

# **BALDOR<sup>®</sup>**

## **GENERATORS**

PRESENTS YOUR

# **TOWABLES**

OPERATOR'S MANUAL



## **BALDOR GENERATORS**

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# TOWABLES

## OPERATOR'S MANUAL

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#### OTHER MANUALS AND ACCESSORIES THAT SHOULD ACCOMPANY YOUR TOWABLE GENERATOR:

**ENGINE OPERATOR'S MANUAL:** This operator's manual includes information in regards to the operation and maintenance of the engine utilized in this generator set.

**AC GENERATOR, ACCESSORIES, AND LOAD CONNECTION DIAGRAMS / ENGINE CONTROLS, ACCESSORIES, AND REMOTE CONNECTION DIAGRAMS:** These diagrams contain information in regards to the internal wiring of the generator set, specifically the AC and Engine Control circuits. These diagrams will also include information for any optional AC or DC powered accessories that are included.

**PARTS LIST:** This is a listing of all parts used by Baldor Generators to build this specific generator set.



Read Operator Manuals prior to using this product. Serious Injury or Death may occur if used improperly.

Operate only in well ventilated area. Exhaust fumes are dangerous & poisonous.

Check fluid levels prior to operation and at regular intervals (see operator manuals) engine damage can occur.

Do not change voltages positions on the selection switch while unit is operating. Always padlock switch position. Damage to generator or load may occur.

Maintenance (Large Side) doors must remain closed during operation. Unit will overheat if doors are open.

Do not reach into running equipment. Serious injury or death may occur.

California Proposition 65 Warning- Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects and other reproductive harm.

### MANUAL OPERATION BEFORE STARTING

1. Connect load via receptacles or hardwire to terminals provided in connection box (see wiring decal inside connection box or O & M manual section 1-2).
  2. Close the load connection box door after connecting wires.
  3. Trip main load breaker to disconnect load.
  4. Select voltage, 120/208 or 120/240 or 277/480 via rotary reconnection switch (Receptacles are live only in 120/240 position). Padlock to prevent tampering.
  5. Move the MASTER CONTROL switch to the RUN/MANUAL position to start (see O & M manual section 2-1)
- NOTE: There is a 15 second delay for engine preheat before engine cranking.
6. Reset main load breaker (Breaker will not reset if the load connection box door is not closed).
  7. Move the MASTER CONTROL switch to the OFF position to stop.

### REMOTE OR AUTOMATIC OPERATION

1. Connect load via receptacles or hard wire to terminals provided in connection box (See wiring decal inside connection box or O & M manual section 1-1).
  2. Close the load Connection box after connecting wires.
  3. Trip main load breakers to disconnect load.
  4. Connect a single pole single throw switch or dry relay contact to the "RR" terminals in the load connection box.
  5. Move the MASTER CONTROL switch to the AUTO START position.
  6. The unit will start when the switch or relay connected to the "RR" terminals is closed.
- NOTE: There is a 15 second delay for engine preheat before engine cranking.
7. Reset main load breaker. (Breaker will not reset if the load connection box door is not closed.)
  8. Stop unit by opening the connection to the "RR" terminals.
  9. Move the MASTER CONTROL switch to the OFF position to avoid unwanted starting.

### FAULT SHUTDOWNS

1. A fault can be indicated by an alarm light located on the control panel.  
Overspeed indicates engine governor allowed speed to exceed safe limits.  
Overcrank: Indicates unit failed to start in preprogrammed time period.  
Low Oil Pressure: Indicates engine safe operating pressure was not maintained.  
Overtemperature: Indicates engine safe operating temperature was exceeded.
2. All faults should be identified and corrected prior to restarting the unit.
3. To clear a fault light, move MASTER CONTROL switch to OFF.
4. Overload situations will cause the main breaker to trip. In this event, load must be reduced and breaker reset.
5. Main Breaker cannot be reset if load connection box door is open. Close door.

**This Decal as Posted On Generator**

## SAFETY WARNINGS



**Improper Maintenance or Repair Can Result in Property Damage, Mechanical Failure, Severe Injury or Death!**

- ◆ Place protective covers and guards over the rotating parts, if rotating parts such as the drive shaft, pulley, belt, etc. are left exposed, they are potentially hazardous.
- ◆ When cleaning, repairing or inspecting, make sure all moving parts have stopped.
- ◆ Prior to working on the generator set, disconnect the spark plug and battery to prevent accidental starting.
- ◆ Use only original equipment or authorized replacement parts. Use of correct parts will assure the operator of the safety integrity that was designed into the unit.
- ◆ Unauthorized modifications to the generator set may impair the function and/or safety of the unit.
- ◆ Do not operate the generator set without a muffler. Inspect periodically and replace if necessary.
- ◆ Do not touch the hot exhaust components or the high voltage spark plug and coil terminals. While Spark Plug Voltages are not normally lethal, an involuntary jerk of the hand caused by a hot surface or by an electrical shock can result in injury.
- ◆ Repair of electrical generating equipment requires specialized skills. Repair personnel must have a thorough understanding of generator and small engine repair procedures.



**Exhaust Fumes/Gases Are Extremely Dangerous And Can Cause Illness Or Death.**

- ◆ Never inhale exhaust gases. They contain carbon monoxide; a colorless, odorless and extremely dangerous gas that can cause unconsciousness or death. Symptoms of carbon monoxide poisoning can include: dizziness, nausea, headaches, sleepiness, vomiting or incoherency. If you or anyone else experiences any of these symptoms, get out into the fresh air immediately. Shut the unit down and do not operate it until it has been inspected and, if necessary, repaired.
- ◆ Never Operate the generator set indoors or in a poorly ventilated area such as a tunnel or cave.
- ◆ CALIFORNIA PROPOSITION 65 WARNING: engine exhaust from this product contains chemicals known to the state of California to cause cancer, birth defects or other reproductive harm.



**Improper Operation Can Result In Property Damage, Mechanical Failure, Severe Injury Or Death.**

- ◆ Know how to stop the engine quickly and understand the operation of all controls.

## SAFETY WARNINGS

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- ◆ Never permit anyone to operate the generator set without proper instructions.
- ◆ Never allow children to operate the generator set.
- ◆ Children and pets must be kept away from the area of operation due to the possibility of burns from hot engine components or injury from any equipment the generator set is powering.
- ◆ Always wear eye protection and Hearing protection when working near the generator set.
- ◆ Operate the generator set only with the guards, shields and other safety items in place and working properly.
- ◆ Do not put hands, feet, tools or other objects near rotating parts.
- ◆ Use reasonable care when moving or lifting the unit. The generator set may move around inside the wrap frame creating "Pinch Points".
- ◆ Do not run the generator set while it is being moved.
- ◆ Do not support the generator set from the top of the wrap frame.
- ◆ Do not operate the generator set while under the influence of alcohol, drugs or medication.
- ◆ When transporting or using a generator set with the wheel option, secure the unit to prevent it from moving around.
- ◆ Do not tamper with or change the engine speed as it has been preset at the factory for proper operation.
- ◆ Keep hands and face away from the carburetor when the air cleaner is being moved. A sudden backfire can cause serious burns.
- ◆ Be careful of hot parts. The muffler and other generator parts become very hot while the engine is running.
- ◆ Do not "jump start" the generator set.
- ◆ Sulfuric acid can cause severe injury and can give off gases, which are corrosive and potentially explosive. Avoid contact with skin, eyes, and clothing. In case of contact, flush area immediately with water.
- ◆ When transporting a generator set, secure it to prevent it from moving or shifting.



**This Generator Set Produces Electricity And With That There Is The Potential Danger For Electrocution.**

- ◆ Know how to stop the engine quickly and understand the operation of all controls.
- ◆ Do not operate electrical equipment while standing in water, on wet ground or with wet hands or shoes.
- ◆ Use extreme caution when working on electrical components. Potentially dangerous voltage is present when the engine is running.

## SAFETY WARNINGS

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- ◆ Always treat the electrical circuits as if they were energized.
- ◆ Disconnect all leads plugged into the unit Prior to working on it.
- ◆ Have the electrical circuits serviced only by qualified technicians.
- ◆ Inspect wiring frequently and replace frayed, broken or poor leads.
- ◆ Do not connect this unit to any building's electrical system unless you utilize an approved transfer switch or the main service entrance switch has been disconnected and locked open.
- ◆ Circuit overload protection must be provided in accordance with national electrical codes and local regulations.
- ◆ Check GFCI Receptacles monthly by using the "Test" and "Reset" buttons designed into them.
- ◆ Depending on your application it may be mandatory to ground or not ground this unit to earth ground. Comply with local electrical codes.

○ ○ ○ ○ FOR GASOLINE OR DIESEL POWERED GENERATOR SETS ○ ○ ○ ○



**Gasoline And Diesel Fuel Are Flammable And Can Cause Explosions, Fire, Injury Or Death!**

- ◆ Operate the generator set on a level surface. If the generator set is tilted, fuel spillage may result.
- ◆ Handle fuel with care. It is highly flammable. Use only clean, properly marked and approved safety containers for refueling and storing fuel.
- ◆ Stop the engine and allow it to cool before refueling.
- ◆ Do not overfill the fuel tank. Only fill the tank to within 1/2" of the top of the tank to allow space for fuel expansion.
- ◆ If fuel is spilled, wipe it up carefully and wait until the fuel has dried before starting the engine.
- ◆ Make sure the fuel cap is properly closed after refueling.
- ◆ Never operate the generator set while smoking.
- ◆ Never operate the generator set near an open flame.
- ◆ Never store the generator set with fuel in the tank indoors or in an enclosed, poorly ventilated enclosure where fuel fumes may reach an open flame, electrical spark or pilot light as on a furnace, water heater, clothes dryer, etc.
- ◆ When transporting over long distances or rough roads, drain the fuel tank to prevent leakage and spillage.

## SAFETY WARNINGS



**Gaseous Fuels are Highly Combustible and can Cause Explosions, Fire, Injury or Death!**

### ○●○○○ **FOR GASOLINE OR DIESEL POWERED GENERATOR SETS** ○●○○○

- ◆ Check all fuel supply piping and their connections on a monthly basis for fuel leaks.
- ◆ Use only approved piping and componentry in your fuel supply system.
- ◆ A professional, experienced technician should only install the fuel supply system.
- ◆ Do not run the fuel line up against any sharp objects.
- ◆ Comply with NFPA regulations and your local codes in regard to shut-off valves, regulators, etc. and any other recommendations or requirements they may have.



