terminal strip and the various wires.

Tech Tip: The brush assembly wire will be the larger one.

3. Set VOM to measure DC voltage
4. Connect one meter lead to Terminal 3 of TB1 and connect the other meter lead to Terminal 2 of TB1.
5. Set AUTO-OFF-MANUAL switch to the MANUAL position. Approximately 10-13 VDC should be measured.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

RESULTS:

1. Approximately 10-13 VDC should be measured. Refer back to flow chart.

TEST 4 – FIXED EXCITATION TEST/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. Disconnect Wires 2, 6, 11, and 44 from the top of Terminal Board 1. Ensure that these wires are isolated from the terminal strip.
2. Connect a jumper wire from Terminal 9 (Wire 14) of Terminal Board 1. Connect the other end of the wire to Terminal 3 (Wire 4) of the same terminal board. See Figure 3.
3. Set a VOM to measure AC Volts.
4. Set the AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

5. Connect one meter test lead to Terminal 4 (Wire 2) of TB1 and connect the other lead to Terminal 5 (Wire 6) of TB1. Measure and record voltage.
6. Connect one meter test lead to Terminal 6 (Wire 11) of TB1 and connect the other lead to Terminal 7 (Wire 44) of TB1. Measure and record voltage.
7. Set the AUTO-OFF-MANUAL switch to the OFF position.
8. Remove jumper wire that was installed in Step 2.
9. Isolate all wires on Terminal 3 of TB1 so that only the brush wire is connected to Terminal 3.
10. Set a VOM to measure DC amperage.

11. Connect one meter lead to Terminal 10 (Wire 15) of TB1 and the other lead to Terminal 3 of TB1 (Wire 4) (see Figure 4).
12. Measure and record static rotor amp draw.
13. Set the AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.

14. Measure and record running rotor amp draw.
15. Set the AUTO-OFF-MANUAL switch to the OFF position.
16. Reconnect all wires to TB1 that were disconnected in Step 9.

RESULTS:

Refer to Chart on the next page : “Test 4 Results - Fixed Excitation Test/Rotor Amp Draw Test.”. Then refer back to the “Problem 1” Flow Chart to proceed.

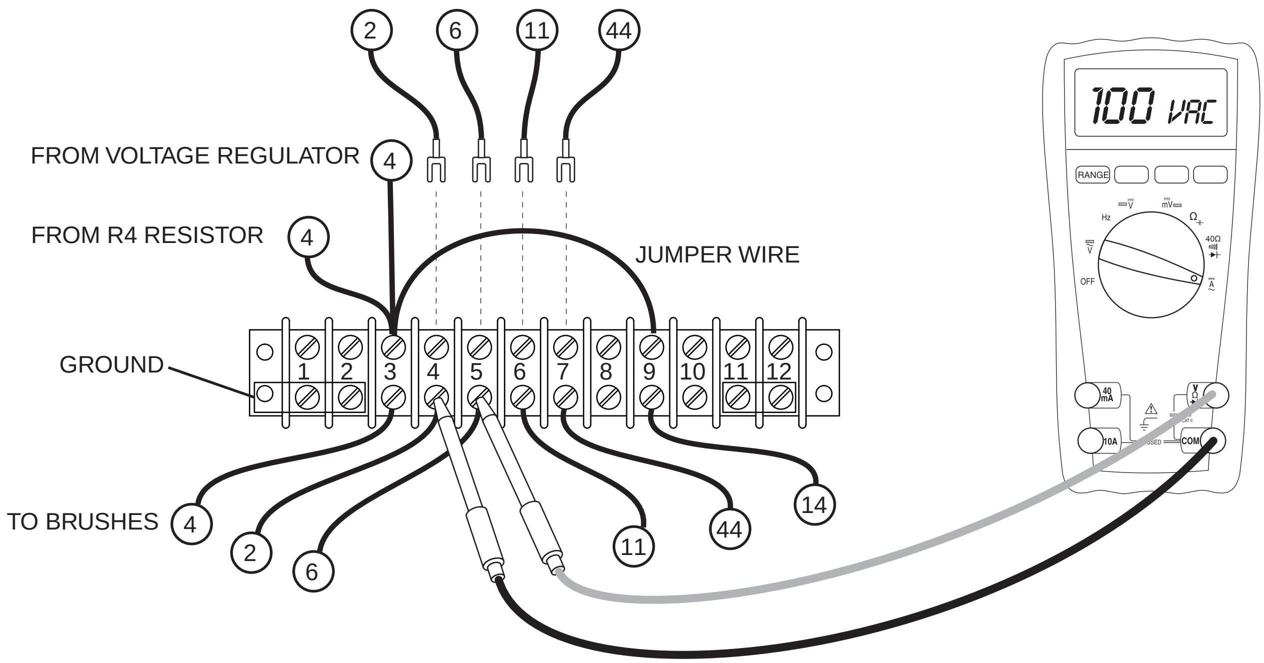


Figure 3. Flashing the Field

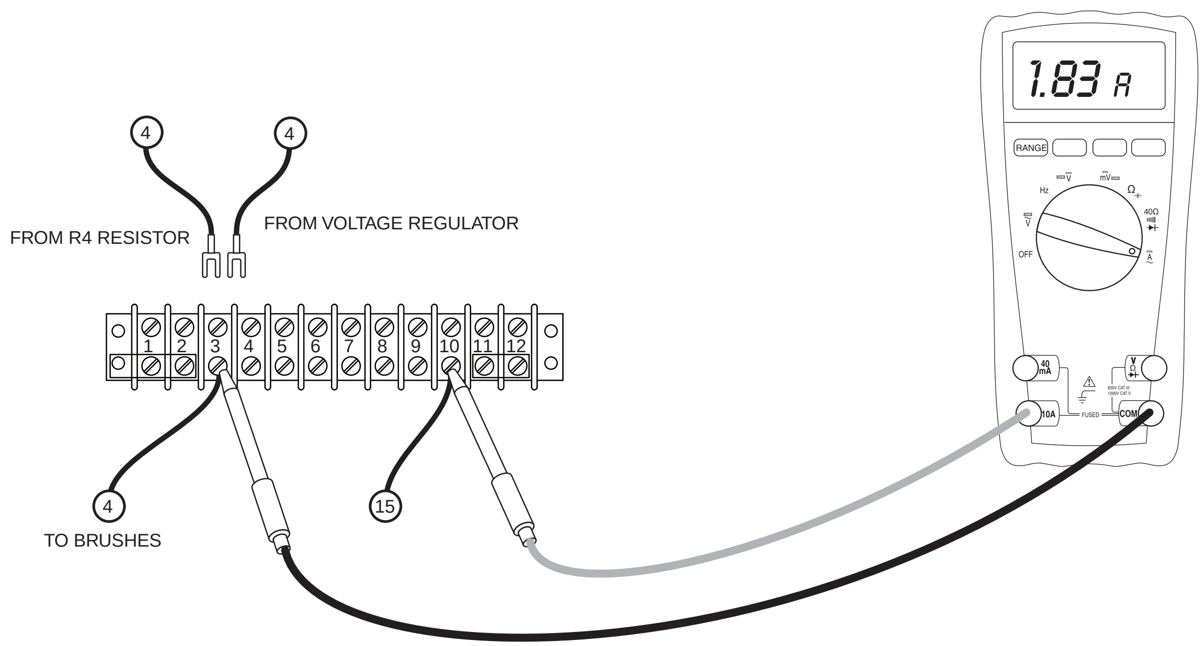


Figure 4. Rotor Amp Draw

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

Results:	Size	A	B	C	D	E	F	G	H
Voltage Results Wire 2 & 6	ALL	Above 60 VAC	Above 60 VAC	Below 60 VAC	Below 60 VAC	Below 60 VAC	Below 60 VAC	Above 60 VAC	Below 60 VAC
Voltage Results Wire 11 & 44	ALL	Above 120 VAC	Below 120 VAC	Above 120 VAC	Below 120 VAC	Below 120 VAC	Below 120 VAC	Above 120 VAC	Below 120 VAC
Static Rotor Amp Draw	22 kW 1-Phase	2.03 Amps	2.03 Amps	2.03 Amps	Zero Current Draw	Above 2.5A	2.03 Amps	Zero Current Draw	2.03 Amps
	22 kW 3-Phase	2.14 Amps	2.14 Amps	2.14 Amps			2.14 Amps		2.14 Amps
	27 kW 1-Phase	1.77 Amps	1.77 Amps	1.77 Amps			1.77 Amps		1.77 Amps
	27 kW 3-Phase	1.82 Amps	1.82 Amps	1.82 Amps			1.82 Amps		1.82 Amps
	36 kW 1-Phase	1.54 Amps	1.54 Amps	1.54 Amps			1.54 Amps		1.54 Amps
	36 kW 3-Phase	1.54 Amps	1.54 Amps	1.54 Amps			1.54 Amps		1.54 Amps
	45 kW 1-Phase	2.58 Amps	2.58 Amps	2.58 Amps			2.58 Amps		2.58 Amps
	45 kW 3-Phase	2.58 Amps	2.58 Amps	2.58 Amps			2.58 Amps		2.58 Amps
	60 kW 1-Phase	2.30 Amps	2.30 Amps	2.30 Amps			2.30 Amps		2.30 Amps
	60 kW 3-Phase	2.30 Amps	2.30 Amps	2.30 Amps			2.30 Amps		2.30 Amps
Running Rotor Amp Draw	27 kW 3-Phase	1.82 Amps	1.82 Amps	1.82 Amps	Zero Current Draw	Above 2.5A	1.82 Amps	Zero Current Draw	Above 2.5A
	27 kW 1-Phase	1.77 Amps	1.77 Amps	1.77 Amps			1.77 Amps		
	22 kW 3-Phase	2.14 Amps	2.14 Amps	2.14 Amps			2.14 Amps		
	22 kW 1-Phase	2.03 Amps	2.03 Amps	2.03 Amps			2.03 Amps		
	36 kW 1-Phase	1.54 Amps	1.54 Amps	1.54 Amps			1.54 Amps		
	36 kW 3-Phase	1.54 Amps	1.54 Amps	1.54 Amps			1.54 Amps		
	45 kW 1-Phase	2.58 Amps	2.58 Amps	2.58 Amps			2.58 Amps		
	45 kW 3-Phase	2.58 Amps	2.58 Amps	2.58 Amps			2.58 Amps		
	60 kW 1-Phase	2.30 Amps	2.30 Amps	2.30 Amps			2.30 Amps		
	60 kW 3-Phase	2.30 Amps	2.30 Amps	2.30 Amps			2.30 Amps		

MATCH RESULTS WITH LETTER AND REFER TO FLOW CHART IN SECTION 2.3 "Problem 1"

TEST 5 – TEST THERMAL PROTECTOR

DISCUSSION:

An open thermal protector will result in loss of excitation. Generator AC output voltage will then drop to approximately 50 percent of rated voltage.

PROCEDURE:

1. Locate DPE Wire 2 where it connects to the excitation circuit breaker. Disconnect the wire from the circuit breaker.
2. Disconnect the connector that plugs into the voltage regulator.
3. Set a VOM to measure resistance (Ω).
4. Connect one meter test lead to Terminal 4 (Wire 2) on TB1, connect the other test lead to Terminal 5 (Wire 6) on TB1. The meter should indicate the resistance of the stator excitation (DPE) winding. Reference chart in the front of this manual for the correct resistance reading depending on your stator.
5. If the meter indicated INFINITY in Step 4, connect the VOM test leads across Wire 5 (bypass wire) and Wire 6. The meter should indicate the resistance of the stator excitation (DPE) winding.

RESULTS:

1. If normal DPE winding resistance was indicated in Step 5, but INFINITY is indicated in Step 4, bypass the thermal protector by connecting Wire 5 to Terminal 4 of TB1.

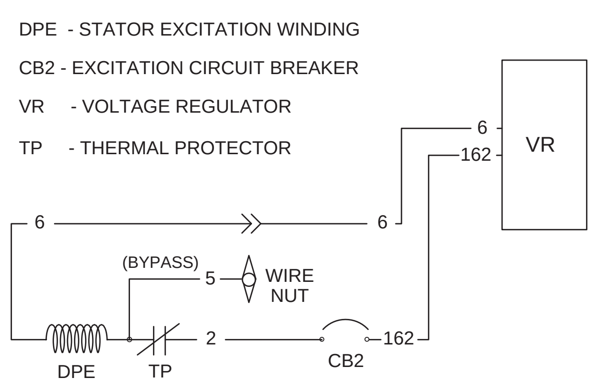


Figure 5. Bypassing the Thermal Protector

TEST 6 – TEST R4 RESISTOR

DISCUSSION:

The R4 resistor is installed with the field boost circuit in series with the rotor. This is done so that the initial DPE and sensing voltages coming out of the stator during field boost are at a level that is acceptable for the voltage regulator.

PROCEDURE:

1. Disconnect Wire 4 from R4 resistor.
2. Set AUTO-OFF-MANUAL switch to the MANUAL position.
3. Set VOM to DC Voltage.
4. Connect one meter test lead to the terminal where Wire 4 was disconnected in Step 1 and connect the other lead to a clean frame ground. Measure and record the voltage.
5. Disconnect Wire 29 from the R4 resistor.
6. Set a VOM to measure resistance (Ω).
7. Connect one meter test lead to the R4 resistor wire where Wire 4 was disconnect in Step 1 and connect the other meter test lead to the R4 resistor wire where Wire 29 was disconnected in Step 5. Measure and record the resistance. Approximately 15 Ohms should be measured.

RESULTS:

1. If battery voltage is measured in Step 4, repair or replace Wire 4 between R4 and TB1 Terminal 3.
2. If battery voltage was not measured in Step 4 and the correct resistance was measured in Step 7, refer back to flow chart.
3. If the correct resistance was not measured in Step 7, replace the R4 resistor and re-test.

TEST 7 – TEST BR1 DIODE

DISCUSSION:

The bridge rectifier is installed on the field flash circuit to benefit two components. It allows for a field flash to occur on the rotor and a field flash to occur on the engine alternator. It also acts as a bridge so that regulated DC voltage from the voltage regulator does not get back to the run circuit during normal operation. If this diode failed closed it would allow for a high DC voltage to get back to the run circuit, potentially damaging critical components.

PROCEDURE:

1. Disconnect Wire 29 from BR1 located in the top of the control panel.
2. Set VOM to measure DC voltage.
3. Connect one meter test lead to BR1 where Wire 29 was disconnected in Step 1 and the other meter test lead to a clean frame ground.
4. Set AUTO-OFF-MANUAL switch to the MANUAL position. Measure and record the voltage. Battery voltage should be measured.

⚠ **Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.**

5. Set AUTO-OFF-MANUAL position to the OFF position.
6. Reconnect Wire 29 to BR1.
7. Disconnect Wire 14 from BR1
8. Connect one meter test lead to the disconnected Wire 14 and the other meter test lead to a clean frame ground.
9. Set AUTO-OFF-MANUAL switch to the MANUAL position.

⚠ **Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.**

10. Measure and record the voltage. Battery voltage should be measured.

RESULTS:

1. If battery voltage was measured in Step 4, repair or replace Wire 29 between BR1 and R4.
2. If battery voltage was not measured in Step 4, but was measured in Step 10, replace BR1.
3. If battery voltage was not measured in Step 10 refer back to flow chart.

TEST 8 – TEST WIRE 14 FIELD BOOST

DISCUSSION:

Battery voltage is delivered to BR1 via Wire 14 from Terminal 9 of TB1. Wire 14 is the run circuit and is controlled by RL2 (Run Relay). This relay must energize before field boost will occur.

PROCEDURE:

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

⚠ **Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.**

2. Connect one meter test lead to Terminal 9 of TB1 and the other meter test lead to a clean frame ground. Measure and record the voltage. Battery voltage should be measured.

RESULTS:

1. If battery voltage was measured, repair or replace Wire 14 between BR1 and Terminal 9 of TB1.
2. If battery voltage was not measured, refer back to flow charts.

TEST 9 – TEST HARNESS CONTINUITY

DISCUSSION:

The voltage regulator receives unregulated alternating current from the stator excitation winding, via Wires 2, 6, and 162. It also receives voltage sensing from the stator AC power windings, via Wires 11 and 44. The regulator rectifies the AC from the excitation winding and based on the sensing signals, regulates the DC current flow to the rotor. The rectified and regulated current flow is delivered to the rotor brushes via Wires 4 (positive) and 1 (negative). This test will verify the integrity of the connector to ensure all proper signals are getting to the voltage regulator.

PROCEDURE:

1. Disconnect the connector that goes in to the voltage regulator.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

2. Set VOM to measure resistance (Ω).
3. Connect one meter lead to Pin 1 and the other test lead to Terminal 4 of TB1. CONTINUITY should be measured.
4. Repeat Step 3 between the following pins and terminals, CONTINUITY should be measured during each step.
   a. Pin 2 to Terminal 5 (Wire 6) of TB1.
   b. Pin 3 to Terminal 9 (Wire 14) of TB1.
   c. Pin 4 to Terminal 6 (Wire 11) of TB1.
   d. Pin 6 to Terminal 7 (Wire 44) of TB1.
   e. Pin 7 to Terminal 3 (Wire 4) of TB1.
   f. Pin 8 to Terminal 2 (Wire 1) of TB1.

AVR Pin Out Chart		
Pin	**Wire**	**Function**
1	162	DPE Winding
2	6	DPE Winding
3	14	Run Circuit
4	11	Power Winding (Sensing)
6	44	Power Winding (Sensing)
7	4	Rotor (Brushes)
8	1	Rotor (Brushes)

5. Set VOM to measure DC voltage.
6. Connect one meter test lead to Pin 3 and the other meter test lead to a clean frame ground.
7. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

8. Measure and record voltage. Battery voltage should be indicated.
9. Disconnect Wire 2 from Terminal 4 of TB1, Wire 6 from Terminal 5 of TB1, Wire 11 from Terminal 6 of TB1, and Wire 44 from Terminal 7of TB1.

Note: Disconnect the Wires from the top of the terminal strip so that the wires are isolated.

10. Set a VOM to measure resistance (Ω).
11. Connect one meter test lead to disconnected Wire 2 and the other meter test lead to disconnected Wire 6. INFINITY should be measured.
12. Repeat Step 11 between the following test points:
    a. Wire 2 to Wire 11
    b. Wire 2 to Wire 44
    c. Wire 6 to Wire 11
    d. Wire 6 to Wire 44
    e. Wire 11 to Wire 44
    f. Wire 2 to Ground
    g. Wire 6 to Ground
    h. Wire 11 to Ground
    i. Wire 44 to Ground

RESULTS:

1. If CONTINUITY was measured in Steps 5 and 6, refer back to flow chart.
2. If INFINITY was not measured between one of the connections, repair or replace the wire.
3. If battery voltage was not measured in Step 10, refer back to flow chart.
4. If anything other than INFINITY is measured in Steps 11 and 12, repair or replace the defective wire.

TEST 10 – AUTOMATIC VOLTAGE REGULATOR

DISCUSSION:

Unregulated AC output from the stator DPE winding is delivered to the voltage regulator, via Wires No. 6 and 162. Stator power winding AC voltage and frequency signals are delivered to the regulator, via the sensing wires. The regulator rectifies the DPE output and, based on the sensing lead signals, regulates the DC current output.

A 12V DC signal is also delivered to the voltage regulator via Wire 14. This allows the voltage regulator to turn on internally and be ready when the stator starts to produce power. The voltage regulator is equipped with three lamps (LED's). These lamps are (a) a red "Regulator" lamp, (b) a yellow "Sensing" lamp, and (c) a green "Excitation" lamp. During normal operation with no faults in the system, all three lamps should be ON. See Section 4.1 for adjustments and installation guidelines and further technical data.

PROCEDURE:

1. Check Dip Switch positions. See Figure 7 in Section 2.1.
   a. Dip Switch One should be down in the "STD" position for standard brush type units.
   b. Dip Switch Two should be in the "HIGH" position for standard brush type units.
2. Ensure all wires and connectors from previous tests are connected.
3. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Record which LED's are illuminated or dimly lit on the AVR.
5. Set AUTO-OFF-MANUAL switch to the OFF position.

Tech Tip: A loose connection could still be present in the harness or pin connectors, even after replacing the voltage regulator.

RESULTS:

1. If any one out of the three LED's were not illuminated, replace voltage regulator. See Section 4.1 for adjustments and installation guidelines.
2. If any one of the three LED's was dimly lit, proceed to investigate that particular circuit.

- Green LED (Power Windings)
- Yellow LED (DPE Winding)
- Red LED (Wire 14 Input, DPE Winding)

TEST 11 – TEST WIRE 14 AVR INPUT CIRCUIT

DISCUSSION:

The voltage regulator powers on by receiving a 12 VDC input signal prior to receiving voltage from the stator. By powering on, the voltage regulator responds more quickly to voltage adjustment procedures.

PROCEDURE:

1. Set VOM to measure DC voltage.
2. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

3. Connect one meter test lead to Terminal 9 of TB1 and the other meter test lead to a clean frame ground. Measure and record the voltage, battery voltage should be indicated.

RESULTS:

1. If battery voltage was measured, repair or replace the wire between AVR connector Pin 1 and Terminal 9 of TB1.
2. If battery voltage was not measured refer back to flow charts.

TEST 12 – TEST STATOR

DISCUSSION:

A Volt-OHM-Milliammeter (VOM) can be used to test the stator windings for the following faults:

- An open circuit condition
- A "short-to-ground" condition
- A short circuit between windings

Note: The resistance of stator windings is very low. Some meters will not read such a low resistance, and will simply indicate CONTINUITY. Recommended is a high quality, digital type meter capable of reading very low resistances.

TESTING 1-PHASE STATORS:

1. Open the Main Line Circuit Breaker.
2. Disconnect Stator Leads 22 and 33 from the 00 neutral blocks.
3. Disconnect Voltage Regulator connector.

Note: Ensure wires are isolated and not touching any components.

4. Set VOM to measure resistance (Ω) between the windings.
   a. Connect one meter test lead to Stator Lead 11 and connect the other meter test lead to Stator Lead 22. Measure and record resistance.
   b. Connect one meter test lead to Stator Lead 44 and connect the other meter test lead to Stator Lead 33. Measure and record resistance.
   c. Connect one meter test lead to Stator Lead 2 at Terminal 4 of TB1 and connect the other meter test lead to Stator Lead 6 at Terminal 5 of TB1. Measure and record resistance.
   d. Refer to chart in the front of this manual for correct resistance readings for the stator being serviced. If reading is INFINITY or a high Ohm reading, an open is possible across that winding.

Tech Tip: If the DPE winding is open it can be temporarily bypassed by connecting Stator Lead Wire 5 to Terminal 6 of TB1, but the stator will need to be replaced.

5. Set VOM to a high resistance scale (Ω) to check for a short to ground.
   a. Connect one meter test lead to Stator Lead 11 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.
      (1) If CONTINUITY is measured disconnect Sensing Wire 11 from the MLCB that runs to TB1 and see if the short is still in Stator lead Wire 11 or if it is located in Sensing Wire 11.
   b. Connect one meter test lead to Stator Lead 44 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.
      (1) If CONTINUITY is measured disconnect Sensing Wire 44 from the MLCB that runs to TB1 and see if the short is still in Stator lead Wire 44 or if it is located in Sensing Wire 44.
   c. Connect one meter test lead to Stator Lead 2 at terminal 4 of TB1 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.
   d. Connect one meter test lead to Stator Lead 11 and connect other meter test lead to Stator Lead 44. INFINITY should be measured.
   e. Repeat Steps 5a through 5d between the following points. INFINITY should be measured at all points. If CONTINUITY is measured between any two points then there is a short between the winding and the DPE winding.

Stator Lead 11 to Terminal 4 of TB1.
Stator Lead 44 to Terminal 4 of TB1.

6. Set VOM to measure resistance (Ω).

Note: Ensure Wires S11 and S44 are still connected to the MLCB

   a. Connect one meter test lead to Terminal 6 of TB1 (Wire S11) and the other meter test lead to Stator lead Wire 11 on the MCLB. CONTINUITY should me measured. If CONTINUITY was not measured, repair or replace Wire S11 between the MLCB and Terminal 6 of TB1.
   b. Connect one meter test lead to Terminal 7 of TB1 (Wire S44) and the other meter test lead to Stator lead Wire 44 on the MCLB. CONTINUITY should me measured. If CONTINUITY was not measured, repair or replace Wire S44 between the MLCB and Terminal 7 of TB1.

<u>RESULTS:</u>

1. If any step indicated CONTINUITY where INFINITY should be present, or INFINITY where CONTINUITY should be present, then either the wire or the component will need to be replaced.
2. If a short to ground was measured on a stator winding, the stator will need to be replaced.
3. If an open winding was measured on the stator, the stator will need to be replaced.

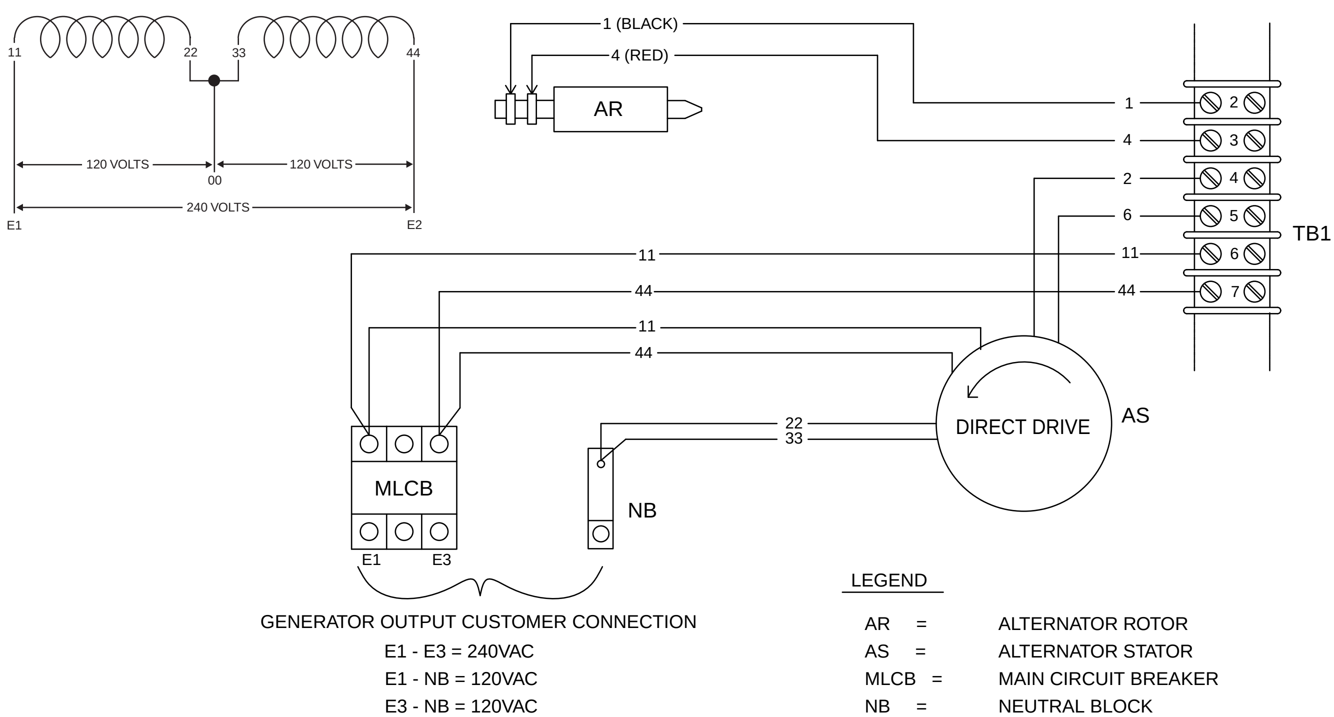


Figure 6. 1-Phase Stator and DPE Windings

4. If a short between two windings was measured, ensure the circuit is completely isolated. If short continues the stator will need to be replaced.

5. If all tests are good, refer back to flow chart and perform the “Stator Insulation Tests” in Section 1.4.

TESTING 3-PHASE STATORS:

1. Disconnect all neutral wires from the neutral block.

2. Disconnect the Voltage Regulator connector.

Note: Ensure wires are isolated and not touching any components.

3. Set VOM to measure resistance (Ω) between the windings.

   a. Connect meter test lead to Stator Lead S1 and connect the other meter test lead to Stator Lead S4. Measure and record the resistance.

   b. Repeat Step 4a between the following points.

Stator Lead S6 and Stator Lead S3
Stator Lead S5 and Stator Lead S2
Terminal 4 (Wire 2) of TB1 and Terminal 5 (Wire 6) of TB1

   c. Refer to chart in the front of this manual for correct resistance readings for the stator being serviced. If reading is INFINITY or high resistance, then an open is possible across that winding.

Tech Tip: If the DPE winding is open it can be temporarily bypassed by connecting Stator Lead Wire 5 to Terminal 6 of TB1.

4. Set VOM to a high resistance scale (Ω) to check for a short to ground.

   a. Connect one meter test lead to Stator Lead S1 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.

      (1) If CONTINUITY is measured, disconnect Sensing Wire 11 from the MLCB that runs to TB1 and see if the short is still in Stator lead S1 or if it is located in Sensing Wire 11.

   b. Connect one meter test lead to Stator Lead S2 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.

   c. Connect one meter test lead to Stator Lead S3 and connect the other meter test lead to a clean frame ground. INFINITY should be measured.

      (1) If CONTINUITY is measured disconnect Sensing Wire 44 from the MLCB that runs to TB1 and see if the short is still in Stator lead Wire S3 or if it is located in Sensing Wire 44.

   d. If CONTINUITY is measured in Steps 4a and 4c then a short exists to ground inside the stator.

5. Set VOM to a high resistance scale (Ω) to check for a short between the windings.

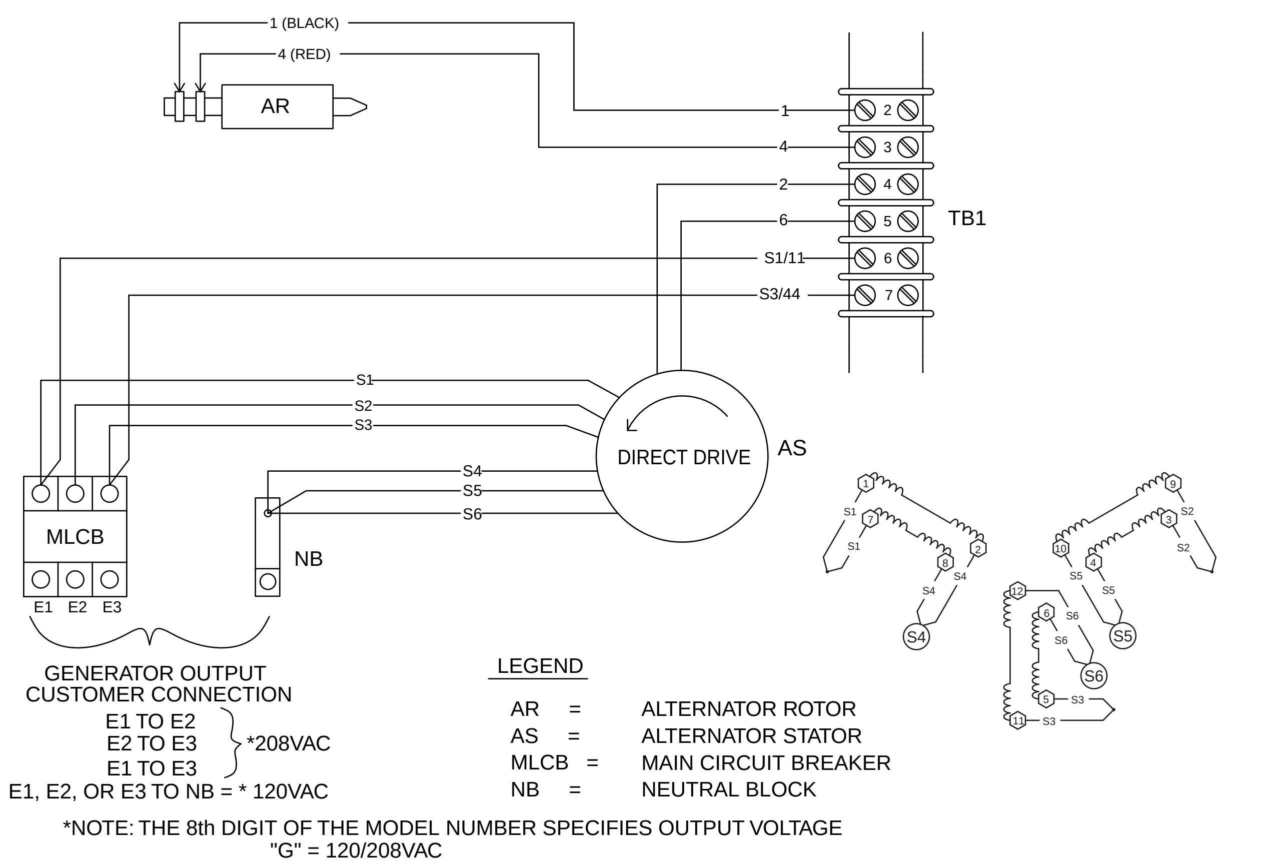


Figure 7. 3-Phase 208 VAC Stator and DPE Windings

a. Connect one meter test lead to Stator Lead S1 and connect the other meter test lead to S5. INFINITY should be measured.

b. Repeat Step 5a between the following points.

Stator Lead S1 and Stator Lead S5
Stator Lead S6 and Stator Lead S5
Terminal 4 of TB1 and Stator Lead S1
Terminal 4 of TB1 and Stator Lead S6
Terminal 4 of TB1 and Stator Lead S5

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

6. Disconnect Wires 11(S1) and 44(S3) from the main breaker (sensing wires to voltage regulator).
   a. Disconnect the voltage regulator connector.
   b. Set a VOM to measure resistance (Ω).
   c. Connect one meter test lead to Sensing Wire 11 that was disconnected in Step 6 and connect the other meter test lead to Terminal 6 of TB1. CONTINUITY should be measured. If INFINITY is measured repair or replace wire between main breaker and Terminal 4 of TB1.
   d. Connect one meter test lead to Sensing Wire 44 that was disconnected in Step 6 and connect the other meter test lead to Terminal 7 of TB1. CONTINUITY should be measured. If INFINITY is measured repair or replace wire between main breaker and Terminal 4 of TB1.

RESULTS:

1. If any step indicated CONTINUITY where INFINITY should be present, or INFINITY where CONTINUITY should be present, then either the wire or the component will need to be replaced.
2. If a short to ground was measured on a stator winding, the stator will need to be replaced.
3. If an open winding was measured on the stator, the stator will need to be replaced.
4. If a short between two windings was measured, ensure the circuit is completely isolated. If short continues the stator will need to be replaced.

TEST 13 – TEST ROTOR ASSEMBLY

DISCUSSION:

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

PROCEDURE:

1. Set a VOM to measure resistance (Ω).
2. Connect one meter test lead to Terminal 2 of TB1 (Wire 1) and connect the other meter test lead to Terminal 3 of TB1 (Wire 4). Measure and record the resistance. Refer to the Rotor/Stator Resistance Table on Page 10 for the proper resistance readings.
   - The meter should read within +/- 3 ohms of the specification in the chart on page 10.
   - If high or low resistance, or a reading of INFINITY was measured, proceed to Step 3 and check slip rings and brushes.
   - If the correct resistance reading is present within 3 ohms of the resistance on page 10 and a good running rotor amp draw was measured in Test 4, stop testing and proceed directly to the results. If a bad running rotor amp draw was measured in Test 4, continue testing.
3. Lift the brushes off of the slip rings and place a non-conductive insulator (such as a paper business card) between the slip rings and both sets of brushes. Connect one meter test lead to the positive (+) slip ring (nearest the rotor bearing) and the other meter test lead to the negative (-) slip ring. Measure and record the reading.
4. With the brushes still isolated from the slip rings, connect one meter test lead to the positive (+) slip ring and the other meter test lead to a clean frame ground. INFINITY should be measured.

Note: Do not reassemble the alternator compartment until a valid resistance reading is present at Terminal 2 of TB1 (Wire 1) and Terminal 3 of TB1 (Wire 4). If an acceptable resistance reading is not present, there are still issues that need to be resolved.

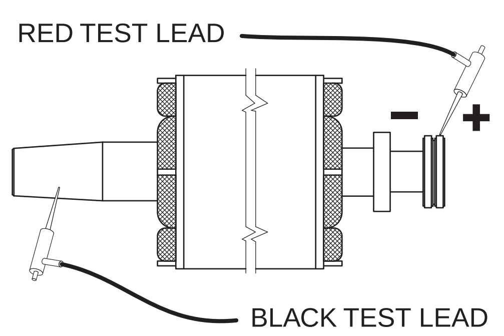


Figure 8. Testing Rotor Insulation

5. Check the brushes to ensure they are making good contact on the slip rings and that they have no visual damage. Ensure that the brushes are riding on the slip rings and are seated properly with the unit at "REST" and while the unit is "RUNNING". There should be no arcing on the slip rings while running as this would be

a clear indication that there is an alignment issue with the brushes and the rotor. Ensure that the positive and negative wires are connected to the corresponding slip rings and that the polarities are not mismatched, i.e. having a positive and negative wire connected to a brush that is contacting the same slip ring. If all tests are good, stop testing and go to results.

Note: Ensure the proper safety measures are followed while the unit is running with the alternator compartment exposed.

RESULTS:

1. If a resistance reading was present in Step 2 and a static rotor amp draw of zero was measured in Test 4, check VOM fuses and redo Test 4.
2. If the rotor assembly had either an open or a direct short to ground in Steps 3 and 4, replace the rotor.
3. If no resistance reading was present in Step 2, but the correct resistance reading was present on the slip rings in Step 3 and the brushes are in good shape, replace the brush assembly and wires. The wires leading up to the control panel are damaged and preventing excitation voltage from getting to the rotor.

Note: A replacement brush assembly will come with two sets of brushes and two sets of wires (Wires 1 and 4). It is possible to test Wires 1 and 4 to find out which wire is defective or open and replace just that individual wire.

4. If the slip rings appear dull or tarnished, they may be polished with fine sandpaper. DO NOT USE METALLIC GRIT TO POLISH SLIP RINGS.
5. If the results of all rotor tests are good, perform "Insulation Resistance Test" in Section 1.4.

Note: Be sure to read Section 1.4, "Testing, Cleaning and Drying", carefully. If rotor tests good, try performing an insulation resistance test. If it failed, try cleaning and drying the rotor and then retest. If the rotor fails the second insulation resistance test, it should be replaced.

TEST 14 – 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 terminals of the generator main circuit breaker (see Figure 1). 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. The no-load voltage should be as follows:

RATED LINE-TO-LINE VOLTAGE	NO-LOAD VOLTAGE
120/240 1-phase	240
120/208 3-phase	208
120/240 3-phase	240
277/480 3-phase	480

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

RESULTS:

1. If zero volts or residual voltage is indicated, refer back to Problem 1 flow chart, Section 2.3.
2. If the voltage reading is higher than residual, but is lower than the stated limits, refer back to Problem 2 flow chart, Section 2.3.
3. If a high voltage is indicated, refer back to Problem 3 flow chart, Section 2.3.

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, depending on the characteristics of the specific generator. If a unit is supplying residual voltage only, either excitation current is not reaching the rotor or the rotor windings are open and the excitation current cannot pass. On current units with liquid-cooled engine, "field boost" current flow is available to the rotor during engine cranking and running.

TEST 15 – TEST AC OUTPUT FREQUENCY

DISCUSSION:

The generator AC frequency is proportional to the operating speed of the rotor. A 4-pole rotor (having two north and two south magnetic poles) will supply a 60 Hertz AC frequency at 1800 rpm. A 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 circuit could be the problem.

PROCEDURE:

1. Connect an accurate AC frequency meter across Terminal 6 (Wire 11) of TB1 and Terminal 7 (Wire 44) of TB1.
2. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

3. Let the engine warm up and stabilize at no-load. When the engine has stabilized, the frequency reading should be 60Hz.

RESULTS:

1. If the AC frequency is high or low, go to Problem 15.
2. If frequency is good, but voltage is high or low, go to Section 4.1 for voltage regulator adjustments.
3. If frequency and voltage are both good, tests may be discontinued.

TEST 16 – ADJUST VOLTAGE REGULATOR

Refer to Section 4.1 for Adjustment of the Automatic Voltage Regulator

TEST 17 – TEST 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. Set AUTO-OFF-MANUAL switch to the MANUAL position. Let the generator 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 59 Hertz. Voltage should not drop below 20 percent of the rated voltage.

RESULTS:

1. If frequency and voltage drop excessively under load, refer back to Problem 4 flow chart, Section 2.3.
2. If frequency and voltage under load are good, discontinue tests.

TEST 18 – TEST FOR AN 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 1.4.

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 unit is not overloaded, but rpm and frequency drop excessively when loads are applied, refer back to Problem 4 flow chart, Section 2.3.

TEST 19 – TEST ENGINE CONDITION

DISCUSSION:

If engine speed and frequency drop excessively under load, the engine may be under-powered. An under-powered engine can be the result of a dirty air cleaner, loss of engine compression, faulty carburetor settings, incorrect ignition timing, lack of fuel, etc.

PROCEDURE:

For engine testing, troubleshooting and repair procedures refer to the 2.4 Mitsubishi Engine Service Manual

PART 3
DC CONTROL LIQUID-COOLED ENGINE UNITS

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2.4 LITER STANDBY GENERATORS

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Information in this section is provided to familiarize the reader with the various components that make up the DC control system on units having a liquid-cooled engine. These components may be divided into three (3) broad categories as follows:

- Components in the generator control console.
- Engine mounted components.
- Engine protective devices.

CONTROL CONSOLE COMPONENTS

LOCATION AND DESCRIPTION:

The control console includes (a) a terminal board, (b) a control board, (c) a driver board, (d) a 15 amp fuse, (e) an automatic voltage regulator, (f) an engine run relay, and (g) an engine start relay.

TERMINAL BOARD:

This 12-position terminal board (Figure 1) provides a convenient connection point for DC control system wiring. Terminals, associated wires and their functions are listed in the following chart.

TERM.	WIRE	FUNCTION
1	0	Common ground
2	1	Ground for (-) brush. (-) side of DC to rotor
3	4	(+) side of DC to rotor from AVR
4	2	Excitation voltage to AVR through DPE breaker
5	6	Excitation voltage to AVR
6	11, S1	AC Sensing voltage to AVR (referenced to Wire 44 or S3)
7	44, S3	AC Sensing voltage to AVR (referenced to Wire 11 or S1)
8	13	Unfused (+) battery
9	14	(+) battery when engine is cranking or running
10	15A	Fused (+) battery, only available when SW1 set to MANUAL or AUTO
11	15	Fused (+) battery
12	15	Fused (+) battery

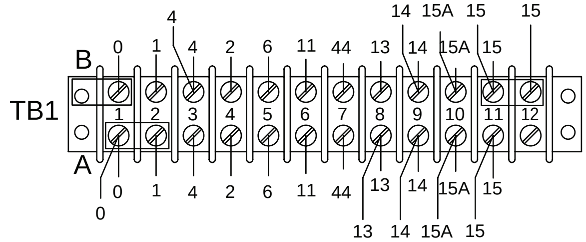


Figure 1. Terminal Board TB1

CONTROL BOARD:

This solid state circuit board controls all standby electric system operations, including engine cranking, startup, running, automatic transfer and shutdown. Other operations controlled by the circuit board include the following:

The circuit board provides automatic engine shutdown in the event of (a) low engine oil pressure, (b) high engine coolant temperature, (c) low coolant level, (d) overspeed, (e) overcrank and rpm sensor loss. See Section 3.1, "Engine Protective Devices/Shutdowns". On occurrence of any one or more of these engine faults, the circuit board will turn on a fault indicator LED (see Figure 3).

System Ready	Green LED
Low Fuel Pressure	Yellow LED
Low Battery	Red LED
Low Oil Pressure	Red LED
Hi Coolant Temp/Low Coolant Level	Red LED
Overspeed/RPM Sensor Loss	Red LED
Over Crank	Red LED

The various functions handled by the control board are listed in the following charts, along with appropriate circuit board connector pin numbers and wire numbers.