**This Generator Set Creates A Significant Amount Of Heat And If Not Handled Properly, Can Become A Substantial Fire Hazard.**

- ◆ Keep the generator set at least three feet away from buildings or other structures.
- ◆ Keep the generator set away from flammable and other hazardous materials (trash, rags, lubricants, explosives, paints, etc.)
- ◆ Keep the generator set free of grass, leaves and excessive grease and oils.
- ◆ Allow the generator set to cool before transporting it or storing it indoors.
- ◆ Have fire extinguisher accessible and nearby while operating the generator set.
- ◆ This generator set must not be used on or near any forest covered brush covered or grass covered land unless the engine's exhaust system is equipped with a spark arrester and it must be maintained in effective working order by the operator.
- ◆ Operation inside an enclosed compartment or building is a potential fire hazard and should not be done unless approval is obtained from Baldor Generators. Engine/Generator overheating can cause severe damage due to restricted, obstructed or improper air-flow that is necessary for the proper cooling of the unit.
- ◆ Hot exhaust gases being discharged by the engine must never be directed toward anything that could catch fire or explode.

## FORWARD

This manual contains the information you need to safely and efficiently operate your generator set. During the preparation of this manual every effort was made to ensure the accuracy of its contents.

Never operate this generator set without first carefully reading this manual and observing all the safety warnings it presents. While safety is built into every Baldor Pow'R Gard generator set, careless or improper operation could possibly result in mechanical failure, property damage, severe injury or death.

Note that this manual covers only very basic information in regards to the engine. A separate owner's manual for the engine is supplied with this unit for your use. Please refer to this manual for information relative to engine operation, maintenance, recommendations and additional safety warnings.

As soon as you receive your generator set, inspect it closely for shipping damage. If you find some damage, notify the transportation company immediately and file a freight damage claim.

Think of this manual as a tool to help you get the most out of your generator set. We strongly suggest that you keep this manual with your generator set and refer to it when questions arise in regards to its operation.

Baldor Generators, formerly Pow'R Gard Generator Corporation has been in business since 1965. The generator sets we manufacture have earned the reputation of being of high quality and a dependable product. We take pride in this fact and continue to keep our quality standards high on our list of priorities. We are also constantly researching new technological ideas to determine if they could be used to make our generator sets even better.

Thank you for purchasing your Baldor Pow'R Gard Generator Set.





**Features & Specifications**

Model		TS25	TS45	TS80	TS130	TS175
<b>G E N E R A T O R</b>	<b>Standby output– 150°C Rise (KVA/KW):</b>					
	3 PH @ 480 Volt	25/20	48/38	81/65	134/107	175/140
	3 PH @ 208/240 Volt	25/20	46/37	72/58	131/105	169/135
	1 PH @ 240 Volt	18/18	27/27	45/45	70/70	80/80
	<b>Continuous Output– 125°C Rise (KVA/KW):</b>					
	3 PH @ 480 Volt	23/18	44/35	75/60	121/97	169/135
	3 PH @ 208/240 Volt	23/18	44/35	69/55	119/95	156/125
	1 PH @ 240 Volt	18/18	25/25	43/43	66/66	75/75
	<b>Voltage – 3 PH Adjustable</b>	208/220/240/ 416/440/460/480	208/220/240/ 416/440/460/480	208/220/240/ 416/440/460/480	208/220/240/ 416/440/460/480	208/220/240/ 416/440/460/480
	<b>Voltage – 1 PH Adjustable</b>	120/127/139/ 240/254/277	120/127/139/ 240/254/277	120/127/139/ 240/254/277	120/127/139/ 240/254/277	120/127/139/ 240/254/277
	<b>Amperage (Continuous):</b>					
	3 PH 480 Volt	27.1	52.6	90.2	145.8	203.0
	3 PH 208 Volt	62.5	121.4	190.8	329.6	433.7
	3 PH 240 Volt	54.1	105.3	165.4	285.7	375.9
	1 PH 240 Volt/120 Volt	75.0/150.0	104.2/208.3	179.2/358.3	275/550	312.5/625.0
	<b>Receptacles:</b>					
	120 Volt, 15 Amp GFCI	4	6	6	6	6
	120/240 Volt, 50 Amp, CS6369 Twistlock	2	3	3	3	3
	<b>Voltage Regulation 1/2%</b>	1/2%	1/2%	1/2%	1/2%	1/2%
	<b>Power Factor – 3 Phase</b>	0.8	0.8	0.8	.08	.08
<b>Frequency</b>	50 or 60 Hertz	50 or 60 Hertz	50 or 60 Hertz	50 or 60 Hertz	50 or 60 Hertz	
<b>Total Harmonic Distortion</b>	<5%	<5%	<5%	<5%	<5%	
<b>Insulation</b>	Class F	Class F	Class F	Class F	Class F	
<b>E N G I N E</b>	<b>Engine Make/Model</b>	Isuzu 4LE	Isuzu 4BG1	John Deere TO4045T	John Deere TO6068	John Deere RG6081T
	<b>Design</b>	Water Cooled 4 Cycle Diesel	Water Cooled 4 Cycle Diesel	Water Cooled 4 Cycle Diesel	Water Cooled 4 Cycle Diesel	Water Cooled 4 Cycle Diesel
	<b>Starting System</b>	12 VDC	12 VDC	12 VDC	12 VDC	12 VDC
	<b>Displacement (cid)</b>	133.0	264.2	276.0	414.0	498.0
	<b>Cylinders</b>	4	4	4	6	6
	<b>HP @ Rated Speed</b>	34.5	64.0	100.0	166.0	211.0
	<b>RPM</b>	1800	1800	1800	1800	1800
	<b>Safety Shutdowns:</b>					
	High Temperature	Std.	Std.	Std.	Std.	Std.
	Low Oil	Std.	Std.	Std.	Std.	Std.
	Overspeed	Std.	Std.	Std.	Std.	Std.
	Overcrank	Std.	Std.	Std.	Std.	Std.
	<b>Fuel Capacity</b>	50	80	80	160	160
	<b>Fuel Consumption (GPH):</b>					
	1/2 Load	1.3	2.0	2.7	4.2	5.6
	Full Load	2.0	3.4	4.9	8.1	10.5
	<b>Approx. Run Time (Hrs.):</b>					
	1/2 Load	38	40	30	38	29
	Full Load	25	24	16	20	15
	<b>Battery Recommendation Min. Cold Cranking Amps (Battery not included)</b>	750	900	900	(2) 750	(2) 750
<b>D I M E N S I O N S (<b>L x W x H</b>):</b>	<b>With Trailer</b>	123" x 62" x 70"	139" x 60" x 81"	139" x 60" x 81"	163" x 66" x 94"	163" x 66" x 94"
	<b>Without Trailer</b>	74" x 38" x 52"	84" x 38" x 61"	84" x 38" x 61"	108" x 42" x 74"	108" x 42" x 74"
	<b>Weight (Lbs.):</b>					
	<b>Without Fuel</b>	2265	3540	3848	5600	6200
	<b>Without Fuel &amp; Trailer</b>	1790	2829	3053	4610	5205



# SWITCHABLE

## ELECTRICAL CONNECTION INFORMATION

**WARNING:** High voltage may be present at receptacles and load studs while engine is operating – **DANGER** of electrical shock is present. Use extreme care.

### LOAD RECEPTACLES

1. Voltage is present in 120/240 volt switch position only.
2. Load wires may be brought into receptacle compartment through access door at control station.

### HARD WIRE LOAD TERMINAL BLOCK

1. Voltage available at load block is outlined in chart below.
2. Cables must be brought into load block compartment through access hole in base of trailer.
3. Opening load block door will cause load disconnect to trip.
4. Do not start engine with load turned “on”. Allow engine to come up to speed and warm up (1).
5. If left unattended, lock all doors to prevent tampering or injury.

<b>AVAILABLE VOLTAGE:</b>	
<b>SWITCH POSITION</b>	<b>STUD</b>
277/480	1-2-3 = 480 VAC, 3 Phase 1-N, 2-N, 3-N = 277 VAC, 1 Phase
120/240	1-2-3 = 240 VAC, 3 Phase 2-3 = 240 VAC, 1 Phase 2-N, 3-N = 120 VAC, 1 Phase 1-N = 180 – 200 VAC, Wild Leg
120/208	1-2-3 = 208 VAC, 3 Phase 2-3 = 208 VAC, 1 Phase 1-N, 2-N, 3-N = 120 VAC, 1 Phase

**NOTE:** To prevent damage to loads and generator, select voltage switch position prior to starting engine.

**NOTE:** Upon switching voltage selector switch, adjust voltage and adjust rheostat (located on engine control panel) for proper voltage.



## CONNECTION INFORMATION

Your new Baldor Generator has all interconnecting wiring terminated at a junction box. All wiring will be clearly labeled as being load; remote start contacts and AC input terminals and are to be connected as described below.

**Load** – These connections are rated and sized according to the KW of the generator. Proper lead wire from these points to the automatic transfer switch (or load switching device) is mandatory. See enclosed transfer switch information for corresponding generator input terminals.

**Remote Start Contacts** – This two-wire connection, once connected to an appropriate switch, will start the generator and perform as described in the remote start/stop literature. These contacts are connected to the “Engine Start Contacts” of the automatic transfer switch.

A Two Pole normally open, closed to operate switch may also be used to start the generator.

**AC Input** – These connections are for units with float type battery chargers or engine block heater combinations. A Constant supply of 120 volts AC (or as specified) is needed at these terminals to power these devices.

**NOTE:** Power is not required when the unit is in operation. Internal battery charging and radiant heat during operation eliminate the need for these devices.

**NOTE:** It is recommended that units utilizing an automatic transfer switch with adjustable time delays have the initial adjustments made prior to start-up.

Factory recommendations are; allow a 2 second delay on start-up, 15-second delay on emergency to normal.



## CONTROL PANEL OPERATION AND FUNCTION

- A. MASTER CONTROL SWITCH** – This switch controls the starting and stopping of the engine via the engine control logic circuitry.