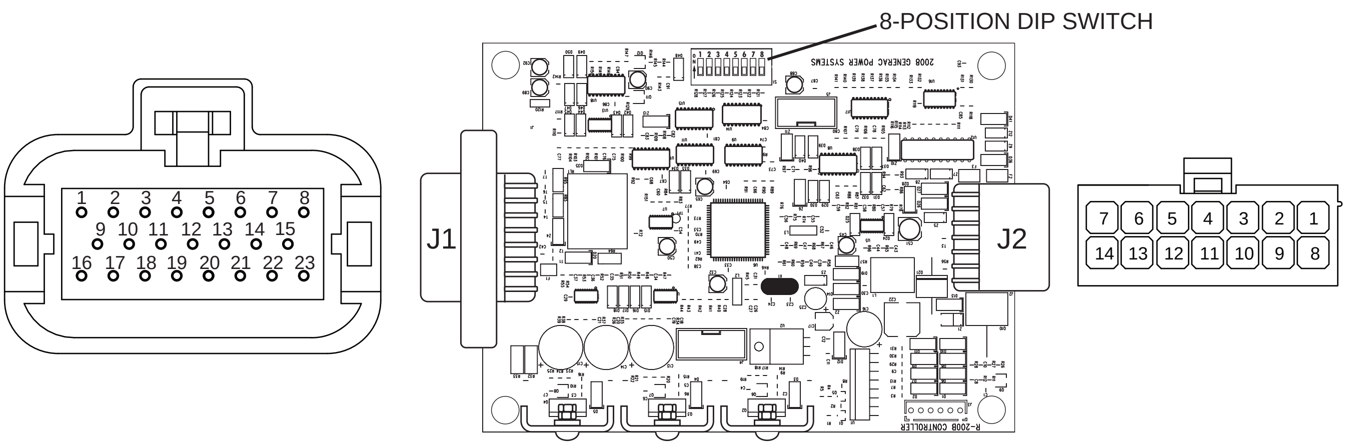


Figure 2. R-200B Control Board

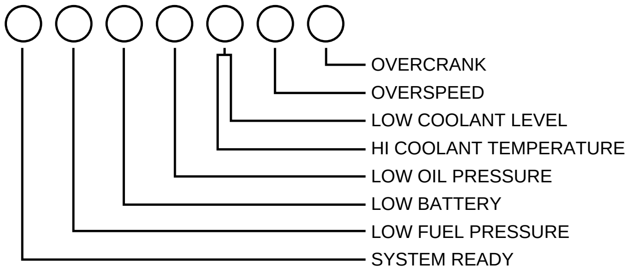


Figure 3 – LED Indicators on Front Panel

R-200B Printed Circuit Board J1 Pin Out Chart

Pin #	Wire #	Function
1	14	During cranking and running the PCB will deliver 12 VDC to the governor driver board that will turn on the governor driver board
2	805	A variable signal from the oxygen sensor will be present on this wire, depending on the fuel/air ratio of the mixture. The PCB will use this signal to control the Air/Fuel Solenoid (Emissions Only)
3	0	Common ground for governor driver board
4	85	Coolant temp shutdown wire, the PCB will look for a ground on this wire when the fault has occurred
5	767	Common ground for governor output signal
6	765	PCB governor output, the board will send a varying 5 VDC signal to the Bosch governor for a reference voltage on the position of the throttle plate
7		Empty
8	573	Coolant level shutdown, the PCB is looking for a 1 VDC signal on wire to indicate that coolant is at correct level, when coolant drops below the sensor the voltage will change from 1 VDC to 5 VDC
9	79	PCB speed sensing signal, the PCB will look for a specific voltage on this wire to ensure the engine is spinning at rated speed
10	0	Common ground for Magnetic Pickup Sensor
11	601	Low fuel pressure, if fuel pressure drops below 5 inches of water column a yellow LED will illuminate on the PCB. It will not shutdown the engine
12	766	Bosch governor will provide a feed back signal that is in relation to the position of the throttle plate
13	804	PCB will apply a voltage to this wire that will be adjusted according to the air/fuel mixture by the oxygen sensor
14		Empty
15		Empty
16		Empty
17	806	The ignition module will send a signal to the board indicating a fault that needs to be addressed
18	769	PCB will send a pulse width modulate signal to the governor driver board that will adjust the position of the throttle plate
19		Empty
20	86	Low oil pressure, the PCB will look for a ground on this wire when a low oil pressure condition occurs
21	SHLD	Shield to protect the signal from the rpm sensor (MP1) from electromagnetic interference
22		Empty
23		Empty

R-200B Printed Circuit Board J2 Pin Out Chart

Pin #	**Wire #**	**Function**
1	808	PCB will apply varying voltage to Wire 808 that will adjust the air/fuel mixture to the engine
2	56A	PCB will apply a ground to Wire 56A that will energize RL1 relay that will engage the crank circuit
3	14A	PCB will apply a ground to Wire 14A that will energize RL2 relay that will engage the run circuit
4	183	When PCB is in GTS mode it will look for an input from a external relay
5	15E	PCB will look for 15E to momentarily open to set the exercise clock at that specific time
6	178	When PCB is in GTS mode it will look for an input from a external relay
7	15A	When AUTO-OFF-MANUAL switch is in AUTO or MANUAL battery voltage will be delivered to the PCB that will power it up.
8	224	When utility voltage is available TR1 will supply 16 VAC line-to-line for utility sensing
9		Empty
10	23	PCB will ground 23 and energize the transfer relay in the transfer switch
11	239	When AUTO-OFF-MANUAL switch is in MANUAL battery voltage will be delivered to the PCB to indicate a manual start.
12	225	When utility voltage is available TR1 will supply 16 VAC line-to-line for utility sensing
13	0	A ground will be applied to this terminal when the generator is built with emission control.
14	0	Common ground to the PCB.

CONTROL BOARD DIP SWITCH SETTINGS:

The Switch "ON" position location is marked on the DIP switch housing (see Figure 4). To activate the DIP switch settings place the AUTO-OFF-MANUAL switch in the OFF Mode, make the DIP switch changes and then push and hold the Set Exercise Switch for five seconds.

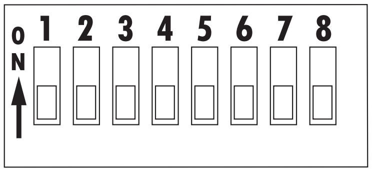


Figure 4. The 8-position Dip Switch

	Switch OFF	Switch ON
Position 1	60 Hz	50 Hz (where applicable)
Position 2	ATS Mode	GTS Mode
Position 3	Low Speed Exercise	Normal Speed Exercise
Position 4	LP	NG
Position 5	Reserved	Reserved
Position 6	22/27kW (1800 rpm) 45kW (3600 rpm)	36kW Turbo (1800 rpm) 60kW Turbo (3600 rpm)
Position 7	2.4L (1800 rpm)	4.2L (1800 rpm)
Position 8	Reserved	Reserved

Note: Dipswitch S2 (if equipped) has no function)

DIP Switch Position 1: Selects the generator output frequency. When OFF, standard 60 Hz operation is selected. When ON, 50 Hz is selected if the generator is capable.

DIP Switch Position 2: Selects the type of transfer switch to be used with the generator. When an "HS" or RTS-type transfer switch is used (ATS Mode) this DIP Switch should be in the OFF Position. When a W-type transfer switch is used (GTS Mode) the generator 2-wire start inputs can be used to control the generator operation. The 2-wire start inputs are labeled as 178 and 183 on the wiring terminals inside the generator's customer connection panel.

DIP Switch Position 3: Selects the engine operating speed in exercise mode.

DIP Switch Position 4: Selects the generator fuel type to meet emissions requirements. When OFF, the generator should be using LP vapor fuel. When ON, natural gas fuel should be used.

DIP Switch Position 5: Reserved for future use. The position of this DIP switch does not affect generator operation.

DIP Switch Position 6: Selects the alternator kW rating. When ON, 36kW turbocharged is selected for 1800 rpm and 60kW turbocharged is selected for 3600 rpm. When OFF, 22kW or 27kW is selected for 1800 rpm and 45kW is selected for 3600 rpm.

DIP Switch Position 7: This switch operates for 1800 rpm only. When ON, 4.2L displacement is selected. When OFF, 2.4L displacement is selected. For 3600 rpm, this switch has no effect, it is unused.

DIP Switch Position 8: Reserved for future use. The position of this DIP switch does not affect generator operation.

BOSCH DRIVER BOARD (DEG)

A solid state circuit board that provides current output to drive the Bosch actuator.

Pin #	Wire #	Function
1	0	Common ground between PCB and driver board
2		Empty
3		Empty
4	14	12 VDC is delivered to the driver board to turn it on from the PCB
5		Empty
6		Empty
7		Empty
8	770	DC output current to the Bosch governor
9	771	DC output current to the Bosch governor
10	0	Common frame ground
11		Empty
12	769	Pulse width module signal from PCB that adjusts the position of the throttle plate

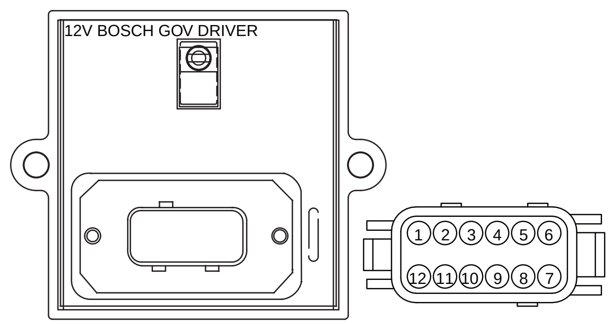


Figure 5. Bosch Driver Board Pin Outs

IGNITION MODULE (IM)

The 2.4L Mitsubishi engine uses a distributor-less ignition system. It utilizes an ignition module to control the spark for each cylinder. Fused battery voltage is delivered to the ignition module via Wire 15 present at all times. When the unit is cranking, Wire 56 delivers battery voltage to the ignition module. This input latches the internal spark circuit to allow spark to continue after Wire 56 voltage is removed. It will utilize both inputs from the crank sensor and the cam sensor to determine the specific point to ignite a particular cylinder. Once the crank circuit is engaged voltage from the crank circuit is removed, but spark still continues until the unit is shutdown or a failure occurs.

Tech Tip: The LED light can be seen from inside the customer connection box, where there are pre-drilled holes for viewing this Red LED.

Pin #	Wire #	Description
1		Empty
2		Empty
3	454	Ignition Module will Ground to Fire Cylinder 4
4	451	Ignition Module will Ground to Fire Cylinder 1
5	452	Ignition Module will Ground to Fire Cylinder 2
6		Empty
7		Empty
8		Empty
9	453	Ignition Module will Ground to Fire Cylinder 3
10	SHLDA	Shield for Cam Sensor
11	56	This 12VDC input coming from Wire 56 latches the ignition circuit internal of the Ignition Module
12	14	12VDC input configures Ignition Module for Natural Gas
13		Empty
14	79	Crank Sensor Input
15		Empty
16	15	12VDC input to Ignition Module that will power it up
17	0	Common Ground for Ignition Module
18	15D	12VDC provided to each coil for firing
19	806	Ignition Module Fault Indicator; the Ignition Module will send a signal to the PCB on this wire to indicate that the ignition module is currently in a fault.
20	SHLD	Shield for Crank Sensor
21	0A	Ground for Crank Sensor
22	0A	Ground for Cam Sensor
23	79A	Cam Position Sensor Input

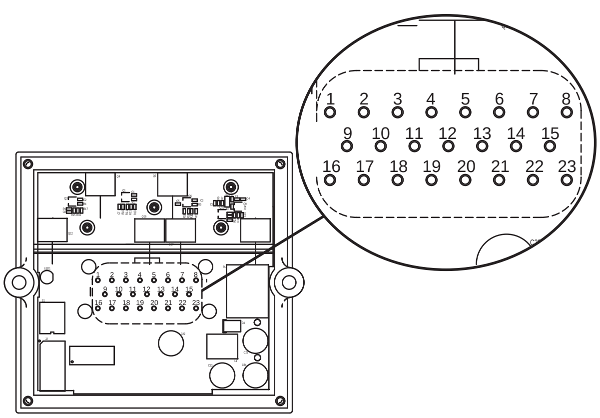


Figure 6. Ignition Module Pin Outs

FLASHING OVERCRANK (RED)(R-200B ONLY):

If the Ignition Module is in a current fault the unit will shutdown in a flashing overcrank. The flashing overcrank will not specify what is wrong, only that there is fault that needs to be corrected.

DIAGNOSTIC LIGHT (RED LED LOCATED ON THE IGNITION CONTROL BOARD):

During normal operation the Red LED, located on the ignition control board, flashes at a 0.5 second ON and a 0.5 second OFF rate. This is considered one (1) blink.

The generator must have been in the OFF mode for 60 seconds prior to cranking for the Flywheel and Cam LED fault diagnostics to be valid.

If multiple fault codes exist then the highest priority fault must be resolved prior to a lower priority fault code being displayed.

The LED fault code blink pattern is displayed for between 60 to 120 seconds after a fault and then the ignition will power itself down.

The Crank and CAM LED fault codes are valid only during the first crank cycle. Crank and CAM LED fault codes displayed during a re-crank are no longer valid.

RED LED Fault Codes with priority as shown:

1. Overspeed Shutdown: LED blinks 4 times, is OFF for 3 seconds and then repeats
2. Missing Flywheel Teeth: LED blinks 5 times, is OFF for 3 seconds and then repeats

Tech Tip: The fault code is only valid during the crank cycle.

3. No Flywheel Signal: LED blinks 2 times, is OFF for 3 seconds and then repeats
4. No Cam Signal: LED blinks 3 times, is OFF for 3 seconds and then repeats

Only one LED fault code is displayed at a time.

ENGINE RUN RELAY (RL2)

An automotive dry contact relay that energizes and closes Wire 15 (fused positive battery voltage) to Wire 14 when the engine is running. Provides (+) battery voltage to the fuel solenoid and field boost through BR1 to the rotor. The relay is energized by a negative potential being applied to the coil on Wire 14A from the printed circuit board.

START RELAY (RL1)

An automotive dry contact relay that energizes and close Wire 15 (fused (+) battery voltage) to Wire 56 when the engine is cranking. Provides (+) battery voltage to operate the starter contactor and the priming fuel solenoid. The relay is energized by a (-) potential being applied to the coil on Wire 56A from the printed circuit board.

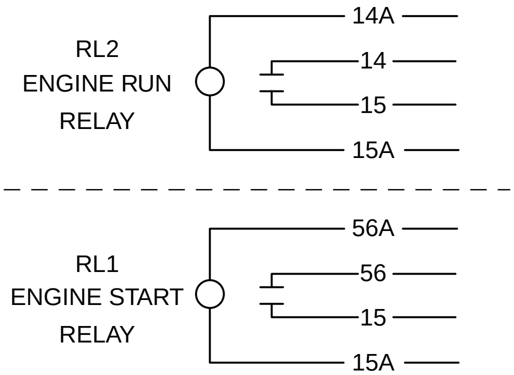


Figure 6. Engine Run and Start Relays

BRIDGE RECTIFIER (BR1)

Used as blocking diodes to prevent back feeding of alternator and rotor voltages into Wire 14 (Run Circuit). While the engine is running (+) DC voltage is allowed to flow into the rotor and battery charge alternator to "flash the field" as necessary.

EXCITATION CIRCUIT BREAKER (CB2)

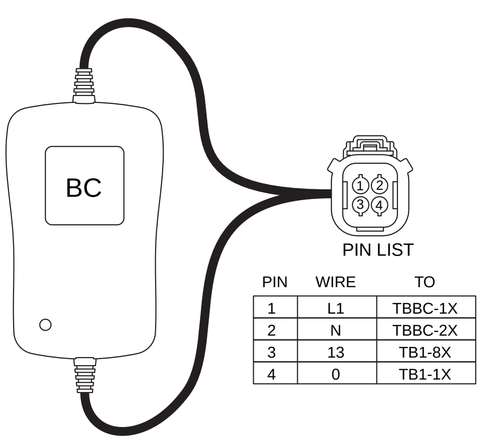
This is sometimes called DPE breaker. The breaker will open when DPE current exceeds rated current. After cooling the breaker will self rest.

SET EXERCISE SWITCH (SW2)

When depressed this switch breaks power to the printed circuit board. When the switch is released the control board wakes up. If the printed circuit board sees good utility voltage and SW1 is in AUTO, the exercise time is set.

BATTERY CHARGER (BCH)

Provides battery charge voltage during non-operational periods for the battery. Power is supplied through 120 VAC utility supply from the distribution panel. The battery charger will supply 13.4 VDC float voltage to the battery.



PIN	WIRE	TO
1	L1	TBBC-1X
2	N	TBBC-2X
3	13	TB1-8X
4	0	TB1-1X

Figure 7. Battery Charger

REMOTE ALARM CONNECTION

The R-200B panel has an optional remote alarm. Pin 9 is an open collector output that may be wired to a 12 VDC relay. The relay is required to have a minimum coil resistance of 90 Ohms. It is recommended that the same relay configuration that is used on the engine run and start relays be used. This would be one side of the coil to fused battery and the other to the Pin 9 open collector output. During alarm conditions the alarm output Pin 9 will be pulled to ground, and the relay will operate.

AUTO-OFF-MANUAL SWITCH (SW1):

The AUTO-OFF-MANUAL is shown in Figure 8. Also see Section 1.5, "Operating Instructions".

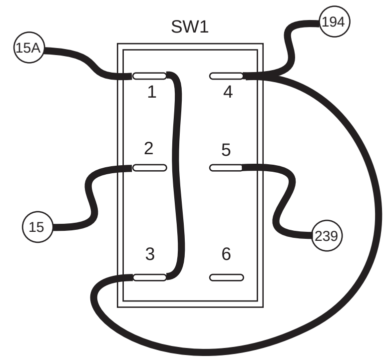


Figure 8. AUTO-OFF-MANUAL Switch

FUSE (F1):

Fuse F1 is connected in series with Wires 13 and 15 and is rated 15 DC amperes. If fuse replacement becomes necessary, use only an identical 15 amp replacement fuse.

ENGINE MOUNTED COMPONENTS

Engine mounted DC control system components include the following:

- A 12 volt battery and battery charge components.
- A starter motor (SM).
- A control contactor (CC).
- Low Oil Pressure Switch (LOS) and High Water Temperature switch (HWT).
- Engine ignition system parts.

BATTERY AND BATTERY CHARGE SYSTEM:

A belt driven alternator delivers a charging voltage to the battery during engine operation. The charging voltage is regulated and rectified by the DC regulator. Alternator maintenance is limited to replacement of defective parts.

STARTER MOTOR AND CONTROL CONTACTOR:

During manual or automatic startup, control board action actuates Engine Start Relay (RL1) which delivers 12 VDC to a control contactor (CC) coil. The coil energizes, its contacts close, and battery power is delivered to the starter motor (SM). The starter motor then energizes and the engine is cranked.

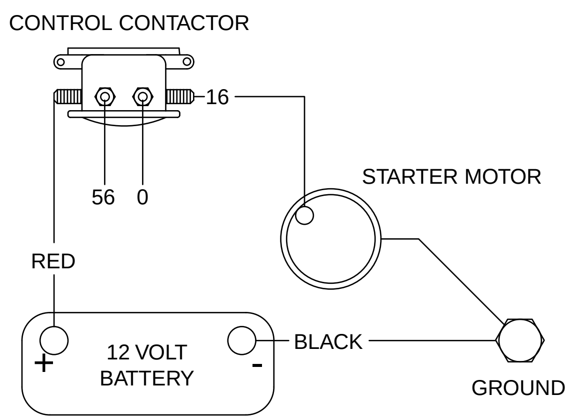


Figure 9. Engine Cranking Circuit

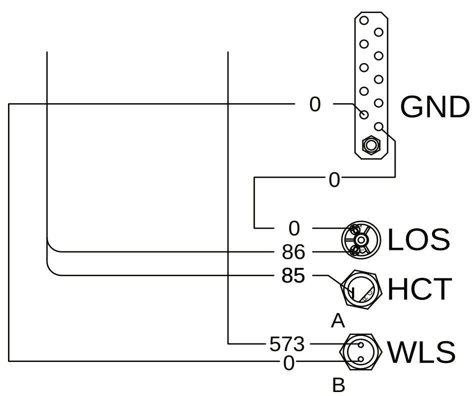


Figure 10. Oil Pressure & Coolant Temperature Circuit

FUEL SOLENOID:

The fuel solenoid (FS) provides a positive shutoff of fuel when the engine is not running. The solenoid is energized open by 12 volts DC (Wire 14); it is de-energized closed.

FUEL PRIMER SOLENOID:

The fuel solenoid (FS2) provides fuel to the mixer during cranking only. The solenoid is energized open by 12 volts DC (Wire 56); it is de-energized closed. This is to allow fuel into the engine before the diaphragm in the fuel regulator has a chance to open and will increase our chance of the generator starting on the first crank attempt.

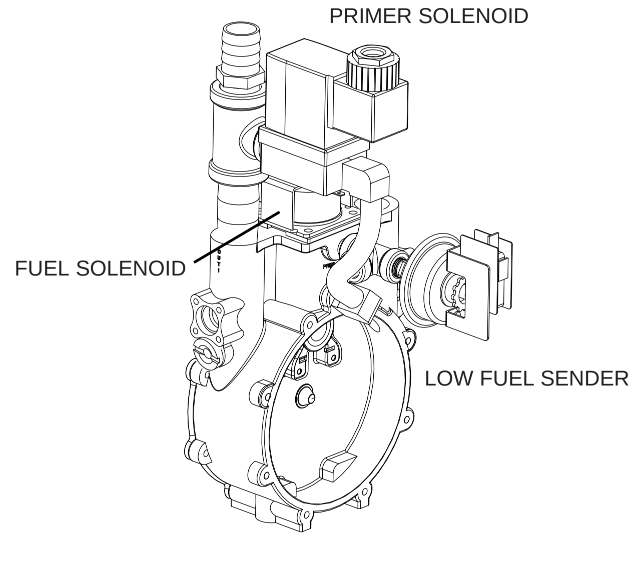


Figure 11. Fuel Solenoid (FS)

CAM SENSOR (MP2)

The cam sensor is installed below the timing belt cover. As the engine is running a magnet installed on the timing gear passes by the tip of the magnetic pickup. This pulse that is generated is read by the ignition module as top dead center. See Section 4.1 for adjustment procedure.

CRANK SENSOR (MP1):

The crank sensor is installed on the flywheel housing. As the engine is running the crank sensor receives a signal every time a flywheel tooth passes the tip of the pickup. The board is programmed to know that 160 teeth are present on the generator flywheel and that every 160 teeth it has made a complete revolution. It will utilize this signal for a speed signal to regulate the engine at the desired speed. See Section 4.1 for adjustment procedure.

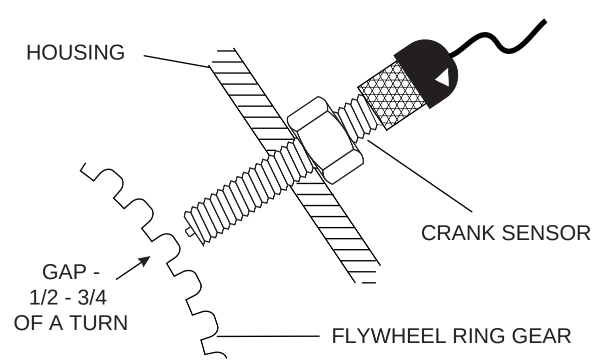


Figure 12. Crank Sensor (MP1)

OXYGEN SENSOR (OS):

On emissions enabled units this sensor sends a feed back signal to the control board that will interpret the air/fuel ratio of the exhaust content.

AIR/FUEL SOLENOID (AFS):

On emissions enabled units a variable 12 VDC signal is applied to the solenoid that will either enrich the mixture or lean the mixture out depending on the input from the oxygen sensor.

ENGINE PROTECTIVE DEVICES/SHUTDOWNS

Standby electric power generators will often run unattended for long periods of time. Such operating parameters as (a) engine oil pressure, (b) engine temperature, (c) engine operating speed, and (d) engine cranking and startup are not monitored by an operator during automatic operation. Because engine operation will not be monitored, the use of engine protective safety devices is required to prevent engine damage in the event of a problem.

Generator engines mount several engine protective devices. These devices work in conjunction with a control circuit board, to protect the engine against such operating faults as (a) low engine oil pressure, (b) high temperature, (c) overspeed, and (d) overcrank. On occurrence of any one or more of those operating faults, control board action will effect an engine shutdown.

LOW OIL PRESSURE SHUTDOWN:

(Red LED Indicator)

See Figure 14. The low oil pressure (LOP) switch has normally closed contacts which are held open by engine oil pressure during cranking and running conditions. Should engine oil pressure drop below approximately 8-12 psi, the switch contacts will close. Control board action will then initiate a 10-second hold-off timer. At the end of 10 seconds, an automatic engine shutdown will occur and the low oil pressure LED will turn on.

LOW FUEL PRESSURE

(Yellow LED Indicator)

The yellow low fuel pressure LED will turn ON if the fuel supply pressure drops below approximately 5 inches water column (i.e. occurs when the low fuel pressure sensing switch on the fuel regulator opens). This is a non-latched fault (visual LED warning only) and does not trigger the controller alarm output. Low fuel pressure sensing is active in all generator operating modes (i.e. MANUAL, OFF and AUTO).

SYSTEM READY LIGHT:

(Green LED Indicator)

This LED is a positive status indicator and dependent upon the following conditions being true:

1. Switch in the AUTO position.
2. No other warning indicator present.
3. Controller is functional.

The System Ready LED will also indicate if utility voltage is present at the control board. The system ready LED will flash every second (at a 0.5 second ON and a 0.5 second OFF rate) when utility voltage is not present at the control board and when the switch is in either the AUTO or MANUAL position. This function is ONLY available with DIP Switch Position 2 in the OFF position (ATS application). The system ready LED will also indicate if the generator is in the GTS Mode (i.e. DIP Switch Position 2 in the ON Position). The system ready LED will flash at a five (5) seconds ON and one (1) second OFF rate in GTS Mode.

Tech Tip: This light will help diagnose 50 percent of Auto Operations problems. Ask the question "Does the generator think that there is a power outage?"

LOW BATTERY:

(Red LED Indicator)

Battery voltage is continuously monitored and a warning LED is lit if the battery voltage drops below approximately 12.2 volts for longer than one (1) minute. The LED will turn off when the battery voltage goes back above approximately 12.5 volts. If however, the battery voltage drops below 6 volts during cranking, or 8 volts while running the low battery LED will stay lit. This is a latched fault and will shut down the engine.

HIGH COOLANT TEMP:

(Solid Red LED Indicator)

The high coolant temperature switch (HWT) has normally-open contacts. These contacts are thermally actuated. If the engine coolant temperature should exceed approximately 245° F. (118° C.), the control board will shut the engine down and the high coolant temperature indicator LED will then illuminate and be solid. Checks are made after the 10 second hold off timer expires.

LOW COOLANT LEVEL:

(Flashing Red High Coolant Temp LED Indicator)

It is possible that engine coolant level might drop low enough so that the high temperature switch is no longer immersed in the liquid coolant. If this happens engine temperatures could increase rapidly but the temperature switch would not sense the high temperature condition and the engine would continue to run. To prevent this occurrence, a low coolant level sensor is provided.

A Low Coolant Alarm occurs if the coolant level is low. Checks are made after the 10 second hold off timer expires. This is a latched fault and will shutdown the engine.

A 5 VDC signal is applied to the positive terminal of the probe. See Figure 14. Point A is the tip of the of the probe and Point B is frame ground. Coolant surrounding the probe allows for continuity between Points A and B.

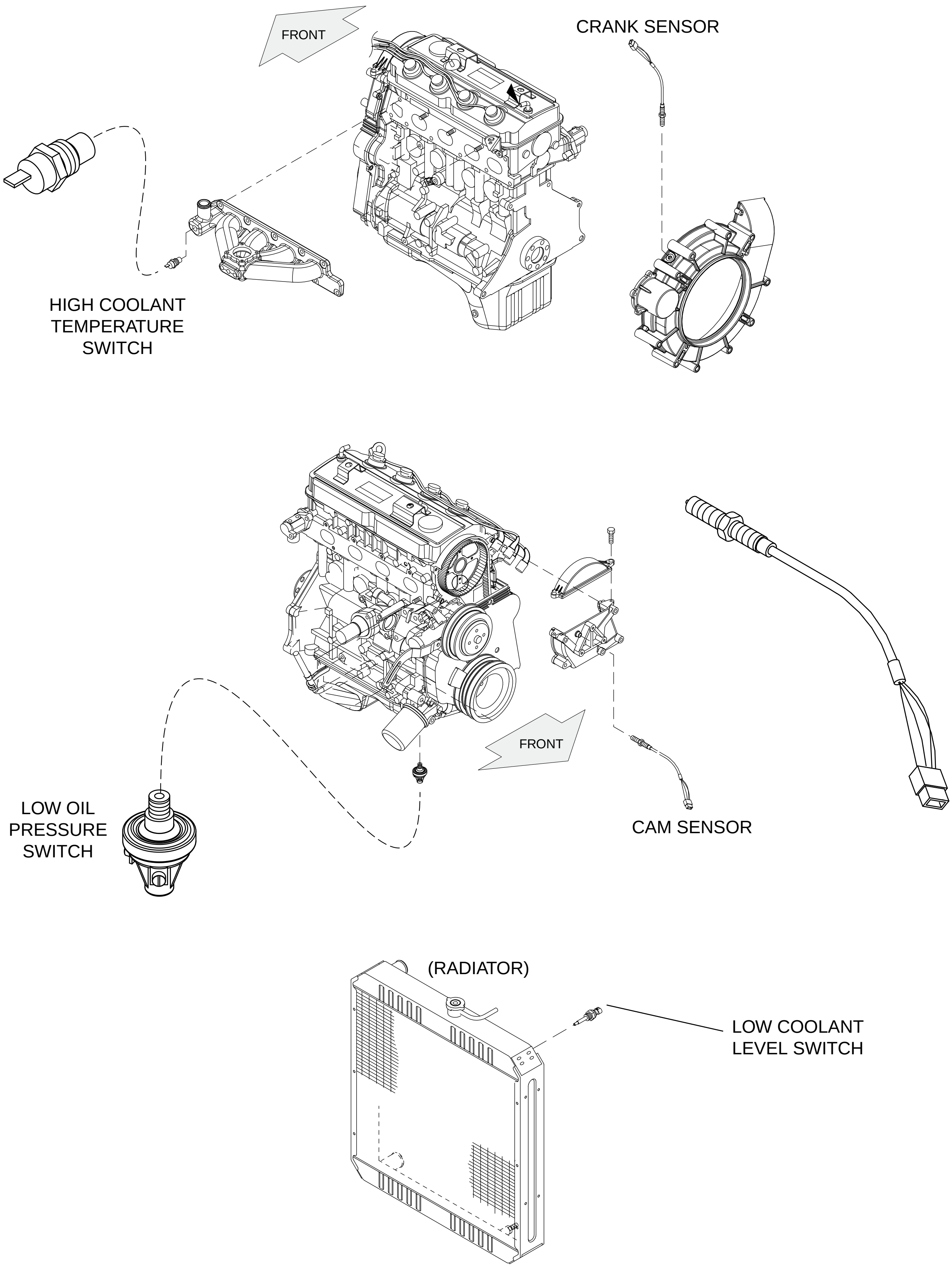


Figure 13. Protective Devices on Liquid-Cooled Engine

A 5 kΩ resister is added to the circuit in parallel with the two terminals causing the 5 VDC to be lowered to 1 VDC or ground. When coolant level drops the signal goes from a 1 VDC signal to a 5 VDC signal and the board will signal an alarm for low coolant and shutdown the unit.

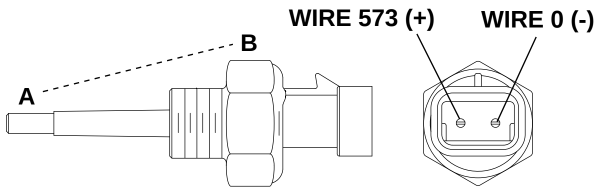


Figure 14. Low Coolant Level Sensor

OVERSPEED:

(Solid Red LED Indicator)

An overspeed shutdown will occur if the engine speed is greater than 4300 rpm for a 3600 rpm engine; 2160 rpm for an 1800 rpm engine; 2250 rpm for an 1800 rpm engine, for three (3) seconds. An overspeed condition will shutdown the engine and activate the over speed LED. An immediate overspeed shutdown will occur if the engine speed is greater than 4500 rpm for a 3600 rpm engine.

RPM SIGNAL FAILURE:

(Flashing Red LED Overspeed Indicator)

If the R-200B controller does not receive a signal from the engine crank sensor, the R-200B controller cannot maintain the generator output frequency or monitor for an overspeed condition. If this signal is lost the R-200B controller will shut down the engine. The engine crank sensor voltages are as follows:

1800 RPM units	3VAC ±0.3
3600 RPM units	5VAC ± 0.3

RPM SIGNAL FAILURE DURING CRANKING:

The engine control board (R-200B controller) will monitor the engine speed signal during engine cranking. If the control board does not see a valid signal within the first four seconds of each crank cycle it will stop the crank cycle, lock out on a shut down fault and flash the overspeed LED.

RPM SIGNAL FAILURE DURING RUNNING:

Running mode is handled differently because there is always the possibility the engine could slow down or stop running do to a temporary overload. To avoid shutting down and latching out on a temporary problem the following is done. If the engine is up and running, and the control board stops receiving a valid engine speed input signal it will respond as follows:

1. It will close the throttle.
2. It will shut down the engine by turning off the fuel supply.
3. It will wait for 15 seconds to ensure the engine has stopped.
4. It will then energize the starter and monitor the engine speed signal.
   a. If the control board does not see the engine speed signal it will stop the crank cycle, lock out on fault, and flash the overspeed LED.
   b. If the control board does see the engine speed input signal during cranking it will start and run the engine normally. If the engine speed signal is again lost while running it will repeat the above procedure one more time.
   c. If the failure should repeat a third time, the control board will shut down the engine, lock out on fault, and flash the over speed LED.

OVERCRANK:

(Red LED Indicator)

Occurs if the engine has not started within the total 90 second crank cycle. This is a latched fault and will shutdown the engine.

IGNITION MODULE FAULT:

(Flashing Red Overcrank Indicator)

If the Ignition Module detects a fault, this indicator will flash and the engine will be shut down. This LED does not indicate the type of fault, only that a fault exists. See “Ignition Module” in this section for further description.

ALARM RESET:

Prior to resetting a shutdown alarm, record the date and type of fault that has caused the generator to shut down.

Ensure that the fault has been resolved. Place the AUTO-OFF-MANUAL switch in the “OFF” position to turn off the corresponding fault LED.

Condition	System Ready	Low Fuel	Low Bat	Low Oil	High Temp	Over Speed	Over Crank	Switch Position Manual	Auto	Off
Generator Switch is in the OFF Mode	OFF	@	X	OFF	OFF	OFF	OFF			O
System Ready for Automatic Start	ON	@	X	OFF	OFF	OFF	OFF		O	
Generator Switch is in the MANUAL Mode	OFF	@	X	OFF	OFF	OFF	OFF	O		
Weekly Exerciser is not Set (Note A)	X	@	Flashing	Flashing	Flashing	Flashing	Flashing	O	O	O
			(--------------------------------------1 sec rate ------------------------------------)							
Battery Voltage <12.2VDC for > 1 minute	X	@	ON (Non-Latching)					O	O	O
Battery Voltage <8VDC while running <6VDC while cranking	OFF	@	ON					O	O	
Unit Shutdown due To Low Oil Pressure	OFF	@	X	ON				O	O	
Unit Shutdown due To High Coolant Temp	OFF	@	X		ON			O	O	
Unit Shutdown due To Engine Overspeed	OFF	@	X			ON		O	O	
Unit Failed to Start During it's Crank Cycle	OFF	@	X				ON	O	O	
Utility Voltage is < 60% of Nominal	Flashing 1 sec rate	@	X					O	O	
Unit Shutdown due To Low Coolant Level	OFF	@	X		Flashing			O	O	
Engine Speed Signal Fault/RPM Signal Loss	OFF	@	X			Flashing		O	O	
Unit Shutdown due to Ignition Module Fault	OFF	@	X				Flashing	O	O	
Control Board is In GTS Mode	Flashing 5 sec ON, 1 sec OFF	@	X					O	O	O
DIP Switch #6 & #7 not set correctly	OFF	@	ON	ON	ON	ON	ON	O	O	O

@ = Low Fuel Pressure is a Yellow LED and will be ON when fuel pressure is less than 5 inches Water Column
X = indicates that the LED can be ON or OFF depending on the Operating Mode (i.e. Manual, OFF or Auto)
Note A: a RED LED fault indication has priority over the flashing LED's used to indicate exercise time not set

NOTES

INTRODUCTION

The schematic diagram on this and the following pages show the DC control system in three (3) modes of operation:

- Utility Available, SW1 in AUTO
- Utility Failure, Engine Cranking, SW1 in AUTO
- Utility failure, Engine Running, SW1 in AUTO

UTILITY SOURCE VOLTAGE AVAILABLE.

Positive (+) battery voltage is supplied from the battery via Wire 13 to the starter contactor (SC), fuse (F2), alternator (ALT) and battery charger (BCH). The alternator and starter contactor are not active at this point. Positive (+) battery voltage from the battery charger provides battery sensing and a battery charge when necessary to keep the battery level up during non-operational periods. At the fuse (F1) it is then switched to Wire 15.

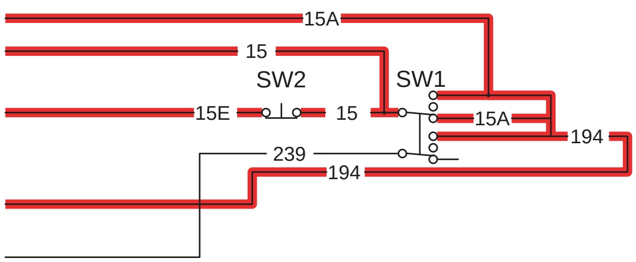


Figure 1.

Wire 15 supplies fused (+) battery voltage to the AUTO-OFF-MANUAL switch (SW1) and momentary switch (SW2). It then feeds down to the terminal block (TB1), Terminal 11, then on to the start relay (RL1), and engine run relay (RL2). At SW1 the (+) battery is switched on to Wires 15A and 194. SW2 is a normally closed switch that shunts the fused (+) battery to Wire 15E. The fused (+) battery voltage is applied to the start relay and engine run relay coils that are currently not active.

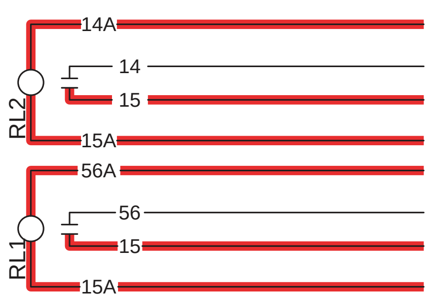


Figure 2.

Wire 15A supplies fused battery voltage to the engine run relay and start relay coils—the relay coils are both de-energized at this point. Wire 15A also places fused (+) battery voltage to PCB J2 Pin 7 (MAN/AUTO input). This tells the control board that the unit is in AUTO or MANUAL.

Wire 15E from the momentary switch supplies fused (+) battery voltage to PCB J2 Pin 5. This is the power supply to control board (PCB) and allows it to function. The control board also senses battery level on Wire 15E.

For configured transfer switches (GTS) the control board looks for a 2-Wire start and ignores inputs of Wires 225 and 224 utility sensing. The control board supplies a 5 volt signal input from J2 Pin 4 to Wire 183 and waits for a return signal on Wire 178, J2 Pin 6.

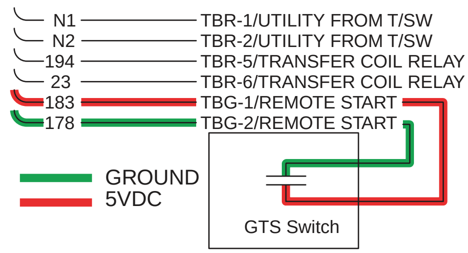


Figure 3.

For RTS transfer switches the control board (PCB) monitors Wires 225 and 224 input at J2 Pin 8 and J2 Pin 12. This is approximately 16 VAC line-to-line stepped down from the N1 and N2 utility supplied to the sensing transformer (TR1). 2-Wire start is ignored in this mode.

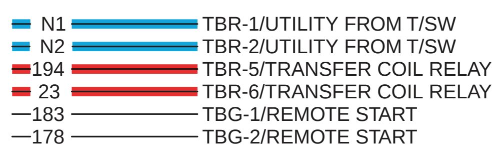
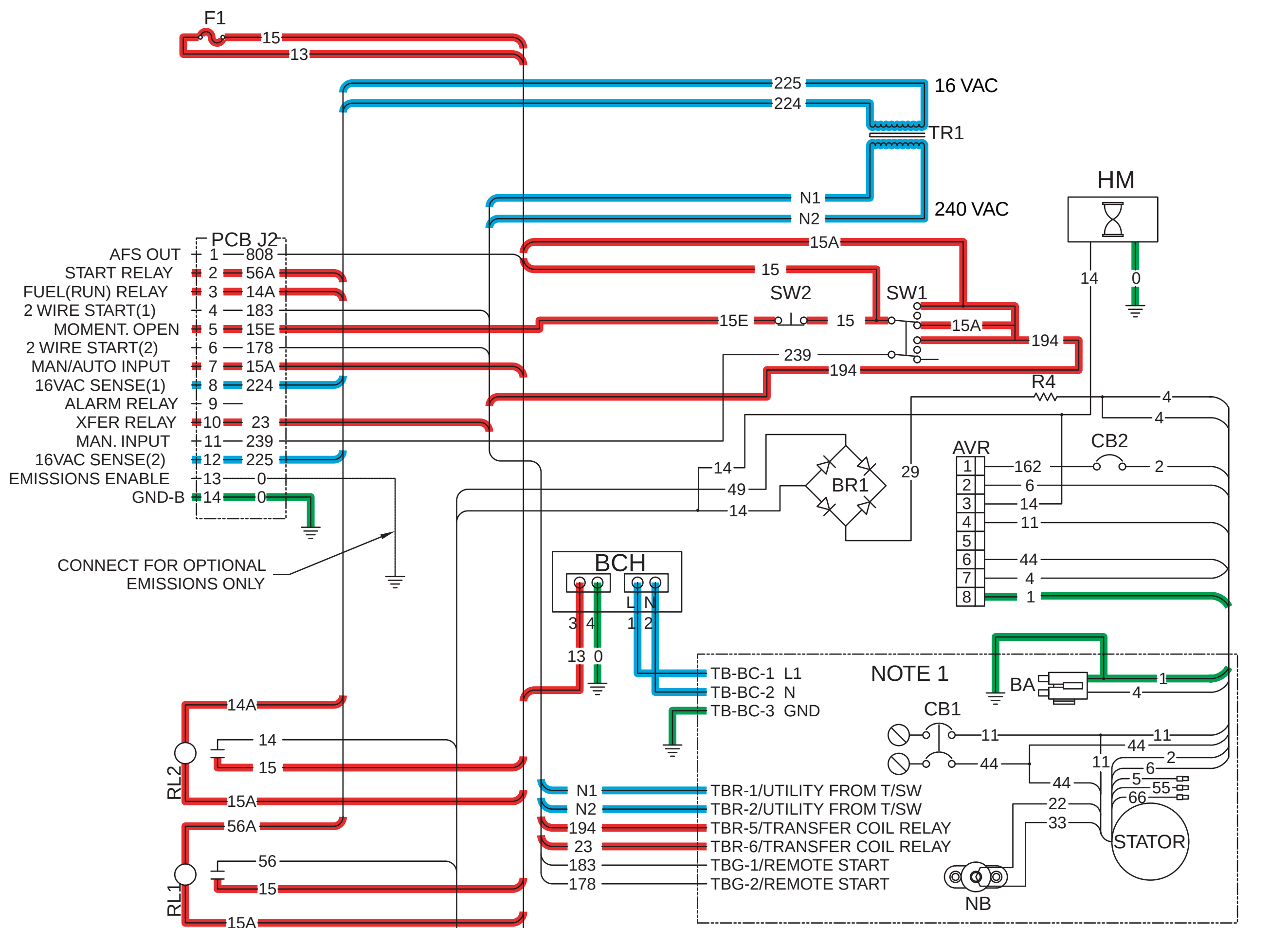


Figure 4.