With this switch in the “Manual” mode, the engine will start and run immediately after a 10 – 20 second time delay.

- CAUTION: Please note that once the engine has been told to start, the gen set should be treated as though it is operational, even though the start delay has not yet allowed the engine to crank.**

With this switch in the “Automatic” mode, the engine can be started and stopped from a remote contact. (Standard switch, transfer switch, etc.) There is a time delay, to cool down, of 60–90 seconds when the unit is shut down from the remote contacts while the Master Control Switch is in the “Automatic Mode.

With this switch in the “Off” position, the engine will immediately stop. The position must also be utilized to clear fault shut–down conditions.

- B. PANEL LIGHTS** – By turning on the panel light switch, the panel lights will be energized and will illuminate the control panel. The fuse next to the switch is to protect this circuit from damage due to excessive current.
- C. FIELD AND CONTROLLER FUSES** – These fuses protect the internal workings of the generator set.
- D. GAUGES** – These gauges monitor some of the more critical operating parameters of the engine as well as the run time of the generator set.

The Voltmeter displays the charging rate that is currently being produced by the engine’s alternator to facilitate the charging of the battery. This gauge should normally be above 12.5V whenever the unit is running. If you ever notice the gauge is reading below 12V while the engine is running please contact the service department at Baldor Generators.

The Temperature Gauge monitors and displays the operating temperature of the engines coolant. The point at which a fault shut–down will occur is approximately 230°F.

The Oil Pressure Gauge displays and monitors the current operating pressure of the engine’s oil system. The trip point at which a fault shutdown will occur is approximately 15 PSI or below.

Fuel level is checked by the owner or is usually a separately supplied fuel tank.

The Hour Meter accumulates and displays the total running time of the generator set.



**E. VOLTAGE ADJUST** – The rheostat allows the user to “fine tune” the generator set’s voltage output. It is normally used to adjust output voltage after switching the output of the generator set to a different voltage.

**F. METERS** – These meters monitor and display the current operating parameters of the generator set.

The Voltmeter monitors and displays the current operating AC output of the generator set.

The Hertz Meter monitors and displays the current operating frequency of the generator set.

The ammeter monitors and displays the amount of current that is being delivered by the generator set. This meter works in conjunction with the Voltmeter Switch (Item G) in determining which output leg to monitor.

**G. AMMETER SWITCH** – The switch allows the user to switch between L1, L2 and L3 to monitor the current in each output leg of the generator.

**H. PANEL LIGHT** – By turning on the panel light switch, the panel lights (Not pictured on diagram) will be energized and will illuminate the control panel.

**I – SYSTEM FAULT INDICATORS** – These lights will come on when a fault condition or a warning condition develops.

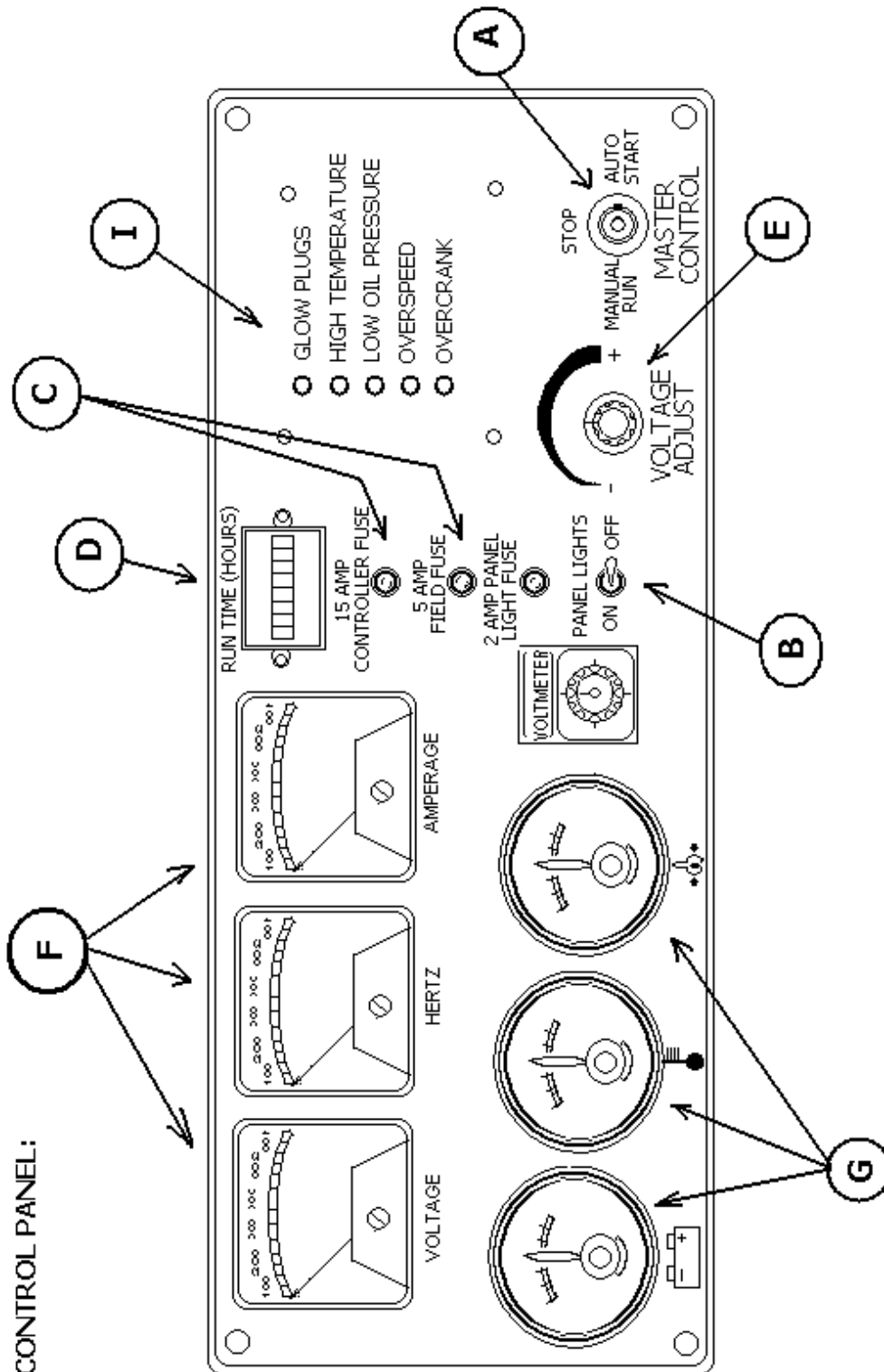
The “Low Oil Pressure” light will come on when the engine’s oil pressure drops below 15 PSI. This condition will trigger a fault shut-down and the unit will stop.

The “Over-crank” light will come on when the engine has failed to start after four attempted crank cycles. Each crank cycle consists of a 12 second time period followed by a 12 second rest time period.

The “Over-speed” light will come on when the engine’s operating speed rises above it’s normal operating parameters. This condition will trigger a fault shut-down and the engine will stop.

High Temperature light will come on when the engine’s operating temperature exceeds the safety set-point.

CONTROL PANEL:





# OPERATION – PRE-START PROCEDURE

1. Fill system fuel tank with clean, fresh diesel fuel.

CAUTION: Wipe up any and all fuel spillage.

2. Fill engine crankcase to full mark with clean, fresh lubricating oil per attached engine operating guide.
3. Radiator coolant should be checked at the beginning of each day and filled in compliance with the engine manufacturer's guidelines.
4. Secure the generator for operation.

Skid mounted – the power generating system should be mounted to a smooth, hard surface suitable for supporting the system under all stress conditions.

Trailer mounted – block wheels to prevent accidental movement.

Adequate clearance must be provided for access doors to fully open.

NOTE: The generating system exhaust also exits radiator end. When positioning a generator system ensure position does not cause a concentration of toxic emissions.

# OPERATION – STARTING

1. Conduct 'Pre-start Procedures.
2. Switch the generator set to the applicable voltage setting.
3. Connect the load(s) to the circuit breaker.

**WARNING:** High voltage is present when the generator set is running.

4. Move the 'Master Control Switch" to the appropriate position.
5. Adjust the voltage if necessary by turning the voltage adjustment knob located on the control panel.

# OPERATION

The prime mover utilized in this power generating system is controlled via an engine control module. Starting is accomplished by commanding the control to "start" the engine. This command can be given by a number of controls.

? The operator control mounted on the front panel.

? The remote controls via the transfer switch or remote start terminal closure.

Initially, the system may be started and operated by placing the operator control in the "manual/run" position. To cease operation, return the switch to the "off" position.

**NOTE:** Clear unit of all loose objects and perform all "pre-start" procedures before operating generator system.

## ENGINE CONTROL MODULE:

The engine control module (ECM) is a microprocessor-based module that monitors the control and safety inputs and provides all the required START and STOP functions automatically.

The following front panel controls and instruments are wired into the microprocessor through the ECM terminal blocks:

### 1. Run-Off-Auto Switch

- a. \* "Run" – run position causes the generator set to start and run immediately.
  - b. \* "Auto" – auto position allows unit to be controlled via any remote single-pole "dry" contact (transfer switch, etc.). Contact closure causes the unit to start and run, while contact opening causes unit to shut down after a preset cool down period.
  - c. "Off" – unit operation is terminated.
- \* – units equipped with Isuzu engines may have a time delay glow plug cycle before starting.

### 2. Lamp Test

Push button energizes all alarm lights simultaneously. This feature is disabled with the run-stop-auto switch in the "stop" position, and has no other effect on unit operation.

## SAFETY INPUTS

### 1. Low Oil Pressure Shutdown – (LOP)

Monitoring of oil pressure begins for a preset time after unit starts and remains in effect until unit is shut down (except as noted in "loss of frequency input" below). The LOP signal is derived from an oil pressure switch gauge mounted on the control panel

### 2. High Temperature Shutdown – (HT)

The engine temperature monitoring begins immediately with the start signal. However, if engine temperature is excessive prior to start (i.e., heat soak after shutdown), the unit is permitted to start.

The high temperature condition is permitted to exist for up to 60 seconds after the unit is running before shutdown when alarm occurs. If the excessive temperature condition is corrected within that time period, the HT circuit reverts to normal monitoring. The HT signal is derived from a monitoring device located on the prime mover.

### 3. Over-speed Adjustment – (OS) – Over Frequency

Over-speed protection is provided by a frequency sensing network within the controller. The trip point of the frequency network is adjustable via a rheostat located on the top of the controller at the right hand side. Clockwise (CW) rotation increases the trip frequency and, thereby, raises the shutdown speed.

## CRANKING CONTROL

### 1. Over-crank Protection

This feature provides a preset second crank cycle. Failure of the engine to start by the end of the crank period results in an "Over-crank" shutdown and alarm indication.

### 2. Cranking Disconnect Adjustment (CDS Adjustment)

The cranking disconnect signal is obtained by a frequency network within the controller. The trip point of the frequency network is not adjustable.

## LOSS OF FREQUENCY

Internal protection against loss of frequency input to the cranking disconnect circuit is programmed in after the unit has started normally. In the event the frequency goes to zero (engine runs out of fuel, frequency signal source fails, etc.) the LOP shutdown circuit is bypassed and a 12-second wait period is initiated. If frequency returns within this time period, LOP monitoring resumes and operation continues normally. If frequency has not returned at the end of this time period, the engine oil pressure status is observed to determine whether the engine is actually running or stopped. If the engine has stopped (i.e., air in fuel, etc.), the cranking cycle will begin in an effort to restart the engine. If the engine has not stopped (loss of input signal, etc.), the unit is shutdown with an "Over-crank" indication and alarm.

**WARNING:** Over-crank indication can mean a loss of crank-disconnect signal during the previous run period. Attempting to restart the engine with no crank-disconnect signal can destroy the starter motor, which can cause serious personal injury.

This is of particular note since the tendency is to pursue only cranking and start related faults. The cranking disconnect signal source is a key component in this system and must be checked out thoroughly whenever an "Over-crank" shutdown occurs.

**NOTE:** The controller does not provide protection against loss of signal during start-up. A shutdown with alarm, due to any of the above conditions, will prevent any subsequent operation of the generator set. The run-stop-auto selector switch on the control panel must be momentarily placed in the stop position to reset these functions.

**CAUTION:** If a dead battery is suspected, remove controller fuse, charge battery (or replace), and then attempting starting. Damage to engine control may result from jump starting.

# TROUBLESHOOTING – GENERATOR

As with any machine, trouble may develop in electrical generators. It may be due to long service or neglect of regular maintenance. Servicing, and checking. Should trouble develop, the following instructions will be helpful in tracing the cause and making repairs.

## SPEED DEVIATIONS:

The generator speed should be maintained at rated nameplate speed. The frequency and voltage of the generator output depends on speed. If the generator runs slower than rated speed, the voltage will drop off.

### NO VOLTAGE

#### CAUSE

#### CHECK AND REMEDY

Loss of residual magnetism in exciter field poles.

Flash Field.

Open in stator windings

Check for continuity in windings. Return to factory for repair if open

Open or short in rotating rectifiers.

Check rectifiers.

Short Circuited.

Clear lead to restore voltage build-up.

Open in alternator field

Check for continuity and return rotor to factory for repair if field coils are open.

Shorted exciter armature

Check for short and replace if faulty.

Shorted leads between exciter armature and generator field.

Test and repair

### LOW VOLTAGE

#### CAUSE

#### CHECK AND REMEDY

Excessive load.

Reduce load. With 3 phase generators, the load on each leg should be as evenly balanced as possible and should not exceed the rated current on any leg.

Low Speed.

Check engine for malfunction or system for over-load.

Line loss.

Increase size of line lead wire.

### **LOW VOLTAGE (Continued)**

#### CAUSE

High resistance connections—  
Connections will be warm or hot

Shorted field.

Low power factor

#### CHECK AND REMEDY

Make better connection electrically and mechanically.

Test field coils for possible short by checking resistance with an ohmmeter or resistance bridge. Return rotor assembly to factory for repair if alternator field coils are shorted.

Reduce inductive (motor) load. Some AC motors draw approximately the same current regardless of load. Do not use motors of larger horsepower rating than is necessary to carry the mechanical load.

### **FLUCTUATING VOLTAGE (May be indicated by flickering lights.)**

#### CAUSE

Irregular speed of engine.

Fluctuating speed.

Loose terminal or load connections.

Defective bearing causing uneven air gap. Replace worn bearing.

#### CHECK AND REMEDY

Check engine for malfunction or load for fluctuation.

Stabilize load. The addition of a lamp load (resistance load) may compensate partially for load changes caused by intermittent motor operation. Do not overload.

Make better connection mechanically and electrically.

### **HIGH VOLTAGE**

#### CAUSE

Excessive speed.

#### CHECK AND REMEDY

Check engine for malfunction.

### **OVERHEATING**

#### CAUSE

Generator overloaded.

Clogged ventilating screens.

#### CHECK AND REMEDY

Reduce load. (Check with ammeter and compare with nameplate rating.)

Clean air passages.

### **OVERHEATING (continued)**

#### CAUSE

High room temperature.

Insufficient circulation.

Low power factor.

Unbalanced load

Dry bearing.

#### CHECK AND REMEDY

Improve ventilation.

Provide cross-ventilation.

Reduce inductive loads or install power factor improvement capacitors.

The load on each leg should be as evenly balanced as possible and should not exceed the rated current on any leg.

Replace bearing.

### **MECHANICAL NOISE**

#### CAUSE

Defective bearing.

Rotor scrubbing on stator.

Loose laminations.

Loose or misaligned coupling.

#### CHECK AND REMEDY

Replace bearing.

Bad bearing; replace. Bent shaft, return to factory. Loosen end bell, tighten; loose drive discs, tighten.

Return to factory.

Tighten or align.

### **GENERATOR FRAME PRODUCES SHOCK WHEN TOUCHED**

#### CAUSE

Static charge.

Grounded armature or field coil.

#### CHECK AND REMEDY

Ground generator frame.

Return to factory for repair.

## TROUBLESHOOTING – ENGINE

### FAULT DIAGNOSIS CHART:

PROBLEM	POSSIBLE CAUSES
Starter motor turns engine too slowly.	1,2,3,4
Will not start	5,6,7,8,9,10,12,13,14,15,16,17,18,19,20,22, 31,32,33
Difficult to start.	5, 7,8,9,10,11,12,13,14,15,16,18,19,20,21,22,24,29,31,32,33
Not enough power.	8,9,10,11,12,13,14,18,19,20,21,22,23,24,25,26,27,31,32,33,61, 63
Misfire.	8,9,10,12,13,14,16, 18,19,20,25,26, 28,29,30, 32
High Fuel consumption.	11, 13,14, 16, 19,20, 22,23,24,25, 27,28,29, 31,32,33, 63
Black exhaust.	11, 13,14,16,17,18,19,20, 22, 24,25, 27,28,29, 31,32,33, 61, 63
Blue/white exhaust.	4, 16, 18,19,20, 25, 27, 31, 33,34,35, 45, 56, 62
Low lubricating oil pressure.	4, 36,37,38,39,40, 42,43,44, 58.
Engine knocks.	9,10,11,12,13,14,15,16,17,18,19,22,26,28,29,31,33,35,36,45,46,59
Runs erratically.	7,8,9,10,11,12,13,14, 16, 20,21, 23, 26, 28,29,30, 33, 35, 45, 59
Vibration.	13,14,20,23,25,26,29,30,33,45, 47,48,49
High lubricating oil pressure.	4,38,41
Engine temperature too high.	11, 13,14,16,18,19,24,25, 45,47,50,51,52,53,54, 57
Crankcase pressure.	25, 31, 33,34, 45, 55, 60
Bad compression.	11,19, 25, 28,29, 31,32,33,34, 46,59
Starts and stops.	10,11,12