UTILITY AVAILABLE, SW1 IN AUTO

- (PCB) MONITORING SHUTDOWNS
- DC VOLTAGE - ALWAYS PRESENT
- GROUND
- (PCB) GROUND CONTROL
- DC VOLTAGE DURING CRANKING
- OXYGEN SENSOR GROUND
- OXYGEN SENSOR OUTPUT 1-3 VAC
- AC VOLTAGE
- FREQUENCY SIGNAL FROM CAMSHAFT AND FLYWHEEL SENSORS
- DC VOLTAGE DURING ENGINE RUN CONDITION
- FIELD FLASH
- 5 VDC / POWER SUPPLY FOR ACTUATOR POSITION FEEDBACK
- PWM / 5 VDC SIGNAL



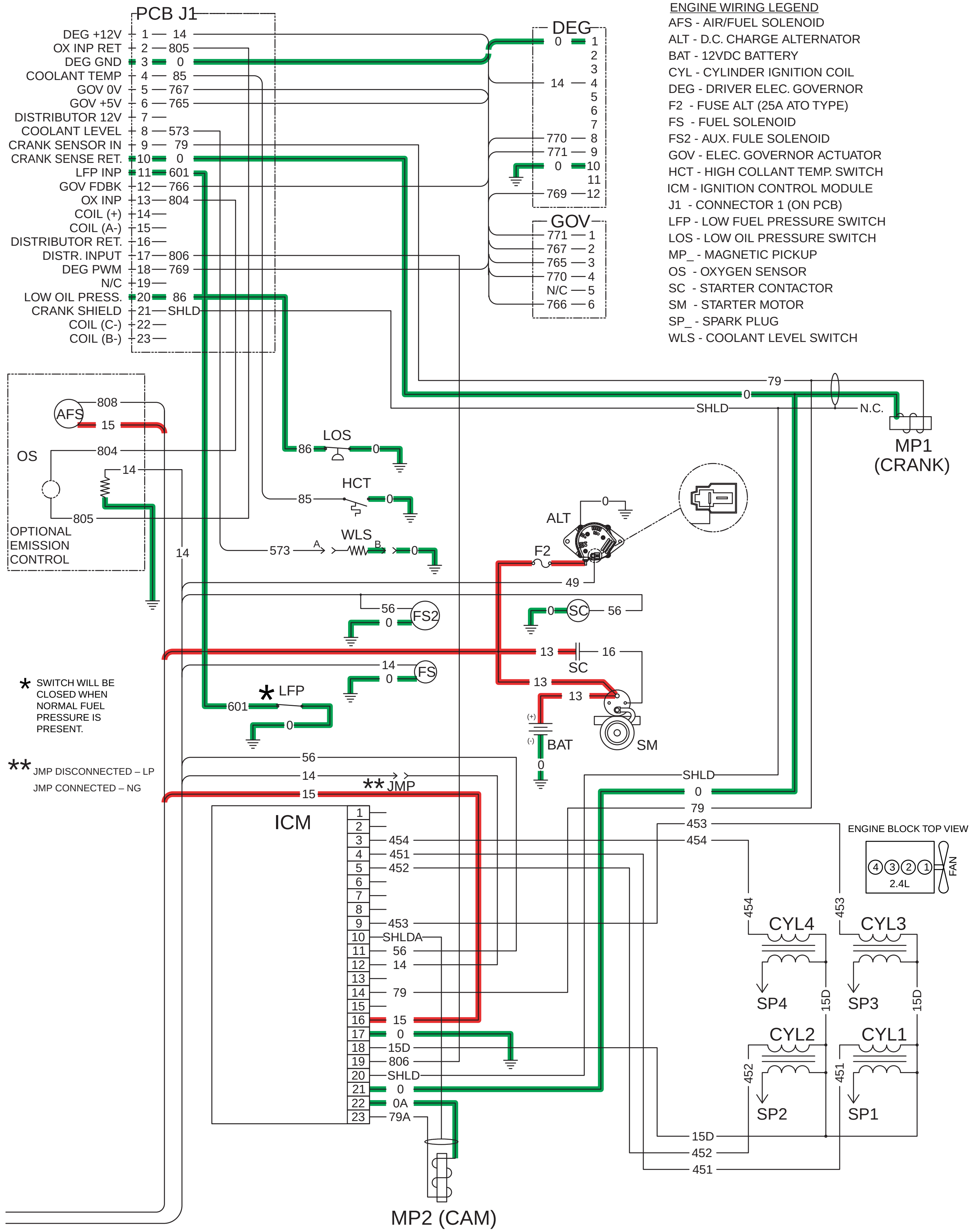
NOTE 1: WIRING SHOWN FOR CB1, NB, BA AND STATOR IS TYPICAL FOR SINGLE PHASE. FOR 3-PHASE, SEE DWG #0F6839.

CUSTOMER CONNECTION & ALTERNATOR LEGEND

BA - BRUSH ASSEMBLY (GENERATOR)
CB1 - MAINLINE CIRCUIT BREAKER
240V OUTPUT TO TRANSFER SWITCH
NB - NEUTRAL BLOCK
TB-BC - BATTERY CHARGER TERMINAL BLOCK
TBG - GTS CONNECT TERMINAL BLOCK
TBR - RTS CONNECT TERMINAL BLOCK

CONTROL PANEL LEGEND

AVR - AUTOMATIC VOLTAGE REGULATOR
BCH - BATTERY CHARGER
BR1 - BRIDGE RECTIFIER
CB2 - CIRCUIT BREAKER (EXCITATION)
F1 - FUSE BAT POWER (15A ATO TYPE)
HM - HOUR METER
J2 - CONNECTOR 2 (ON PCB)
R4 - FIELD BOOST RESISTOR
RL1 - RELAY 1 (START RELAY)
RL2 - RELAY 2 (ENGINE RUN)
SW1 - AUTO/OFF/MANUAL SWITCH
SW2 - SET EXERCISER SWITCH - NORMALLY CLOSED
TR1 - TRANSFORMER (6VA UTIL/16 VAC)


PCB J1
DEG +12V 1 14
OX INP RET 2 805
DEG GND 3 0
COOLANT TEMP 4 85
GOV 0V 5 767
GOV +5V 6 765
DISTRIBUTOR 12V 7
COOLANT LEVEL 8 573
CRANK SENSOR IN 9 79
CRANK SENSE RET. 10 0
LFP INP 11 601
GOV FDBK 12 766
OX INP 13 804
COIL (+) 14
COIL (A-) 15
DISTRIBUTOR RET. 16
DISTR. INPUT 17 806
DEG PWM 18 769
N/C 19
LOW OIL PRESS. 20 86
CRANK SHIELD 21 SHLD
COIL (C-) 22
COIL (B-) 23
DEG
GOV
ENGINE WIRING LEGEND
AFS - AIR/FUEL SOLENOID
ALT - D.C. CHARGE ALTERNATOR
BAT - 12VDC BATTERY
CYL - CYLINDER IGNITION COIL
DEG - DRIVER ELEC. GOVERNOR
F2 - FUSE ALT (25A ATO TYPE)
FS - FUEL SOLENOID
FS2 - AUX. FULE SOLENOID
GOV - ELEC. GOVERNOR ACTUATOR
HCT - HIGH COLLANT TEMP. SWITCH
ICM - IGNITION CONTROL MODULE
J1 - CONNECTOR 1 (ON PCB)
LFP - LOW FUEL PRESSURE SWITCH
LOS - LOW OIL PRESSURE SWITCH
MP_ - MAGNETIC PICKUP
OS - OXYGEN SENSOR
SC - STARTER CONTACTOR
SM - STARTER MOTOR
SP_ - SPARK PLUG
WLS - COOLANT LEVEL SWITCH
OS
OPTIONAL
EMISSION
CONTROL
LOS
HCT
WLS
ALT
F2
FS2
SC
FS
LFP
BAT
SM
MP1
(CRANK)
N.C.
* SWITCH WILL BE
CLOSED WHEN
NORMAL FUEL
PRESSURE IS
PRESENT.
** JMP DISCONNECTED – LP
JMP CONNECTED – NG
** JMP
ICM
ENGINE BLOCK TOP VIEW
2.4L
FAN
CYL4
CYL3
CYL2
CYL1
SP4
SP3
SP2
SP1
MP2 (CAM)

INITIAL POWER LOSS.

For RTS transfer switches, line-to-line voltage is sensed at TR1 and reduced to about 16 VAC line-to-line and sensed at the PCB at J2 Pin 8 and Pin 12. If this voltage drops below 60 percent of operating voltage, the board will start a 15 second timer. If the utility voltage is still below 60 percent of operating voltage the engine will begin the cranking cycle.

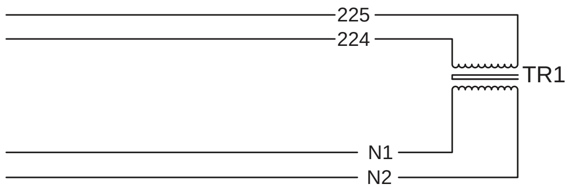


Figure 5.

For GTS configured units utility sensing is done at the transfer switch, nothing will happen at the generator until the transfer switch signals the generator for a start via Wires 178 and 183. All timers are controlled by the GTS transfer switch.

CRANKING AND INITIAL START UP.

For RTS transfer switches, after voltage is not sensed for 15 seconds the engine will begin to crank.

For GTS configured switches, after voltage is not sensed at the transfer switch utility sensing board for a pre-determined amount of time, a contact will close in the switch completing a current path for 2-Wire start. 2-Wire start is sensed by the unit as a low on Wire 183 at J2 Pin 4. 2-Wire start consists of a current limited ground source on J2 Pin 6 going out on Wire 178 at the customer connection, through a normally open contact in the GTS and returning on Wire 183 J2 Pin 4.

Figure 6.

The starter is now activated. Wire 56A is brought low to ground by control board (PCB) J2 Pin 2; this creates a difference of potential across the coil to the start relay (RL1). The start relay closes the contact connecting fused (+) battery voltage to Wire 56. Fused (+) battery voltage is brought by the Wire 56 to the starter contactor.

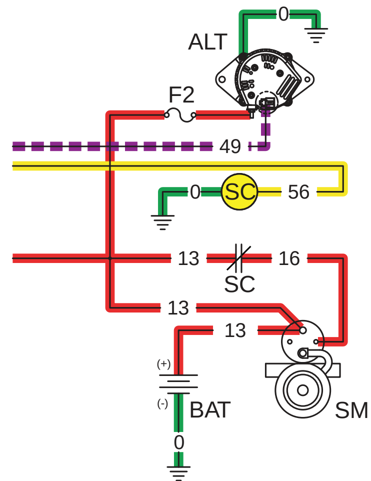


Figure 7.

The starter contactor closes its contact connecting (+) battery voltage Wire 13 to Wire 16. Wire 16 connects (+) battery voltage to the starter solenoid creating a difference of potential across the starter solenoid coil. The starter solenoid closes (+) battery voltage to the starter motor causing the motor to spin, cranking the engine over. The initial crank cycle will be a 15-second crank followed by a 7-second rest. This will be followed by 5 additional cycles of 7 second cranks followed by 7 second rests. If the engine fails to start after a total of 90 seconds, the over crank LED will illuminate. Voltage from Wire 56 is also delivered to the primer solenoid (FS2); fuel is then delivered to the mixer assembly which will aid in starting the engine

The fuel solenoid is activated. Wire 14A is brought low to ground by control board (PCB) J2 Pin 3; this creates a difference of potential across the coil of the engine run relay (RL2). Engine run relay closes fused (+) battery voltage to Wire 15 to Wire 14. Wire 14 carries voltage to the fuel solenoid (FS), this creates a difference of potential across the coil and opens the demand regulator. Wire 14 provides DC voltage to the diode bridge (BR1). At this stage, Wire 14 also feeds 12 VDC to (TB1) Terminal 9, and to the positive side of the hour meter, up to Pin 12 on the Ignition Control Module (ICM) on natural gas and on to the Emission Control, Pin 2, if fitted. At the negative (-) side of BR1 provides (+) battery voltage for the field flash of the alternator (Wire 49) and rotor (Wire 29). Wire 29 is jumped through 0 ohm jumper (R4) to Wire 4.

Electronic governor driver (DEG) is activated. Control Board (PCB) sends (+) battery voltage to J1 Pin 1 to DEG Pin 4 also on Wire 14. From PCB Pin 18 a 5 VDC PWM signal is sent on Wire 769 to DEG Pin 12. The 5 VDC PWM signal is converted to a high current output and sent to drive the governor. DEG Pin 8 (Wire 770) is the (-) to Bosch governor actuator (GOV) Pin 4. DEG Pin 9 (Wire 771) is the (+) to GOV Pin 1.

Electronic governor actuator activated. Power is received from the electronic driver on Pins 1 and 4 of the actuator. PCB J1 Pin 6 (Wire 765) supplies 5

VDC power supply to governor Pin 3 for the actuator position feedback circuit. PCB J1 Pin 5 (Wire 767) is the 0 VDC to governor Pin 2 for the actuator position feedback circuit. Pin 6 of governor feeds a 0 to 5 VDC feedback to PCB J1 Pin 12 via Wire 766.

Ignition control module controls the ignition to each cylinder by individual coils. The ignition control module is powered by battery voltage via Wire 15. When the ignition control module is at rest the ignition control module will blink 0.5 seconds (ON) and then 0.5 seconds (OFF); this is considered one blink (Normal). During cranking operations, Wire 56, and Pin 11 applies voltage to the ignition control module. This input coming from Wire 56 latches the ignition circuit internal of the ignition control module. Power is then applied to Wire 15D to the ignition coils and the ignition control module pulls Wires 451, 452, 453 and 454 to ground individually to allow the magnetic field to build inside the ignition coil and then release it. This action then discharges and spark is applied to that cylinder being fired during that compression stroke. If Wire 14, Pin 12 is connected during cranking and running operations. The ignition control module is set to run for natural gas operations. If Wire 14, Pin 12 is disconnected, it will set the ignition control module for LP fuel operations.

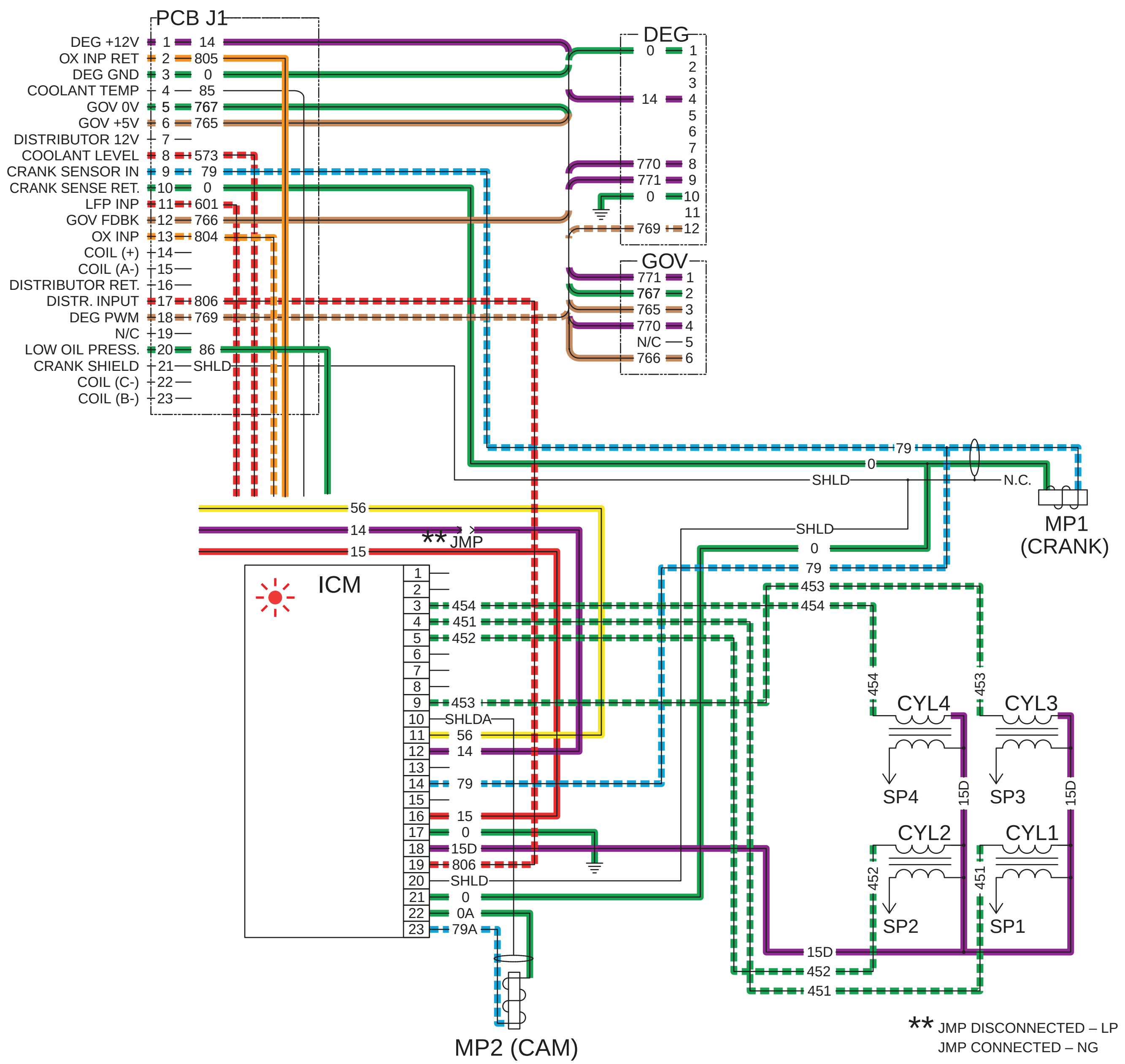
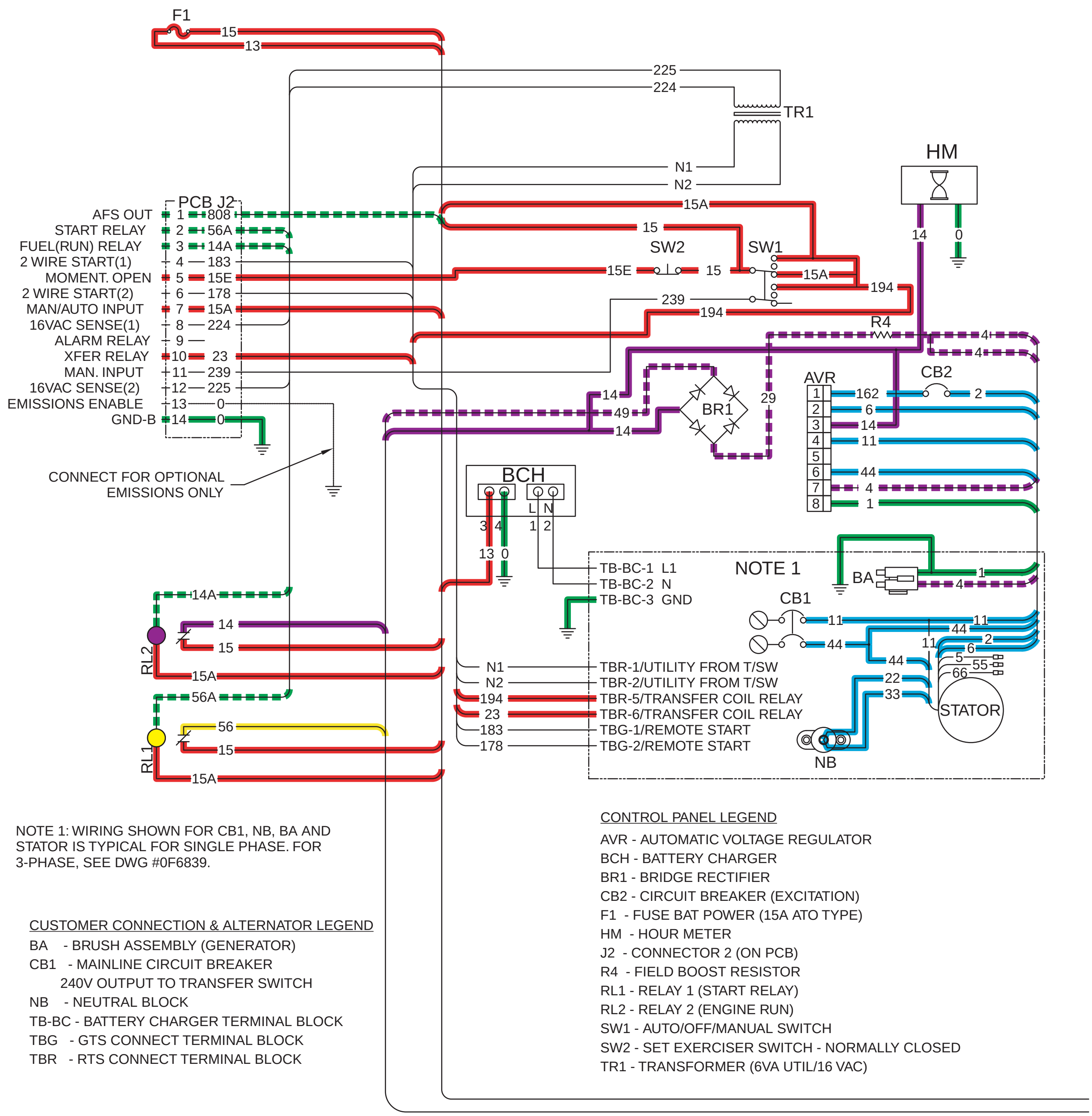


Figure 8.

UTILITY FAILURE, ENGINE CRANKING, SW1 IN AUTO

- (PCB) MONITORING SHUTDOWNS
- DC VOLTAGE - ALWAYS PRESENT
- GROUND
- (PCB) GROUND CONTROL
- DC VOLTAGE DURING CRANKING
- OXYGEN SENSOR GROUND
- OXYGEN SENSOR OUTPUT 1-3 VAC
- AC VOLTAGE
- FREQUENCY SIGNAL FROM CAMSHAFT AND FLYWHEEL SENSORS
- DC VOLTAGE DURING ENGINE RUN CONDITION
- FIELD FLASH
- 5 VDC / POWER SUPPLY FOR ACTUATOR POSITION FEEDBACK
- PWM / 5 VDC SIGNAL



NOTE 1: WIRING SHOWN FOR CB1, NB, BA AND STATOR IS TYPICAL FOR SINGLE PHASE. FOR 3-PHASE, SEE DWG #0F6839.

<u>CUSTOMER CONNECTION & ALTERNATOR LEGEND</u>

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240V OUTPUT TO TRANSFER SWITCH
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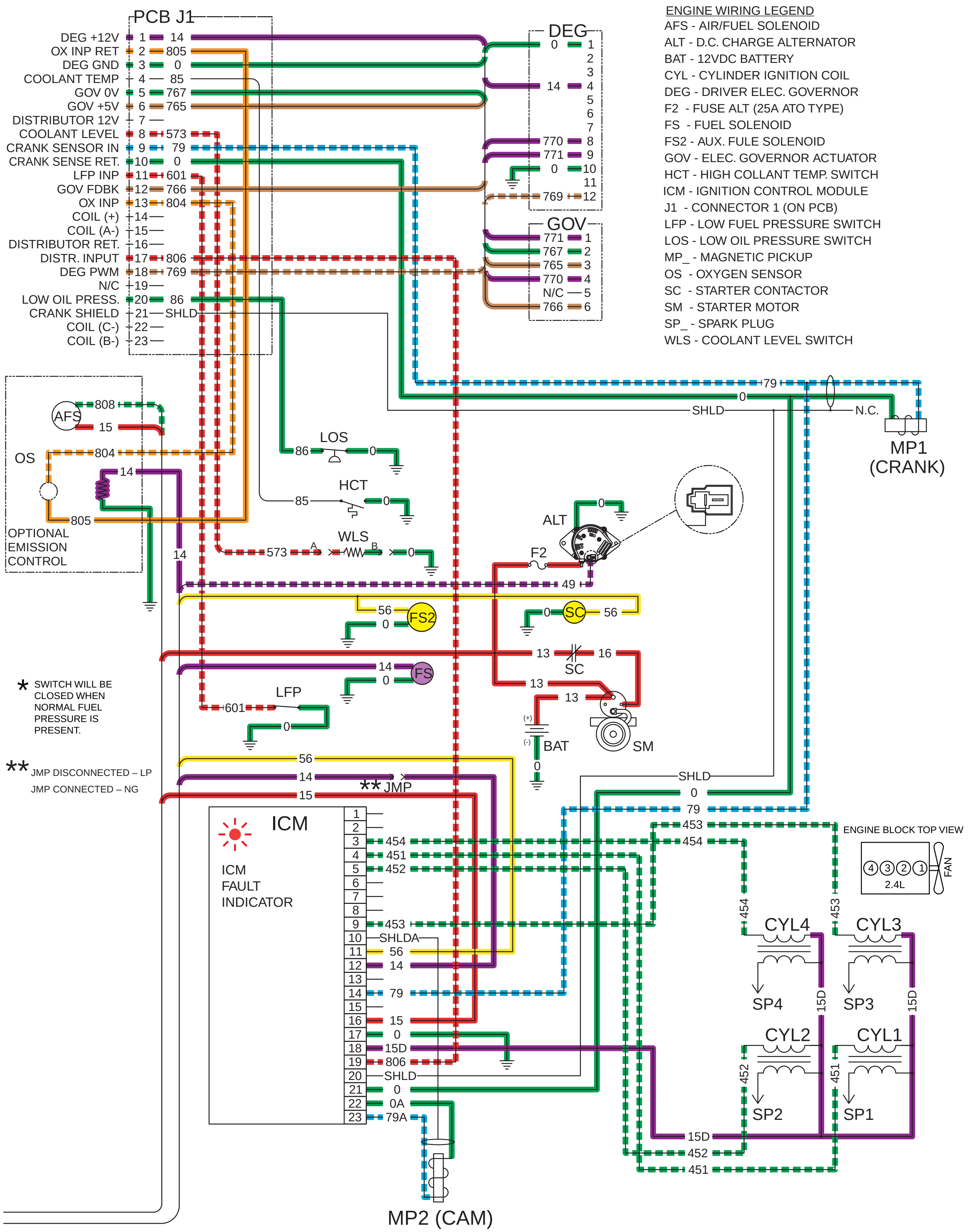
TBR - RTS CONNECT TERMINAL BLOCK

<u>CONTROL PANEL LEGEND</u>

AVR - AUTOMATIC VOLTAGE REGULATOR
BCH - BATTERY CHARGER
BR1 - BRIDGE RECTIFIER
CB2 - CIRCUIT BREAKER (EXCITATION)
F1 - FUSE BAT POWER (15A ATO TYPE)
HM - HOUR METER
J2 - CONNECTOR 2 (ON PCB)
R4 - FIELD BOOST RESISTOR
RL1 - RELAY 1 (START RELAY)
RL2 - RELAY 2 (ENGINE RUN)
SW1 - AUTO/OFF/MANUAL SWITCH
SW2 - SET EXERCISER SWITCH - NORMALLY CLOSED
TR1 - TRANSFORMER (6VA UTIL/16 VAC)


PCB J1
DEG +12V 1 14
OX INP RET 2 805
DEG GND 3 0
COOLANT TEMP 4 85
GOV 0V 5 767
GOV +5V 6 765
DISTRIBUTOR 12V 7
COOLANT LEVEL 8 573
CRANK SENSOR IN 9 79
CRANK SENSE RET. 10 0
LFP INP 11 601
GOV FDBK 12 766
OX INP 13 804
COIL (+) 14
COIL (A-) 15
DISTRIBUTOR RET. 16
DISTR. INPUT 17 806
DEG PWM 18 769
N/C 19
LOW OIL PRESS. 20 86
CRANK SHIELD 21 SHLD
COIL (C-) 22
COIL (B-) 23
DEG
GOV
ENGINE WIRING LEGEND
AFS - AIR/FUEL SOLENOID
ALT - D.C. CHARGE ALTERNATOR
BAT - 12VDC BATTERY
CYL - CYLINDER IGNITION COIL
DEG - DRIVER ELEC. GOVERNOR
F2 - FUSE ALT (25A ATO TYPE)
FS - FUEL SOLENOID
FS2 - AUX. FULE SOLENOID
GOV - ELEC. GOVERNOR ACTUATOR
HCT - HIGH COLLANT TEMP. SWITCH
ICM - IGNITION CONTROL MODULE
J1 - CONNECTOR 1 (ON PCB)
LFP - LOW FUEL PRESSURE SWITCH
LOS - LOW OIL PRESSURE SWITCH
MP_ - MAGNETIC PICKUP
OS - OXYGEN SENSOR
SC - STARTER CONTACTOR
SM - STARTER MOTOR
SP_ - SPARK PLUG
WLS - COOLANT LEVEL SWITCH
MP1 (CRANK)
OS
AFS
OPTIONAL EMISSION CONTROL
LOS
HCT
WLS
ALT
F2
FS2
SC
FS
LFP
BAT
SM
* SWITCH WILL BE CLOSED WHEN NORMAL FUEL PRESSURE IS PRESENT.
** JMP DISCONNECTED – LP
JMP CONNECTED – NG
** JMP
ICM
ICM FAULT INDICATOR
ENGINE BLOCK TOP VIEW
2.4L
FAN
CYL4
CYL3
CYL2
CYL1
SP4
SP3
SP2
SP1
MP2 (CAM)

ENGINE RUNNING:

When the engine reaches 600 to 800 RPM the control board will turn off the starter. Ground will be removed from PCB Pin 2 disengaging the starter motor at the SC.

Using field boost on Wire 4 the rotor begins to create a magnetic field. The magnetic field will induce a voltage on the stator windings as the rotor spins. Wires 11 and 44 are the sensing leads connecting to Pins 4 and 6 of the automatic voltage regulator (AVR). The stator also induces an excitation voltage on Wires 162 and 6 of the AVR connected to Terminals 1 and 2. The AVR rectifies the excitation voltage to produce the field voltage. The AVR uses the sensing voltage to know how much field voltage to supply into the rotor.

When the system is equipped with an RTS switch the control board will start a 10 second warm up timer after engine comes up to speed. After approximately 10 seconds, the control board will initiate a transfer by grounding PCB J2 Pin 10. At the transfer switch, the grounding of Wire 23 will produce a difference of potential across the transfer relay coil, forcing transfer of the load from utility to standby generator voltage.

When equipped with a GTS configured switch all transfer control is controlled at the transfer switch.

RETURN OF UTILITY:

For RTS transfer switches, utility will return and be sensed via N1 and N2. The transformer (TR1) steps down this voltage. The stepped down sensing voltage is sent to the control board (PCB) at J2 Pin 8 (Wire 224) and Pin 12 (Wire 225). After 80 percent of utility voltage is sensed for a period of 15 seconds the PCB will remove ground from J2 Pin 10 (Wire 23). The difference of potential is removed from transfer relay of transfer switch, forcing the load to be transferred from generator to utility source. After transfer the control board will initiate a one minute cool down timer.

For GTS configured units the timers are located in the transfer switch.

SHUTDOWN:

For RTS transfer switches the unit will shut down after the cool down timer has completed its time out.

For GTS configured transfer switches the 2-Wire start circuit opens. This is seen at the control board as a return of 5 VDC on J2 Pin 4.

In both cases the control board will remove ground from J2 Pin 3, removing the power to the fuel system. The control board will also remove the ground driver enable line at J1 Pin 18 (Wire 769), allowing the actuator to close.

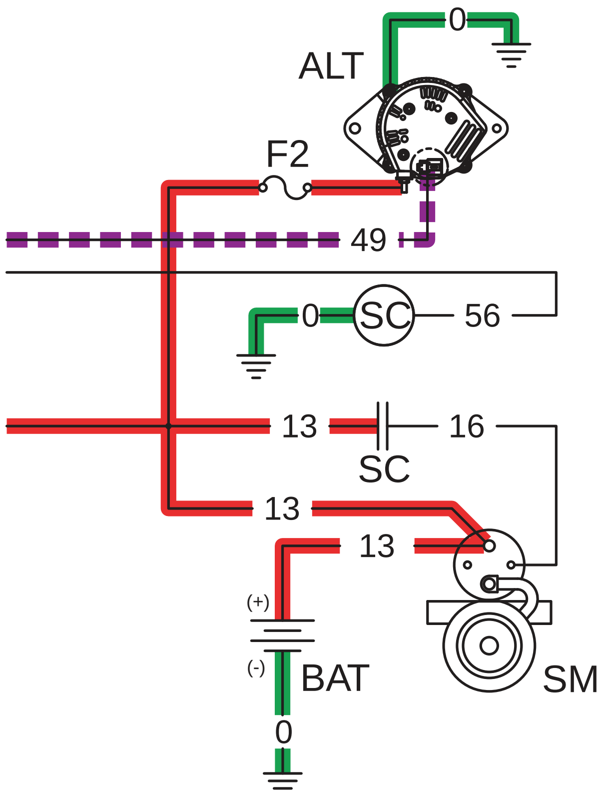


Figure 9. Starter and Battery Charge Circuit — Unit Running

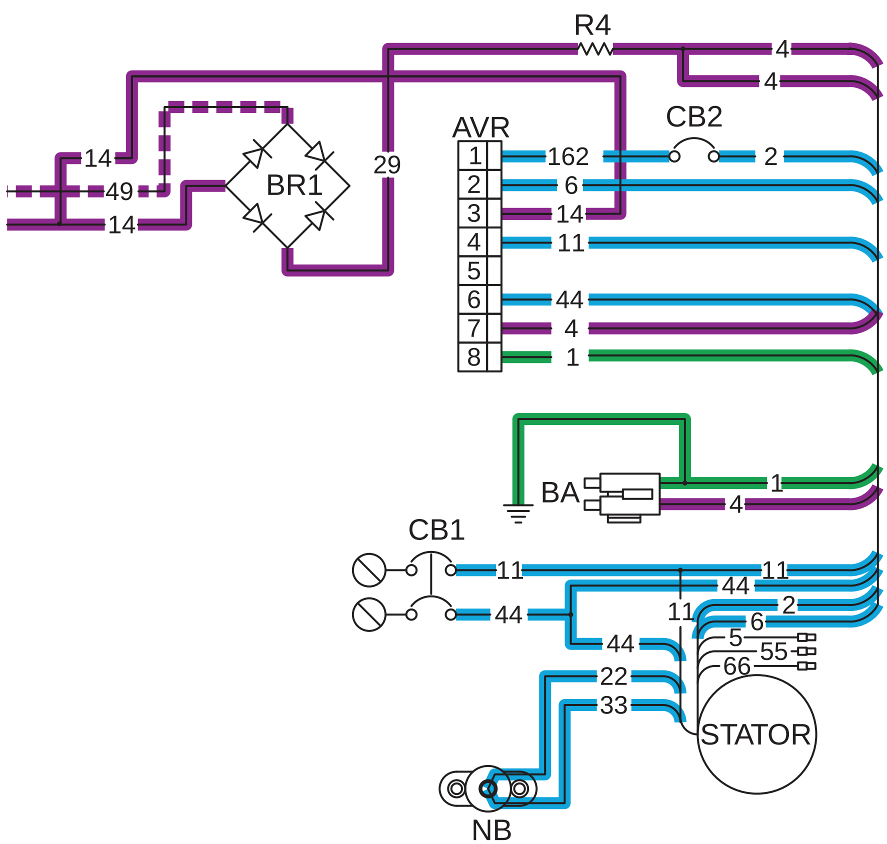
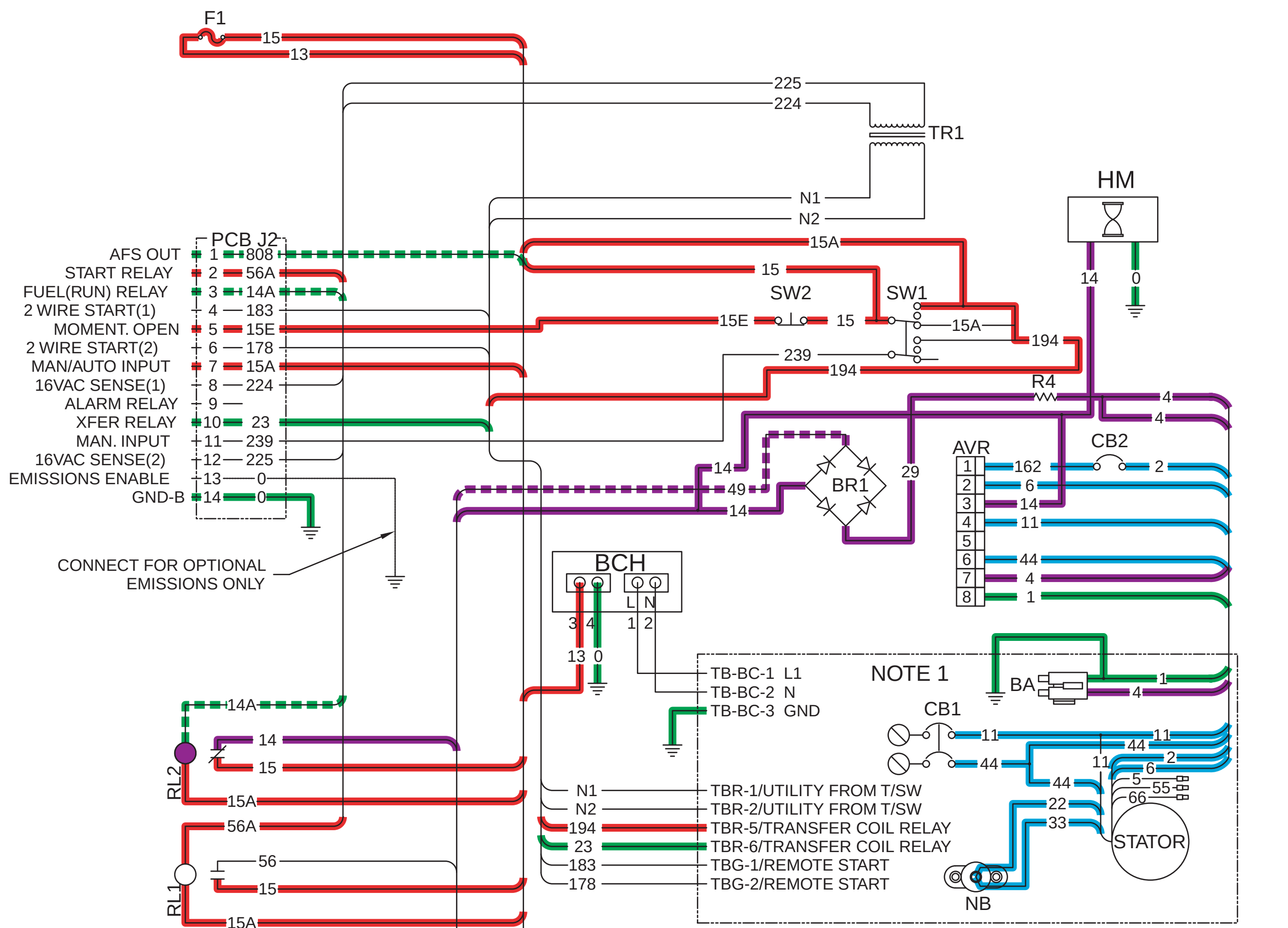


Figure 10. AVR and Stator Circuit — Unit Running

UTILITY FAILURE, ENGINE RUNNING, SW1 IN AUTO

- (PCB) MONITORING SHUTDOWNS
- DC VOLTAGE - ALWAYS PRESENT
- GROUND
- (PCB) GROUND CONTROL
- DC VOLTAGE DURING CRANKING
- OXYGEN SENSOR GROUND
- OXYGEN SENSOR OUTPUT 1-3 VAC
- AC VOLTAGE
- FREQUENCY SIGNAL FROM CAMSHAFT AND FLYWHEEL SENSORS
- DC VOLTAGE DURING ENGINE RUN CONDITION
- FIELD FLASH
- 5 VDC / POWER SUPPLY FOR ACTUATOR POSITION FEEDBACK
- PWM / 5 VDC SIGNAL



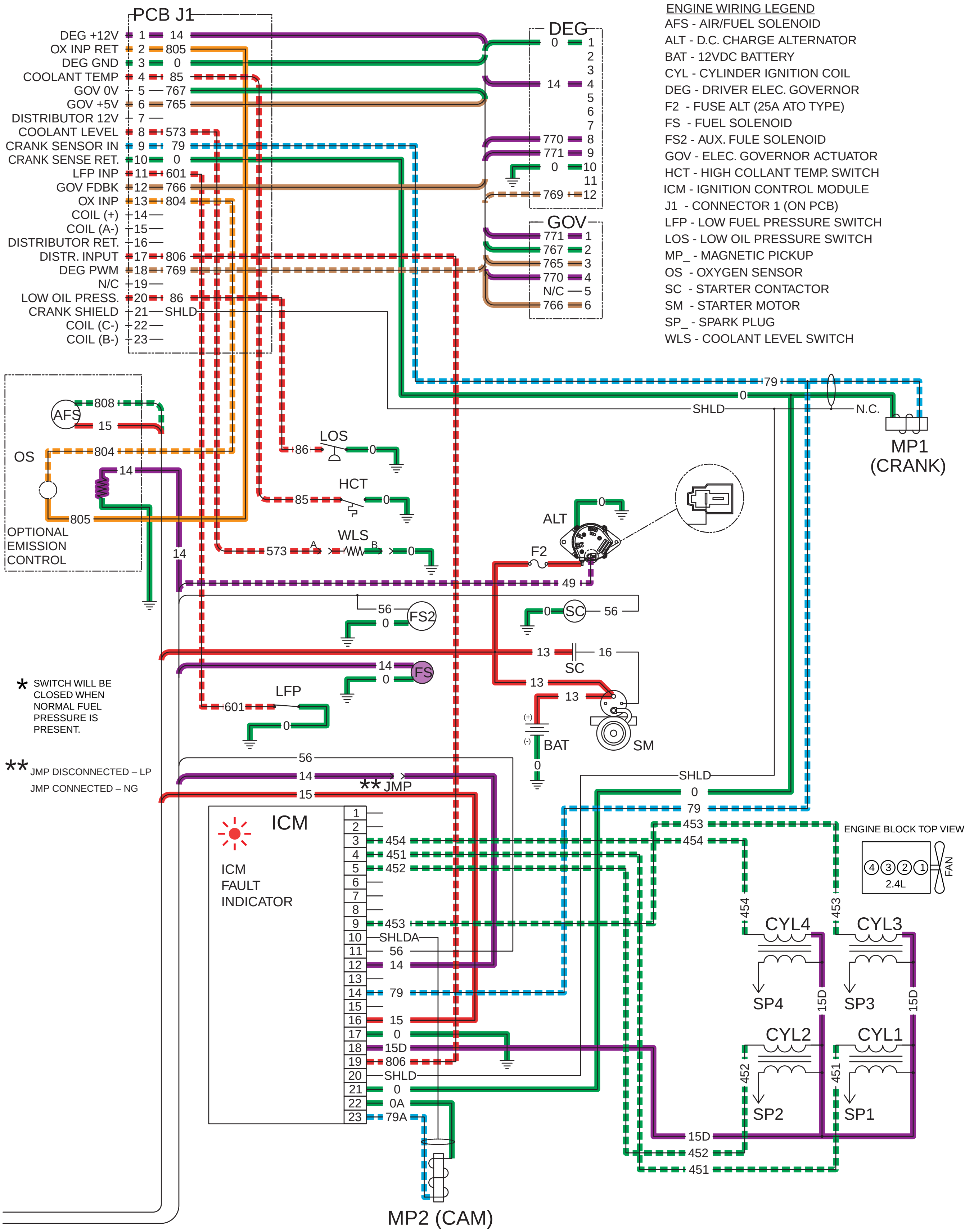
NOTE 1: WIRING SHOWN FOR CB1, NB, BA AND STATOR IS TYPICAL FOR SINGLE PHASE. FOR 3-PHASE, SEE DWG #0F6839.