### CODE LIST OF POSSIBLE CAUSES

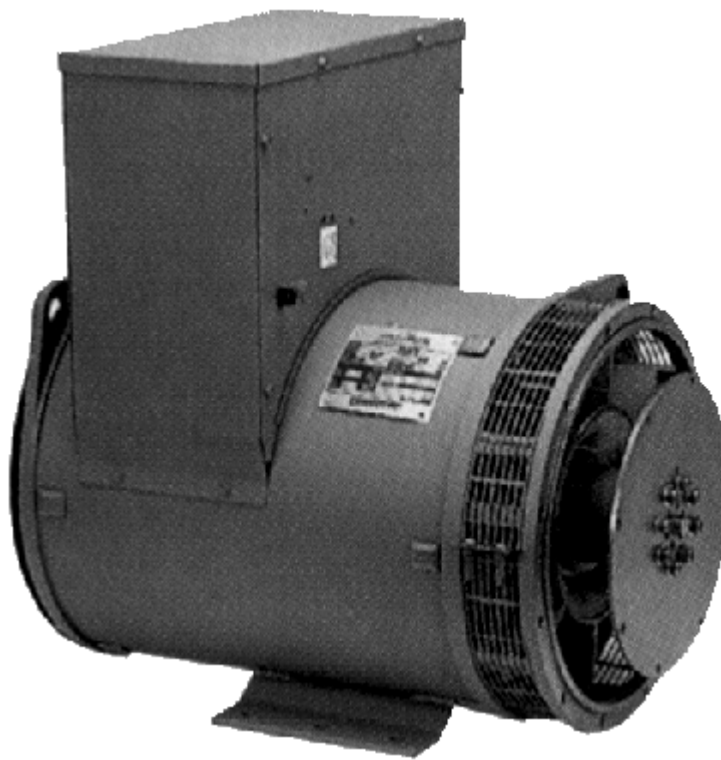
- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. Battery capacity low.</li> <li>2. Bad electrical connections.</li> <li>3. Fault in starter motor.</li> <li>4. Fault in starter motor.</li> <li>5. Wrong grade of lubricating oil.</li> <li>6. Low engine speed from starter motor.</li> <li>7. Stop control fault.</li> <li>8. Restriction in fuel lift pipe.</li> <li>9. Fault in fuel lift pump.</li> <li>10. Dirty fuel filter element.</li> <li>11. Restriction in air filter or induction system.</li> <li>12. Air in fuel system.</li> <li>13. Fault in fuel injection pump.</li> <li>14. Fault in atomizers or not correct type.</li> <li>15. Cold start equipment not used correctly.</li> <li>16. Fault in cold start equipment.</li> <li>17. Broken fuel injection pump drive.</li> <li>18. Fuel injection pump timing not correct.</li> <li>19. Valve timing not correct.</li> <li>20. Bad compression.</li> <li>21. restriction in fuel tank vent.</li> <li>22. Type or grade of fuel not correct.</li> <li>23. Restriction of engine speed control movement.</li> <li>24. Restriction in exhaust pipe.</li> <li>25. Cylinder head gasket leaks.</li> <li>26. Engine temperature too high.</li> <li>27. Engine temperature too low.</li> <li>28. Valve tip clearances not correct.</li> <li>29. Valves not free.</li> <li>30. Wrong high pressure pipes.</li> <li>31. Worn cylinder bores.</li> <li>32. Valves and seats do not seal correctly.</li> </ol> | <ol style="list-style-type: none"> <li>33. Piston rings not free or are worn or broken.</li> <li>34. Valve stems and/or guide worn.</li> <li>35. West type air cleaner too full or wrong oil used.</li> <li>36. Crankshaft bearings worn or damaged..</li> <li>37. Not enough lubricating oil in the pump.</li> <li>38. Gauge not correct.</li> <li>39. Lubricating oil pump worn.</li> <li>40. Relief valve not free to close.</li> <li>41. Relief valve not free to open.</li> <li>42. Relief valve spring broken.</li> <li>43. Fault in suction pipe of lubricating oil pump.</li> <li>44. Dirty lubricating oil filter element.</li> <li>45. Piston damaged.</li> <li>46. Piston height not correct.</li> <li>47. Fan damaged.</li> <li>48. Fault in engine mounting (housing).</li> <li>49. Flywheel housing or flywheel not aligned correctly.</li> <li>50. Fault in thermostat or wrong type.</li> <li>51. Restriction in coolant passages.</li> <li>52. Water pump drive belt loose.</li> <li>53. Restriction in radiator.</li> <li>54. Fault in water pump.</li> <li>55. Restriction in breather pipe.</li> <li>56. Damaged valve stem oil seals (where used).</li> <li>57. Not enough coolant in system.</li> <li>58. Restriction in sump strainer.</li> <li>59. Valve spring broken.</li> <li>60. Fault in exhaust or vacuum pipe leakage.</li> <li>61. Turbo charger impeller damage, or dirty impeller.</li> <li>62. Turbo charger lubricating oil seal leaks.</li> <li>63. Induction system leaks (turbo charged engines.)</li> </ol> |
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# MAGNAPLUS GENERATOR

## 280 -- 430 Frame Installation, Operation and Maintenance Manual



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## SAFETY

**PLEASE REMEMBER SAFETY FIRST.** If you are not sure of the instructions or procedures contained herein, seek qualified help before continuing.

This service manual emphasizes the safety precautions necessary during the installation, operation, and maintenance of your MagnaPLUS generator. Each section of this manual has caution and warning messages. These messages are for your safety, and the safety of the equipment involved. If any of these cautions or warnings is not readily understood, seek clarification from qualified personnel before proceeding.

Before any service work is done, disconnect all power sources and lock out all controls to prevent an unexpected start-up of the generator set driver. Proper grounding (earthing) of the generator frame and distribution system in compliance with local and national electrical codes and specific site requirements must be provided. These safety precautions are necessary to prevent potential serious personal injury, or even death.

The hazards associated with lifting or moving your MagnaPLUS generator are pointed out in the installation and maintenance sections. Incorrect lifting or moving can result in personal injury or damage to the unit.

Prior to start-up of the unit ensure that all generator leads are properly connected to the generator link board located inside the connection box. Always assume that there will be voltage present at the generator terminals whenever the generator's shaft is rotating, and proceed accordingly. Residual voltage is present at the generator terminals and at the automatic voltage regulator panel connections even with the regulator fuse removed. Caution must be exercised, or serious injury or death can result.

This manual is not intended to be a substitute for properly trained personnel. Installation and repairs should only be attempted by qualified, trained people. The cautions and warnings point out known conditions and situations that are potentially hazardous. Each installation may well create its own set of hazards

When in doubt, ask. Questions are much easier to handle than mistakes caused by a misunderstanding of the information presented in this manual.

---

## RECEIVING AND STORAGE

### RECEIVING AND STORAGE

Upon receipt of the generator, it is recommended that it be carefully examined for possible shipping damage. The generator was given to the freight carrier in good condition; thus, the carrier is responsible for the product from the factory dock to the destination. Any damage should be noted on the freight bill before accepting the shipment. Any claims for damage must be promptly filed with the delivering carrier.

### UNPACKING AND HANDLING

Carefully read all instruction tags shipped with the unit. When lifting, attach an overhead crane to the lifting lug(s) on the generator frame. Apply lifting forces in a vertical direction. When transporting single bearing generators, the generator's rotor must be adequately supported to prevent damage.

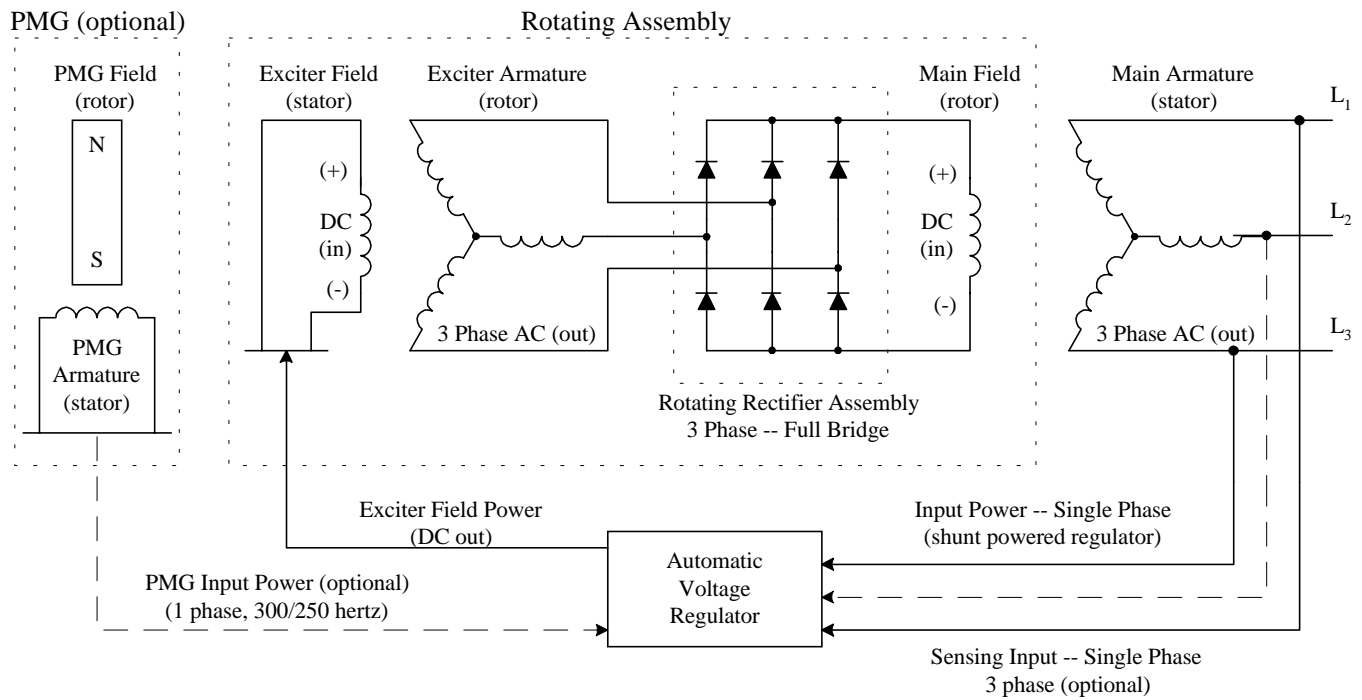
#### WARNING

**THE LIFTING LUG (S) ON THE GENERATOR ARE DESIGNED TO SUPPORT THE GENERATOR ONLY. DO NOT LIFT A COMPLETE GENERATOR AND DRIVER ASSEMBLY BY MEANS OF LIFTING LUG (S) ON THE GENERATOR. PERSONAL INJURY OR EQUIPMENT DAMAGE MAY RESULT.**

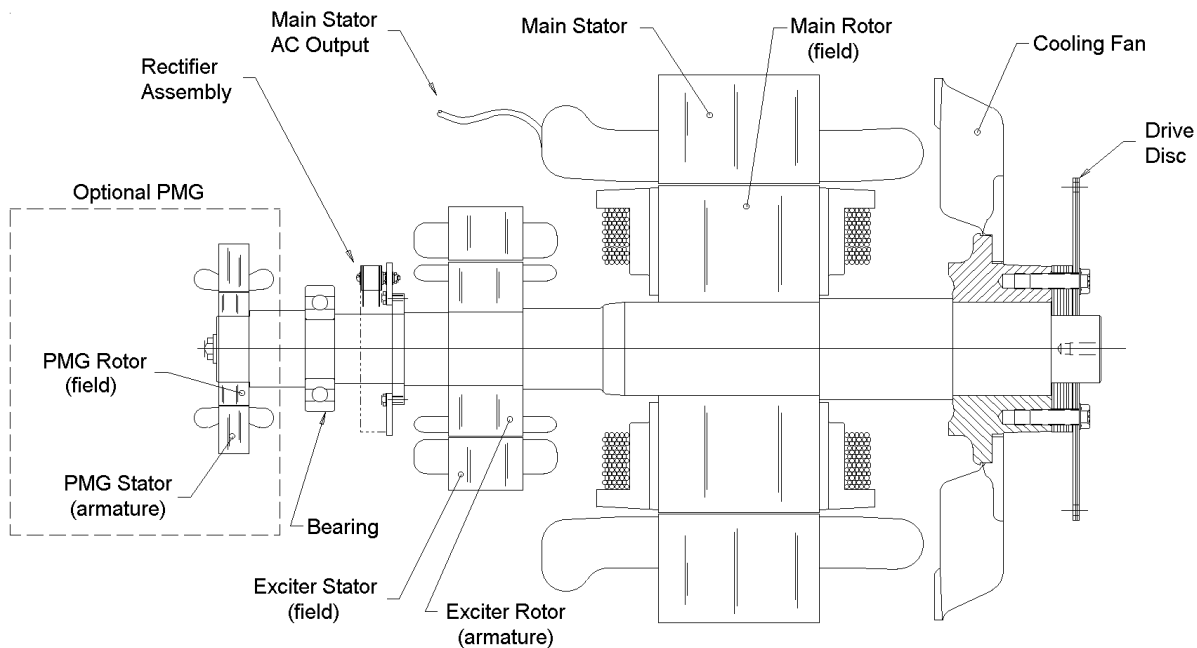
### STORAGE

In the event that the generator is not immediately installed on its prime mover, it is recommended that the unit be stored indoors in a clean, dry area, which is not subject to rapid changes in temperature and humidity. If the generator is stored for a long period of time, the generator should be tested, cleaned and dried as required before being put into service. See the maintenance section of this manual for further information. If the unit has been stored in an area where it has been subject to vibration, it is recommended that the bearing(s) be inspected and replaced as necessary.

# PRINCIPLES OF OPERATION



**FIGURE 1 -- MagnaPLUS Circuit Diagram**



**FIGURE 2 -- Typical MagnaPLUS Layout Diagram**

# PRINCIPLE OF OPERATION

MagnaPLUS generators are a brushless, self excited, and externally voltage regulated, synchronous AC generator. The generator is made up of six major components: main stator (armature), main rotor (field), exciter stator (field), exciter rotor (armature), rectifier assembly, and voltage regulator. In understanding the above terminology, note the following: stators are stationary, rotors rotate, a field is an electrical input, and an armature is an electrical output. These system components are electrically interconnected as shown in figure 1 and physically located as shown in figure 2.

The generator's exciter consists of a stationary field and a rotating armature. The stationary field (exciter stator) is designed to be the primary source of the generator's residual magnetism. This residual magnetism allows the exciter rotor (armature) to produce AC voltage even when the exciter stator (field) is not powered. This AC voltage is rectified to DC by the rotating rectifier assembly and fed directly to the main rotor (field). As the generator shaft continues to rotate, the main rotor (field) induces a voltage into the generator's main stator (armature). At rated speed, the main stator's voltage produced by the residual magnetism of the exciter allows the automatic voltage regulator to function. The regulator provides voltage to the exciter resulting in a build-up of generator terminal voltage. This system of using residual magnetism eliminates the need for a special field flashing circuit in the regulator. After the generator has established the initial residual voltage, the regulator provides a controlled DC field voltage to the exciter stator resulting in a controlled generator terminal voltage.

## ***Voltage Regulation***

In the standard configuration (shunt excited), the automatic voltage regulator receives both its input power and voltage sensing from the generator's output terminals (See Figure 1). With the optional PMG configuration, the regulator receives input power from the PMG. The regulator automatically monitors the generator's output voltage against an internal reference set point and provides the necessary DC output voltage to the exciter field required to maintain constant generator terminal voltage. Adjusting the regulator's reference set point changes the generator's terminal voltage. Consult the regulator manual for specific adjustment and operating instructions.

## ***MOTOR STARTING***

When a motor is started, the motor draws a large surge of current. This starting current is equivalent to the motors locked rotor or stall current and is 5 to 10 times' normal full load current. When the generator supplies this in-rush of starting current, the generator voltage dips temporarily. If the motor is too large for the generator, the generator's voltage dips greater than 30 percent. This may result in the motor starter de-energizing or the motor stalling. MagnaPlus

generators generally supply .3 to .4 horsepower per generator kW in motor starting capability. For specific data contact Marathon Electric.

## ***PARALLEL OPERATION***

All MagnaPlus generators are built with 2/3 pitch main stator windings and full amortisseur (damper) windings. These features make the MagnaPlus generators suitable for parallel operation when equipped with the proper voltage regulators and voltage regulator accessories. Consult with the factory for further information relative to parallel operations.

## ***NONLINEAR LOADING***

Solid state electronic control devices (variable frequency drives, precision motor controls, battery chargers, etc.) utilize electronic switching circuits (thyristors, SCRs, Diodes, etc.). These switching circuits introduce high frequency harmonics, which distort the normal waveform of the generator. This creates additional heat in the generator windings and may cause the generator to over-heat. Problems that can occur are not limited to the generator. Poor wave shape may adversely effect various loads connected to the generator. Consult Marathon Electric for further information relative to nonlinear loads.

---

## ***INSTALLATION***

### ***PREPARATION FOR USE***

Although the generator has been carefully inspected and tested in operation prior to shipment from the factory, it is recommended that the generator be thoroughly inspected. Check all bolts for tightness and examine the insulation on lead wires for chafing prior to proceeding with installation. Remove all shipping tapes, bags, skids and rotor support blocking. For two bearing units, rotate the shaft by hand to ensure that it rotates smoothly without binding.

## WARNING

**DISABLE AND LOCKOUT ANY ENGINE CRANKING DEVICES BEFORE ATTEMPTING TO INSTALL OR SERVICE THE GENERATOR. FOR ELECTRIC START SETS, DISCONNECT THE CRANKING BATTERY. FOR AIR START, DISCONNECT THE AIR SUPPLY. FOR MOTOR GENERATOR SETS, OPEN THE POWER SUPPLY TO THE DRIVE MOTOR. FAILURE TO COMPLY WITH THESE SAFETY PROCEDURES COULD RESULT IN SEVERE PERSONAL INJURY OR EQUIPMENT DAMAGE.**

**NEVER "BAR OVER" THE ENGINE GENERATOR SET USING THE GENERATOR'S FAN. THE FAN IS NOT DESIGNED FOR THIS PURPOSE. BARRING OVER THE SET WITH THE FAN COULD DAMAGE THE FAN AND RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE.**

## GENERATOR MOUNTING

### Single Bearing Units.

Single bearing units are provided with an SAE flywheel housing adapter flange and flexible drive discs. Coupling the generator's shaft to the engine flywheel is accomplished with special steel drive discs bolted to the shaft. In addition to the drive discs, there may be a hub spacer, spacer discs, or a combination of hub spacer and spacer discs inserted between the drive discs and the shaft to achieve the proper shaft extension ("G" dimension per SAE J620c). Holes are provided in the periphery of the coupling discs, which correspond to tapped holes in the prime mover's flywheel. The outside diameter of the drive discs fit in a rabbet in the flywheel so that concentricity is assured.

Grade 8 place bolts and hardened washers are recommended to mount the drive discs to the flywheel. DO NOT USE SPLIT TYPE LOCK WASHERS. Split lock washers when biting into the drive disc cause stress risers, which may result in the disc fracturing.

The SAE flywheel housing adapter ring and the engine flywheel housing are designed to match each other with no further alignment necessary. Use grade 5 or greater mounting bolts. MagnaPLUS generator frames are constructed with two or three boltholes per foot. The feet should be shimmed where necessary to obtain solid contact with the sub-base. With the frame securely bolted to the engine flywheel housing, there is no side thrust or pull on the generator frame, thus no real need to secure the feet with more than one bolt per foot.

## GENERATOR MOUNTING

### Two Bearing Generators -- Direct Drive

Two bearing generators are provided with a keyed shaft extension. For direct drive generators, the assembler furnishes a flexible coupling, which is installed between the

driver and the generator's shaft. Aligning the generator and its driver as accurately as possible will reduce vibration, increases bearing life, and ensure minimum coupling wear. It may be necessary to shim the generator feet for proper support and alignment. Secure the feet of the generator with grade 5 or greater bolts through the holes provided in the mounting feet. Consult the coupling manufacturer's instructions for alignment specifications and procedures.

## GENERATOR MOUNTING

### Two Bearing Units -- Belt Driven

Two bearing MagnaPLUS generators can be belt driven provided belts are sized and applied correctly. Please refer to your supplier of belts and sheaves for correct sizing and tensioning specifications. A bearing life calculation should be performed. Marathon Electric recommends a minimum B-10 life of 40,000 hours. If cog type belts are used, a vibration may be introduced which could lead to premature failure of the bearings.

## END PLAY TESTING

Refer to the engine manual for recommended endplay specifications and measurement procedures. If endplay is not to specification, it is an indication that the generator shaft is not moving freely in the assembly, and normal life of the thrust bearing could be impaired. Probable causes of this problem are:

1. Improper seating of drive discs in the flywheel resulting in misalignment.
2. Improper mating of generator frame to engine flywheel housing resulting in misalignment.
3. Improper "G" dimension per SAE J620c on either the engine or generator.

## TORSIONAL VIBRATION

Torsional vibrations are generated in all rotating shaft systems. In some cases, the amplitude of these vibrations at critical speeds may cause damage to the generator, its driver, or both. It is therefore necessary to examine the torsional vibration effect on the entire rotating system. IT IS THE RESPONSIBILITY OF THE GENERATOR SET ASSEMBLER TO ASSURE THE TORSIONAL COMPATIBILITY OF THE GENERATOR AND ITS DRIVER. Drawings showing pertinent dimensions and weights of the rotating assembly will be supplied by Marathon Electric upon request.



## ENVIRONMENTAL CONSIDERATIONS

The MagnaPLUS generator is designed for heavy-duty industrial applications; however, dirt, moisture, heat and vibrations are enemies of rotating electrical machinery. Excessive exposure to the elements may shorten generator life. The temperature of the cooling air entering the intake openings of the generator should not exceed the ambient temperature shown on the generator's nameplate. Generators intended for outdoor application should be protected with housings having adequate ventilation. Although the standard insulation systems are moisture and humidity resistant, space heaters are recommended for extreme conditions. If the generator is to be installed in an area where blowing sand and dust are present, the enclosure should be fitted with filters. Filters reduce erosion on the generator's insulation by blocking high velocity abrasive particles generated by the flow of cooling air through the generator. Consult the factory for appropriate filters and generator deratings required.

## WIRING CONNECTIONS

Wiring of the generator and accessories should be done in accordance with good electrical practices. Follow government, industry and association standards.