<u>CONTROL PANEL LEGEND</u>

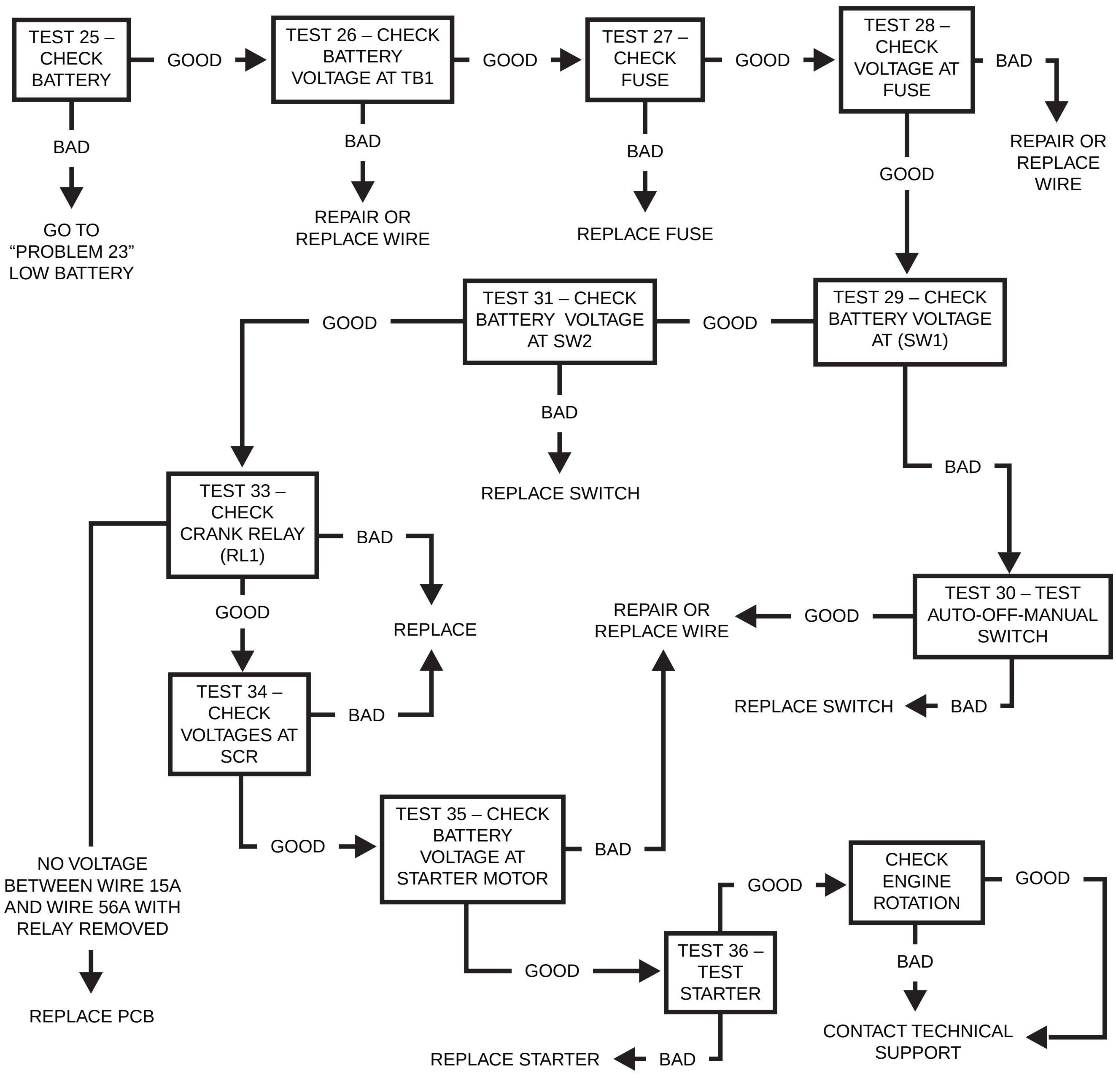
AVR - AUTOMATIC VOLTAGE REGULATOR
BCH - BATTERY CHARGER
BR1 - BRIDGE RECTIFIER
CB2 - CIRCUIT BREAKER (EXCITATION)
F1 - FUSE BAT POWER (15A ATO TYPE)
HM - HOUR METER
J2 - CONNECTOR 2 (ON PCB)
R4 - FIELD BOOST RESISTOR
RL1 - RELAY 1 (START RELAY)
RL2 - RELAY 2 (ENGINE RUN)
SW1 - AUTO/OFF/MANUAL SWITCH
SW2 - SET EXERCISER SWITCH - NORMALLY CLOSED
TR1 - TRANSFORMER (6VA UTIL/16 VAC)

<u>CUSTOMER CONNECTION & ALTERNATOR LEGEND</u>

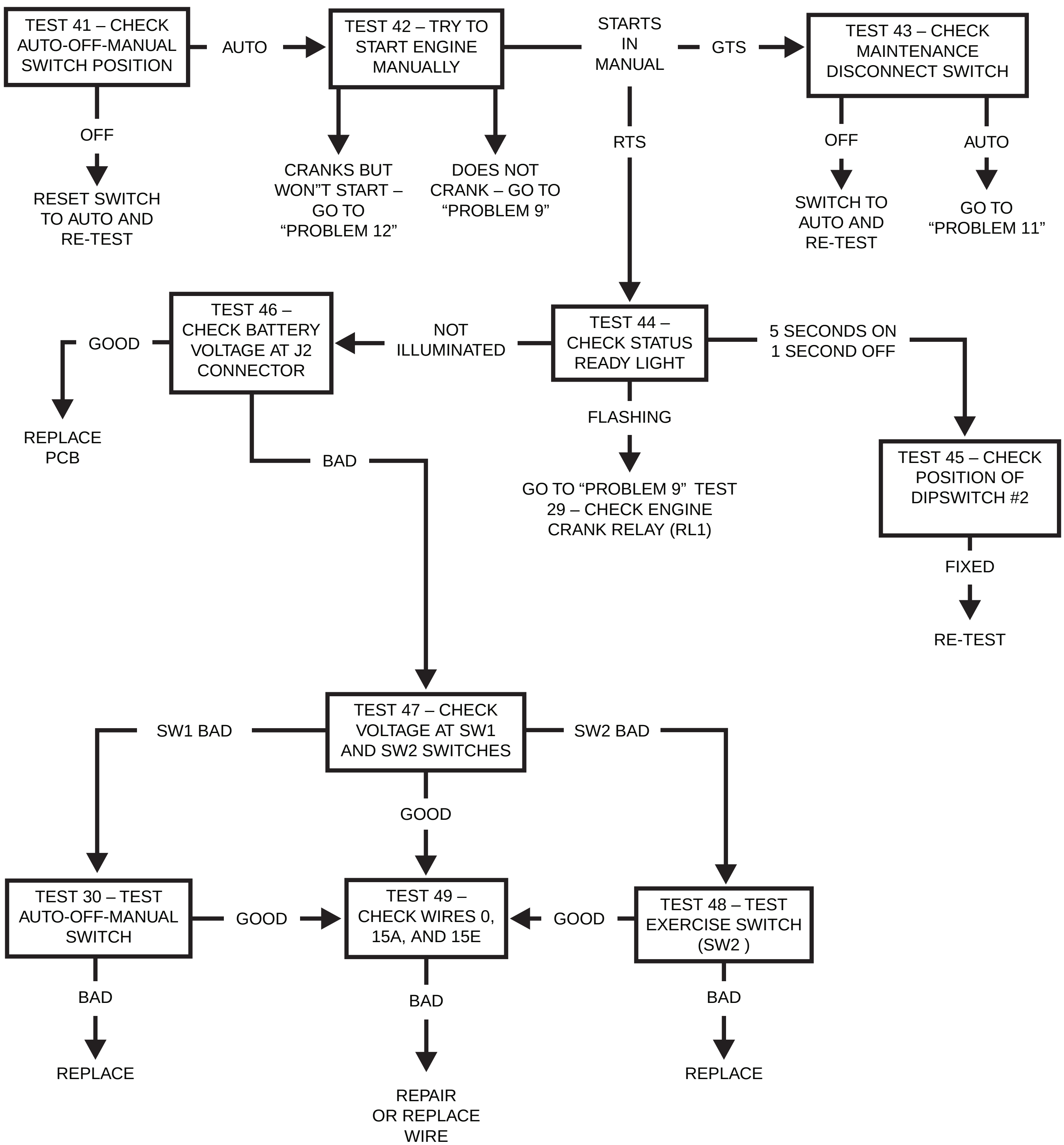
BA - BRUSH ASSEMBLY (GENERATOR)
CB1 - MAINLINE CIRCUIT BREAKER
240V OUTPUT TO TRANSFER SWITCH
NB - NEUTRAL BLOCK
TB-BC - BATTERY CHARGER TERMINAL BLOCK
TBG - GTS CONNECT TERMINAL BLOCK
TBR - RTS CONNECT TERMINAL BLOCK


PCB J1
DEG +12V
OX INP RET
DEG GND
COOLANT TEMP
GOV 0V
GOV +5V
DISTRIBUTOR 12V
COOLANT LEVEL
CRANK SENSOR IN
CRANK SENSE RET.
LFP INP
GOV FDBK
OX INP
COIL (+)
COIL (A-)
DISTRIBUTOR RET.
DISTR. INPUT
DEG PWM
N/C
LOW OIL PRESS.
CRANK SHIELD
COIL (C-)
COIL (B-)
DEG
GOV
ENGINE WIRING LEGEND
AFS - AIR/FUEL SOLENOID
ALT - D.C. CHARGE ALTERNATOR
BAT - 12VDC BATTERY
CYL - CYLINDER IGNITION COIL
DEG - DRIVER ELEC. GOVERNOR
F2 - FUSE ALT (25A ATO TYPE)
FS - FUEL SOLENOID
FS2 - AUX. FULE SOLENOID
GOV - ELEC. GOVERNOR ACTUATOR
HCT - HIGH COLLANT TEMP. SWITCH
ICM - IGNITION CONTROL MODULE
J1 - CONNECTOR 1 (ON PCB)
LFP - LOW FUEL PRESSURE SWITCH
LOS - LOW OIL PRESSURE SWITCH
MP_ - MAGNETIC PICKUP
OS - OXYGEN SENSOR
SC - STARTER CONTACTOR
SM - STARTER MOTOR
SP_ - SPARK PLUG
WLS - COOLANT LEVEL SWITCH
AFS
OS
OPTIONAL EMISSION CONTROL
LOS
HCT
WLS
ALT
F2
MP1 (CRANK)
FS2
SC
FS
LFP
BAT
SM
* SWITCH WILL BE CLOSED WHEN NORMAL FUEL PRESSURE IS PRESENT.
** JMP DISCONNECTED – LP
JMP CONNECTED – NG
** JMP
ICM
ICM FAULT INDICATOR
ENGINE BLOCK TOP VIEW
2.4L
FAN
CYL4
CYL3
CYL2
CYL1
SP4
SP3
SP2
SP1
MP2 (CAM)

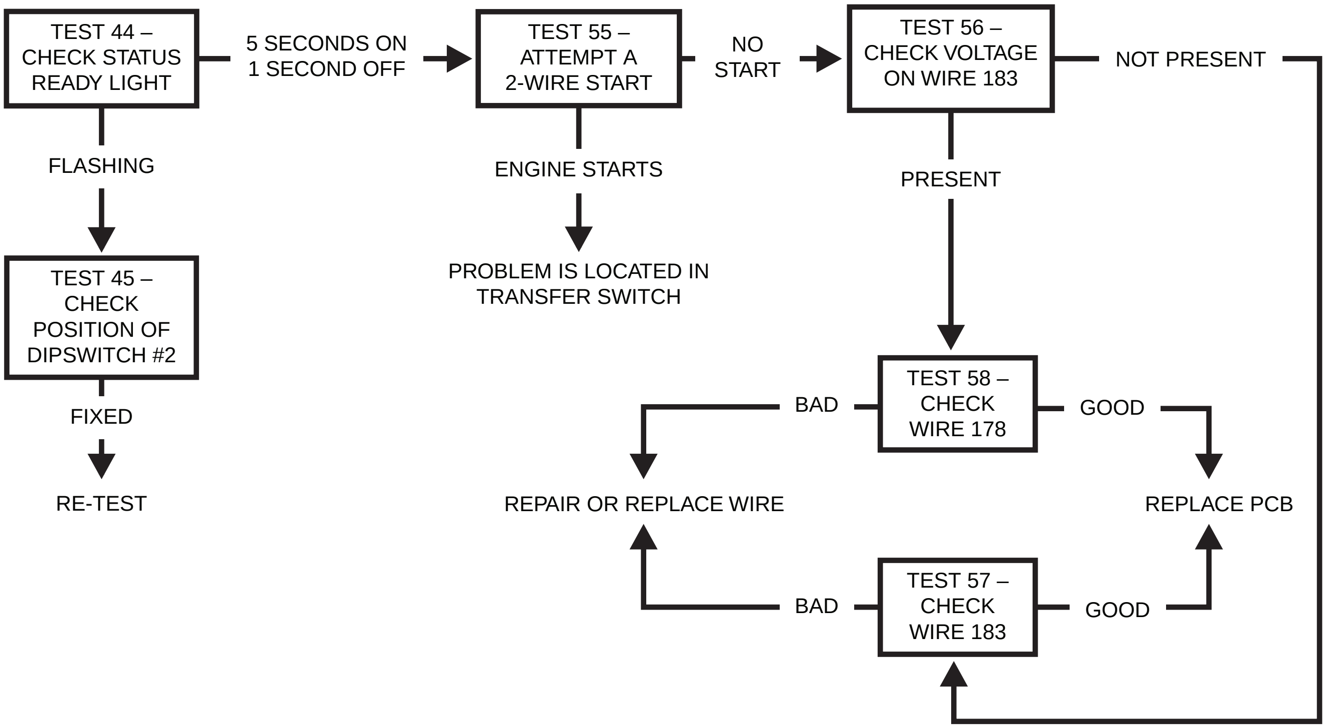
Problem 9 – Unit Will Not Crank When AUTO-OFF-MANUAL Switch is Set to MANUAL



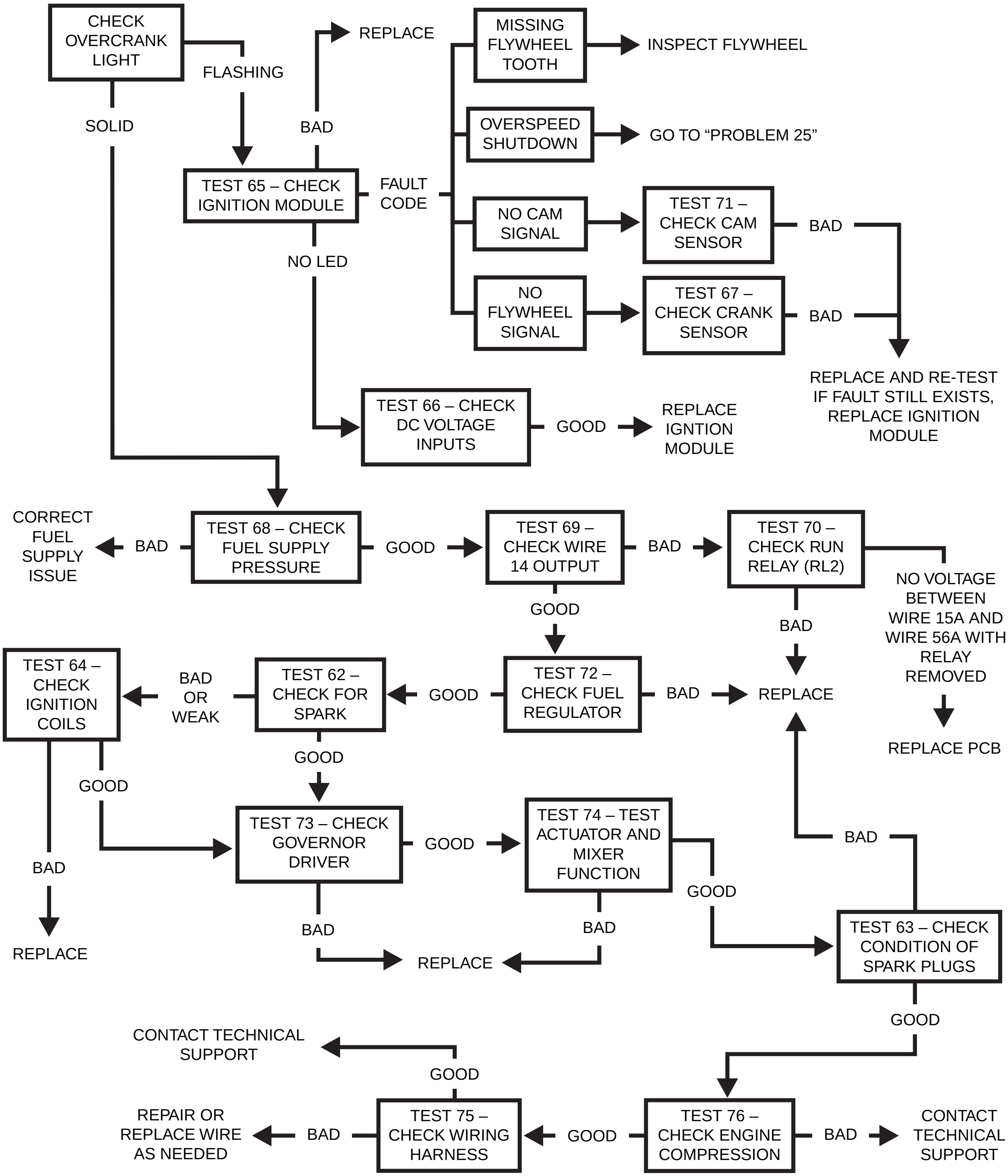
Problem 10 – Engine Will Not Crank When Utility Power Fails



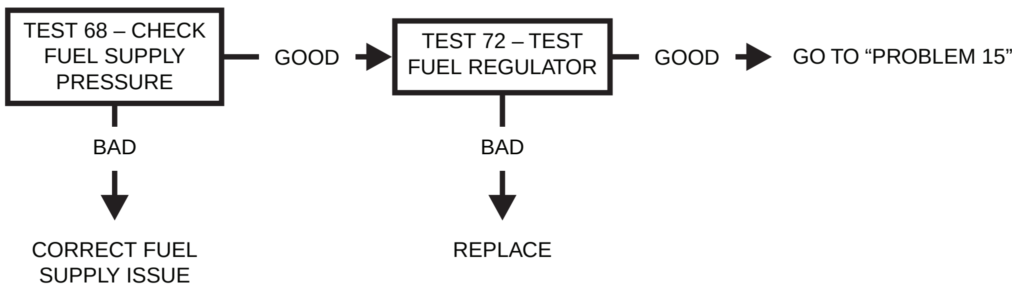
Problem 11 – Engine Will Not Crank With a 2-wire Start



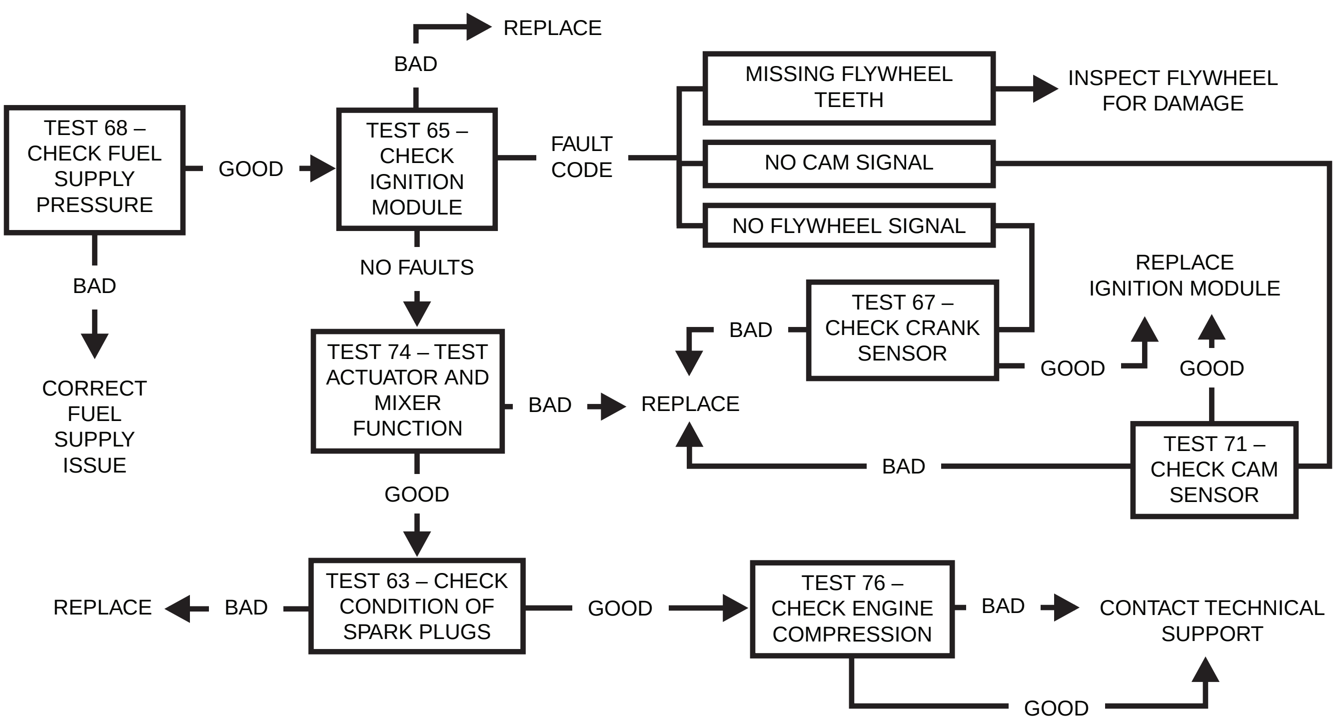
Problem 12 – Unit Cranks But Will Not Start



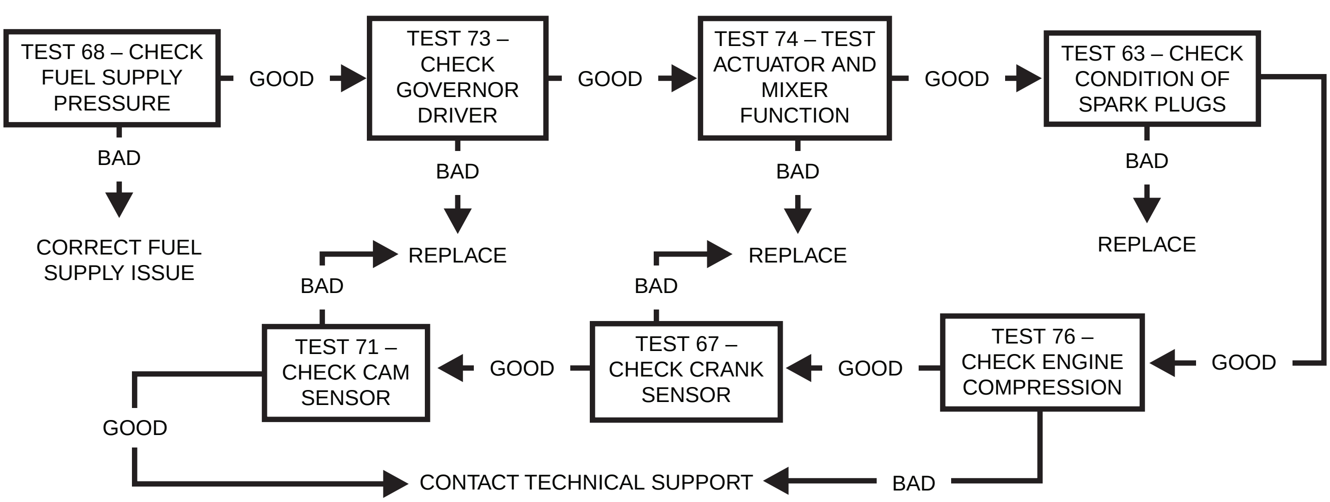
Problem 13 – Unit Starts and Runs Then Shuts Down



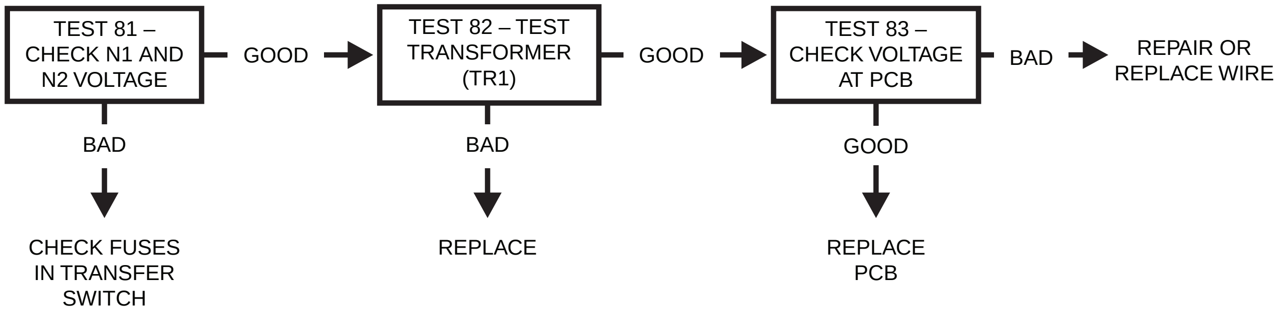
Problem 14 – Unit Cranks and Starts, but Backfires



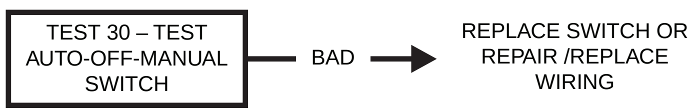
Problem 15 – Unit Starts Hard and Runs Rough/Lacks Power



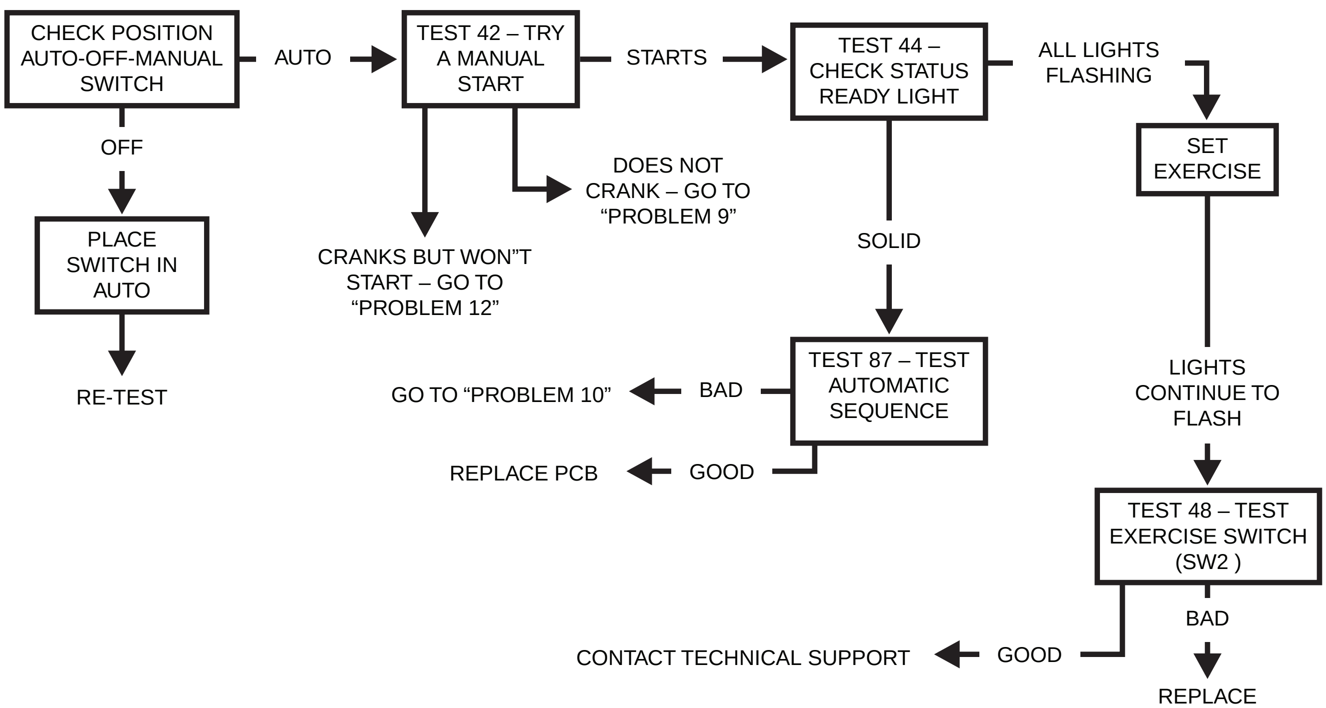
Problem 16 – Unit Starts and Transfer Occurs When Utility Power is Available



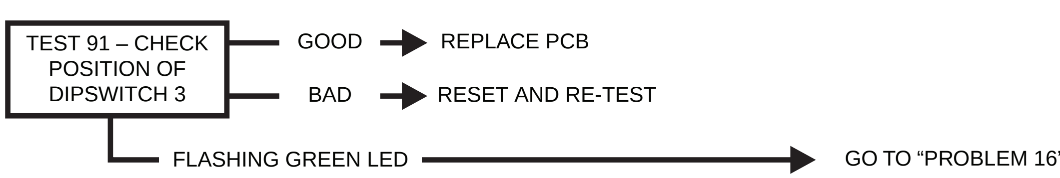
Problem 17 – Generator Starts Immediately In AUTO but No Transfer To Standby Utility Voltage Present



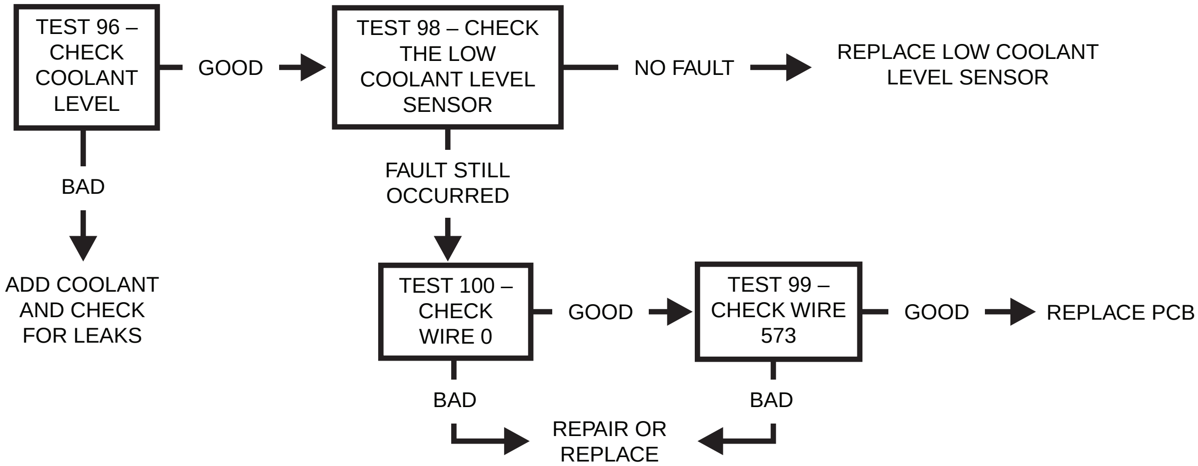
Problem 18 – Generator Will Not Exercise



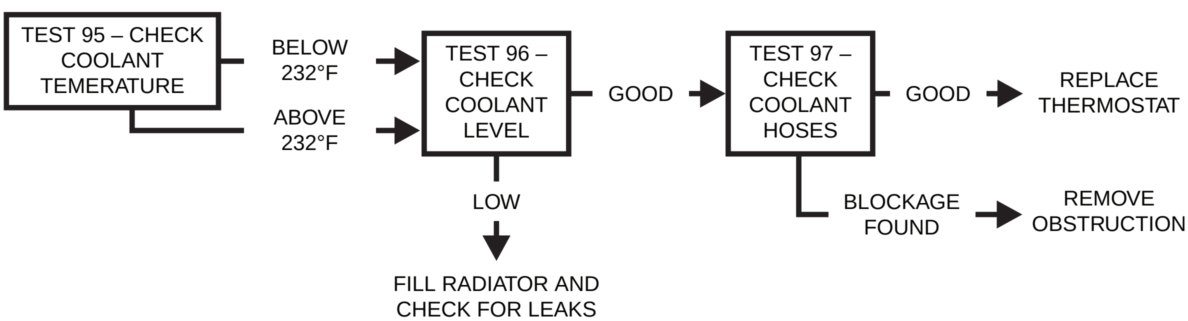
Problem 19 – Generator Will Not Low Speed Exercise



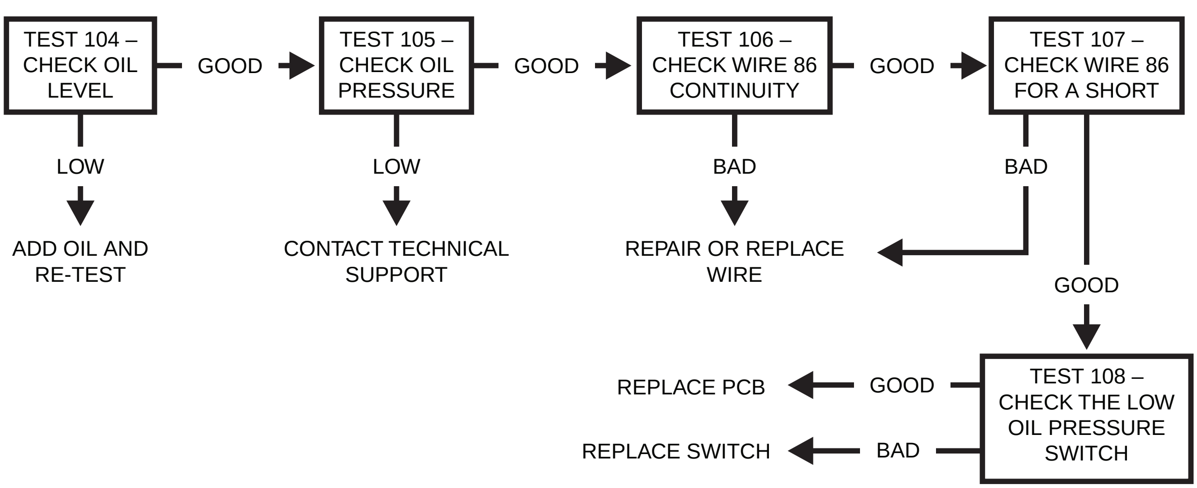
Problem 20 – High Temp/Low Coolant (Flashing LED)



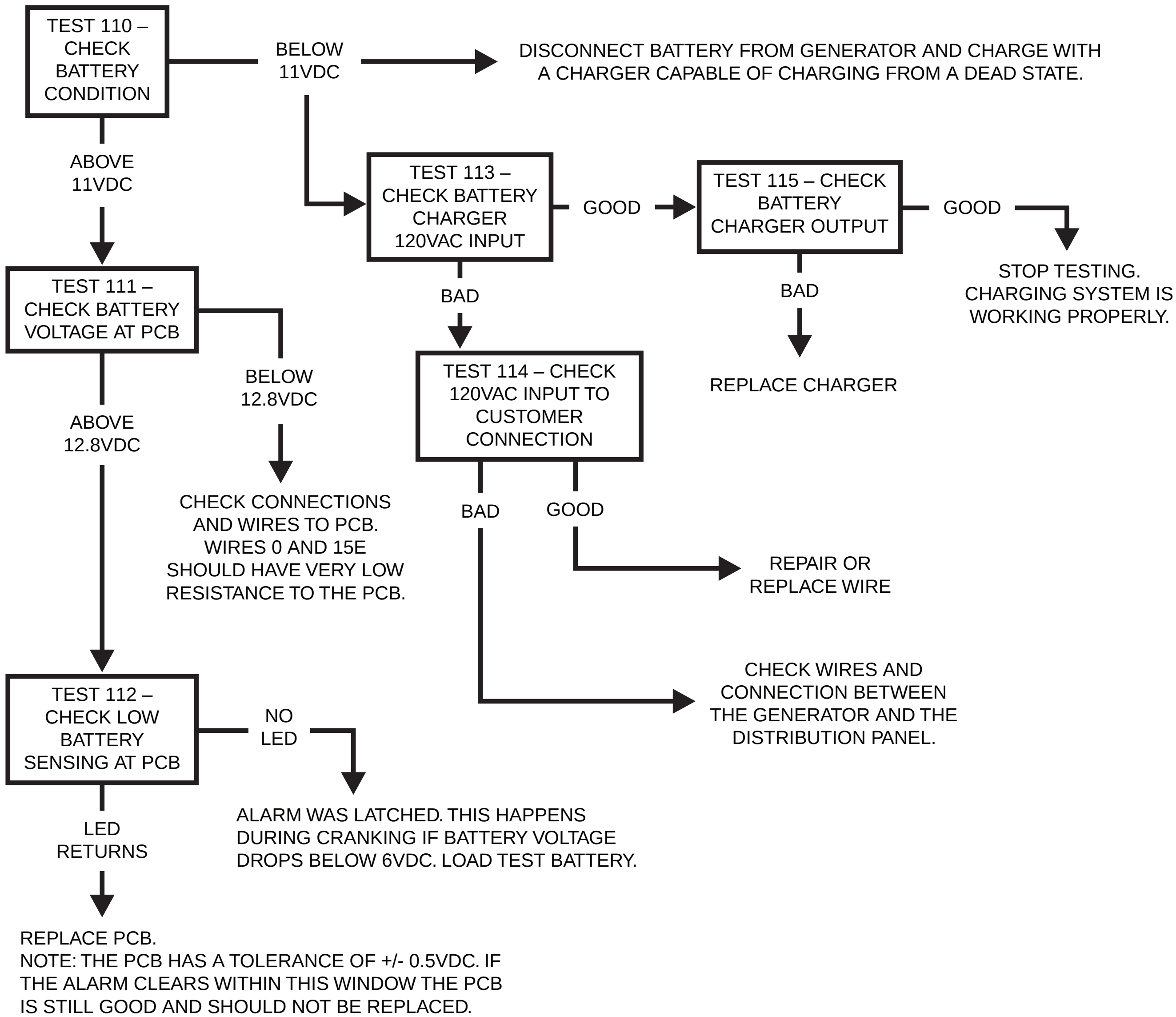
Problem 21 – High Temp/Low Coolant (Solid LED)



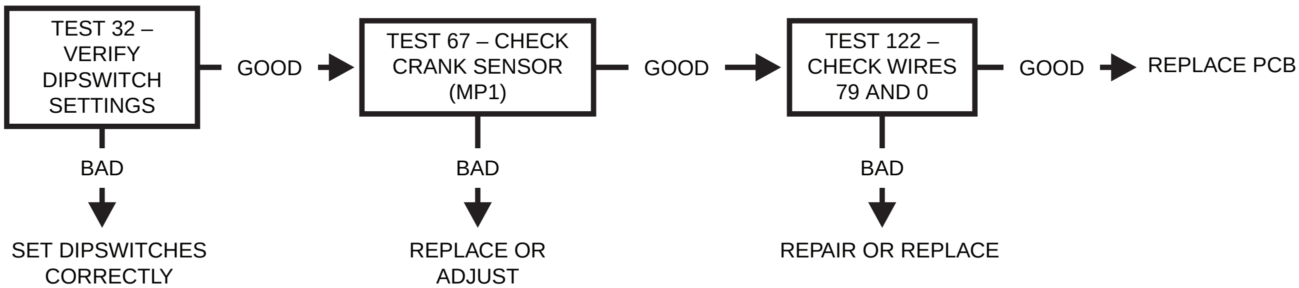
Problem 22 – Low Oil Pressure



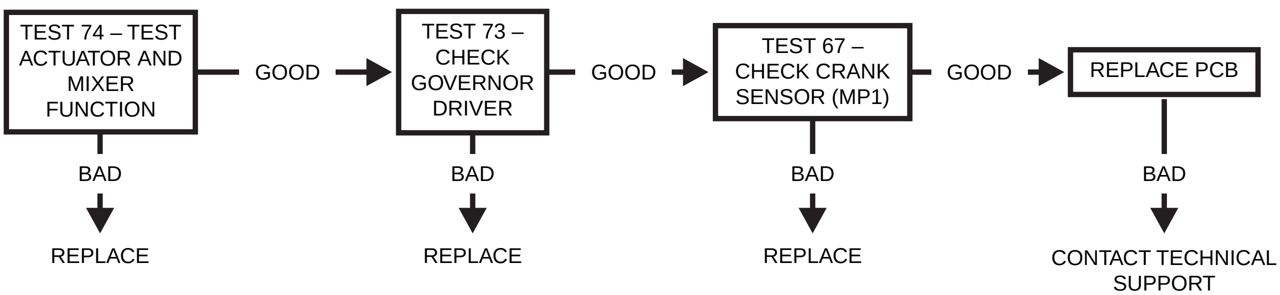
Problem 23 – Low Battery Alarm/Dead Battery



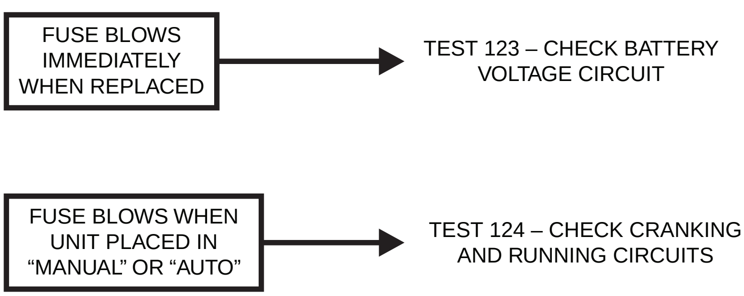
Problem 24 – Overspeed LED Flashing



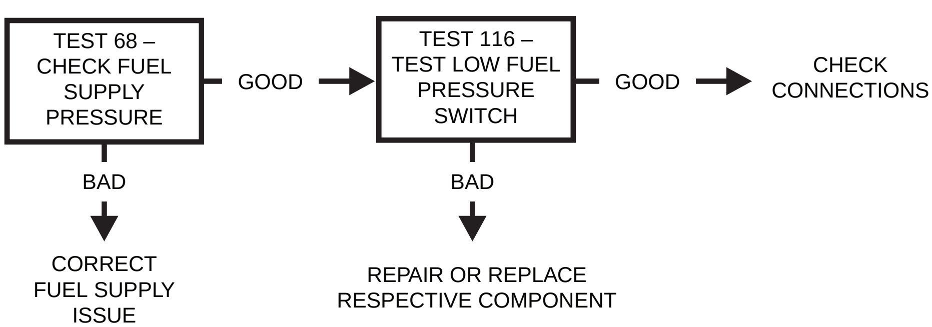
Problem 25 – Overspeed LED Solid



Problem 26 – 15 Amp Fuse Blows



Problem 27 – Low Fuel Pressure LED Flashing



INTRODUCTION

This section is provided to familiarize the service technician with acceptable procedures for the testing and evaluation of various problems that could be encountered on standby generators with liquid-cooled engines. Use this section of the manual in conjunction with Section 3.3, "Troubleshooting Flow Charts". The numbered tests in this section correspond with those of Section 3.3.

Most tests can be performed with an inexpensive volt-ohm-milliammeter (VOM). An AC frequency meter is required, where frequency readings must be taken. A clamp-on ammeter may be used to measure AC loads on the generator.

Testing and troubleshooting methods covered in this section are not exhaustive. We have not attempted to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis might be performed. We have not undertaken any such broad evaluation. 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 product's safety.

SAFETY

Service personnel who work on this equipment must be made 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 be ignited 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 don't understand a component, device or system, do not work on it.

TEST 25 – CHECK VOLTAGE AT BATTERY

PROCEDURE:

1. Set a VOM to measure DC voltage.
2. Connect one meter test lead to the positive terminal of the battery and connect the other meter test lead to the negative terminal on the battery. Measure and record the voltage
3. Set the AUTO-OFF-MANUAL switch to the MANUAL position. Measure and record the voltage.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

RESULTS:

1. If voltage was above 12VDC in Step 2, but dropped below 10VDC the battery may have a dead cell or a direct short between the cells and would need to be replaced. The battery can be load tested using a hand held device or taken to a facility with the capability of testing the state of a battery.
2. If voltage was above 12VDC in Steps 2 and 3, refer back to flow chart.
3. If voltage was below 12VDC in Steps 2 and 3, refer back to flow chart.

TEST 26 – CHECK BATTERY VOLTAGE AT TB1 TERMINAL STRIP

PROCEDURE:

1. Open the front control panel.
2. Set the VOM to measure DC volts.
3. Place the negative test (-) lead to Terminal 1 of TB1 (Wire 0) and the positive lead to Terminal 8 of TB1 (Wire 13) on the terminal strip.

RESULTS:

1. If battery voltage is present on Wire 13, refer back to flow chart.
2. If little or no battery voltage is present, verify that Wire 13 is not pinched or cut or in any other way prevented from having proper battery voltage. Repair or replace Wire 13 between TB1 and the battery.

TEST 27 – CHECK 15 AMP FUSE (F1)

PROCEDURE:

1. Locate the fuse in the lower left of the control panel.
2. Pull the 15 amp fuse (F1) from the lower left of the control panel and inspect the fuse.
3. Set VOM to measure resistance (Ω).
4. Check for CONTINUITY between the blades of the fuse.