The generator conduit box construction allows cable entry from multiple sides. A hole saw or other appropriate tool may be used to provide for conduit entrance. Protect the interior of the generator from shavings when drilling or sawing. An approved connector must be used in conjunction

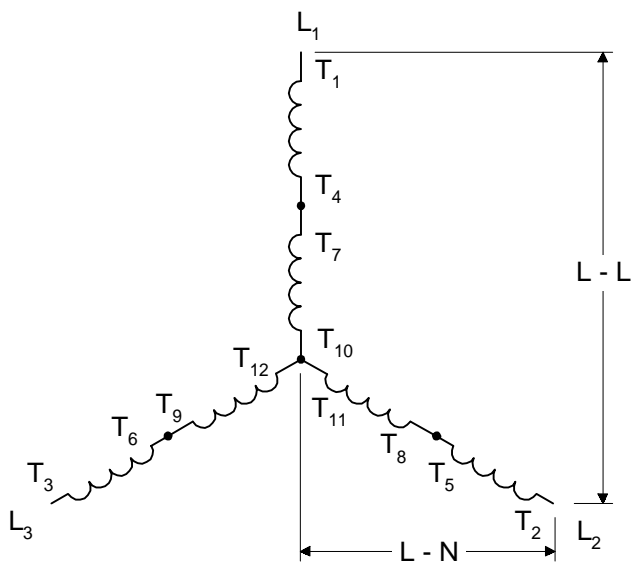
with the conduit. To minimize the transmission of vibration, it is essential that flexible conduit be used for all electrical entrance to the generator conduit box.

All MagnaPLUS generators are equipped with link boards (terminal strips) for both internal and external connections. All connections made to the studs of the link board should be made with high quality ring terminals. Ring terminal sizes are 6 mm (280 Series Frames) and 10 mm (360 and 430 Series Frames). Torque link board connections to the following specifications: 280 frame -- 5.4 NM (4 Ft LB); 360 & 430 frame -- 27 NM (20 Ft LB).

Refer to the connection diagram supplied with the generator and / or the proper diagrams shown in this manual. Install all inter-component and external wiring in accordance with national and local electrical codes. The neutral in the following connection diagrams shown below may be either grounded (earthed) or left above ground potential (floating). See national and local codes and / or the system distribution wiring schematic diagram for the proper connection of the neutral.

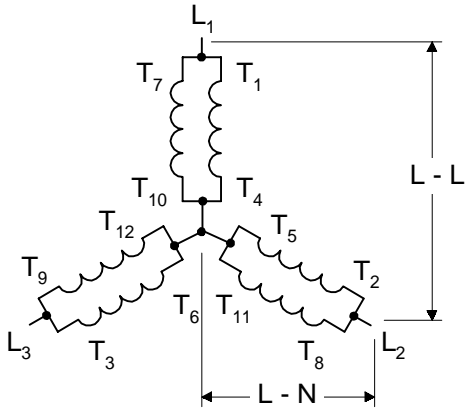
The following connection diagrams are shown for twelve lead generators. Ten lead generators have the same terminal designations except for leads T10, T11, and T12. These three leads are internally connected inside the generator and brought out as a single lead (T0). Ten lead generators can only be connected in a wye configuration

### HIGH WYE CONNECTION



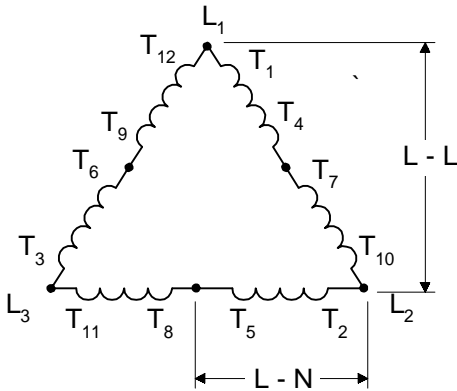
VOLTAGE (HIGH WYE)		
Hz	L-L	L-N
60	480	277
	460	266
	440	254
	416	240
	380	219
50	416	240
	400	231
	380	219

### LOW WYE CONNECTION



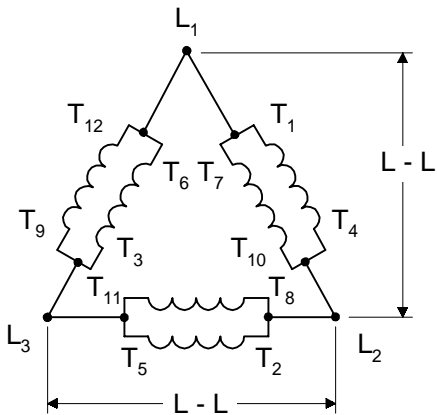
VOLTAGE (LOW WYE)		
Hz	L-L	L-N
60	240	139
	230	133
	220	127
	208	120
	190	110
50	208	120
	200	115
	190	110

### HIGH DELTA CONNECTION



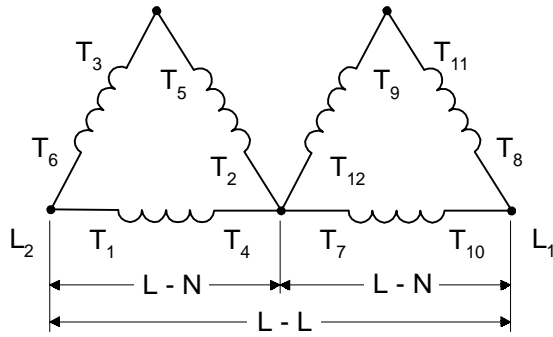
VOLTAGE (HIGH DELTA)		
Hz	L-L	L-N
60	277	139
	240	120
50	240	120
	220	110
	200	100

### LOW DELTA CONNECTION



VOLTAGE (LOW DELTA)		
Hz	L-L	L-N
60	120	NA
	110	NA
50	110	NA
	100	NA

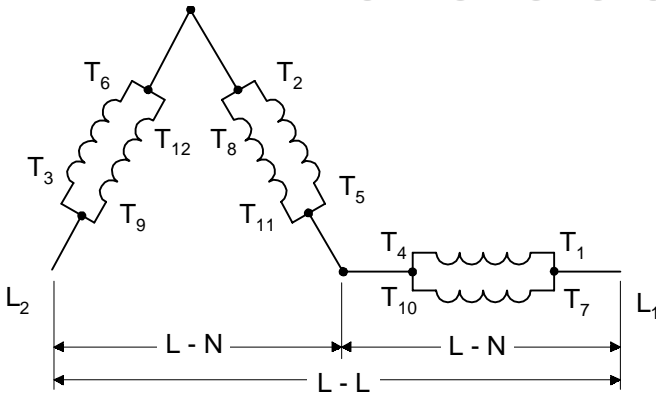
## DOUBLE DELTA -- SINGLE PHASE CONNECTION



VOLTAGE (DOUBLE DELTA)		
Hz	L-L	L-N
60	240	120
	220	110
50	220	110

Note: Single-phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

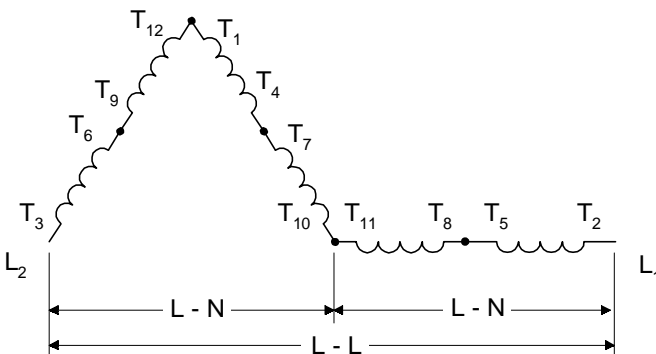
## LOW ZIG ZAG -- SINGLE PHASE CONNECTION



VOLTAGE (LOW ZIGZAG)		
Hz	L-L	L-N
60	240	120
	220	110
50	220	110
	200	100

Note: Single-phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

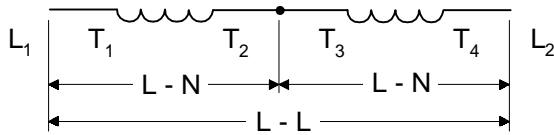
## HIGH ZIG ZAG -- SINGLE PHASE CONNECTION



VOLTAGE (HIGH ZIGZAG)		
Hz	L-L	L-N
60	480	240
	460	220
50	415	208
	380	190

Note: Single-phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

## DEDICATED SINGLE PHASE CONNECTION



VOLTAGE (DEDICATED)		
Hz	L-L	L-N
60	240	120
	220	110
50	220	110
	200	100

## OPERATION

### PRE-START INSPECTION

Before starting the generator for the first time, the following inspection checks are recommended:

1. A visual inspection should be made for any loose parts, bad connections, or foreign materials.
2. Bar the set over by hand for at least 2 revolutions to be sure that there is no interference and that the set turns freely. If the set does not turn freely, check for clearance in the generator and exciter air gap.
3. Check all wiring against the proper connection diagrams, and ensure that all connections and terminations are tight and properly insulated.

### WARNING

**MAGNAPLUS GENERATORS MAY HAVE VOLTAGE PRESENT AT THE LEAD TERMINALS WHEN THE SHAFT IS ROTATING. DO NOT PERMIT OPERATION OF THE GENERATOR UNTIL ALL LEADS HAVE BEEN CONNECTED AND INSULATED. FAILURE TO DO THIS MAY RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE**

4. Verify that all equipment is properly grounded (earthed).
5. Clear the surrounding area of any materials that could be drawn into the generator.
6. Check all fasteners for tightness.
7. Check all access plates, covers, screens and guards. If they have been removed for assembly or inspection, reinstall and check for security.

8. Review all prime mover prestart-up instructions, and ensure that all recommended steps and procedures have been followed.
9. Remove any masking materials affixed during painting. Inspect the generator, prime mover, and any accessory equipment to ensure that nameplates, and all safety warning / caution signs and decals provided with the equipment are in place and clearly visible.

**Note: It is strongly recommended that the authority having jurisdiction over the installation site be consulted to determine if any additional warning or caution notices, or additional safety devices are required by local codes / standards. Any such required notices or devices should be installed prior to initial startup.**

### START-UP

The following procedure should be followed when starting the generator set for the first time.