RESULTS:

1. If the fuse is open, replace the fuse. If the fuse blows again verify for shorts to ground, then go to Problem 26 in Section 3.3.
2. If the fuse is good, refer back to flow chart.

TEST 28 – CHECK BATTERY VOLTAGE AT 15 AMP FUSE (F1)

PROCEDURE:

1. Open the front of the control panel.
2. Set the VOM to measure DC volts.
3. Place the negative test (-) lead to a clean ground and positive test (+) lead to Wire 13.

Note: The meter lead will be inserted directly into the fuse holder.

RESULTS:

1. If battery voltage is present at Wire 13, refer back to flow chart.
2. If little or no voltage battery voltage is present, check the fuse holder and Wire 13. If needed repair or replace Wire 13 between the fuse block and the terminal strip.

TEST 29 – CHECK BATTERY VOLTAGE AT AUTO-OFF-MANUAL SWITCH (SW1)

PROCEDURE:

1. Set AUTO-OFF-MANUAL switch to the AUTO position.
2. Set the VOM to measure DC volts.
3. Place the Negative test (-) lead to a clean frame ground and the positive test (+) lead to Wires 15, 15A and 194.

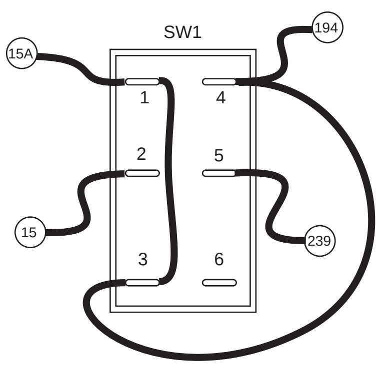


Figure 1. AUTO-OFF-MANUAL

RESULTS:

1. If the battery voltage is present at the wires mentioned in Step 3, refer back to flow chart.
2. If there is little or no battery voltage present at the wires mentioned in Step 3, proceed to troubleshoot either an open wire or defective switch.
   a. Wire 15A will only have voltage with the AUTO-OFF-MANUAL switch in the AUTO position.
   b. Wire 15 is fused battery voltage and comes from TB1 Terminal 10 and should have DC voltage present at all times.
   c. Wire 194 will only have voltage with the AUTO-OFF-MANUAL switch in the AUTO position and when DC voltage is present on Wire 15A..

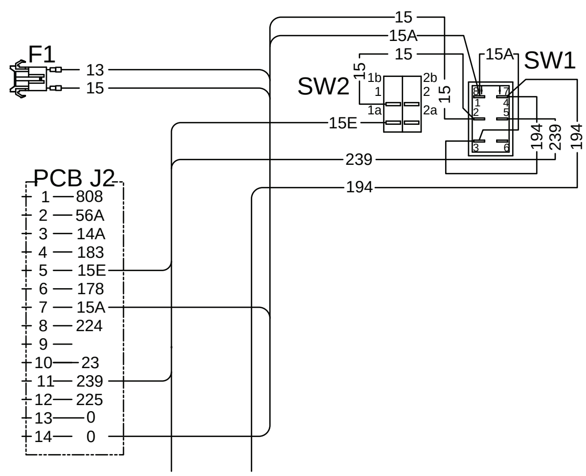


Figure 2. AUTO-OFF-MANUAL Switch Wiring

TEST 30 – TEST AUTO-OFF-MANUAL SWITCH

DISCUSSION:

When the AUTO-OFF-MANUAL switch is set to AUTO position, battery voltage (12 VDC) is delivered to the circuit board via Wire 15A, the closed switch terminal. This voltage is needed to operate the circuit board. Setting the switch to its "Manual" position delivers battery voltage to the circuit board for its operation. In addition, when the switch is set to "Manual", 12 VDC is supplied to the circuit board via Wire 239.

PROCEDURE:

Disconnect all wires from switch terminals, to prevent interaction. Then, use a VOM to test for continuity across switch terminals as shown in the following chart. Reconnect all wires and verify correct positions when finished.

TERMINALS	SWITCH POSITION	READING
2 and 3	AUTO MANUAL OFF	INFINITY CONTINUITY INFINITY
2 and 1	AUTO MANUAL OFF	CONTINUITY INFINITY INFINITY
5 and 6	AUTO MANUAL OFF	INFINITY CONTINUITY INFINITY
5 and 4	AUTO MANUAL OFF	CONTINUITY INFINITY INFINITY

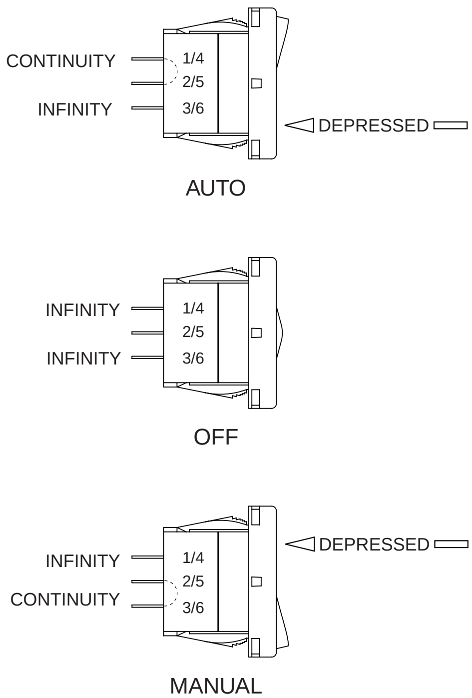


Figure 3. AUTO-OFF-MANUAL Switch Test Points

RESULTS:

1. Replace AUTO-OFF-MANUAL switch, if defective. Refer back to flow chart if necessary.

TEST 31 – CHECK BATTERY VOLTAGE AT EXERCISE SWITCH (SW2)

PROCEDURE:

1. Locate the SW2 (Exercise) switch on the front of the control panel.
2. Set VOM to measure DC voltage.
3. Place the negative (-) test lead to a clean frame ground and the positive (+) test lead to Wires 15 and 15E on SW2. See Figure 2.

RESULTS:

1. If battery voltage is present at both wires, refer back to flow chart.
2. If little or no battery voltage is present, refer to Figure 2 and check for an open between the SW1 (AUTO-OFF MANUAL) switch and the SW2 (Exercise) switch.

TEST 32 – CHECK CONTROL BOARD DIP SWITCHES

DISCUSSION:

There are 8 dip switches located on the printed circuit board. These are utilized to configure a unit to function properly according to its design parameters.

	Switch OFF	Switch ON
Position 1	60 Hz	50 Hz (where applicable)
Position 2	ATS Mode	GTS Mode
Position 3	Low Speed Exercise	Normal Speed Exercise
Position 4	LP	NG
Position 5	Reserved	Reserved
Position 6	22/27kW (1800 rpm) 45kW (3600 rpm)	36kW Turbo (1800 rpm) 60kW Turbo (3600 rpm)
Position 7	2.4L (1800 rpm)	4.2L (1800 rpm)
Position 8	Reserved	Reserved

Note: Dipswitch S2 (if equipped) has no function)

PROCEDURE:

1. Remove the 15 amp fuse from the fuse holder in the control Panel, located in the lower left side of the control panel.
2. Verify that the dip switches are set according to the chart above.
3. Re-install the 15 amp fuse to the fuse holder in the control panel.

Note: Any time a dip switch change is made the power must be cycled.

4. Turn the AUTO-OFF-MANUAL switch to the MANUAL position to verify the unit starts properly.

RESULTS:

1. If the unit doesn't start, verify the dipswitches per the chart above, refer back to the flow chart.
2. If the unit starts and runs properly, stop testing.

TEST 33 – CHECK ENGINE CRANK RELAY (RL1)

DISCUSSION:

The (RL1) start relay is used to energize the starter solenoid to turn the engine over. The control board holds Wire 56A open until it gets voltage from the AUTO-OFF-MANUAL switch on Wire 239 in the MANUAL position, or in AUTO the position on Wire 15A, if control board senses a utility loss and/or receives a 2-Wire start from the transfer switch. The control board then grounds Wire 56A and in the (RL1) start relay the contacts change state to allow voltage from Wire 15 to Wire 56 on the starter contactor relay (SCR). This action allows the starter to crank the engine.

PROCEDURE:

1. Locate the Engine Start Relay (RL1 BLACK), it is located in the back of the control panel in the center (see Figure 4).

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

2. Set the VOM to measure DC voltage.
3. Remove the RL1 relay from the socket.

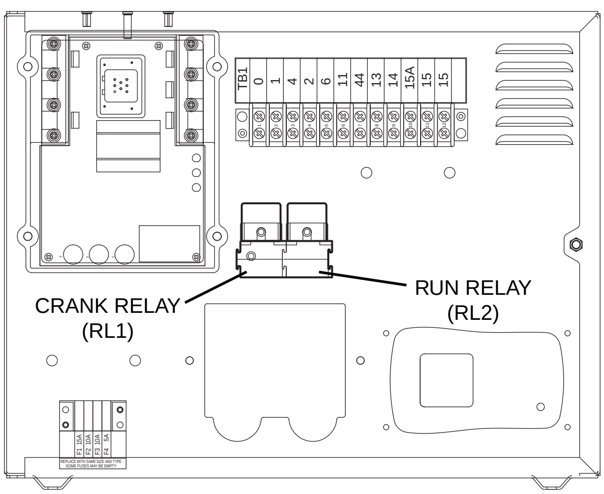


Figure 4. RL1 and RL2 Location

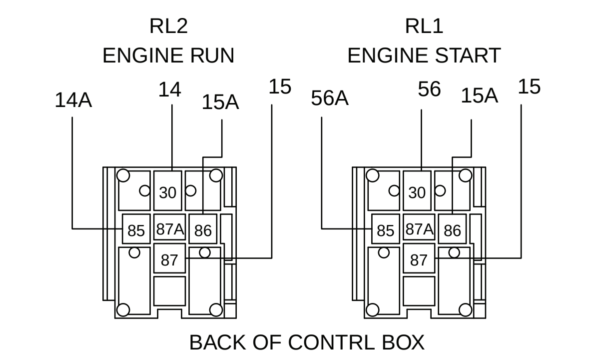


Figure 5. Engine Start Relay Wiring

4. Connect one meter test lead to Terminal Connection 87 (Wire 15) on the RL1 socket and connect the other meter test lead to a clean frame ground. Battery should be present at all times.
   - If little or no battery voltage is present, verify that Wire 15 is not pinched or cut or in any other way prevented from having proper battery voltage.
   - If battery voltage is present , check Wire 15A in Step 5.
5. Set AUTO-OFF-MANUAL switch to the AUTO position.
6. Connect one meter test lead to Terminal Connection 86 (Wire 15A) on the RL1 socket and connect the other meter test lead to a clean frame ground; battery voltage should be measured.
   - If little or no battery voltage is present, verify that Wire 15A is not pinched or cut or in any other way prevented from having proper battery voltage.
   - If battery voltage is present, check Wire 56A in Step 7
7. Connect one meter test lead to Terminal Connection 85 (Wire 56A) on the RL1 socket and connect the other meter test lead to Terminal Connection 86 (Wire 15A).
8. Set AUTO-OFF-MANUAL switch to the MANUAL position.
9. Measure and record the voltage.
   - If battery voltage is measured, proceed to Step 10.
   - If little or no battery voltage is present in Step 9, verify that Wire 56A is not pinched or cut or in any other way prevented from having proper battery voltage.

Note: 56A receives a ground from Pin 2 of the J2 Connector.

   - If Wire 56A has been verified good, replace the printed circuit board.

10. Re-insert RL1 relay.
11. Locate the Starter Contactor Relay (SCR), on the back of the control panel (see Figure 6).
12. Turn the AUTO-OFF-MANUAL switch to the MANUAL position.
13. Connect one meter lead to Wire 56 at the SCR and connect the other meter test lead to a clean frame ground.
    - If battery voltage is present during cranking, refer back to flow chart.
    - If little or no battery voltage is present, verify that Wire 56 is not pinched or cut or in any other way prevented from having proper battery voltage.
    - If Wire 56 has been verified good, replace the RL1 relay.

Note: The resistance of relay RL1 (between Terminals 85 and 86) is 90 Ohms across the coil.

RESULTS:

1. Refer back to flow chart.

TEST 34 – CHECK BATTERY VOLTAGE AT STARTER CONTACTOR RELAY (SCR)

DISCUSSION:

The Starter Contactor Relay (SCR) is used to apply battery voltage to the starter solenoid allowing the starter motor to turn the engine over during cranking operations. The control board grounds Wire 56A on the engine start relay (RL1), this action allows battery voltage to Wire 56 on the starter contactor relay (SCR). When Wire 56 has battery voltage applied to the (SCR), the battery voltage from Wire 13 is permitted though the (SCR) relay and to Wire 16 that goes to the starter solenoid.

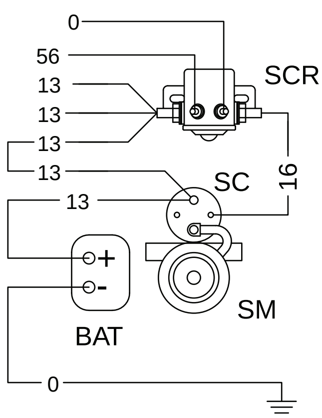


Figure 6. Starter Contactor Relay

PROCEDURE:

1. Connect one meter test lead to Wire 13 at the Starter Contactor and the other meter test lead to a clean frame ground. Battery voltage should always be present.
   - If battery voltage is present, go to Step 2.
   - If little or no battery voltage is present, verify that Wire 13 is not pinched or cut or in any other way prevented from having proper battery voltage.
2. Connect one meter test lead to Wire 16 at the Starter Contactor and the other meter test lead to a clean frame ground.
3. Turn the AUTO-OFF-MANUAL switch to the MANUAL position. Battery voltage should be measured during cranking.

RESULTS:

1. If battery voltage is present at Wires 13 and 16, refer back to flow chart.
2. If little or no battery voltage is present on Wire 16 and Wires 56 and 13 have battery voltage present, replace the starter contactor relay (SCR).

TEST 35 – CHECK BATTERY VOLTAGE AT STARTER MOTOR (SM)

PROCEDURE:

1. Set the VOM to measure DC voltage.
2. Place the Negative (-) test lead to a clean frame ground and the positive (+) test lead to Wire 16 on the starter solenoid.
3. Turn the AUTO-OFF-MANUAL switch to the MANUAL position.

RESULTS:

1. If battery voltage is present when placing the AUTO-OFF-MANUAL switch to the MANUAL position and the engine still didn't turn over, replace the starter motor.
2. If battery voltage is present when the placing the AUTO-OFF-MANUAL switch to the MANUAL position and the starter motor tried to engage (pinion engaged), but engine did NOT crank, check for mechanical binding of the engine or rotor.
3. If there is little or no battery voltage present , verify Wire 16 is not pinched or cut and inspect for any other conditions that would not allow battery voltage to Wire 56.

TEST 36 – TESTING STARTER MOTOR

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.

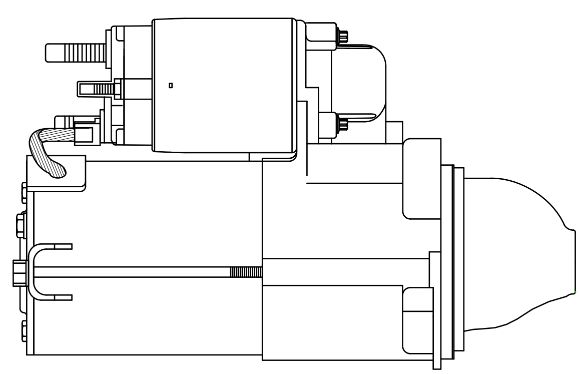


Figure 7. Starter Motor

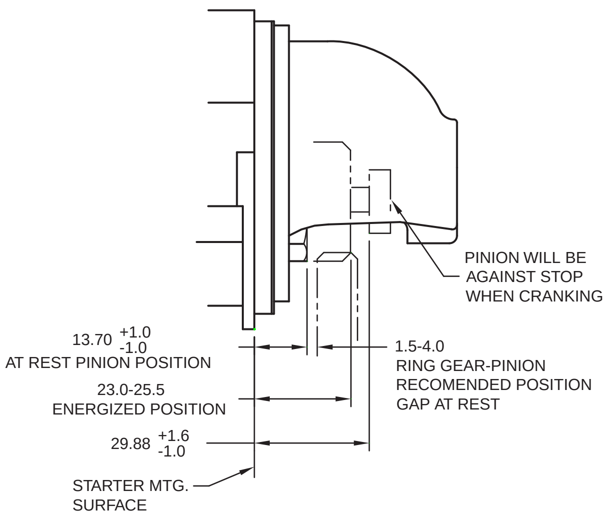


Figure 8. Check Pinion Gear Operation

<u>TOOLS FOR STARTER PERFORMANCE TEST:</u>

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.

<u>MEASURING CURRENT:</u>

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.

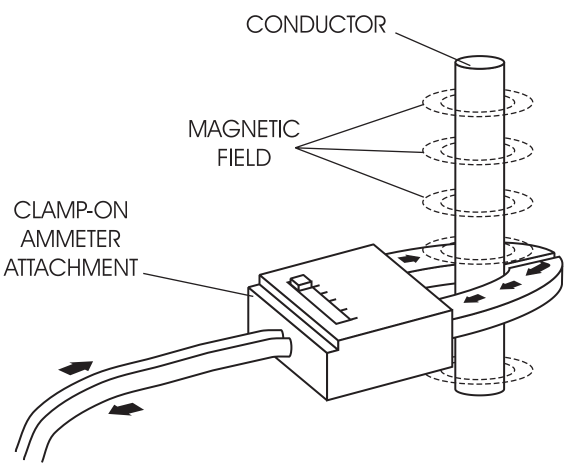


Figure 9. Clamp-On Ammeter

<u>TACHOMETER:</u>

A tachometer is available from your parts source. The tachometer measures from 800 to 50,000 rpm, Figure 10.

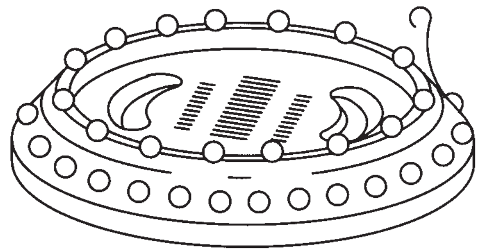


Figure 10. Tachometer

<u>TEST BRACKET:</u>

A starter motor test bracket may be made as shown in Figure 11. A growler or armature tester is available from an automobile diagnostic service supplier.

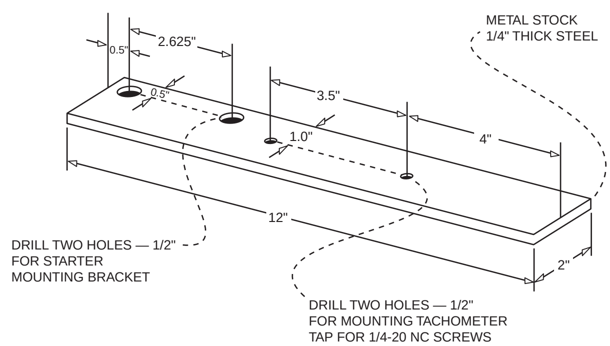


Figure 11. Test Bracket

<u>REMOVE STARTER MOTOR:</u>

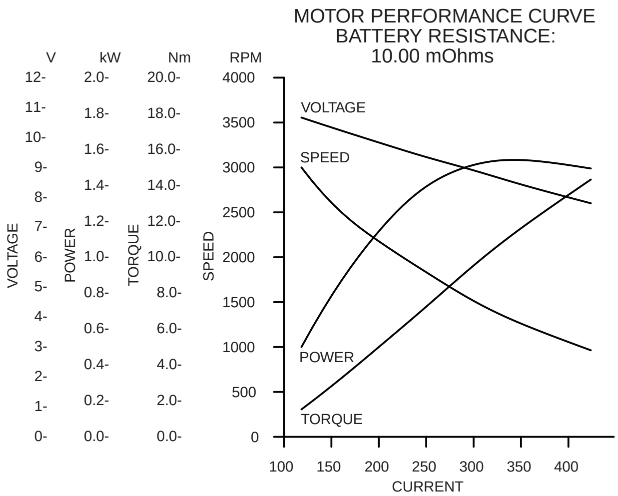
It is recommended that the starter motor be removed from the engine when testing starter motor performance. Assemble starter to test bracket and clamp test bracket in vise, Figure 12.

<u>TESTING STARTER MOTOR:</u>

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

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:



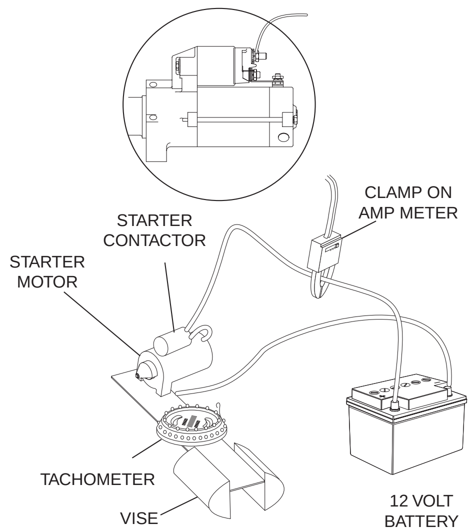


Figure 12. Testing Starter Motor Performance

TEST 41 – CHECK AUTO-OFF-MANUAL SWITCH POSITION

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:

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 1.6 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 cool down 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, go to Problem 10 in Section 3.3.
3. If engine cranks but won’t start, go to Problem 12 in Section 3.3.
4. If engine cranks and starts, but transfer to “Standby” does NOT occur, refer to the appropriate transfer switch diagnostic manual.
5. If transfer to “Standby” occurs, but retransfer back to “Utility” does NOT occur when utility source voltage is restored, refer to the appropriate transfer switch diagnostic manual.

TEST 42 – 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. Set the generator main line circuit breaker to its OFF (or open) position.
2. Set the generator AUTO-OFF-MANUAL switch to MANUAL.
   a. The engine should crank cyclically through its “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, refer back to flow chart.
2. If the engine does not crank manually, proceed to Problem 9 in Section 3.3.

TEST 43 – CHECK MAINTENANCE DISCONNECT SWITCH

DISCUSSION:

In a GTS type transfer switch a maintenance disconnect switch is installed in the switch to disable its automatic features to prevent a generator from starting and a transfer occurring while a technician is working on a piece of equipment.

PROCEDURE:

1. Locate the Maintenance Disconnect Switch inside the transfer switch.
2. It should be in the Automatic position.

RESULTS:

1. If the switch was in the "AUTO" position, refer back to flow chart.
2. If the switch was "OFF", place in "AUTO" position and re-try a simulated power outage.

TEST 44 – CHECK STATUS READY LIGHT

DISCUSSION:

On the main control panel there is a green LED which indicates the status of the unit. With the AUTO-OFF-MANUAL switch in the OFF position this LED will not be illuminated. In the AUTO position it will be flashing if a there is a loss of utility power, and it will be solid when utility is available and generator is awaiting a power failure. The LED will flash 5 seconds on and 1 second off if the generator is set up for a 2-Wire start transfer switch (GTS).

PROCEDURE:

1. Observe the LED

RESULTS:

1. Refer back to flow chart

TEST 45 – CHECK POSITION OF DIP SWITCH 2

DISCUSSION:

Located on the printed circuit board there are 8 dip switches. These switches are used to configure the printed circuit board depending on the configuration of the unit and the type of installation. Dip Switch 2 tells the printed circuit board what type of transfer switch is installed.

PROCEDURE:

1. Verify position of Dip Switch 2.

OFF	ON
ATS	GTS

RESULTS:

1. If switch is in the ON position it is configured for a GTS or 2-Wire start system. Switch to the OFF position and refer back to flow chart.

Note: If a change is made remove F1 (15 amp Fuse) for 10 seconds and re-insert.

TEST 46 – CHECK BATTERY VOLTAGE AT J2 CONNECTOR

DISCUSSION:

Battery voltage is delivered to the board via two wires, 15E and 15A. Wire 15E provides power to the printed circuit board in all three positions of the AUTO-OFF-MANUAL switch. Wire 15A provides power to the printed circuit board to let it know that it is in the AUTO position. These two inputs are crucial to the auto operation of the generator.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

1. Disconnect the white 14 pin J2 connector going into the printed circuit board.
2. Set AUTO-OFF-MANUAL switch to the AUTO position.
3. Set VOM to measure DC voltage.

Refer to Figure 2 in Section 3.1.

4. Connect one meter lead to Pin 5 (Wire 15E) and the other meter lead to a clean frame ground. Measure and record the voltage.
5. Connect one meter lead to Pin 7 (Wire 15A) and the other meter lead to a clean frame ground.

RESULTS:

1. Battery voltage should be measured in Steps 4 and 5. Refer back to flow chart.

TEST 47 – CHECK VOLTAGE AT AUTO-OFF MANUAL (SW1) & EXERCISE (SW2) SWITCHES

DISCUSSION:

Voltage on 15E is delivered to the board from the SW2 (Exercise) switch. Voltage on 15A is delivered to the board from the SW1 (AUTO-OFF-MANUAL) switch when the switch is in the AUTO or MANUAL position.

PROCEDURE:

1. Set VOM to measure DC voltage.
2. Connect one meter lead to Wire 15E at SW2 and connect the other meter test lead to a clean frame ground. Measure and record the voltage.
3. Set AUTO-OFF-MANUAL position to the AUTO position.
4. Connect one meter lead to Wire 15A at SW1 Terminal 1 and connect the other meter test lead to a clean frame ground. Measure and record the voltage.

RESULTS:

1. Battery voltage should be measured in Steps 2 and 4. Any reading other than battery voltage indicates a failure of that component or wiring leading to the component. Refer to Test 30 to troubleshoot the AUTO-OFF-MANUAL switch. Refer to Test 48 to troubleshoot the Set Exercise Switch.

TEST 48 – TEST EXERCISE SWITCH (SW2)

DISCUSSION:

The exercise switch is a normally closed switch that opens when it is pressed. This momentary opening removes voltage from Wire 15E from the printed circuit board and will set the exercise time at the specific time and date that the switch is pressed.

PROCEDURE:

1. Disconnect Wires 15E and 15 from the SW2 (Exercise) switch.
2. Set VOM to measure resistance (Ω).
3. Connect one meter test lead to the terminal where Wire 15E was removed and connect the other meter test lead to the terminal where Wire 15 was removed. CONTINUITY should be measured.
4. Actuate the switch back and forth. The meter should change from CONTINUITY to INFINITY.

RESULTS:

1. If the switch did not change from a closed state to an open state each time it was pressed, replace the switch.

TEST 49 – CHECK WIRES 0, 15A, 15E

DISCUSSION:

If the printed circuit board does not receive a good signal from all three wires the AUTO operation of the generator could be effected. If the board has a high resistance on the ground circuit it would cause voltages to be lower than nominal and could cause the generators logic to be distorted.

PROCEDURE:

1. Disconnect the J2 (14 Pin) connector from the printed circuit board.
2. Disconnect Wire 15A from the AUTO-OFF-MANUAL switch.
3. Disconnect Wire 15E from the SW2 (Exercise) switch.
4. Set VOM to measure resistance (Ω).

Refer to Figure 2 in Section 3.1.

5. Connect one meter test lead to J2 Pin 5 (Wire 15E) and connect the other meter test lead to the disconnected Wire 15E. CONTINUITY should be measured.
6. Connect one meter test lead to J2 Pin 7 (Wire 15A) and connect the other meter test lead to disconnected Wire 15A. CONTINUITY should be measured.
7. Connect one meter test lead to J2 Pin 14 (Wire 0) and connect the other meter test lead to a clean frame ground. Measure and record the resistance.

RESULTS:

1. If anything other than CONTINUITY was measured in Steps 5 and 6 repair or replace that particular wire.
2. If a reading higher than 0.5 Ohms (Ω) was measured in Step 7, clean the ground studs.

TEST 55 – ATTEMPT A 2-WIRE START

DISCUSSION:

The generator will utilize Wire 183 and 178 to look for a 2-Wire start signal from the transfer switch. The printed circuit board will put 5 VDC on Wire 183 and wait to see the same 5 VDC on 178, when the wires are connected either through a relay or a circuit board. The generator will start up and stay running as long as those wires are kept closed.

PROCEDURE:

1. Set AUTO-OFF-MANUAL switch to the AUTO position.
2. Place a jumper wire across terminal to TB-G 1 (Wire 183) and TB-G 2 (Wire 178) of Terminal Block G (Located in the customer connection area.

⚠ **Caution: When performing Step 2, the generator will crank and start.**

RESULTS:

1. Refer back to flow chart.

TEST 56 – CHECK VOLTAGE ON WIRE 183

DISCUSSION:

This test will verify that 5 VDC is getting to the terminal strip.

PROCEDURE:

1. Set AUTO-OFF-MANUAL switch to the AUTO position
2. Set VOM to measure DC voltage.
3. Connect one meter lead to Terminal 1 (Wire 183) of TB-G and the other meter lead to a clean frame ground. Measure and record the voltage.

RESULTS:

1. A voltage of 5 VDC should be measured in Step 3. Refer back to flow chart.

TEST 57 – CHECK WIRE 183

PROCEDURE:

1. Disconnect the J2 (14 Pin) connector from the printed circuit board
2. Connect one meter lead to Pin 4 of the J2 and connect the other meter test lead to Terminal 1 (Wire 183) of TB-G. CONTINUITY should be measured.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

RESULTS:

1. If anything, but CONTINUITY was measured repair or replace the wire between J2 Pin 4 and Terminal 1 of TB-G.
2. If CONTINUITY was measured, refer back to flow chart.

TEST 58 – CHECK WIRE 178

PROCEDURE:

1. Disconnect the J2 (14 Pin) connector from the printed circuit board.
2. Connect one meter lead to Pin 6 of the J2 and connect the other meter test lead to Terminal (Wire 178) of TB-G. CONTINUITY should be measured.

RESULTS:

1. If anything but CONTINUITY was measured repair or replace the wire between J2 Pin 6 and Terminal 2 of TB-G.
2. If CONTINUITY was measured, refer back to flow chart.

TEST 62 – CHECK FOR SPARK

CAUTION: When checking for spark on the unit, make sure to have the fuel supply turned off to the unit.

PROCEDURE:

1. Locate the spark plug wires on top of the valve cover and mark them so they can be replaced in the proper location.
2. Remove spark plug wires from the valve cover.
3. Working one cylinder at a time, connect an in-line spark plug tester to the spark plug and the spark plug wire on each cylinder.

Tech tip: Make sure the spark plug tester is secure, so it can give the most accurate spark reading.

3. Turn the AUTO-OFF-MANUAL switch to the MANUAL position

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Observe the spark plug tester window while the engine is cranking over.

RESULTS:

1. If spark is bright and strong for each plug then it is good. Refer back to flow chart.
2. If any of the spark plugs has no spark or a weak spark, then replace the respective plug and refer back to flow chart.

TEST 63 – CHECK THE CONDITION OF THE SPARK PLUGS

PROCEDURE:

1. Locate the spark plug wires on top of the valve cover and mark them so they can be replaced in the proper location.
2. Remove spark plug wires from the valve cover.
3. Remove the spark plugs one at a time and inspect for the conditions shown in Figure 14.
4. Check the gap of each plug. The gap should be between 0.042" – 0.046".

RESULTS:

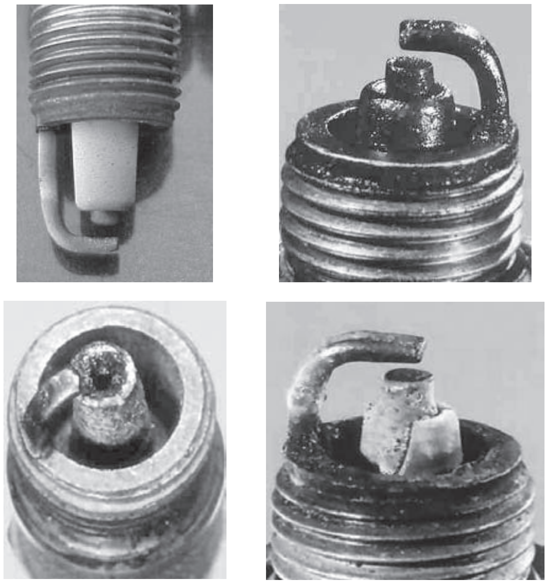
1. If the spark plugs exhibit any possible signs of any of the symptoms shown in Figure 14, replace the spark plugs and investigate the possible cause of the problem.
2. Refer back to the troubleshooting flowchart.

Tech tip: For further information about checking the spark plugs reference Section 1.8.

ASSEMBLY:

1. Reinstall the spark plugs into the cylinder head.
2. Torque each spark plug to 18 ft-lb.
3. Reconnect the spark plug wires to the spark plugs.

NORMAL MISFIRES



PRE-IGNITION DETONATION

Figure 14. Spark Plug Conditions

TEST 64 – CHECK IGNITION COILS

DISCUSSION:

A weak spark can be caused by the ignition coils insulation breaking down and providing an alternate path to ground. A no spark condition can be caused by an ignition coil being in an open circuit condition or a direct short condition, internal winding to winding or to ground.

The Ignition Control Module acts as an electronic switch to ground in the coil primary circuit. When the switch is closed, battery voltage positive (+) is (Wire 15D) applied to the coil primary circuit builds a magnetic field around the primary coil. When the switch opens, the power is interrupted and the primary field collapses inducing the high voltage into the secondary coil windings and the spark plug fires the cylinder.

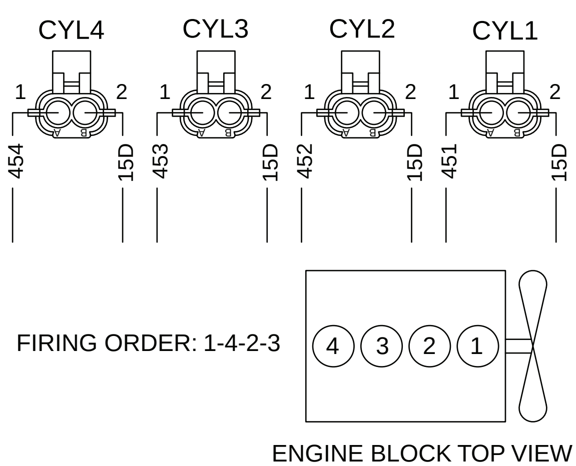


Figure15. Ignition Coils

PROCEDURE:

1. Check the ignition coil resistance between Wire 451 and 15D, Wire 452 and 15D, Wire 453 and 15D, and Wire 454 and 15D. The resistance readings across the terminals should be approximately 0.3 Ohms to 0.8 Ohms. Resistance readings between each terminal and ground should be infinite.
2. Turn off Fuel supply
3. Set VOM to measure DC voltage.
4. Connect one meter test lead to Wire 15D on the female side of the coil connector and the other meter test to a clean frame ground.
5. Set AUTO-OFF-MANUAL switch to the MANUAL position; measure the voltage.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

6. Repeat steps 4 and 5 for all coils.

RESULTS:

1. If any of the coil resistances measured were not within the range specified, or there was any readings to ground, replace the suspected ignition coil(s).
2. If 10VDC is measured in step 3 then refer back to flow chart. If no voltage was measured in step 3 then inspect for a loose or pinched wire between the coil and the ignition module.

TEST 65 – CHECK IGNITION CONTROL MODULE

DISCUSSION:

The Ignition Control Module controls all aspects of the engine ignition based on the inputs it receives from the Crank Sensor (MPU1) and the Cam Sensor (MPU2). In the previous tests the inputs to the Ignition Control Module were checked to verify the integrity of the ignition coils. Now the Ignition Control Module will be checked to see what the incoming signals from the Crank and Cam Sensors are indicating.

Tech Tip: Electronic Ignition engine timing is entirely controlled by the Ignition Control Module. Electronic ignition engine timing is NOT adjustable. Do not attempt to check base timing. False readings can be received. The Ignition Control Module has a red diagnostic LED inside which is visible without removing the ignition cover, but the ignition module may need to be removed to view the back of the module. This red LED will

indicate if the ignition has been energized. The LED will flash at a 0.5 second ON and a 0.5 second OFF interval when the ignition is energized. This is considered (1) blink.

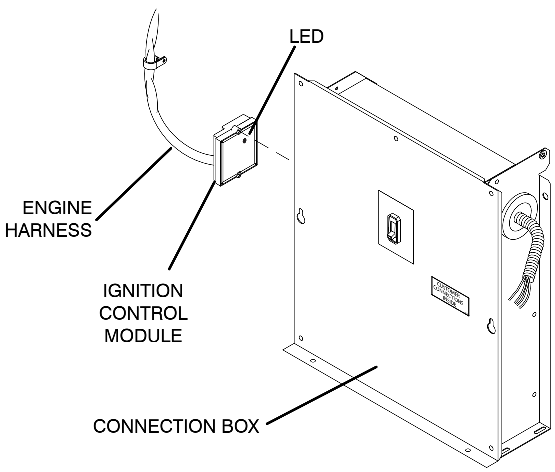


Figure 16. Ignition Control Module

PROCEDURE:

1. Locate the Ignition module on the control panel assembly.
2. Observe the pre-drilled holes where the ignition module bolts hold the ignition module to the control panel assembly.

Note: The hole is inside the customer connection box.

3. Turn the AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Observe the Red LED code on the ignition module. The fault LED is only valid during cranking in the first cycle.

Tech Tip: The ignition cover does not need to be removed to see the RED LED.

RED LED Fault Codes with priority as shown:		
1	Overspeed Shutdown	LED blinks 4 times, is OFF for 3 seconds and then repeats
2	Missing Ignition Control Module Teeth	LED blinks 5 times, is OFF for 3 seconds and then repeats
3	No Ignition Control Module Signal	LED blinks 2 times, is OFF for 3 seconds and then repeats
4	No Cam Signal	LED blinks 3 times, is OFF for 3 seconds and then repeat

Tech Tip: The highest priority fault will be displayed and must be resolved before the lower priority fault code will be displayed on the ignition module. After the code has blinked for 60-120 seconds the ignition module will power itself down and clear the code that was displayed.

RESULTS:

1. If the red LED blinks normally and then goes out and stays out during cranking, go to Test 66.
2. If the ignition module displays a code, solve that problem first and then verify the ignition module for a lower priority code to solve. If there is no lower LED code, refer back to flow chart
3. If the LED is not illuminated, refer back to flow chart.

TEST 66 – CHECK DC VOLTAGE INPUTS TO IGNITION MODULE

PROCEDURE:

1. Disconnect the Ignition Module connector.
2. Set a VOM to measure DC voltage.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

Refer to Figure 6 in Section 3.1.

3. Connect one meter test lead to Pin 16 (Wire 15) and connect the other meter test lead to a clean frame ground. Battery voltage should be measured.

Step 4 is for Natural Gas units Only, if LP proceed to Step 5.

4. Connect one meter test lead to Pin 12 (Wire 14) and connect the other meter test lead to a clean frame ground.
5. Set AUTO-OFF-MANUAL switch to the MANUAL position. Battery voltage should be measured.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

6. Connect one meter test lead to Pin 11 (Wire 56) and connect the other meter test lead to a clean frame ground. Battery voltage should be measured.

Note: The unit must still be cranking to get voltage at Wire 56.

RESULTS:

1. If the Battery voltage is lower than 10 VDC on any of the

Wires 15, 14 (NG Only), and 56 proceed to investigate the following circuits:

- Wire 15 is fused DC voltage from the 15 amp fuse.
- Wire 14 is fused DC voltage that is only available when the unit is cranking or running and is supplied from the RL2 (Run) relay.
- Wire 56 is fused DC voltage that is only available when the unit is cranking and is supplied from the RL1 (Crank) relay.

2. If battery voltage is measured, refer back to flow chart.

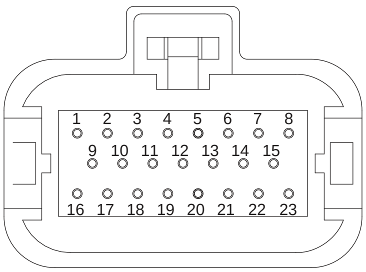


Figure 17. Ignition Control Module Harness End Pin-outs

TEST 67 – CHECK CRANK SENSOR

DISCUSSION:

The Crank Sensor (MPU1) is the primary sensor for ignition information to the Ignition Control Module. The input is used by the Ignition Control Module to determine engine speed and angular position of the crankshaft. The PCB utilizes this signal for crank detection and speed reference for governing. The location of the crank sensor is shown in Figure 18.

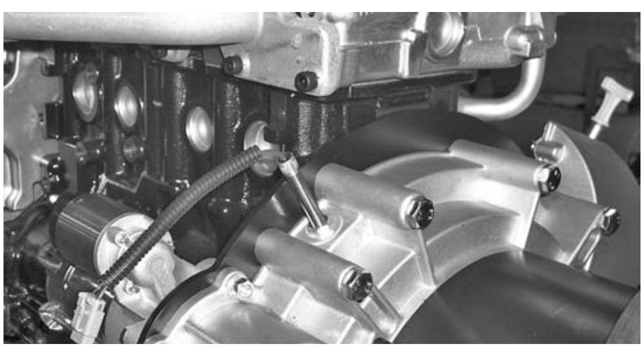


Figure 18. Crank Sensor (MPU1)

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE (FLASHING OVERSPEED):

1. Disconnect the Crank Sensor (MPU1) from the engine harness.
2. Set the VOM to measure resistance (Ω).

Tech Tip: A breakout harness is available to measure voltage and resistance in-line with the crank sensor. See Figure 4, Section 4.1.

3. Connect one meter test lead to Wire 79 and the other meter test lead to Wire 0. on MPU1. Measure resistance.
   - If the Crank Sensor resistance is approximately 700 to 1000 Ohms, go to Step 4.
   - If the Crank Sensor resistance is not within limits, replace the Crank Sensor and refer to “Crank Sensor Installation and Adjustments,” located in Section 4.1.
4. Disconnect Wire 14 from the fuel solenoid to disable starting.
5. Set a VOM to measure AC voltage.
6. Set the AUTO-OFF-MANUAL Switch to MANUAL.
7. Connect one meter test lead to Wire 79 and the other meter test lead to Wire 0. Approximately 1.5 VAC should be measured.
8. Refer to Figure 6 in Section 3.1. With the ignition module connector connected connect one meter test lead to Pin 10, Wire 79 and connect the other meter test lead to Pin 9, Wire 0.
   - Crank Sensor resistance is being measured in this step and should be the same as measured in Step 3.

Note: If acceptable Crank Sensor resistance was measured in Step 3 and Step 8 and good voltage was measured in Step 7, an issue may still exist whereby the tip of the Crank Sensor is dirty and may need to be cleaned. See section 4.1 for cleaning and reinstallation of the Crank Sensor.

PROCEDURE (IGNITION MODULE FAULT):

1. Disconnect the Crank Sensor (MPU1) from the engine harness.
2. Set the VOM to measure resistance (Ω).

Tech Tip: A breakout harness is available to measure voltage and resistance in-line with the crank sensor. See Figure 4, Section 4.1.

Refer to Figure 17 in Section 3.4, and Figure 6 in Section 3.1.

3. Connect one meter test lead to Wire 79 and the other meter test lead to Wire 0. Measure resistance.
   - If the Crank Sensor resistance is approximately 700 to 1000 Ohms, go to Step 4.
   - If the Crank Sensor resistance is not within limits, replace the Crank Sensor and refer to “Crank Sensor Installation and Adjustments,” located in Section 4.1.

4. Disconnect Wire 14 from the fuel solenoid to disable starting
5. Set a VOM to measure AC voltage.
6. Set the AUTO-OFF-MANUAL Switch to MANUAL.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.

7. Connect one meter test lead to Wire 79 and the other meter test lead to Wire 0. Approximately 1.5 VAC should be measured.

Tech Tip: A breakout harness is available to measure voltage and resistance in-line with the crank sensor. See Figure 4, Section 4.1.

8. Connect one meter test lead to Pin 14 (Wire 79) and connect the other meter test lead to Pin 21 (Wire 0).
   - Crank Sensor resistance is being measured in this step and should be the same as measured in Step 3.

Note: If acceptable Crank Sensor resistance was measured in Step 3 and Step 8 and good voltage was measured in Step 7, an issue may still exist whereby the tip of the Crank Sensor is dirty and may need to be cleaned. See section 4.1 for cleaning and reinstallation of the Crank Sensor.

RESULTS:

1. If resistance was measured in Step 3 but not in Step 8 then a connection issue exists between the Crank Sensor and the connector which could be caused by either a bad pin connection or an open wire.
2. If good resistance was measured in Step 3 and Step 8, but little or no voltage was measured in Step 7, refer to section 4.1 for adjustment and reinstallation of the Crank Sensor.
3. If resistance was measured in Step 3 and Step 8 and good voltage was measured in Step 7, refer back to the flow chart.

TEST 68 – CHECK FUEL SUPPLY AND FUEL PRESSURE TO THE UNIT

DISCUSSION:

The engine-generator set was factory tested and adjusted using the primary fuel source (natural gas) as the fuel supply.

- An adequate gas supply and sufficient fuel pressure must be available or the engine will not start or run properly.
- Minimum gaseous fuel pressure at the generator fuel inlet connection is 5 inches water column.
- Maximum gaseous fuel pressure at the generator fuel inlet connection is 14 inches water column.
- The gaseous fuel system must be properly tested for leaks following installation and periodically thereafter. No leakage is permitted. Leakage testing 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 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 (top port-where the low fuel pressure switch is located) on the fuel regulator should be between 5 to 14 inches water column when measured with a manometer.

The fuel pressure can be checked using the recommended fuel pressure tester kit or any fuel pressure tester that measures inches of water column.

1. Turn off fuel to primary regulator by whatever means are provided.
2. Connect a manometer to Test Port B (see Figure 22).
3. Turn fuel supply back on.
4. Measure and record the NOT RUNNING pressure.
5. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.

6. Measure and record the RUNNING pressure.

Note: The difference in pressure between Not Running and Running should not be greater than 1” of water column and must remain within specifications.

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 5 to 14 inches water column at all load requirements. If proper fuel supply and pressure is maintained, refer back to flow chart.

TEST 69 – CHECK WIRE 14 FOR BATTERY VOLTAGE

DISCUSSION:

Wire 14 is used to apply battery voltage to the fuel solenoid to move the plunger up to allow fuel to the mixer assembly.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

1. Locate the fuel solenoid on top of the fuel regulator
2. Set a VOM to measure DC voltage
3. Turn the AUTO-OFF-MANUAL switch to the Manual position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Disconnect Wire 14 from the Fuel Solenoid.
5. Connect one meter test lead to Wire 14 and the other meter test lead to a clean frame ground. Battery voltage should be measured.

Note: DC voltage is only available on Wire 14 during cranking and running operations.

Tech Tip: Place a screw driver over the solenoid during cranking and see if the screw driver is magnetically drawn to the solenoid. If the screw driver is pulled in the fuel solenoid is getting voltage.

RESULTS:

1. If Wire 14 has no battery voltage present during cranking and running, the run relay could be the problem; refer back to the flow chart.
2. If voltage is present on Wire 14, refer back to flow chart.

TEST 70 – CHECK ENGINE RUN RELAY (RL2)

DISCUSSION:

The (RL2) run relay is used to energize the run circuit (Wire 14). The control board holds Wire 14A open until it gets voltage from the AUTO-OFF-MANUAL switch on Wire 239 in the MANUAL position, or in the AUTO position if the control board senses a utility loss and/or receives a 2-Wire start from the transfer switch. The control board then grounds Wire 14A. The (RL2) run relay contacts change state to allow voltage from Wire 15 to Wire 14. This action provides DC voltage to the run circuit.

PROCEDURE:

1. Locate the Engine Run Relay (RL2 BLACK), it is located in the back of the control panel in the center. See Figure 19.
2. Set the VOM to measure DC voltage
3. Remove the RL2 relay from the socket

Refer to Figure 20.

4. Connect one meter test lead to Terminal Connection 87 (Wire 15) and connect the other meter test lead to a clean frame ground; battery voltage should be present at all times.
   - If little or no battery voltage is present, verify that Wire 15 is not pinched , cut or any other conditions that would not allow voltage to be present on Wire 15
   - If battery voltage is present , check Wire 15A in Step 5

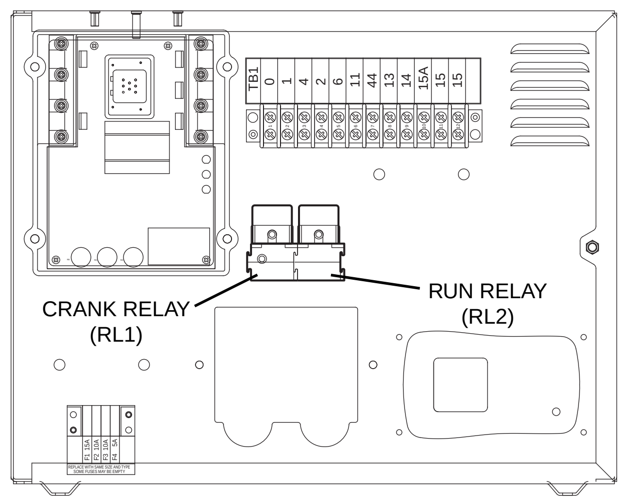


Figure 19. Engine Run Relay Location

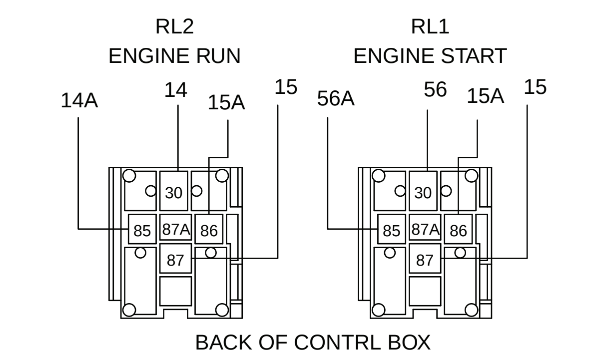


Figure 20. Engine Run Relay Wiring

5. Set AUTO-OFF-MANUAL switch to the AUTO position.
6. Connect one meter test lead to Wire 15A and connect the other meter test lead to a clean frame ground; battery voltage should be measured.

- If little or no battery voltage is present, verify that Wire 15A is not pinched , cut and look for any other conditions that would not allow voltage to be present on Wire 15A.
- If battery voltage is present, check Wire 14A in Step 7

7. Connect one meter test lead to Terminal Connection 85 (Wire 14A) on the RL2 socket and connect the other meter test lead to Terminal Connection 86 (Wire 15A).
8. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

9. Measure and record the voltage.
   - Battery voltage should be measured.
   - If little or no battery voltage is present in Step 9, verify that Wire 14A is not pinched, cut or any other conditions that would not allow voltage to be present on Wire 14A.
   - If Wire 14A has been verified good, replace the printed circuit board.
10. Re-insert RL2 relay.
11. Locate the main fuel solenoid located on top of the fuel regulator.
12. Turn the AUTO-OFF-MANUAL switch to the MANUAL position

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

13. Connect one meter test lead to Wire 14 at TB1 Terminal 9 and the other meter test lead to a clean frame ground.
    - If battery voltage is present during cranking and voltage was not measured in Test 69 then inspect for a pinched or cut Wire 14 between TB1 and the fuel solenoid (FS1).
    - If there is little or no battery voltage present, verify Wire 14 is not pinched, cut and inspect for any other conditions that could exist between TB1 and the RL2 relay.
    - If Wire 14 has been verified good, replace the RL2 relay.

RESULTS:

1. Refer back to flow chart.

Note: Resistance between Terminals 87 and 85 of relay RL2 is 90 Ohms.

TEST 71 – CHECK CAM SENSOR

DISCUSSION:

The camshaft position sensor (MPU2) identifies when Piston #1 is at Top Dead Center (TDC) of the compression stroke. The Ignition Control Module uses this information to synchronize the firing of the individual coils. The location of the Camshaft position sensor (MPU2) is shown in Figure 21.

PROCEDURE:

1. Locate the Cam Sensor near the timing belt cover (see Figure 21).
2. Disconnect the Cam Sensor from the engine harness.
3. Set VOM to measure resistance (Ω).
4. Place the Positive test (+) lead to Wire79A and negative test (-) lead to Wire 0A of MPU2.

RESULTS:

1. If Cam Sensor resistance is approximately 700 to 1000 Ohms , refer to Section 4.1 for proper adjustments.
2. If Cam Sensor resistance is not with-in limits , replace the Cam Sensor and refer to "Cam Sensor Installation and Adjustments," located in Section 4.1.

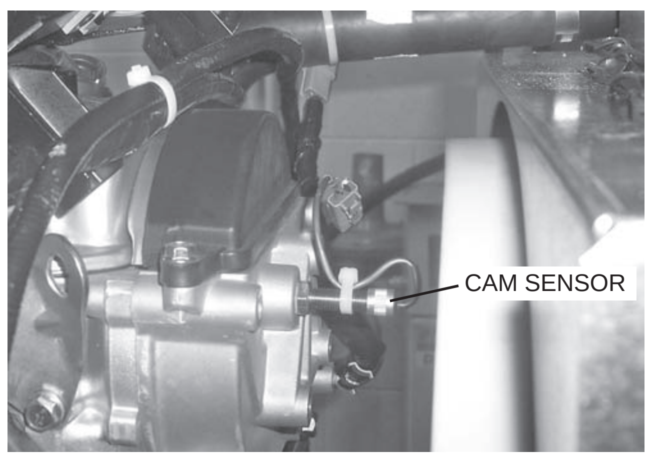


Figure 21. Cam Sensor

TEST 72 – CHECK FUEL REGULATOR

DISCUSSION:

If Wire 14 had voltage but fuel is still not getting to the Bosch governor, the fuel solenoid may not be opening properly or not at all. There are two fuel solenoids on the unit which provide fuel during two conditions: cranking and running. The (FS) Fuel solenoid is used during normal cranking and running operations. The (FS2) fuel solenoid is only used during cranking operations and is controlled by (+) voltage on Wire 56. This is the cold start fuel solenoid.

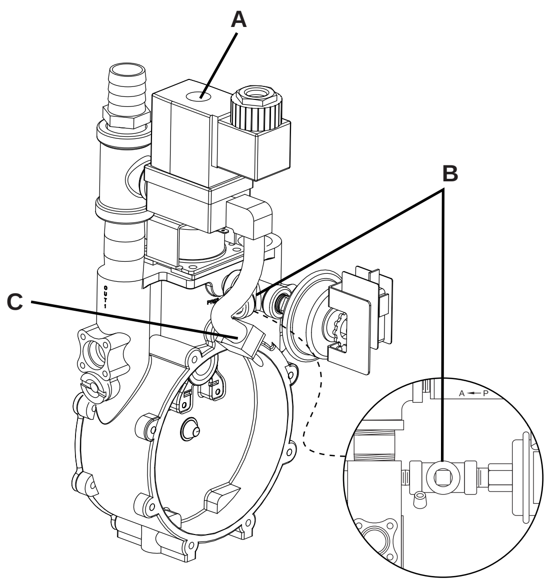


Figure 22. Fuel Regulator Test Points

PROCEDURE:

1. Disconnect the hose from Test Port C shown in Figure 22.
2. Connect a manometer to the port from which the hose was removed.
3. Set AUTO-OFF-MANUAL switch to the MANUAL position. A nominal fuel pressure reading of between 5 – 14 inches of water column should be measured.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Set a VOM to measure DC voltage.
5. Disconnect Wire 56 from the Cold Start Solenoid (FS2).
6. Connect one meter test lead to disconnected Wire 56 and connect the other meter test lead to a clean frame ground.
7. Set AUTO-OFF-MANUAL switch to the MANUAL position. Battery voltage should be measured. If battery voltage is measured, proceed to Step 8. If battery voltage is not measured, repair or replace Wire 56 between the Cold Start Solenoid and the Starter Contactor.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

8. Hold the blade of a screw driver over Test point A (see Figure 22).
9. Set AUTO-OFF-MANUAL switch to the MANUAL position. The Solenoid should magnetize and pull the screw driver securely to the solenoid.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

RESULTS:

1. If proper pressure was measured in Step 3 and DC voltage was measured in Step 6 and the screw driver was pulled in Step 9, then refer back to flow chart.
2. If fuel pressure was not measured then the fuel solenoid (FS1) is not opening. Replace the solenoid.
3. If the screw driver did not pull in then the cold start solenoid (FS2) is not opening. Replace the solenoid.

Tech Tip: Air leaks maybe present in the fuel lines causing the engine fuel mixture to run either too lean or to rich. Spraying carb cleaner or brake cleaner around the fuel lines while running will show if an air leak is present because the engine will suck the liquid in and speed up for a moment.

TEST 73 – CHECK GOVERNOR DRIVER

The governor on product using the R-200B control board is built into the control board and controls the engine much in the same manner as an external governor controller. There is a Governor Driver Board that takes the Pulse Width Modulated Signal from the R-200B control board output and then converts that signal to a variable DC signal to drive the actuator.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

1. Locate the governor driver in the upper right corner of the control panel (see Figure 5 in Section 3.1).
2. Disconnect the driver connector.
3. Set a VOM to measure DC voltage.

Refer to Figure 5 in Section 3.1.

4. Connect one meter test lead to Pin 4 (Wire 14) and the other meter test lead to Pin 1 on the female side of the connector.
5. Turn the AUTO-OFF-MANUAL switch to the MANUAL position. Approximately 10VDC should be measured.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

RESULTS:

1. If voltage was not measured in Step 5, replace the printed circuit board.
2. If voltage was measured, refer back to the flow chart.

TEST 74 – CHECK THE ACTUATOR AND MIXER FUNCTION

DISCUSSION:

The actuator is controlled by the governor controller (located on the PCB) and the governor driver module. The amount of fuel entering the engine is controlled by the amount of engine vacuum produced across the mixer during cranking.

PROCEDURE:

1. Verify that there is no binding throughout the full range of motion of the actuator butterfly using a screw driver. If it is binding or it stops moving at one point in the range of motion, replace the actuator.

Note: The actuator will offer stiff resistance to a change in position. It is only critical that the full range motion of the butterfly is good.

2. Disconnect the engine wiring harness from the Bosch governor actuator. (See Figure 23)
3. Set a VOM to measure DC voltage.
4. Connect one meter test lead to Pin 1 (Wire 771) and connect the other meter test lead to Pin 4 (Wire 770) on the female side of the 6 pin connector. Refer to Figure 23.
5. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

Measure and record the voltage. Approximately 10VDC should be measured. If proper voltage was not measured, proceed to step 5a

a. Disconnect the female connector from the governor driver module and leave the female connector disconnected from the actuator.
b. Set VOM to measure resistance. (Ω)
c. Connect one meter test lead to Pin 1 (Wire 771) on the female side of the engine harness at the actuator and the other meter test lead to Pin 9 of the engine harness at the governor driver board. If CONTINUITY is measured then proceed to step 5d. If CONTINUITY was not measured then repair or replace Wire 771 between the actuator and the governor driver board and proceed to step 5d.
d. Connect one meter test lead to Pin 4 (Wire 770) on the female side of the engine harness at the actuator and the other meter test lead to Pin 8 of the engine harness at the governor driver board. If CONTINUITY is measured, replace the governor driver board. If CONTINUITY was not measured then repair or replace Wire 770 between the actuator and the governor driver board and proceed to step 5e.

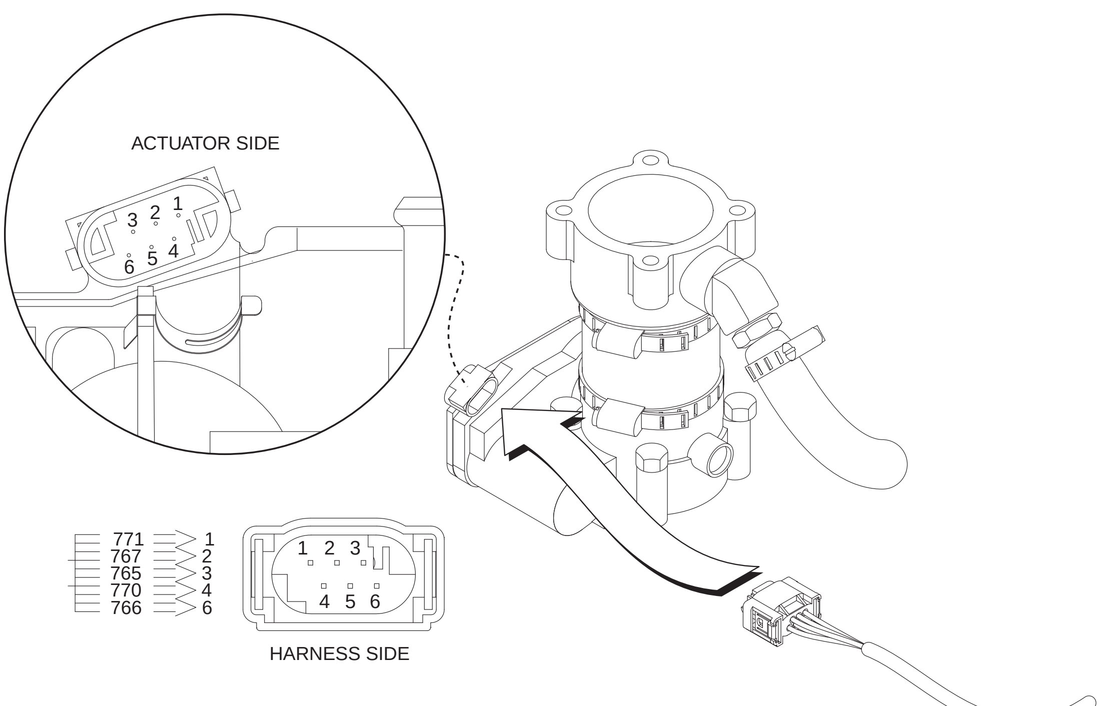


Figure 23. Bosch Actuator and Mixer Assembly

e. When the defective wire(s) has been repaired verify CONTINUITY for both Wires 770 and 771 and repeat Step 5 to verify that the correct voltage is still not being measured. If approximately 10VDC is still not measured then replace the governor driver board.

6. Disconnect the harness from the governor driver board (located in the control panel) and reconnect the harness to the actuator. Refer to Figure 5 in Section 3.1.

7. Using a small jumper wire, apply a 9 volt alkaline battery (negative side) to Pin 8 (Wire 770) and (positive side to) Pin 9 (Wire 771) at the female side of the harness that was disconnected in Step 6.

a. If the actuator opens all the way, reconnect the harness and go to Step 8.

b. If the actuator opens a little, replace the Bosch governor actuator.

c. If the actuator failed to open, proceed to Step 8.

8. Disconnect the J1 connector from the PCB and ensure the engine harness is connected to the actuator.

9. Set a VOM to measure resistance (Ω).

10. Measure and record the resistance across J1 Pin 12 (Wire 766) and J1 Pin 6 (Wire 765), then measure and record the resistance across J1 Pin 12 (Wire 766) and J1 Pin 5 (Wire 767) while the actuator is in the “AT REST” position. If the proper resistance (see below) is measured proceed to Step 11. If an open circuit was measured between Pins 12 and 6, proceed to Step 10a. If an open circuit was measured between Pins 12 and 5, proceed to Step 10g.

- At Rest: Pin 12 and Pin 6 – Approximately 1.4K Ohms.
- At Rest: Pin 12 and Pin 5 – Approximately 700 Ohms.

a. Disconnect the engine harness from the Bosch actuator and leave the J1 connector disconnected from the PCB.

b. Set a VOM to measure resistance (Ω).

c. Connect one meter test lead to Pin 6 on the female side of the engine harness at the actuator and connect the other meter test lead to J1 Pin 12 located at the printed circuit board. If CONTINUITY was measured, proceed to Step 10d. If CONTINUITY was not measured then repair or replace Wire 766 between the J1 connector and the actuator and proceed to Step 10d.

d. Connect one meter test lead to Pin 3 on the female side of the engine harness at the actuator and connect the other meter test lead to J1 Pin 6 located at the printed circuit board. If CONTINUITY was measured, proceed to Step 10e. If CONTINUITY was not measured then repair or replace Wire 765 between the J1 connector and the actuator and proceed to Step 10f.

e. If CONTINUITY is present on both Wires 765 and 766, replace the actuator.

f. When the defective wire(s) has been repaired-verify CONTINUITY for both Wires 765 and 766 and repeat Step 10 to verify if the circuit is still open. If a resistance value is present proceed to Step 11. If an open circuit still exists, replace the actuator.

g. Disconnect the engine harness from the Bosch actuator and continue to leave the J1 connector disconnected from the PCB.

h. Set aVOM to measure resistance (Ω).

i. Connect one meter test lead to Pin 2 on the female side of the engine harness at the actuator and connect the other meter test lead to J1 Pin 5 located at the printed circuit board. If CONTINUITY was measured, replace the actuator. If CONTINUITY was not measured then repair or replace Wire 767 between the J1 connector and the actuator and proceed to Step 10j.

j. When the defective wire(s) has been repaired-verify CONTINUITY for Wire 767 and repeat Step 10 to verify if the circuit is still open. If a resistance value is present proceed to Step 11. If an open circuit still exists, replace the actuator.

10. Disconnect the engine harness from the Governor Driver located in the control panel.

11. Using a small jumper wire, apply a 9 volt alkaline battery to Pin 9 (negative side, Wire 771) and Pin 8 (positive side, Wire 770) at the female side of the harness that was disconnected in Step 11

12. Set a VOM to measure resistance (Ω).

13. Measure and record the resistance across J1 Pin 12 (Wire 766) and J1 Pin 6 (Wire 765), then measure and record the resistance across J1 Pin 12 (Wire 766) and J1 Pin 5 (Wire 767) while the actuator is in the “FULL OPEN” position.

- Full Open: Pin 12 and Pin 6 – Approximately 600 Ohms.
- Full Open: Pin 12 and Pin 5 – Approximately 1.4K Ohms.

RESULTS:

1. If the resistance values in the “AT REST” and “FULL OPEN” positions are within range, refer back to the flow chart.

2. If the resistance values are not within the specified ranges and the wire integrity was verified to be good in Steps 10a through 10j, replace the actuator.

TEST 75 – CHECKING WIRING HARNESS

DISCUSSION:

Starting or running issues are sometimes caused by something as simple as a bad or intermittent electrical connection. Electrical connections can be very difficult to properly diagnose, especially when there is an intermittent connection.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

Obtain and refer to the proper electrical print (wiring, schematic or harness) for the unit being serviced.

Measure the resistance between the starting point and all ends of the individual circuits, and check for shorts to ground as well. Move the connectors and wires while measuring the resistance to look for bad connections. Verify all ground connections. With circuits involving voltage (i.e. Wire 14), measure voltage on the circuit at all points looking for voltage drops. Be sure to use the same ground reference point for all voltage measurements. Again, while taking the readings, move the wires and connectors and note any changes in the readings observed.

RESULTS:

Resistance readings should be within 0.2 Ohms of the resistance of the meter leads.

Voltage readings should be within ± 5% of the source voltage reading. If any readings are outside these tolerances, verify that all connections are clean and tight and then retest. If the readings continue to remain outside the tolerances, repair or replace the bad connection(s) and/or wire(s).

TEST 76 – CHECK ENGINE COMPRESSION AND CONDITION

DISCUSSION:

If the engine cranks but will not start, or if it starts hard and runs rough, one possible cause of the problem is a mechanical failure or excessive wear in the engine.

PROCEDURE:

1. Warm up the engine, if it will start and run.
2. Shut engine down and remove all spark plugs.
3. Use an automotive type compression tester to check engine compression.
4. Compression pressure should be as follows:

Standard	160 psi (12.1 kg/cm2) at 350 rpm
Minimum	120 psi (8.4 kg/cm2) at 350 rpm

Difference between cylinders should not exceed 15 psi (1.1 kg/cm2)

If compression is low in any cylinder, pour a small amount of clean engine oil into the spark plug opening. Then, retest compression and evaluate as follows:

- If compression pressure increases after adding the oil, check for worn or damaged piston rings.
- If compression pressure did NOT increase after adding the oil, check for sticking or improperly seated valves.
- If compression in any two adjacent cylinders is low and adding oil did NOT increase the compression pressure, check for a leaking head gasket (indicated by oil in the coolant).

TEST 81 – CHECK N1 AND N2 SENSING VOLTAGE

DISCUSSION:

During installation 240 VAC or 208 VAC must be provided to the N1 and N2 terminal in the customer connection area. The generator will step this down to a voltage approximately 16-19 VAC. This is the reference voltage to determine when a utility failure has occurred. The voltage will be stepped down from the incoming 240 VAC or 208 VAC, to 16 VAC using a transformer (T1). This lower voltage is a safe voltage for the printed circuit board to use.

PROCEDURE:

1. Set VOM to measure AC voltage.
2. Connect one meter test lead to Terminal N1 at Terminal Board TBR in the customer connection box and the other meter test lead to N2 on the same TB.
3. Measure and record the line-to-line voltage.

RESULTS:

1. If approximately 240 VAC or 208 VAC is measured line-to-line, refer back to flow chart.
2. If 0 VAC was measured, then the problem is located in the transfer switch.

Tech Tip: The RTS transfer switch has two BUS type fuses to protect N1 and N2. Check these fuses before proceeding.

TEST 82 – TEST TRANSFORMER (TR1)

PROCEDURE:

1. Set a VOM to measure AC voltage.
2. Connect one meter lead to Terminal 1 of TR1 and the other meter test lead to Terminal 4 of TR1(see Figure 24). Measure and record the voltage.
3. Connect one meter test lead to Terminal 8 of TR1 and the other meter test lead to Terminal 5 of TR1. Measure and record the voltage.

RESULTS:

1. If 240 or 208 VAC was measured in Step 2, and 16-19 VAC was measured in Step 3, then TR1 is good. Refer back to flow chart.
2. If 240 or 208 VAC was measured in Step 2, and 0 VAC was measured in Step 3, replace the TR1 transformer.
3. If 0 VAC was measured in Step 2, repair or replace wiring between Terminal Board R and the transformer.

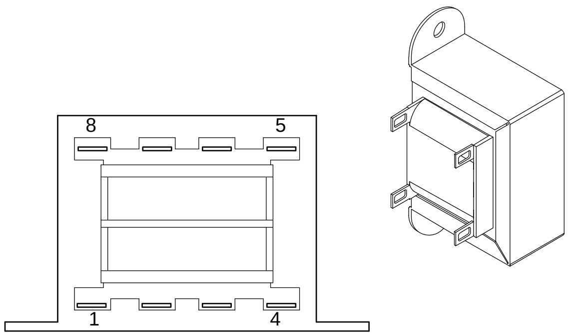


Figure 24. Transformer (TR1)

TEST 83 – CHECK VOLTAGE AT PRINTED CIRCUIT BOARD

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

1. Disconnect the 14 pin J2 connector going into the circuit board.
2. Connect one meter test lead to Pin 8 (Wire 224) of J2 and the other meter test lead to Pin 12 (Wire 225) of J2. Measure and record the voltage.

RESULTS:

1. If 16-19 VAC was measured, replace printed circuit board.
2. If 0 VAC is measured, repair or replace wiring between the J2 connector and the TR1 transformer.

TEST 87 – TEST AUTOMATIC SEQUENCE

DISCUSSION:

Refer to Section 1.6 for proper automatic sequences of generator.

PROCEDURE:

1. Set AUTO-OFF-MANUAL switch to the AUTO position.
2. Disconnect Utility by whatever means provided.

Caution! The engine will crank and possibly start when utility power is disconnected.

3. The green LED will immediately begin to flash, indicating a utility failure has occurred.
4. After the appropriate timers have expired, the generator should start and transfer.

RESULTS:

1. Refer back to flow chart.

TEST 91 – CHECK POSITION OF DIPSWITCH 3

DISCUSSION:

The generator will operate at 1800 RPM or 3600 RPM while in a utility failure or in a MANUAL run mode. The RPM can be lowered during exercise to reduce wear and tear on the generator and to reduce the noise that is produced. This is done by programming a DIP switch to either enable or disable this “Low Speed Exercise” function.

PROCEDURE:

1. Locate the 8 dip switches on the printed circuit board (see Figure 2, Section 3.1).
2. Dip Switch 3 should be set as follows:

ON	Normal Exercise Mode
OFF	Low Speed Exercise Mode

RESULTS:

1. If a change is made, remove F1 (15 Amp Fuse) for 10 seconds and then re-insert.
2. If unit will not low speed exercise, verify green LED status light is solid.
3. Refer back to flow chart.

TEST 95 – CHECK COOLANT TEMPERATURE AT THERMAL ADAPTER

PROCEDURE:

1. Aim a laser pointed heat gun toward the lower coolant return hose.
2. Record the reading.

RESULTS:

1. Refer back to flow chart.

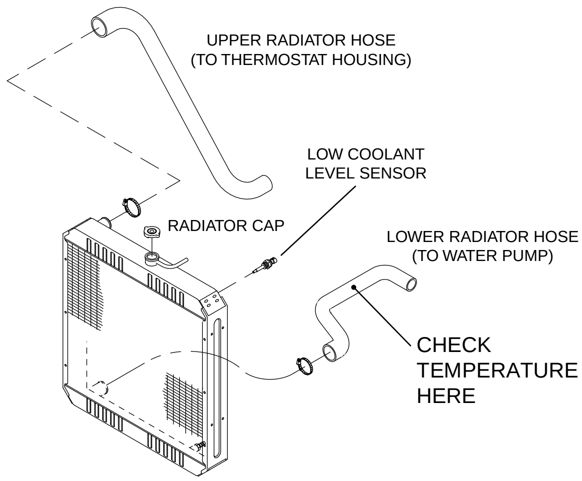


Figure 25. Coolant System Identification

TEST 96 – CHECK COOLANT LEVEL

DISCUSSION:

The coolant is used to cool the engine by dissipating heat away from the engine. The coolant is then cooled by passing it though the radiator. If the coolant is not filled to the proper level for cooling, the engine may become damaged from excess heat build up over a period of time.

PROCEDURE:

1. Remove the black rain cap on top of the generator housing.

CAUTION: Coolant is under pressure and at high temperature. Exercise extreme caution when removing cap! Do NOT remove radiator cap from a hot engine.

2. Remove the radiator cap from the top of the radiator.
3. Make sure the coolant level is visible at the bottom of the filler neck.

RESULT:

1. If coolant level is low, fill the radiator with coolant prescribed by owners manual. Check for leaks. Check oil for a milky color (this may be a sign of a leak internal to the engine).
2. If coolant level is normal, refer back to flow chart.

TEST 97 – CHECK COOLANT HOSES

DISCUSSION:

If maintenance is not performed regularly, the radiator hoses can become cracked or dry rotted, and may even break down due to weather exposure. The hose clamps can also become loose, causing coolant leaks. With proper maintenance this is avoidable. Check the radiator hoses when troubleshooting coolant issues.

PROCEDURE:

1. Locate the upper and lower radiator hoses

Tech tip: For further information about checking coolant hoses reference Section 1.8.

RESULTS:

1. If no problem is found with either the upper or lower hoses on the generator and the problem continues, replace the thermostat. Reference 2.4L Mitsubishi Engine Service Manual for thermostat disassembly and assembly instructions.
2. If the hose displays blockage, remove the blockage from the area that is being affected.

TEST 98 – CHECK LOW COOLANT LEVEL SENSOR

DISCUSSION:

The printed circuit board checks for low coolant after the 10 second hold off timer expires. This is a latched fault and will shutdown the engine. The R-200B Controller applies 5 VDC to the positive terminal of the probe. Point “A” is the tip of the of the probe and Point “B” is frame ground (see Figure 26). Coolant surrounding the probe allows for continuity between Points “A” and “B”.

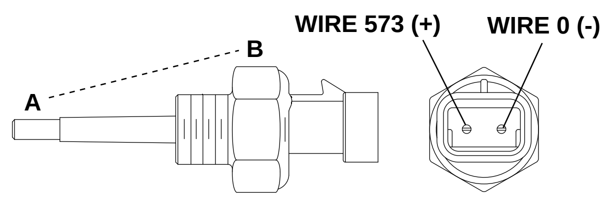


Figure 26. Low Coolant Level Sensor

A 5K Ohm resister in parallel with the two terminals causes the 5 VDC signal to be lowered to 1 VDC (or ground). When coolant level drops, the signal changes from a 1 VDC signal to a 5 VDC signal. The board will recognize this as a low coolant level condition and shutdown the generator.

PROCEDURE:

1. Disconnect the low coolant sensor plug.
2. Insert a jumper wire between Pins 1 and 2, Wires 573 and 0, of the female side of the connector.
3. Set AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to “MANUAL”.

4. Observe if the fault occurred again.

Warning: This procedure is for testing purposes only. DO NOT leave the sensor bypassed.

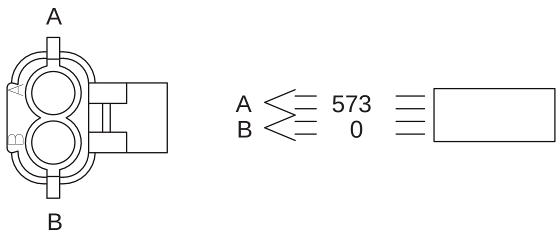


Figure 27. Low Coolant Level Sensor Harness Connector

RESULTS:

1. If the unit stayed running, replace the low coolant level switch.
2. Dirty coolant may also affect the continuity of the probe.
3. If the unit shuts down and the control panel displays a low coolant fault, refer back to flow chart.

TEST 99 – CHECK WIRE 573 TO PRINTED CIRCUIT BOARD

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

PROCEDURE:

1. Disconnect the J1 connector going into the printed circuit board.
2. Set a VOM to measure resistance (Ω).
3. Connect one meter test lead to Pin 8 of J1 and connect the other meter test lead to the positive side of the female low coolant level sensor plug (+). CONTINUITY should be measured.

RESULTS:

1. If CONTINUITY is measured, replace the printed circuit board.
2. If INFINITY is measured, repair or replace the wire between the J1 connector and the printed circuit board.

TEST 104 – CHECK OIL LEVEL

PROCEDURE:

1. Remove the oil dipstick and observe the oil level.

RESULTS:

1. If oil level is low, reference the front of this manual for crankcase capacity and fill oil to proper level.
2. If oil level is too high, remove the excess oil from the engine.
3. If oil level is correct, refer back to flow chart.

TEST 105 – CHECK ENGINE OIL PRESSURE

DISCUSSION:

If the engine can't maintain a certain oil pressure range, engine damage may result due to improper lubrication. If the engine has too much oil pressure the engine may suffer severe internal and/or external damage during running operations.

PROCEDURE:

1. Remove the oil pressure switch from the engine block.

Note: Refer to Figure 14 in Section 3.1 "Engine Protective Devices" for location of sensor.

2. Insert oil pressure gauge.
3. Turn the AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

4. Record the results.

RESULTS:

1. If the unit doesn't have oil pressure after 10 seconds, shut the unit down and reference the 2.4L Mitsubishi Engine Service Manual.
2. If the oil pressure is within operating range between 58-90psi, refer back to flow chart.

TEST 106 – CHECK WIRE 86 FOR CONTINUITY

DISCUSSION:

The control board uses Wire 86 to monitor the low oil pressure switch for a possible problem with the engine internal oil pressure. If Wire 86 is shorted or pinched the unit will shutdown after 10 seconds of running.

PROCEDURE:

1. Turn the AUTO-OFF-MANUAL switch to the OFF position.
2. Locate the low oil pressure switch and the J1 Connector on the PCB, located inside of the control panel.
3. Disconnect Wire 86 from the low oil pressure switch. Disconnect the J1 Connector from the control board in the control panel.
4. Set VOM to measure resistance (Ω).

5. Place the positive lead to Wire 86 and the negative lead to J1 Connector Pin 20. Continuity should be measured.

RESULTS:

1. If there is no continuity, verify Wire 86 is not pinched and/or shorted to ground.
2. If Wire 86 shows continuity, refer back to flow chart.

TEST 107 – CHECK WIRE 86 FOR A SHORT TO GROUND

PROCEDURE:

1. Disconnect the J1 Connector from the printed circuit board.
2. Isolate Wire 86 from the low oil pressure switch.
3. Set a VOM to measure resistance (Ω).
4. Connect one meter test lead to disconnected Wire 86 and the other meter test lead to a clean frame ground.

RESULTS:

1. If resistance is measured to ground, the wire is shorted to ground. Repair or replace Wire 86.
2. If Wire 86 is not shorted, refer back to flow chart.

TEST 108 – CHECK LOW OIL PRESSURE SWITCH

PROCEDURE:

1. Locate the low oil pressure sender (see Figure 14, Section 3.1).
2. Set a VOM to measure DC voltage.
3. Connect one meter test lead to Wire 86 and the other meter test lead to a clean frame ground. 0 VDC should be measured.
4. Set the AUTO-OFF-MANUAL switch to the MANUAL position.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

5. The VOM should read 0 VDC while cranking and should read 5 VDC once the unit is at its rated speed and oil pressure is above 10psi.

RESULTS:

1. The voltage that should be measured should start at 0 VDC, indicating the switch is closed. The voltage should slowly climb to 5 VDC, indicating proper function of the switch.
2. If the switch stayed at 0 VDC, replace the switch.
3. If the switch climbed to 5 VDC, replace the printed circuit board.

TEST 110 – CHECK BATTERY CONDITIONS

DISCUSSION:

Typical float voltage is about 13.4 VDC when the generator is sitting idle, with a properly functioning battery charger. The Low Battery alarm will operate for two reasons: if the voltage sensed at main PCB is below about 12.2 VDC for one minute or if battery voltage sensed at main PCB drops below 6 VDC during a crank cycle. If either of these things occurs it is a good indication of a bad battery. If the low battery alarm is on and it is not a latched alarm, the unit will still attempt to crank and run when needed. All tests are to be preformed with utility present and the unit in AUTO, not running unless otherwise specified.

Tech Tip: The 120 VAC input is a separate terminal strip in the customer connection box that must be connected during installation in order for the battery charger to function properly.

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

TEST 111 – CHECK BATTERY VOLTAGE AT PCB

PROCEDURE:

1. Open the control panel to gain access to the J2 Connector on the main PCB.
2. Set a VOM to measure DC volts.
3. Connect the positive test lead to J2 Pin 5 (Wire 15E) and the negative test lead to a clean frame ground. Measure and record voltage.

RESULTS:

1. Measured voltage should be above 12.8 VDC. Refer back to flow chart.

TEST 112 – CHECK LOW BATTERY SENSING AT PCB

PROCEDURE:

1. Be sure battery voltage is being maintained at a steady voltage.
2. Switch AUTO-OFF-MANUAL switch to OFF, then back to AUTO.

3. Wait one (1) minute and observe.

RESULTS:

1. If low battery LED returns, replace PCB.
2. If low battery LED does not return, most likely this as a "Latched Alarm." The low battery alarm is latched if the battery voltage drops below 6 volts during engine cranking.
3. The battery can be load tested using a hand held device or taken to a facility with the capability of testing the state of a battery.
4. Refer back to flow chart.

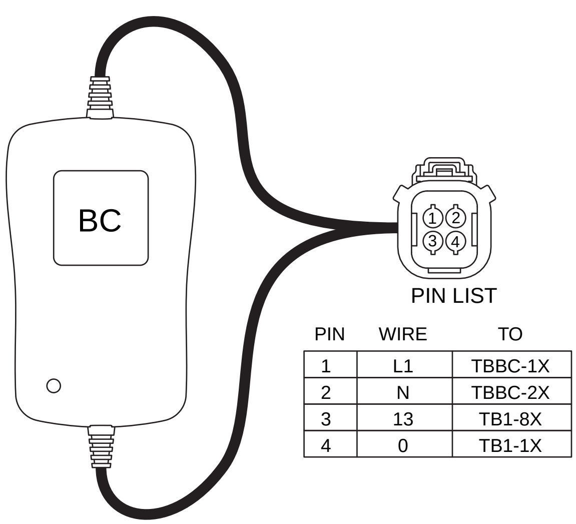
TEST 113 – CHECK BATTERY CHARGER 120VAC INPUT

PROCEDURE:

1. Disconnect battery charger connector plug.
2. Set a VOM to measure AC voltage.
3. Connect one meter test lead to Pin 1 on the female side of the battery charger connector harness and connect the other meter test lead to Pin 2 on the female side of the battery charger connector. Measure and record the voltage (see Figure 28).

RESULTS:

1. 120 VAC should be measured, refer back to flow chart.



PIN	WIRE	TO
1	L1	TBBC-1X
2	N	TBBC-2X
3	13	TB1-8X
4	0	TB1-1X

Figure 28. Battery Charger Connector Pin Numbers

TEST 114 – CHECK 120VAC INPUT TO CUSTOMER CONNECTION

PROCEDURE:

1. Connect one meter test lead to Terminal L1 on TB-BC located in the customer connection area and connect the other meter test lead to Terminal N on TB-BC. Measure and record the voltage.

RESULTS:

1. 120VAC should be measured. Refer back to flow chart.

TEST 115 – CHECK BATTERY CHARGER OUTPUT

PROCEDURE:

1. Disconnect the negative battery lead from the battery.
2. Set a VOM to measure DC voltage.
3. Connect one meter test lead to the positive terminal of the battery and connect the other meter test lead to the disconnected negative battery lead. Measure and record the voltage.

RESULTS:

1. 13.4 VDC should be measured. Refer back to flow chart.

TEST 116 – TEST LOW FUEL PRESSURE SWITCH

DISCUSSION:

The Low Fuel Pressure Switch is a normally open switch that will close when pressure is above 5 inches of water column. Wires 601 and 0 are connected to the switch. The PCB will monitor Wire 601 for a ground indicating unit has 5 inches of water column or greater. When the switch is open 5 VDC will be present on Wire 601 indicating a low fuel pressure condition has occurred. This fault will not shutdown the engine. It will only illuminate an LED on the PCB indicating that there is an issue with fuel.

PROCEDURE:

1. Remove Wires 601 and 0 from the switch.
2. Turn OFF the fuel supply to the generator.
3. Set a VOM to measure resistance (Ω).
4. Connect one meter test lead to one terminal of the switch and the other meter test lead to the other terminal on the switch where Wires 601 and 0 were removed. INFINITY should be measured.
5. Turn ON the fuel supply to the generator.

6. Repeat Step 4, however this time CONTINUITY should be measured.
7. Set the AUTO-OFF-MANUAL SWITCH to the AUTO position.
8. Set a VOM to measure DC voltage.

Note: Wires 601 and 0 should still be removed.

9. Connect one meter test lead to Wire 601 and connect the other meter test to a clean frame ground. 5 VDC should be measured.
10. Set aVOM to measure resistance (Ω).
11. Connect one meter test lead to Wire 0 and the other meter test lead to a clean frame ground. CONTINUITY should be measured.
12. If 5 VDC was measured in Step 9 proceed to the results. If 5 VDC was not measured, proceed to Step 13.
13. Disconnect the J1 connector from the PCB.
14. Set aVOM to measure resistance (Ω).

Tech Tip: Reference Section 1.7 for proper procedures in testing connector plugs and incoming wires.

15. Connect one meter test lead to Wire 601 that was removed from the switch and connect the other meter test lead to Pin 11 J2. CONTINUITY should be measured.

RESULTS:

1. If Steps 4, 5, 9, and 11 tested good, check for bad crimps on connectors or possibly a switch that has gone out of calibration in which the switch would need to be replaced.
2. If either Steps 4 or 5 failed, replace the switch.
3. If Steps 4 and 5 tested good, but no voltage was measured in Step 12 and Step 15 was good, replace printed circuit board.
4. If Steps 4 and 5 tested good, but no voltage was measured in Step 12, and Step 15 tested bad, repair or replace Wire 601 between the printed circuit board and the Low Fuel Pressure switch.

TEST 122 – CHECK WIRES 79 AND 0

DISCUSSION:

The Magnetic Pickup receives a signal from the flywheel and sends it back to the printed circuit board via Wires 79 and 0. If an open condition exists on either of these wires the printed circuit board will shut down the unit due to lack of sensing. The magnetic pickup has an resistance of approximately 700 to 1000 Ohms (Ω). This resistance can be measured at the solder point connections on the printed circuit board.

PROCEDURE:

1. Removed the printed circuit board from its mounted location on the control panel door.

Refer to Figure 29.

2. Trace Wires 79 and 0 through the J1 Connector Plug Pins 9 and 10 to the solder points on the PCB.

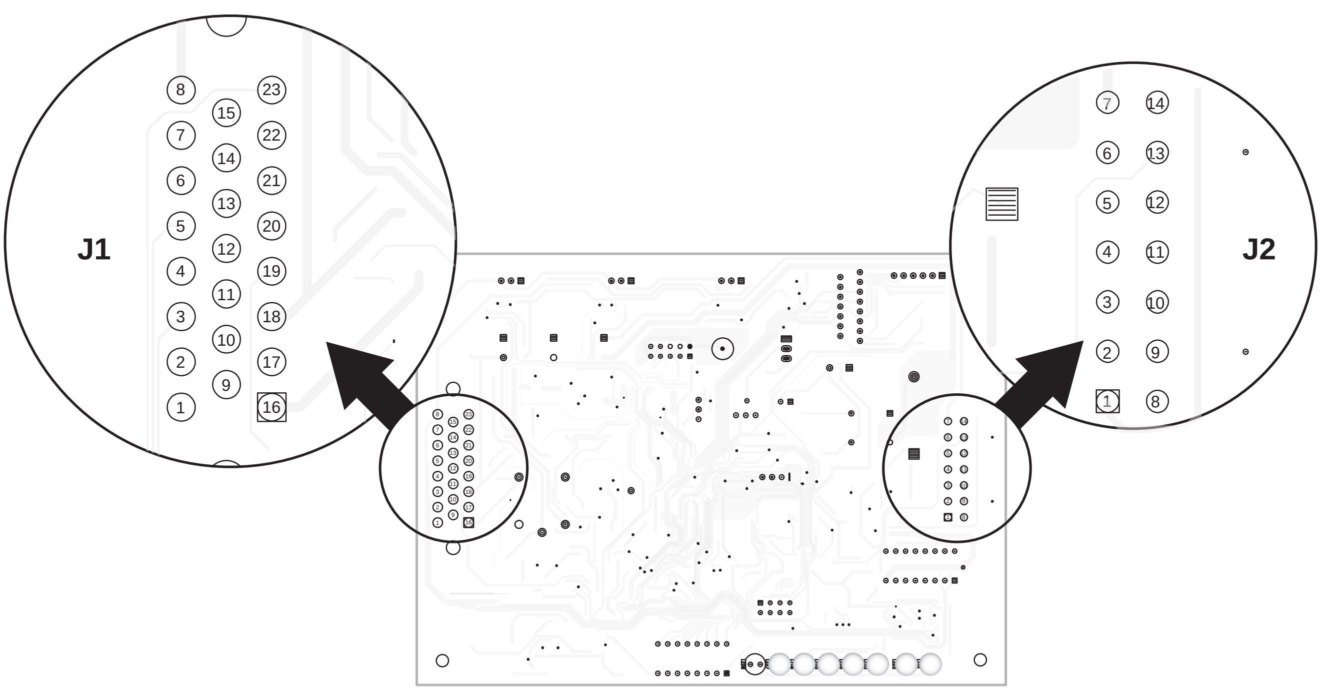


Figure 29. Printed Circuit Board Solder Points

3. Set a VOM to measure resistance (Ω).
4. Connect one meter test lead to one solder pin and connect the other meter test lead to the other solder pin.

RESULTS:

1. Approximately 1000 Ohms (Ω) should be measured. If 700 to 1000 Ohms (Ω) was measured at the sensor but not at the solder point connections on the PCB, refer to Section 1.7 for inspecting harness connections and incoming wires.
2. If correct resistance is measured, refer back to flow chart.

TEST 123 – CHECK BATTERY VOLTAGE CIRCUIT

DISCUSSION:

When the AUTO-OFF-MANUAL switch is in the OFF position Wires 15 and 15E have battery voltage present at all times. Voltage (+) from Wire 15 is delivered to the:

- Exercise switch
- Run Relay (Normally Open Contact)
- Start Relay (Normally Open Contact)
- Ignition Module
- Air/Fuel Solenoid (Emission Units Only)
- AUTO-OFF-MANUAL switch

Voltage (+) from Wire 15E is delivered to the Printed Circuit Board.

The individual circuits may be isolated and tested using a 15 amp re-setable circuit breaker (i.e. P/N 0E5840) with AWG 14 gage wires attached to the terminal posts (see Figure 30) using female spade connectors. Install male spade connectors on the loose ends of these wires. Remove the fuse from the fuse holder (F1) and insert the male spade connectors in place of the fuse. The circuit breaker will now act as the fuse during the remainder of this procedure.

Note: Without using a re-setable circuit breaker, it is possible that up to 9 fuses could be used in this test.

While isolating the circuits, pay special attention to when the breaker trips and does not trip. When the breaker does not trip it will be a clear indication that the short is located on the wire that was just isolated.

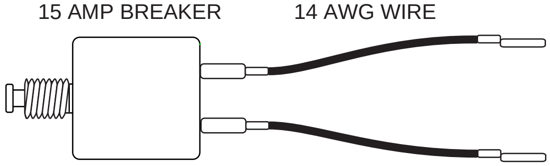


Figure 30. Assembly of 15 Amp Circuit Breaker with 14 AWG Wire and Spade Connectors

PROCEDURE:

1. Pull the circuit breaker to the Open position or remove the fuse.
2. Isolate Wire 15 from Terminal Block 1 Terminal 11 (to the fuse block). It is the 14AWG gage wire (see Figure 1, Section 3.1).
3. Push circuit breaker to the Closed position or re-install the fuse.
   - If the breaker tripped or the fuse blew, the short is either located in the Fuse Block or Wire 15 between the Fuse Block and TB1 Terminal 11.
   - If the breaker did not trip or the fuse did not blow, continue testing.
4. Pull the circuit breaker to the Open position or remove the fuse.
5. Isolate Wire 15 from Terminal Block 1 Terminal 11 (to the AUTO-OFF-MANUAL switch).
6. Push circuit breaker to the Closed position or re-install the fuse.
   - If the breaker tripped or the fuse blew, proceed to Step 15.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 7.
7. Pull the circuit breaker to the Open position or remove the fuse.
8. Reconnect Wire 15 to Terminal 11 of TB1.
9. Isolate Wire 15 from the Exercise (SW2) switch.
10. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, the short is located between the SW2 switch TB1 Terminal 11.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 11.
11. Pull the circuit breaker to the Open position or remove the fuse.
12. Reconnect Wire 15 to the SW2 switch.
13. Isolate the 14 pin J2 connector from the printed circuit board.
14. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, the short is located between the SW2 switch and the J2 connector.
    - If the breaker did not trip or the fuse did not blow, replace the printed circuit board.
15. Isolate Wire 15 from Terminal 11 of TB1 (to the crank and run relays).

16. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, proceed to Step 17.
    - If the breaker did not trip or the fuse did not blow, the short is located in the relay circuits. Check each individual wire for a short and inspect relays and the relay connection blocks for any indication of a short.
17. Pull the circuit breaker to the Open position or remove the fuse.
18. Reconnect wires to Terminal 11 of TB1.
19. Isolate Wire 15 from Terminal 12 of TB1 that goes to the Ignition Module.
20. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, proceed to Step 25
    - If the breaker did not trip or the fuse did not blow, proceed to Step 21.
21. Pull the circuit breaker to the Open position or remove the fuse.
22. Reconnect Wire 15 to Terminal 12 of TB1.
23. Isolate the connector plug from the Ignition Module.
24. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, the short is located between Terminal 12 of TB1 and the Ignition Module connector plug.
    - If the breaker did not trip or the fuse did not blow, replace the Ignition Module.
25. Pull the circuit breaker to the Open position or remove the fuse.
26. (Emissions Units Only) Isolate Wire 15 from Terminal 12 (to the Air/Fuel Solenoid).
27. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 28.
28. Pull the circuit breaker to the Open position or remove the fuse.
29. Reconnect Wire 15 to Terminal 12 of TB1.
30. Isolate Wire 15 from the Air/Fuel Solenoid.
31. Push circuit breaker to the Closed position or re-install the fuse.
    - If the breaker tripped or the fuse blew, the short is located between Terminal 12 of TB1 and the Air/Fuel Solenoid.
    - If the breaker did not trip or the fuse did not blow, replace the Air/Fuel Solenoid.

TEST 124 – CHECK CRANKING AND RUNNING CIRCUITS

When the AUTO-OFF-MANUAL switch is in the MANUAL position Wires 15A, 14, and 56 have battery voltage present during cranking. Voltage (+) from Wire 15A is delivered from the AUTO-OFF-MANUAL switch to the:

- Printed Circuit Board
- Run Relay
- Start Relay

Voltage (+) from Wire 14 is delivered from the Run Relay to the:

- Fuel Solenoid
- Ignition Module (for NG only)
- Hour Meter
- Oxygen Sensor
- Governor Driver Board
- Voltage Regulator

Voltage (+) from Wire 56 is delivered from the start relay to the:

- Cold Start Solenoid
- Starter Contactor Relay
- Ignition Module

The individual circuits may be isolated and tested using a 15 amp re-setable circuit breaker (i.e. P/N 0E5840) with AWG 14 gage wires attached to the terminal posts (see Figure 30) using female spade connectors. Install male spade connectors on the loose ends of these wires. Remove the fuse from the fuse holder (F1) and insert the male spade connectors in place of the fuse. The circuit breaker will now act as the fuse during the remainder of this procedure.

Note: Without using a re-setable circuit breaker, it is possible that up to 17 fuses could be used in this test.

While isolating the circuits, pay special attention to when the breaker trips and does not trip. When the breaker does not trip it will be a clear indication that the short is located on the wire that was just isolated.

Note: Wire 56 does not run through the terminal board.

PROCEDURE:

1. Pull Circuit Breaker to Open position or remove fuse.
2. Isolate the 14 pin J2 Connector from the printed circuit board (see Figure 2, Section 3.1).
3. Isolate Wires 15A from Terminal 10 of Terminal Board 1 that go to the printed circuit board and the AUTO-OFF-MANUAL switch.
4. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position (see Figure 1, Section 3.1).

- If the breaker tripped or the fuse blew, the short is located in the wiring between the AUTO-OFF-MANUAL switch and Terminal 11 of TB1.
- If the breaker did not trip or the fuse did not blow, proceed to Step 5.

5. Pull the circuit breaker to the Open position or remove the fuse.
6. Reconnect Wires 15A to Terminal 11 of TB1. Keep J2 connector isolated.
7. Isolate Wires 15A from Terminal 11 that go to the start and run relays.
8. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, the short is located in the wiring between the J2 connector and Terminal 11 of TB1.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 9.
9. Pull the circuit breaker to the Open position or remove the fuse.
10. Reconnect J2 connector to printed circuit board, leaving the run and start Wires 15A isolated.
11. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, replace the printed circuit board.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 12.
12. Pull the circuit breaker to the Open position or remove the fuse.
13. Reconnect J2 connector to printed circuit board and Wires 15A that go to the run and start relays.
14. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, the short is located in the relay circuits. Check each individual wire for a short and inspect relays and the relay connection blocks for any indication of a short. The relay coils should measure approximately 90 (Ω) Ohms.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 15.
15. Pull the circuit breaker to the Open position or remove the fuse.
16. Isolate Wire 56 from the Cold Start Solenoid (FS2) and the Starter Contactor Relay.
17. Remove Start Relay (RL1) and isolate the connector plug going into the Ignition Module.
18. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, the short is located in the harness and each individual wire will need to be checked for a short to ground.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 19.
19. Pull the circuit breaker to the Open position or remove the fuse.
20. Reconnect the Start Relay (RL1).
21. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, replace the Start Relay (RL1).
    - If the breaker did not trip or the fuse did not blow, proceed to Step 22.
22. Pull the circuit breaker to the Open position or remove the fuse.
23. Reconnect Wire 56 to the Starter Contactor Relay.
24. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, replace the Starter Contactor Relay. A reading of approximately 4.4 (Ω) Ohms should be measured across the coil.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 25.
25. Pull the circuit breaker to the Open position or remove the fuse.
26. Reconnect Wire 56 to the Cold Start Solenoid.
27. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
    - If the breaker tripped or the fuse blew, replace the Cold Start Relay. A reading of approximately 6.5 (Ω) Ohms should be measured across the coil.
    - If the breaker did not trip or the fuse did not blow, proceed to Step 28.
28. Pull the circuit breaker to the Open position or remove the fuse.
29. Reconnect the connector plug to the ignition module.

30. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Ignition Module.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 31.
31. Pull the circuit breaker to the Open position or remove the fuse.
32. Isolate the following components from Wire 14: Engine Run Relay (RL2), Fuel Solenoid (FS1), Ignition Module (NG units only), Oxygen Sensor (Emission units only), Hour Meter, Automatic Voltage Regulator, and Governor Driver Board (DEG).
33. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, the short is located in somewhere in the Wire 14 circuit and not in any component. The wires can be isolated at TB1 to determine which wire it is that is shorted to ground.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 34.
34. Reconnect the Run Relay (RL2).
35. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Run Relay (RL2). A reading of approximately 120 (Ω) Ohms should be measured across the coil.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 36.
36. Reconnect the Fuel Solenoid (FS1).
37. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Fuel Solenoid (FS1). A reading of approximately 15.3 (Ω) Ohms should be measured across the coil.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 38.
38. Reconnect the Voltage Regulator.
39. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Automatic Voltage Regulator.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 40 for natural gas units and Step 42 for LP Vapor.
40. Reconnect the Ignition Module.
41. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Ignition Module.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 42 for emissions enabled units and Step 44 for standard units.
42. Reconnect the Oxygen Sensor.
43. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Oxygen Sensor.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 44
44. Reconnect the Governor Driver Board.
45. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Governor Driver Board.
   - If the breaker did not trip or the fuse did not blow, proceed to Step 46
46. Reconnect the Hour Meter.
47. Push circuit breaker to the Closed position or re-install the fuse and set AUTO-OFF-MANUAL switch to the MANUAL position.
   - If the breaker tripped or the fuse blew, replace the Hour Meter.

Tech Tip: Connect a 12VDC battery to the new hour meter and let run till the desired time is reached.

PART 4 GENERATOR ADJUSTMENTS AND ACCESSORIES

2.4 LITER STANDBY GENERATORS

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VOLTAGE REGULATOR ADJUSTMENT AND INSTALLATION

Two dip switches are provided on the Voltage Regulator.

- **Dip Switch 1** should be set to the STD position (Down position).
- **Dip Switch 2** should be set to the HIGH position (Up position).

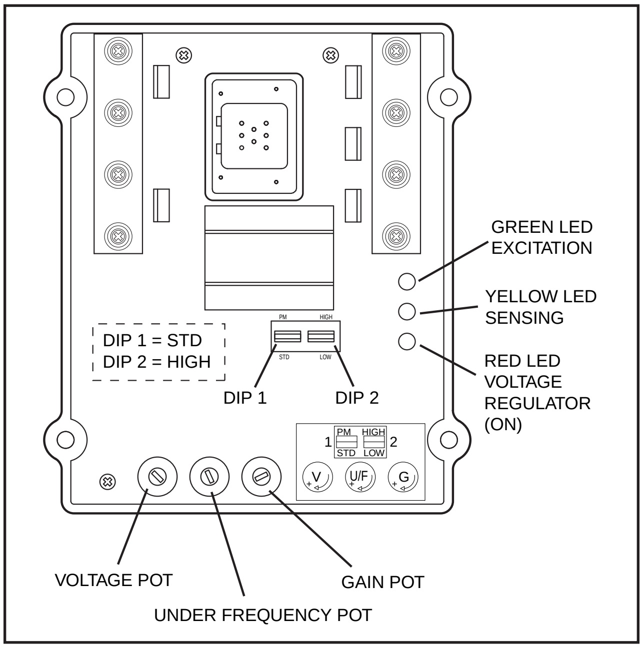

Figure 1. Voltage Regulator

Three adjustment potentiometers are provided on the Voltage Regulator.

- **Voltage Adjust (V)** adjusts the line-to-line AC output voltage of the Generator's alternator.
- **Under Frequency Adjust (U/F)** – The Voltage Regulator has adjustable volts per frequency characteristic, which means that the alternator output voltage can be made to vary directly with frequency. If the frequency drops the voltage can be made to drop so that the load on the engine is reduced. When the frequency rises the voltage will rise. The point at which the regulator becomes V/F is adjustable (for example, Figure 2 shows a 58Hz V/F set point). Turning the U/F adjust pot fully counter-clockwise (CCW) makes the voltage regulator totally volts per frequency regulated. Turning the U/F adjust pot fully clockwise (CW) makes the voltage regulator a constant voltage device.
- **Gain Adjust (G)** determines how sensitive the voltage regulator is and how fast the voltage regulator will respond to a change in the alternator voltage. If the gain is too low, the alternator voltage may recover too slowly or be too low. If the gain is too high, the alternator voltage may recover too fast or become unstable.

PROCEDURE:

1. Connect an accurate AC Voltmeter and AC Frequency meter to the Generator's AC output leads.
2. On the Voltage regulator, set the potentiometers as follows;
   a. Set the "Voltage Adjust" pot (V) to its centered (midpoint) position.
   b. Set the "Under Frequency Adjust" pot (U/F) to its centered (midpoint) position.
   c. Set the "Gain Adjust" pot (G) to its centered (midpoint) position.
3. Turn OFF all electrical loads. Startup and initial adjustment will be done under a "No-Load" condition.
4. Start the Generator and let the engine stabilize and warm-up at no-load
5. With the Generator running at 60Hz at no-load, observe that all three regulator lamps (LEDs) are ON. These LEDs are the; GREEN "Excitation" LED, YELLOW "Sensing" LED and RED "Regulator" LED
6. If the Red lamp (LED) is flashing turn the Gain pot (G) slowly counter-clockwise (CCW), until the flashing stops.
7. Adjust the Voltage Adjust pot (V) to obtain the Generator's rated line-to-line output voltage.

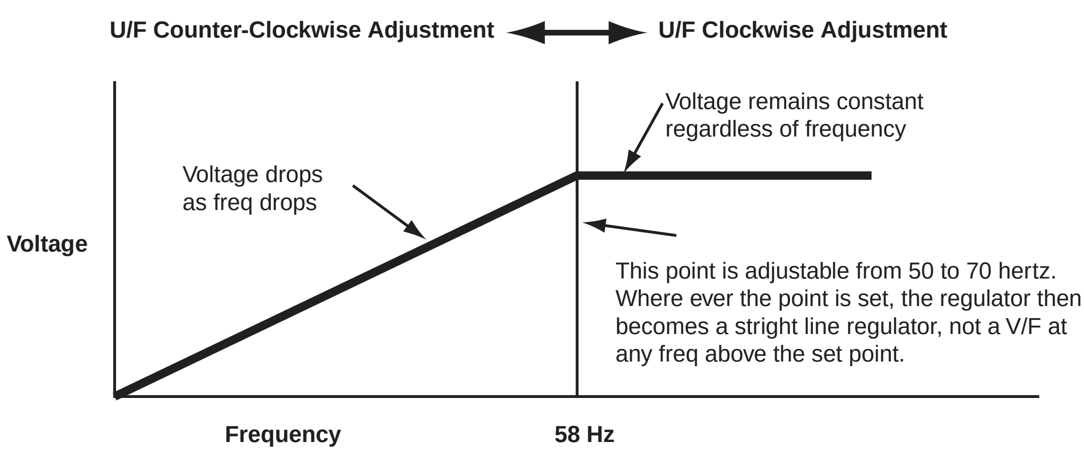

Figure 2. 58Hz V/F set point

8. Slowly turn the Under Frequency pot (U/F) CCW until the alternator output voltage starts to drop and then slowly turn the pot back to the point where the voltage was just before it started to drop.
9. Apply an electrical load and check that the Generator AC output voltage recovers at this load.
10. With electrical load still applied readjust the Gain pot, if needed, until the RED lamp (LED) stops flashing.
11. Turn off all electrical loads and then recheck the regulator lamps (LEDs) at No-Load.
12. When all adjustments have been completed, let the engine run at no-load for a few minutes to stabilize the internal engine-generator temperatures and then shut the Generator down.

CRANK SENSOR INSTALLATION AND ADJUSTMENTS

This instruction explains the procedure for setting the magnetic pick-up voltage output to its optimum value for each respective speed. The technician will need the Magnetic Pickup Test Kit Harness to perform this adjustment (see Figure 4). The adjustment is performed with the engine running at rated speed.

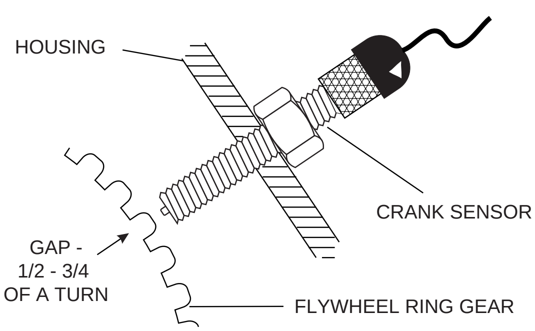

Figure 3. Crank Sensor (MPU1)

PROCEDURE:

1. Set the AUTO-OFF-MANUAL switch to the OFF position.
2. Disconnect the negative (-) battery cable from the battery.
3. Turn the fuel supply off to the unit
4. With the magnetic pick-up removed, use a flashlight and verify that a flywheel tooth is directly below and centered in the magnetic pick-up hole. Use an appropriate tool on the crankshaft damper mounting bolt to rotate the crankshaft and flywheel in the direction of normal rotation. If access to crankshaft damper mounting bolt is not possible, then reconnect the battery and turn the engine over by toggling the manual switch to align the tooth underneath the hole.
5. Lightly screw the magnetic pick-up down until it contacts the top of the flywheel tooth (Figure 3).

WARNING: DO NOT use the alternator fan/blower blades to rotate the flywheel! This could cause blade failure and total destruction of the alternator. DO NOT use a pipe wrench on the fan drive.

6. Back out the magnetic pick-up one 1/2 to 3/4 of a turn.
7. Connect the breakout harness to the magnetic pick-up in-line with the engine control harness (Figure 4).

Technician Note: The steps below in this procedure must be done with breakout harness and with a Fluke 87 / equivalent multi-meter.

Figure 4. Breakout Harness

8. Reconnect the negative (-) battery cable to the battery.
9. Turn the fuel supply back on to the unit.
10. Set the AUTO-OFF-MANUAL switch to the MANUAL position to verify the unit starts.

Caution! The engine will crank and possibly start when the AUTO-OFF-MANUAL switch is set to "MANUAL".

- If the unit starts, proceed to Step 11.
- If the unit does not start and if any alarms are displayed on the control board as; (Flashing overspeed), Verify steps one (1) though six (6) were performed correctly. Verify that the magnetic pick-up is producing AC voltage using the breakout harness while the engine is cranking. Turn the Fuel supply off until magnetic pick-up voltage is obtained.

Magnetic pick-up note: The magnetic pick-up may need to be turned in or out a very small amount to get the magnetic pick-up to produce AC voltage.

11. Set the multimeter to read AC Voltage and insert leads into Wires 79 positive and 0 ground on the breakout harness.

CAUTION: If the magnetic pick-up is screwed in too far, the magnetic pick-up will be damaged by the rotating flywheel.

12. With the unit running at (Rated Speed: 3600RPM or 1800RPM), slowly adjust the magnetic pick-up to provide the specific voltage for the applicable control board. Verify the part number before adjusting the magnetic pick-up to the appropriate voltage.

1800 RPM units	3VAC ±0.3
3600 RPM units	5VAC ± 0.3

13. Tighten down the magnetic pick-up lock nut to prevent the magnetic pick-up from coming loose during running operations. Use Loctite (blue 232 removable), if available.
14. Re-verify the magnetic pick-up voltage at rated speed.
15. Turn the unit OFF and remove the breakout harness and reconnect the magnetic pick-up connector to the engine harness.

Removal and Inspection Tip: When the magnetic pick-up has been removed, verify that there is no debris on the tip of the sensor. If there are any metal shavings on the tip they may distort the signal to the PCB and/or ignition module causing speed related shutdowns (Figure 5). Remove the debris from the magnetic pick up tip and reinstall to the rated speed voltage set point.

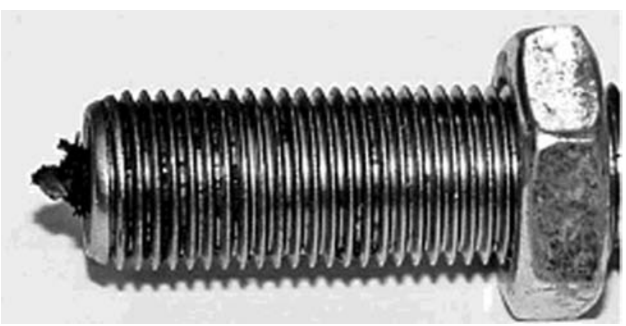

Figure 5. Metal Filings on Tip of Sensor

Troubleshooting TIP: The magnetic pick-up has a resistance of approximately 700 to 1000 Ohms between the small red Wire 79 and the small black Wire 0 disconnected from the engine harness.

CAM SENSOR INSTALLATION AND ADJUSTMENTS

PREPPING THE UNIT FOR THIS PROCEDURE:

1. Remove both side doors from the enclosure.
2. Turn the AUTO-OFF-MANUAL switch to the OFF position.
3. Turn the fuel supply off to the unit.
4. Disconnect the positive (+) and negative (-) battery cables from the battery.
5. Remove the 10mm bolts from both fan housing guards on the radiator assembly (Figure 6).

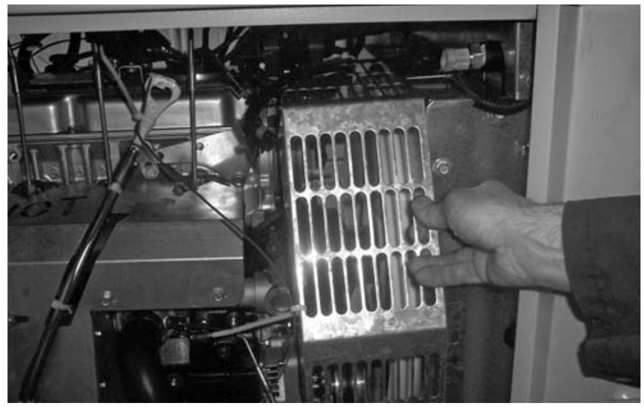

Figure 6

6. Remove the two ignition bracket bolts (Figure 7)

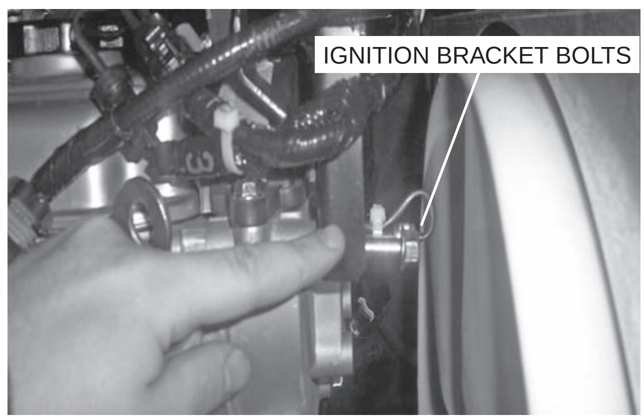

Figure 7

7. Cut any zip ties on the harness that will not allow the next step to be performed.
8. Place the ignition coils and bracket on top of the valve cover and away from the timing belt cover (Figure 8).
9. Remove the top (black) timing belt cover from the engine (Figure 8).

ADJUSTMENT PROCEDURE:

1. Slowly rotate the engine clockwise (tightening direction) on the crankshaft and align the cam pin to the cam sensor (Figures 9, 10 and 13).
2. Using a brass or non-ferrous feeler gauge, verify the gap on the cam sensor to the cam pin and magnet. Cam sensor gap specifications; 0.015" ± 0.001" (Figure 10).

RESULTS:

1. If the gap is not within specifications, adjust cam sensor to the gap specifications mentioned above.
2. If the gap is within specifications, go to Step 9 under "Replacement Procedure."

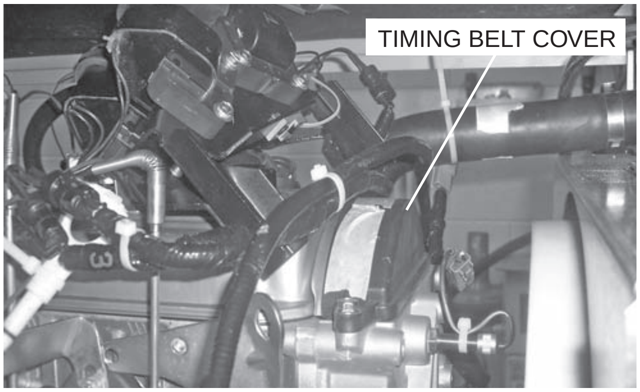

Figure 8

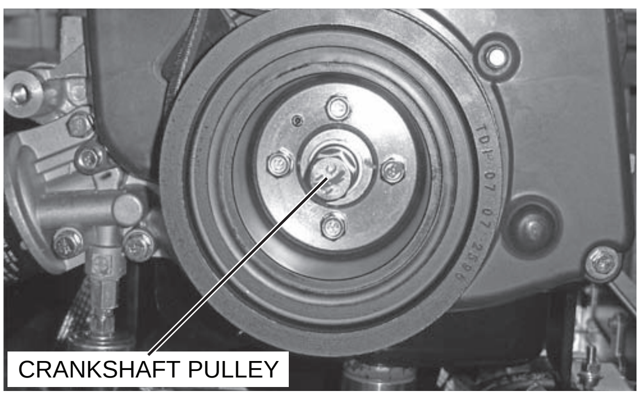

Figure 9

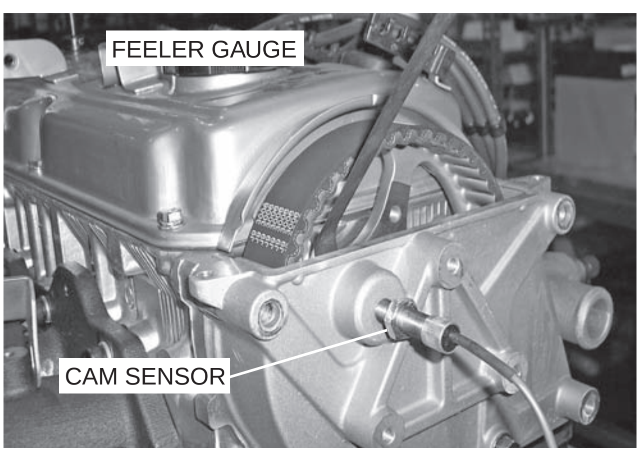

Figure 10

REPLACEMENT PROCEDURE:

Initial set up for installing the cam sensor and cam sensor pin on the 2.4L Mitsubishi engine.

1. Remove the cam sensor from the middle of the timing cover (Figure 11).

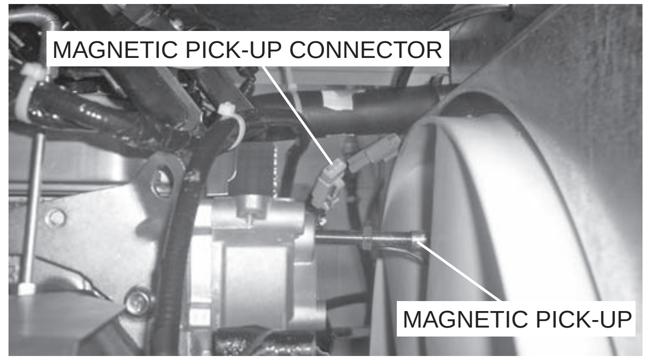

Figure 11

2. Remove the cam pin from the camshaft pulley (see Figure 13).
3. Clean the cam sprocket threads and the cam pin threads with clean non-oil based solvent (Figure 12).

Figure 12

4. Remove excess solvent with a clean paper towel or cloth.
5. Apply Loctite (blue 232 removable) to the cam pin threads and lightly screw the cam pin into the camshaft pulley. Tighten the cam pin hand tight and then turn one flat side to the right (see Figure 13).

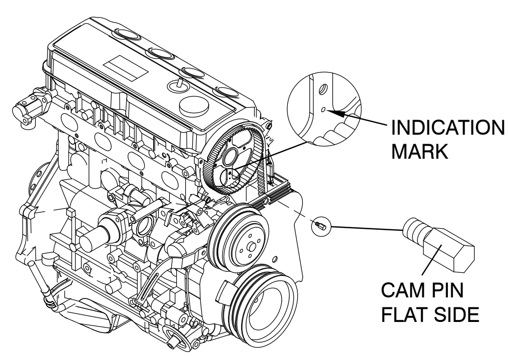

Figure 13

6. Using an inspection mirror, visually inspect that the cam pin is aligned with the cam sensor hole (Figure 14).

Figure 14

Installation Tip: Measure about 1 inch from the tip of the cam sensor and apply a paint or magic marker line across the sensor. This line represents about how much of the cam sensor must be screwed into the timing belt housing until it contacts the cam pin. (Figure 15).

Figure 15

7. Lightly screw the cam sensor into the cam sensor hole until the marker line is reached on the cam sensor.
8. Using a brass feeler gauge, set the cam sensor gap to 0.015” ± 0.001”.
9. Tighten the lock nut on the cam sensor and zip tie the wire to the cam sensor (Figure 16).

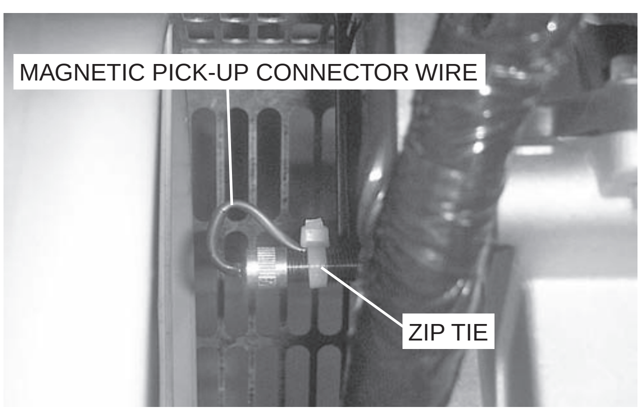

Figure 16

Warning: If the cam sensor wire is not tied down properly, the radiator fan can damage and/or cut the wire on the cam sensor, causing the unit to shut down due to a loss of cam signal going to the ignition control module.

10. Re-install the upper timing belt cover on the engine and torque the timing belt cover bolts to 8 ft-lbs or 11Nm (Figure 17).

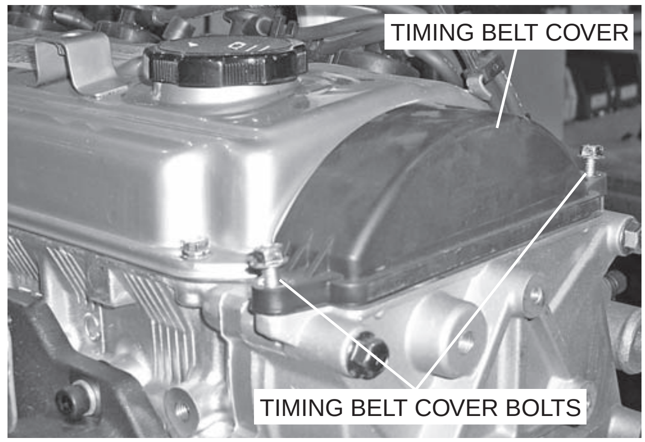

Figure 17

11. Re-install the ignition bracket and bolts with the ignition coils to the side of the timing belt cover. Torque ignition bracket bolts to 17 ft-lbs or 24 Nm (Figure 18).

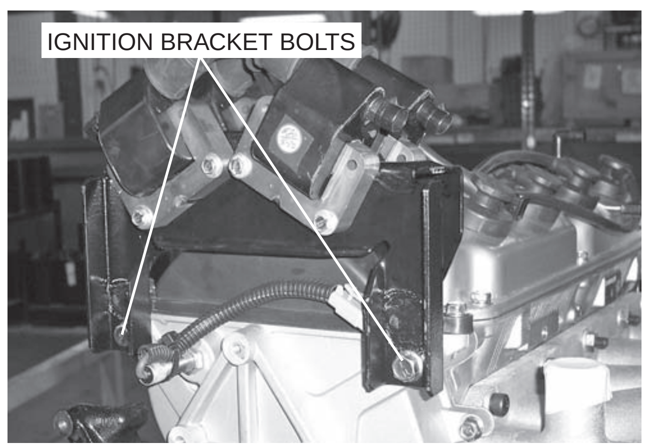

Figure 18

12. Reconnect the cam sensor connector to the engine harness.
13. Zip tie any loose wiring to a clear and safe location.
14. Re-install the fan housing guards to the radiator assembly.

COLD WEATHER START INSTALL INSTRUCTIONS

BATTERY WARMER:

1. Verify that a 120V AC line has been run out to the generator and is brought in via stub-ups or is accessible near by.
2. Remove all components from shipping carton.
3. Remove the two main access doors from the generator.
4. The generator control switch must be in the OFF position.
5. Locate the battery and disconnect the battery cables. Disconnect the negative battery cable first from the battery post indicated by (-) or NEG.
6. Remove the battery from the generator.
7. Verify battery voltage is at an acceptable level.
8. Wrap the battery warmer (Item 1, Figure 1) around the battery and fasten in place with the provided wire ties.

Note: Do not wrap battery warmer below battery side tabs (See Figure 1).

9. Remount the battery in the battery compartment.
10. Reconnect the battery cables to battery posts. Connect the positive cable first to the battery post indicated by (+) or POS.
11. Plug the 120V cord from the battery warmer into the 120V outlet that has been run to the generator or connect the warmer to the 120V source that has been run to the generator.

OIL AND OIL FILTER:

12. It is recommended for cold weather to use Mobil-1 5W30 synthetic oil. The unit needs at least 10 hours of break in before changing over to synthetic oil if going into a newly installed unit.
13. Remove the drain plug and drain oil into an appropriate oil pan for disposal and replace the drain plug.
14. Remove the used oil filter and install the new oil filter.
15. Fill the engine with the proper amount of synthetic oil.
16. After the unit has been run, check for leaks and check the oil level on the dipstick.

BLOCK HEATER INSTALL INSTRUCTIONS

1. Disconnect battery cables to prevent accidental start-up. Disconnect the negative battery cable first from the battery post indicated by (-) or NEG.
2. Drill holes in frame, if needed, using mounting drawing and template included in kit to find correct placement. Be sure to select the appropriate template for your generator. Most 22 & 27 KW generators already include the mounting holes.
3. See Figure 2, next page. Assemble block heater (Item 1) and bracket (Item 5) as shown, and attach it to the frame using specified screws (Item 3), lock washers (Item 6), flat washers (Item 4), and nuts (Item 7).
4. Remove radiator pressure cap. DANGER: Do not remove the radiator pressure cap while the engine is hot. Serious burns to skin and eyes from boiling liquid or steam could result.
5. Drain all coolant from radiator into a clean drain pan.
6. Drain coolant from engine block by removing existing plug from the right side of the engine block (See View "A"). Use a funnel and a second clean drain pan. Replace plug with 3/8" BSPT X 3/8" NPT adapter (Item 10). Next, install the 3/8" NPT 45° barbed fitting (Item 12). Use Teflon pipe sealant on all pipe fittings to ensure proper thread sealing.

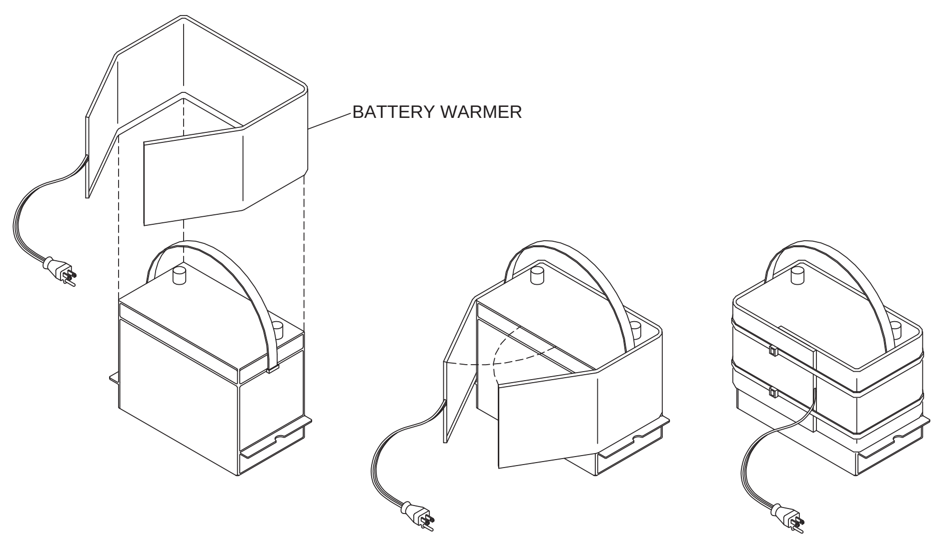

Figure 1. Battery Warmer Installation

Item	Qty	Description
1	1	HEATER BLOCK 1500W 120V
2	1	HOSE COOL 5/8 ID 20R3 (48" LG)
3	4	SCREW HHC M6-1.0 X 20 G8.8
4	4	WASHER FLAT 1/4-M6 ZINC
5	1	BRACKET HEATER W/WELDNUTS
6	4	WASHER LOCK M6-1/4
7	2	NUT HEX M6 X 1.0 G8 YEL CHR
8	4	CLAMP HOSE 7/8" OD DOUBLE WIRE
9	1	BARBED STR 3/8NPT X 5/8
10	1	ADAPTER 3/8 BSPT M X 3/8 NPT F
11	1	HOSE COOL 5/8 ID 20R3 (18" LG)
12	1	BARBED EL 45 3/8NPT X 5/8OD
13	1	TEE BRANCH 3/8NPT FMF BRASS
14	1	REFLEX WRAP 25MM 1200 X 25 (15"LG)
15	1	SWITCH HI-TEMP 245D X 3/8NPT

7. Remove temperature switch/sensor (Item 15) from the intake manifold (located on the left side of the engine) and replace it with the 3/8" NPT tee (Item 13). The 3/8 NPT tee should be oriented as shown. Install the 3/8" NPT barbed fitting (Item 9) into the lower fitting of the 3/8" NPT tee (Item 13). Use Teflon pipe sealant on all pipe fittings to ensure proper thread sealing.
8. Install coolant hose (Item 11) as shown. The hose should connect the top of the block heater to the 3/8" NPT 45° barbed fitting (Item 12) on the right hand side of the generator (radiator side being front). If you are installing the block heater on a 22 or 27 kW generator, the hose (Item 11) will need to be trimmed to 14" in.
9. Install the protective wrap (Item 14) over the block heater hose (Item 11). If you are installing the block heater on a 22 or 27 kW generator, the protective wrap should be trimmed to 11" in length.

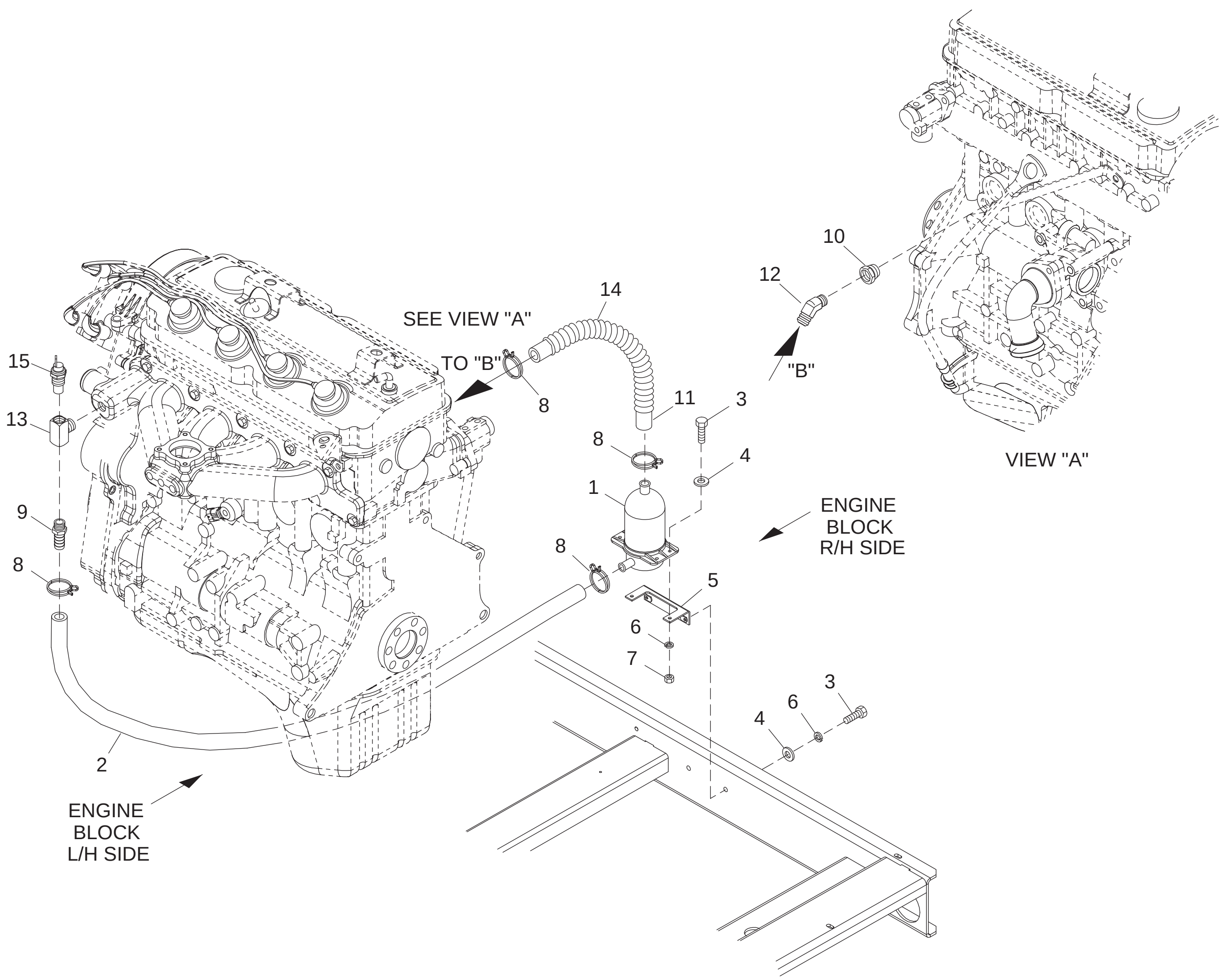

Figure 2. Block Heater Installation

10. Install coolant hose (Item 2) to block heater as shown. Clamp the other end of the hose shut with a soft jaw clamp. Take care not to damage the hose.
11. Slowly fill the engine with fresh coolant until coolant drips out of the coolant hose (Item 2).
12. Bleed out air from block heater and hoses by releasing clamp pressure from open end of hose (Item 2) and with open end of hose held vertically away from the ground and at the same elevation as the left side barbed fitting (Item 9). If needed fill the hose with coolant using a funnel. The entire hose should be full of coolant. Connect the hose onto the 3/8" NPT barbed fitting (Item 9).
13. Continue to fill the engine with fresh coolant until coolant drips out of the brass tee (Item 13). Reinstall the temperature switch/sensor (Item 15) into the upper fitting of the 3/8" NPT (Item 13).

Note: Block heater failure will occur if the next steps are not done properly.

14. Check that both block heater hoses (Item 2 & Item 11) are routed away from exhaust manifolds.
15. Top off the radiator with coolant.
16. Plug block heater into appropriate 120V power source.
17. Reconnect battery cables to battery posts. Connect the positive cable first to the battery post indicated by (+) or POS.
18. Run engine at least 20 min. or until coolant temperature stabilizes to get rid of any air pockets in the coolant lines.
19. Check coolant level after engine fully cools down, use caution when removing radiator pressure cap. Coolant should be just below the fill cap neck. Top off if needed.
20. Recheck tightness of all hose connections.
21. Clean up all coolant that may have spilled during the installation of the block heater kit.

ENGINE TORQUE SPECIFICATIONS

Item	Specification (ft-lbs)
Ignition system	
Crankshaft pulley bolts	18
Spark plugs	18
Water pump pulley bolts	6.5
Exhaust manifold	
Water pump bolts	10
Thermostat housing bolts	17.5
Timing belt	
Auto-tensioner bolts	17.5
Camshaft sprocket bolt	65
Counterbalance shaft sprocket bolt	33
Crankshaft bolt	87
Engine support bracket bolt	35
Idler pulley bolt	26
Oil pump sprocket nut	40
Tensioner “B” bolt	14
Tensioner arm bolt	16
Tensioner pulley bolt	35
Timing belt cover bolts (bolt, washer assembly)	8
Timing belt cover bolts (flange bolt and nut)	8
Inlet manifold and water pump	
Engine hanger bolt	14
Pressure switch	7.2
Water temp gauge	21.5
Water outlet fitting bolts	14.5

Item	Specification (ft-lbs)
Rocker arms and camshaft	
Rocker arms and rocker arm shaft bolts	23
Rocker cover bolts	3
Thrust screw	14
Cylinder head and valves	
Cylinder head bolts	120 → +90° → +90°
Oil pan and oil pump	
Drain plug	32.5
Flange bolt	27
Front case bolts	17.5
Oil filter bracket bolts	14
Oil filter	14
Oil pan bolts	5
Oil pump cover bolts	13
Oil pump cover screws	7.2
Oil screen bolts	14
Plug	17.5
Relief plug	32.5
Piston and connecting rod	
Connecting rod cap nuts	120 → +90° → +90°
Crankshaft and cylinder block	
Bearing cap bolts	2.5 → +90° to 100°
Bell housing cover bolts	6.5
Oil seal case bolts	8
Rear plate bolts	8

ALTERNATOR TORQUE SPECIFICATIONS

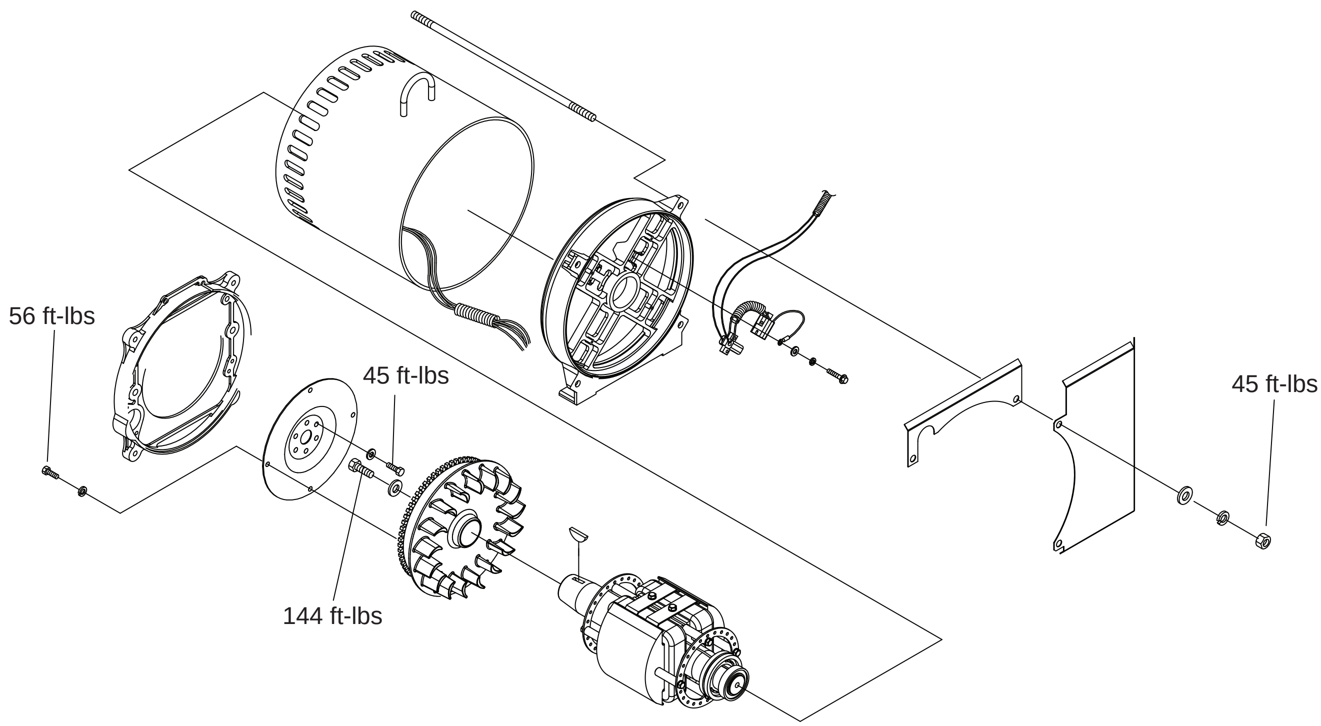

Figure 19. 35 kW-60 kW Alternator Torque Specs

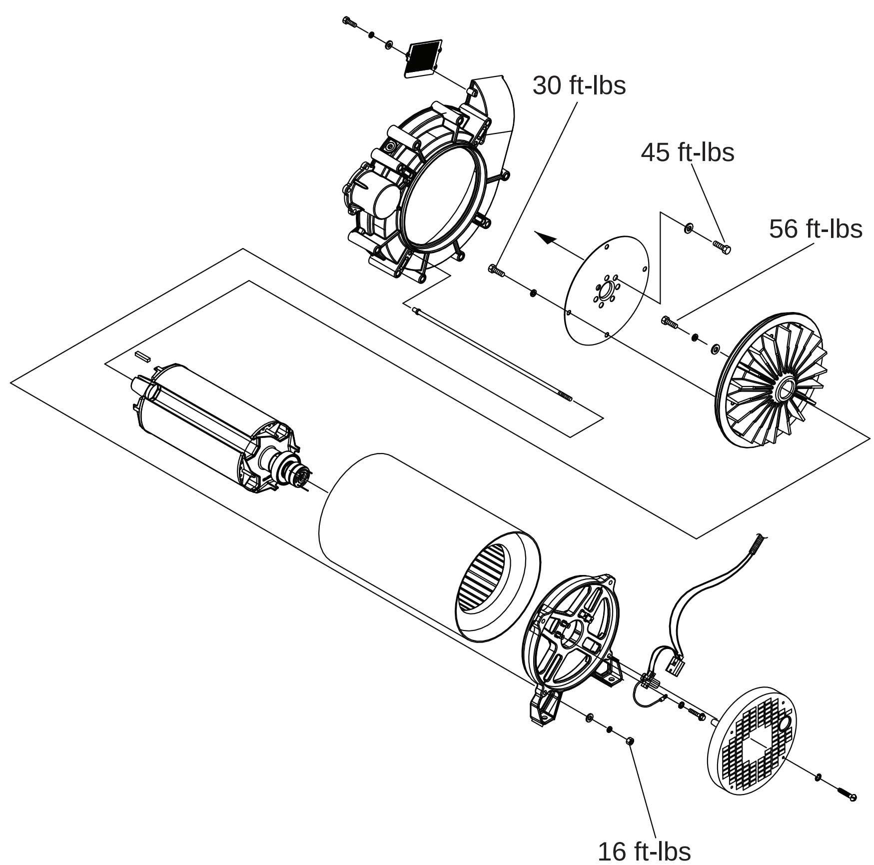

Figure 20. 22 and 27 kW Alternator Torque Specs

NOTES

PART 5
ELECTRICAL
DATA

2.4 LITER STANDBY GENERATORS

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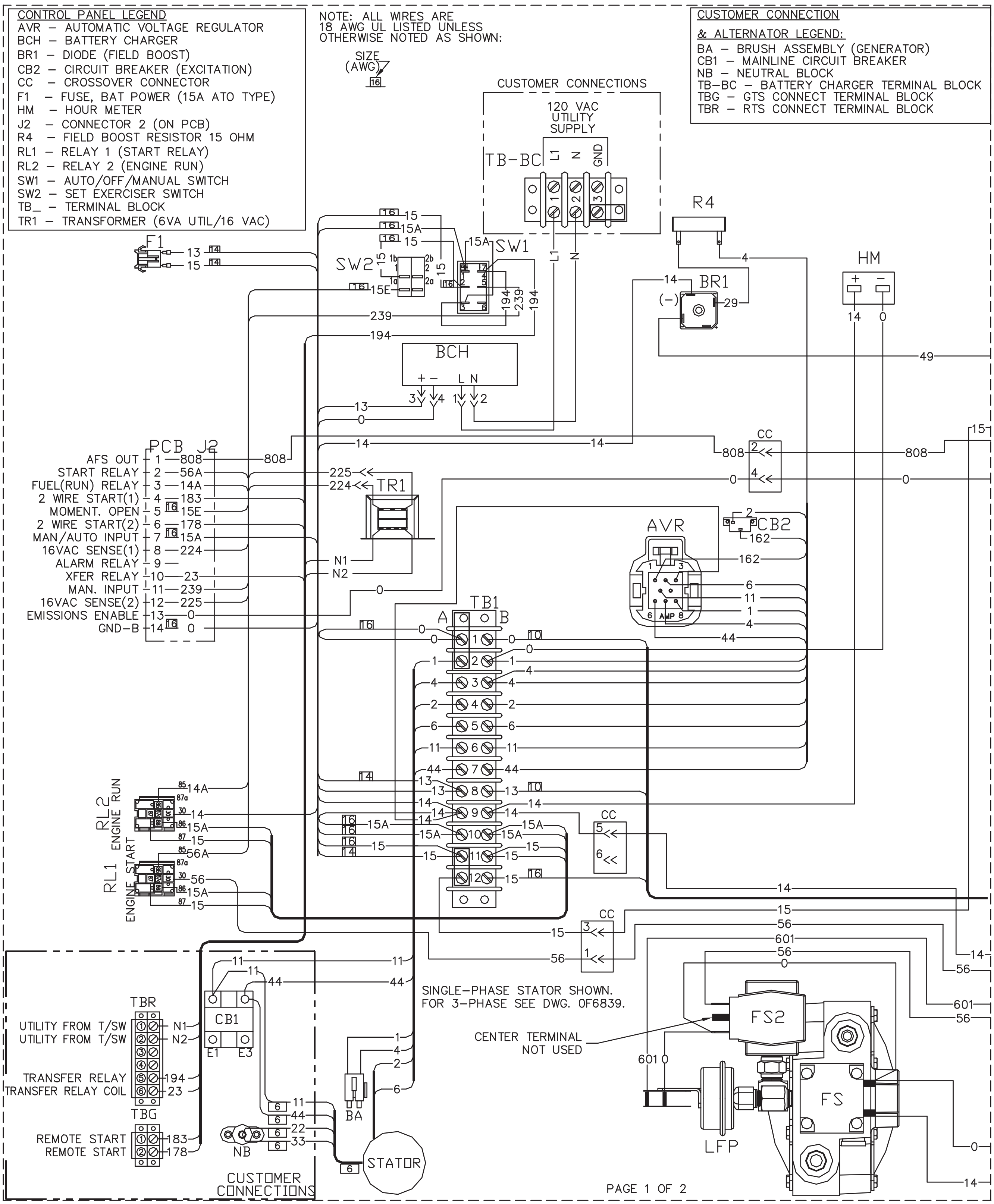
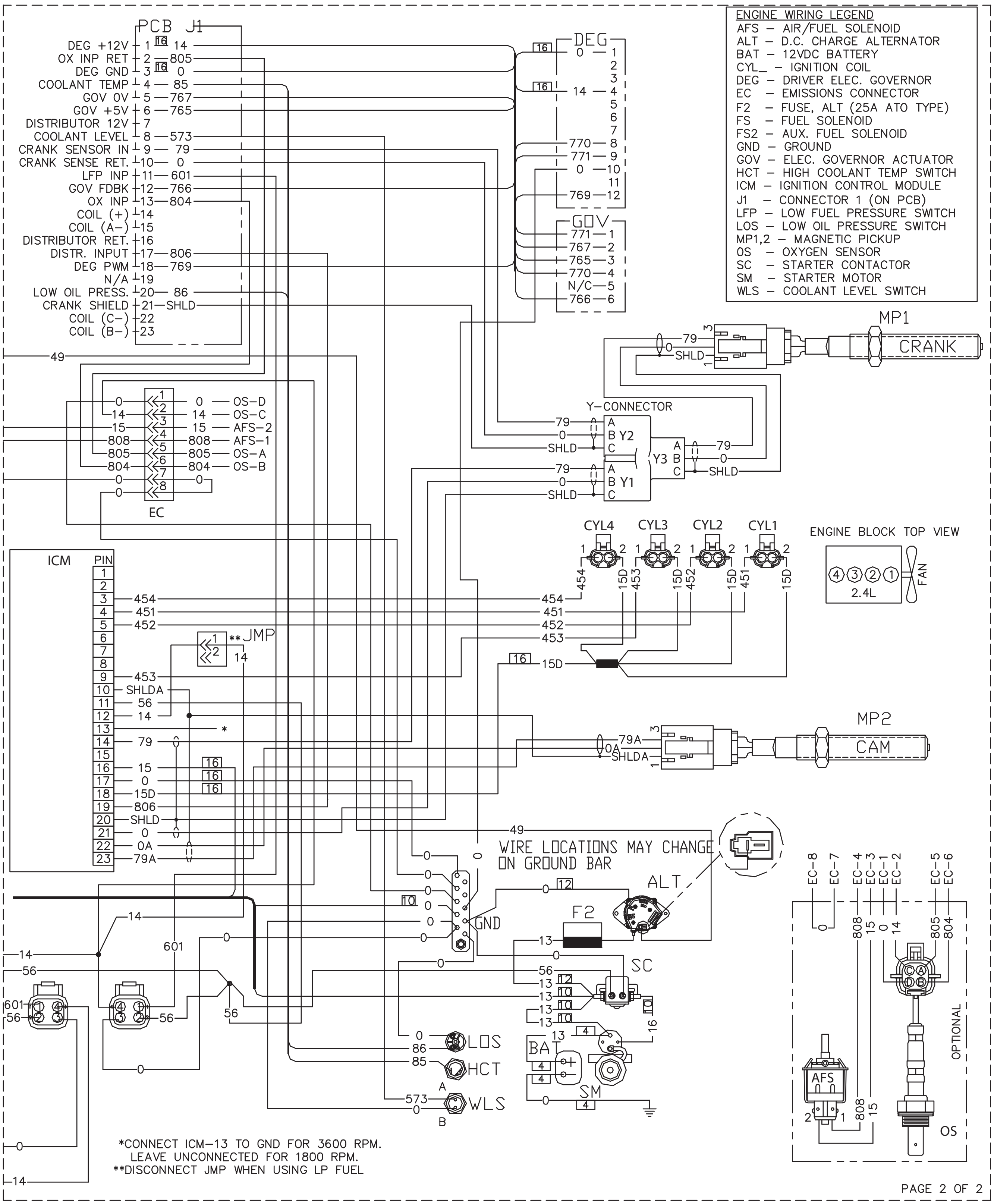
0F6839-D	Alternator Configurations	146

DRAWING #0G8839-B



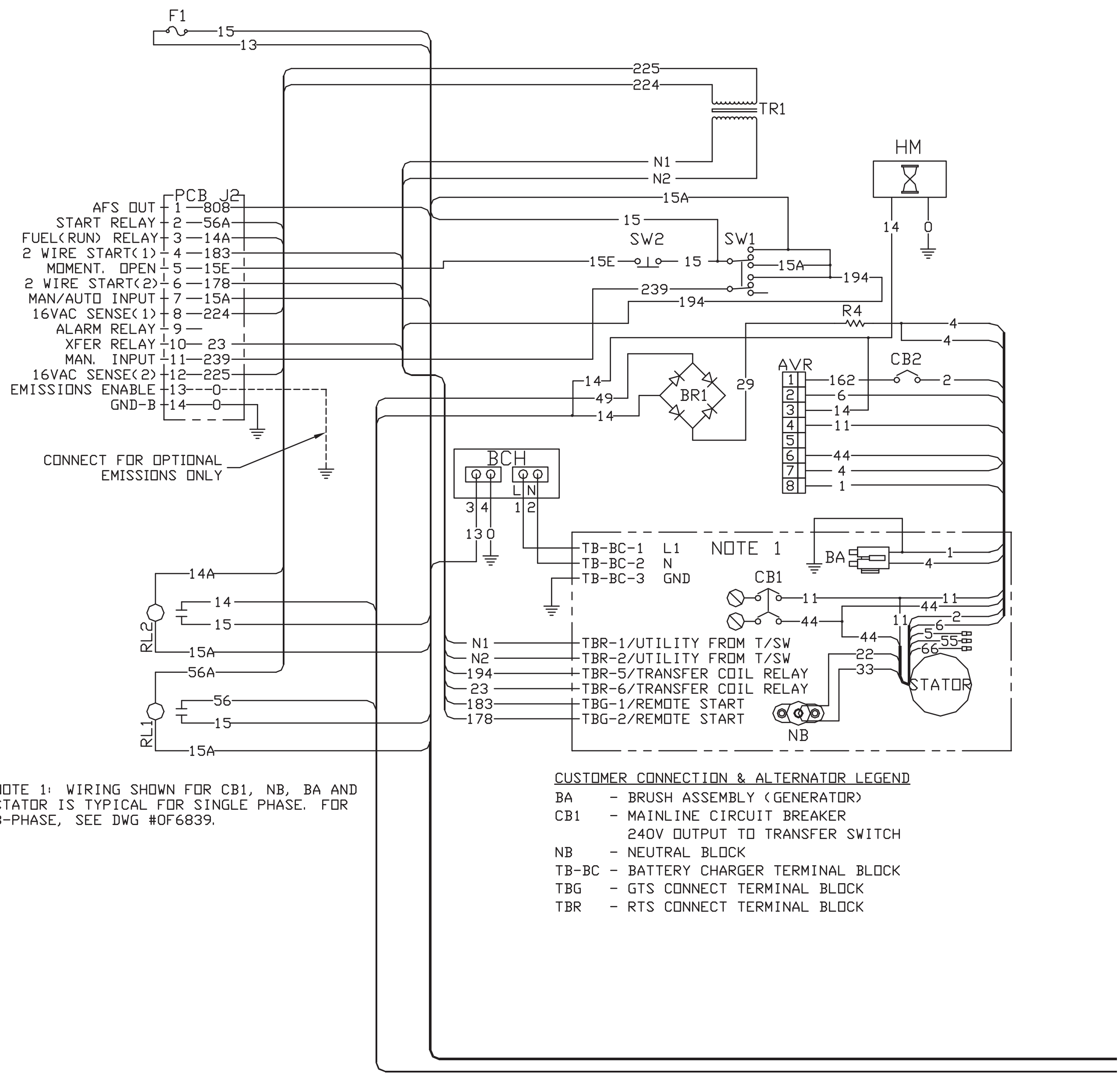
DRAWING #0G8839-B



DRAWING #0G8840-B

CONTROL PANEL LEGEND

AVR - AUTOMATIC VOLTAGE REGULATOR
BCH - BATTERY CHARGER
BR1 - BRIDGE RECTIFIER
CB2 - CIRCUIT BREAKER (EXCITATION)
F1 - FUSE BAT POWER (15A ATO TYPE)
HM - HOUR METER
J2 - CONNECTOR 2 (ON PCB)
R4 - FIELD BOOST RESISTOR
RL1 - RELAY 1 (START RELAY)
RL2 - RELAY 2 (ENGINE RUN)
SW1 - AUTO/OFF/MANUAL SWITCH
SW2 - SET EXERCISER SWITCH
TR1 - TRANSFORMER (6VA UTIL/16 VAC)

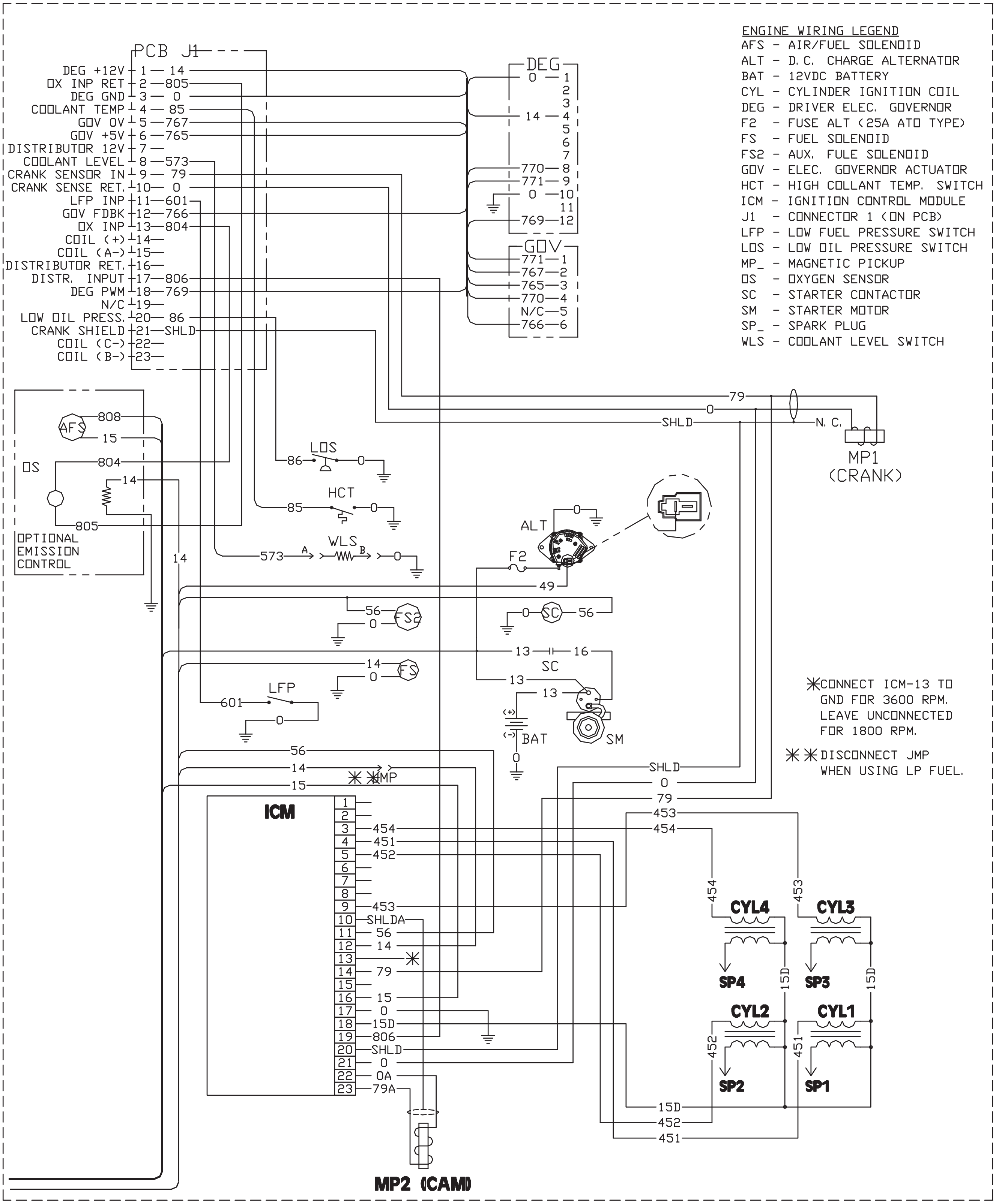


NOTE 1: WIRING SHOWN FOR CB1, NB, BA AND STATOR IS TYPICAL FOR SINGLE PHASE. FOR 3-PHASE, SEE DWG #0F6839.

CUSTOMER CONNECTION & ALTERNATOR LEGEND

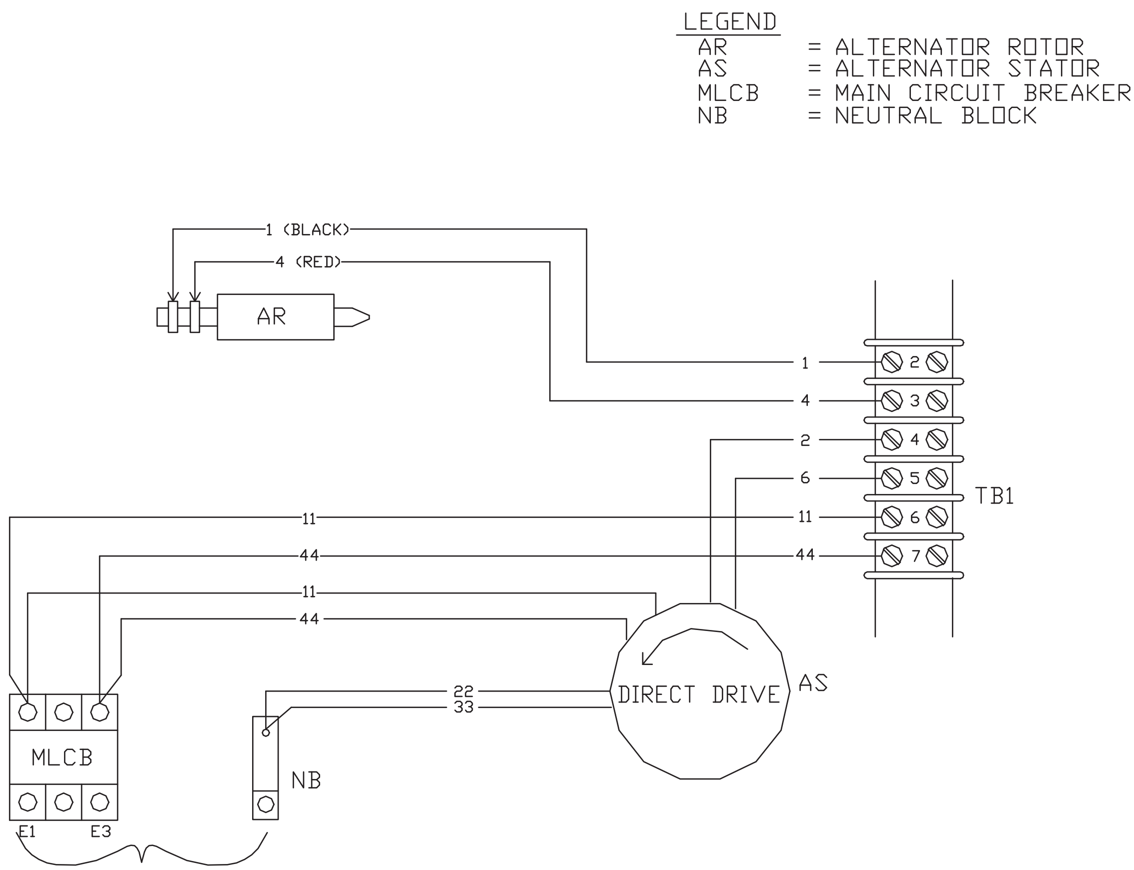
BA - BRUSH ASSEMBLY (GENERATOR)
CB1 - MAINLINE CIRCUIT BREAKER 240V OUTPUT TO TRANSFER SWITCH
NB - NEUTRAL BLOCK
TB-BC - BATTERY CHARGER TERMINAL BLOCK
TBG - GTS CONNECT TERMINAL BLOCK
TBR - RTS CONNECT TERMINAL BLOCK

DRAWING #0G8840-B



DRAWING #0F6839-D

OPTION 1 - SINGLE PHASE, R-SERIES CONTROL PANEL, 240V



GENERATOR OUTPUT
CUSTOMER CONNECTION

E1 - E3 = 240VAC
E1 - NB = 120VAC
E3 - NB = 120VAC

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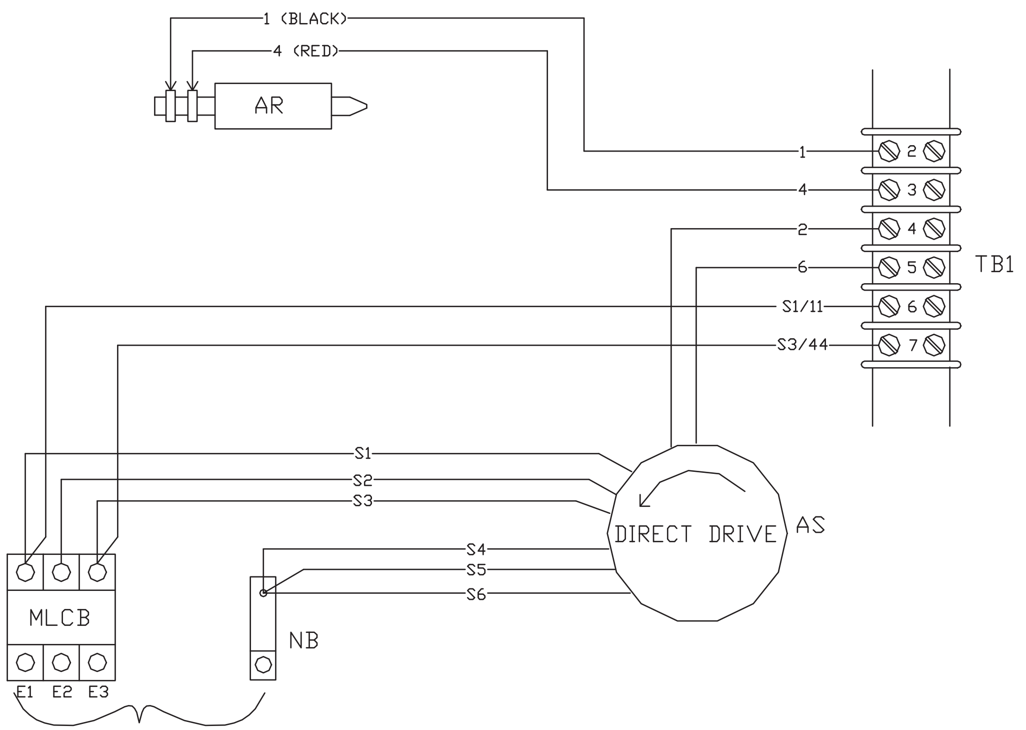
OPTION 2 - THREE PHASE, R-SERIES CONTROL PANEL, 6-WIRE 120/208V

LEGEND
AR = ALTERNATOR ROTOR
AS = ALTERNATOR STATOR
MLCB = MAIN CIRCUIT BREAKER
NB = NEUTRAL BLOCK



GENERATOR OUTPUT
CUSTOMER CONNECTION
E1 TO E2
E2 TO E3 } *208VAC
E1 TO E3
E1, E2, OR E3 TO NB = * 120VAC
*NOTE: THE 8th DIGIT OF THE MODEL NUMBER SPECIFIES OUTPUT VOLTAGE
"G" = 120/208VAC

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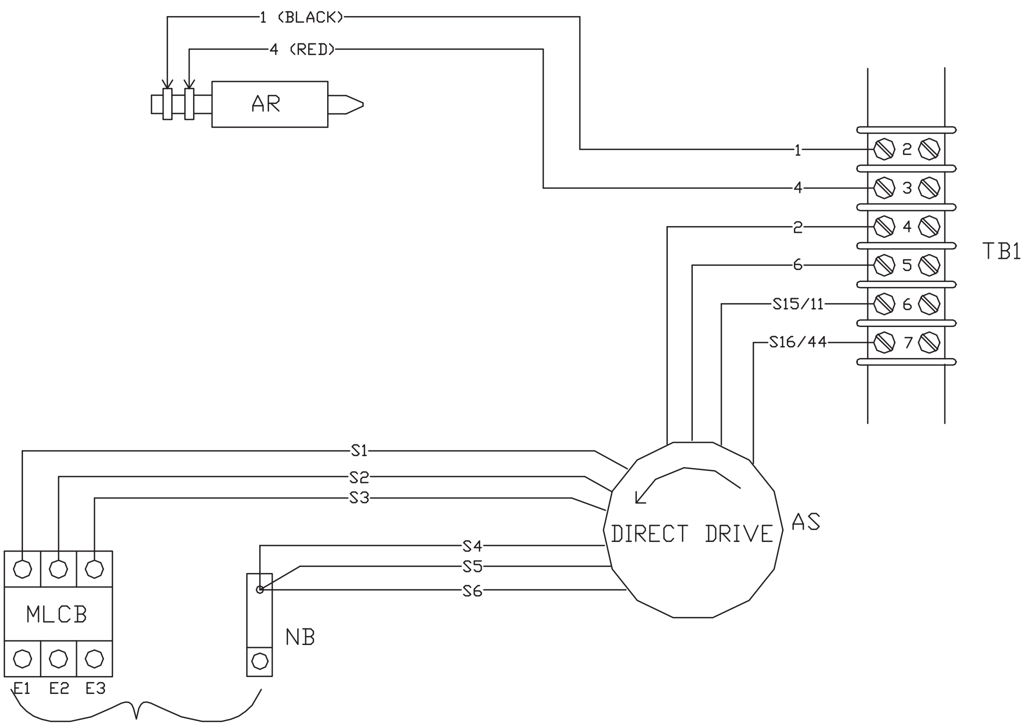
OPTION 3 - THREE PHASE, R-SERIES CONTROL PANEL, 6-WIRE 277/480V

LEGEND
AR = ALTERNATOR ROTOR
AS = ALTERNATOR STATOR
MLCB = MAIN CIRCUIT BREAKER
NB = NEUTRAL BLOCK



GENERATOR OUTPUT
CUSTOMER CONNECTION

E1 TO E2 }
E2 TO E3 } *480VAC
E1 TO E3 }

E1, E2, OR E3 TO NB = * 277VAC

*NOTE: THE 8th DIGIT OF THE MODEL NUMBER SPECIFIES OUTPUT VOLTAGE
"K" = 227/480VAC

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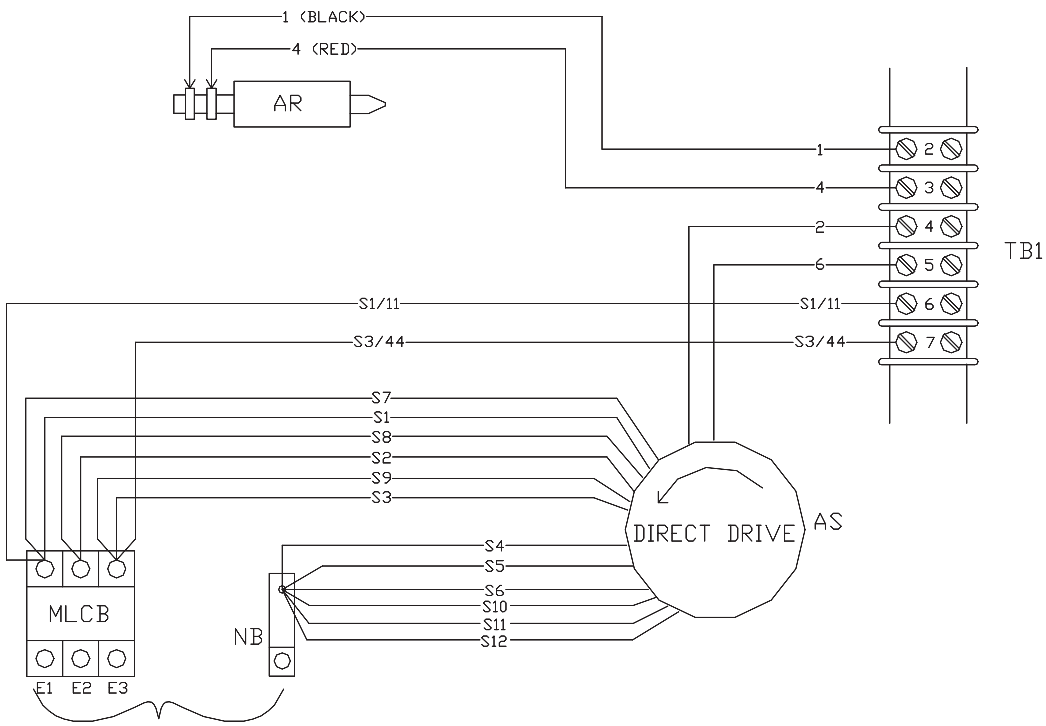
OPTION 4 - THREE PHASE, R-SERIES CONTROL PANEL, 12-WIRE 120/208

LEGEND

AR	= ALTERNATOR ROTOR
AS	= ALTERNATOR STATOR
MLCB	= MAIN CIRCUIT BREAKER
NB	= NEUTRAL BLOCK



GENERATOR OUTPUT
CUSTOMER CONNECTION

E1 TO E2
E2 TO E3 } *208VAC
E1 TO E3

E1, E2, OR E3 TO NB = * 120VAC

*NOTE: THE 8th DIGIT OF THE MODEL NUMBER SPECIFIES OUTPUT VOLTAGE
"G" = 120/208VAC

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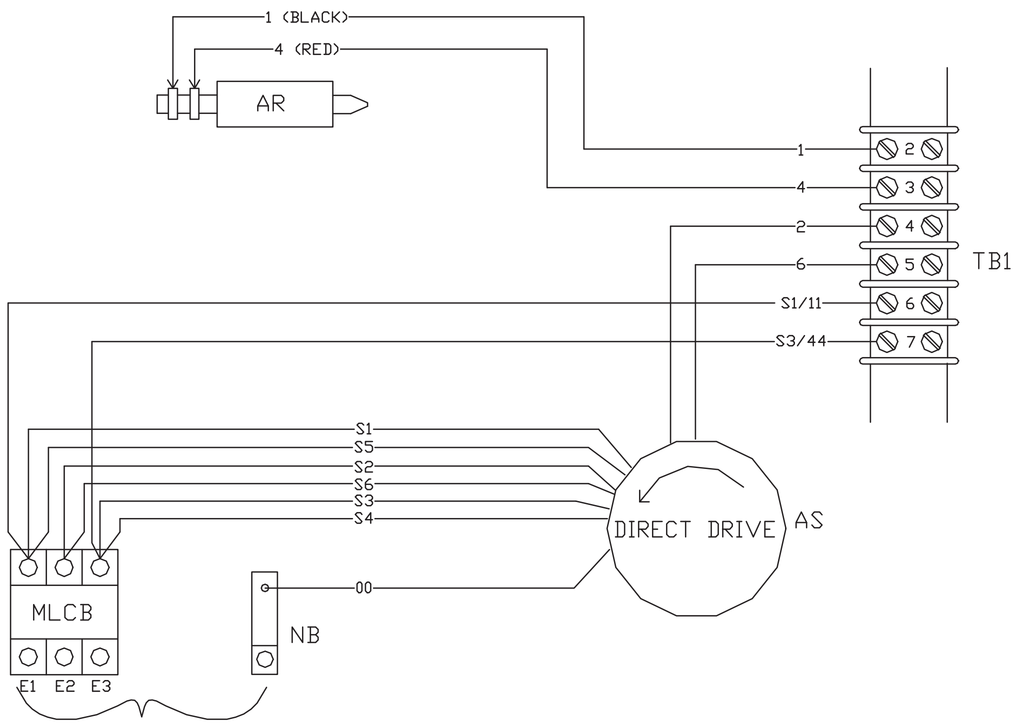
OPTION 5 - THREE PHASE DELTA, R-SERIES CONTROL PANEL, 7-WIRE 120/240V

LEGEND
AR = ALTERNATOR ROTOR
AS = ALTERNATOR STATOR
MLCB = MAIN CIRCUIT BREAKER
NB = NEUTRAL BLOCK



GENERATOR OUTPUT
CUSTOMER CONNECTION

E1 TO E2
E2 TO E3 } *240VAC
E1 TO E3

E1, OR E3 TO NB = * 120VAC

*NOTE: THE 8th DIGIT OF THE MODEL NUMBER SPECIFIES OUTPUT VOLTAGE
"j" = 120/240VAC

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TO FIND	KNOWN VALUES	1-PHASE	3-PHASE
KILOWATTS (kW)	Volts, Current, Power Factor	$\frac{E \times I}{1000}$	$\frac{E \times I \times 1.73 \times PF}{1000}$
KVA	Volts, Current	$\frac{E \times I}{1000}$	$\frac{E \times I \times 1.73}{1000}$
AMPERES	kW, Volts, Power Factor	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times 1.73 \times PF}$
WATTS	Volts, Amps, Power Factor	Volts x Amps	E x I x 1.73 x PF
NO. OF ROTOR POLES	Frequency, RPM	$\frac{2 \times 60 \times \text{Frequency}}{\text{RPM}}$	$\frac{2 \times 60 \times \text{frequency}}{\text{RPM}}$
FREQUENCY	RPM, No. of Rotor Poles	$\frac{\text{RPM} \times \text{Poles}}{2 \times 60}$	$\frac{\text{RPM} \times \text{Poles}}{2 \times 60}$
RPM	Frequency, No. of Rotor Poles	$\frac{2 \times 60 \times \text{Frequency}}{\text{Rotor Poles}}$	$\frac{2 \times 60 \times \text{Frequency}}{\text{Rotor Poles}}$
kW (required for Motor)	Motor Horsepower, Efficiency	$\frac{HP \times 0.746}{\text{Efficiency}}$	$\frac{HP \times 0.746}{\text{Efficiency}}$
RESISTANCE	Volts, Amperes	$\frac{E}{I}$	$\frac{E}{I}$
VOLTS	Ohms, Amperes	I x R	I x R
AMPERES	Ohms, Volts	$\frac{E}{R}$	$\frac{E}{R}$

E = VOLTS I = AMPERES R = RESISTANCE (OHMS) PF = POWER FACTOR

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