1. The generator output must be disconnected from the load. Be sure that the main circuit breaker or fused disconnect is in the open position.
2. Open the input power to the automatic voltage regulator. Remove the fuse or disconnect and insulate one of the regulator input power leads. (See separate regulator manual)
3. Verify that all prime mover start-up procedures have been followed.
4. If the unit is provided with space heaters, ensure that they are de-energized. In some installations, a set of auxiliary contacts on the main circuit breaker or transfer switch will automatically open the space heater circuit when the generator is connected to the load.
5. Start the prime mover, and adjust it for proper speed. See generator nameplate.

6. The purpose of this initial test with the regulator out of the circuit is to detect any wiring mistakes without exposing the unit to undue risk. Check all line to line and line to neutral voltages for balanced voltage. If voltages are balanced shut down the set and reconnect the regulator. If voltages are unbalanced, shut down the equipment and check for improper wiring. If the problem persists, consult the factory.

With the regulator de-energized, the residual voltage should be 10 - 25% of rated value. It is recommended that this residual voltage and driver RPM be recorded for use as a future troubleshooting benchmark.

#### **WARNING**

**QUALIFIED ELECTRICAL PERSONNEL MUST CONDUCT THE FOLLOWING TEST. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.**

7. Start the set and adjust the terminal voltage to the desired value by means of the regulator voltage adjustment. If the regulator is equipped with a stability adjustment, follow the instructions in the regulator manual to adjust the stability. Again, check all line to line and line to neutral voltages for balance. It is recommended practice to record the no load excitation (DC voltage to the exciter stator), generator terminal voltage, and driver speed as a benchmark for future troubleshooting.
8. Close the main circuit breaker to the load.
9. Monitor the generator output current to verify that it is at or below nameplate value.
10. Check generator speed (frequency) under load. Adjust as necessary. (Refer to prime mover or governor manuals)

### **SHUTDOWN PROCEDURE**

There are no specific instructions for shutting down the generator; however, several good practices should be observed to prolong equipment life.

1. It is advisable to disconnect all loads (open main circuit breaker or disconnect) prior to shutdown. This is especially important if loads can be damaged by low voltage or low frequency conditions during generator "coast down".
2. Isolate all conditions that could apply voltage to the generator terminals while the generator is at rest. Failure to comply could result in personnel injury or equipment damage.

3. If the unit is equipped with space heaters, verify that the heater circuit is energized.

### **MAINTENANCE**

The following maintenance procedures should be followed to ensure long equipment life and satisfactory performance. Maintenance intervals will depend upon operating conditions.

1. Routinely check intake and exhaust air screens to ensure that they are clean and free of debris. Clogged intake air screens will reduce cooling airflow and result in higher operating temperatures. This will reduce generator life and may result in generator damage.
2. All MagnaPLUS generators are equipped with double shielded ball bearings lubricated for the life of the bearing. Every 1,000 hours check the bearing(s) for smooth, quiet operation. For continuous duty generators, recommended practice is to replace the bearing during major overhauls of the engine.
3. Periodically inspect the unit for any buildup of contamination (dirt, oil, etc.) on the windings. If the wound components have become coated with heavy concentrations of oil and grime, the unit should be disassembled and thoroughly cleaned. This operation is not one that can be accomplished effectively on site, but rather one that should be conducted by an authorized service center equipped with the appropriate apparatus and solvents necessary to properly clean and dry the generator.

#### **WARNING**

**QUALIFIED ELECTRICAL PERSONNEL MUST CONDUCT THE FOLLOWING TEST. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.**

4. Every 2,000 operating hours or in conjunction with scheduled engine maintenance check the DC no load excitation voltage per item #7 in the startup procedure. Compare this voltage with the value recorded during initial startup. If this value of no load excitation voltage is markedly higher than the benchmark reading, it is an indication of problems in the exciter, main field, or the rotating rectifier assembly. Ensure that RPM is the same as initial test.
5. Monitor and record insulation resistance with a 500 volt mega-ohm meter. The minimum acceptable reading is 2 mega-ohms. If the reading drops below the minimum, the generator should be cleaned and dried at an authorized service shop. Consult Marathon Electric for more information.

## **DRYING WINDINGS**

Generators in service may inadvertently have their windings exposed to splashing or sprayed water. Units that have been in transit or storage for long periods of time may be subjected to extreme temperature and moisture changes causing excessive condensation. Regardless of the source of moisture, wet windings should be thoroughly dried out before operating the unit. If this precaution is not taken, serious damage to the generator can result. The following procedures may be utilized in drying the generator's windings. Winding wetness and situation limitations will influence the method selected.

### **Space Heaters**

An electric heater may have been supplied with the generator. When energized from a power source other than the generator, the heater will gradually dry the generator. Enclosing the unit with covering and inserting additional heating units can accelerate this process. A hole should be left at the top of the covering to permit the escape of moisture. Care should be taken not to overheat various accessory equipment mounted with the generator.

### **Forced Air**

Another method to dry the generator is to run the set with no excitation (see startup procedure item #2). The natural flow of ambient air through the generator will tend to dry the windings. This method can be accelerated by adding a source of heat at the air intake to the generator. Heat at point of entry should not exceed 80 C (180 F).

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## **TESTING**

### ***Visual Inspection***

Remove covers and look for any obvious problems: burnt windings, loose connections, broken wires, frayed insulation, cracked brackets, missing hardware, etc. Check for foreign objects that may have been drawn into the generator. Verify that the generator's air gaps (main rotor and exciter) are free from obstructions. If possible, rotate the generator manually to ensure free rotation. Never "bar over" the engine generator set using the generator fan.

### **WARNING**

**QUALIFIED ELECTRICAL PERSONNEL MUST CONDUCT THE FOLLOWING TEST. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.**

### ***Constant Excitation Test (12V BATTERY TEST)***

The generator "no load" voltage is dependent on exciter input voltage and generator speed. With the generator operating at rated speed and 12 volts dc applied to the exciter field, the generator's terminal voltage will be near rated value.

1. Shutdown the generator set and connect a voltmeter on the generator terminals.
2. Disconnect the regulator's F+ (F1) and F- (F2) leads and connect them to a 12V battery. Caution should be taken to ensure that the battery is not exposed to any potential arcing.
3. With no load on the generator (main breaker open) run the generator at rated speed. Measure the generator's terminal voltage and compare this value with values recorded during installation.

If voltage readings are normal, the main generator and excitation are operating properly. Troubleshooting should continue with the regulator. If readings are not normal the problem is in the generator. Continue testing diodes, surge suppressor, and windings.

### ***Continuity / Resistance Test***

The generator has four components that can be checked using an ohmmeter: exciter stator, exciter rotor, main stator and main rotor. Each of these components is comprised of various windings that form a complete electrical path of relatively low resistance. Using an ohm meter measure the loop resistance of each component. Compare these measured values with the values listed in the specification section of this manual. Note that very small resistance values require precision equipment to make accurate measurements; however, a standard ohmmeter will provide a good indication of winding continuity.

## Insulation Test

Insulation resistance is a measure 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 be degraded by contaminants: dust, dirt, oil, grease, and especially moisture. Most winding failures are due to a breakdown in the insulation system. In many cases, low insulation resistance is caused by moisture collected when the generator is shutdown

Insulation resistance is measured with a megger (mega-ohm meter). A megger measures insulation resistance by placing 500 volts between the winding and the frame of the generator. Caution must be taken to remove all electronic devices (regulators, diodes, surge protectors, capacitors, protective relays, etc.) from the winding circuit before checking the insulation. Winding insulation can be checked on the main stator, main rotor, exciter stator, and exciter rotor. Minimum resistance is 2 mega-ohms. If the winding resistance is low it must be dried (see maintenance section) or repaired.

## DIODE TESTING

If the generator is close coupled to an engine, it may be necessary to "bar over" the engine in order to gain access to a given area of the rectifier assembly. **NEVER** use the generator's fan as a fulcrum to accomplish this. Use the engine manufacturer's recommended practice to manually turn over the engine. To prevent possible injury to personnel, and damage to the equipment, ensure that the engine cannot start during this procedure.

Remove the two main rotor leads and the three exciter rotor leads from the rectifier assembly (figure 4). The rectifier assembly is now electrically isolated from the generator. The diodes remain mounted and the diode leads remain connected to the terminal posts. Using an ohmmeter or a battery light continuity tester, place one test probe on the diode lead terminal post. In succession, touch the other test probe to the lead screw hole in each heat sink. Reverse the probes and repeat the procedure. You have now tested the three diodes connected to this terminal post in both the forward and reverse direction. Repeat the procedure using the other diode terminal post.

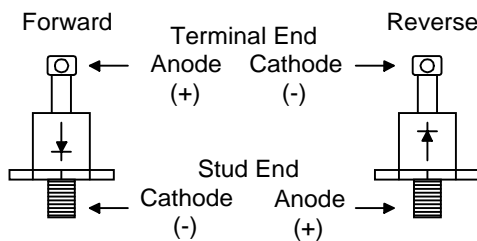


FIGURE 3: DIODE POLARITY

When the positive test probe is connected to the diode's anode and the negative test probe is connected to the diode's cathode (forward biased), the diode will switch on and conduct electricity (figure 3). This is observed by a low resistance reading when using an ohm meter or the lighting of the bulb when using a battery light continuity tester. Reversing the test leads (reverse biased) will result in the diode switching off and no electricity will be conducted. The results of these tests should indicate one of three conditions:

1. **Good diode:** Will have a much greater resistance in one direction than the other. Typical reverse biased resistance will be 30,000 ohms or greater, while forward biased resistance will be less than 10 ohms. The battery-light tester will have the light "on" in one direction and "off" in the other.
2. **Shorted condition:** Ohmmeter reading will be zero, or very low in both directions. The continuity tester will have the light "on" in both directions.
3. **Open condition:** Ohmmeter will have a maximum (infinity) reading in both directions. Continuity tester light will be off in both directions.

Diode failure after a 25 hour "run-in" period is generally traceable to external causes such as a lightning strike, reverse current, line voltage spikes, etc. All 6 diodes are essentially in the same circuit. When a diode is stressed to failure, there is no easy method to determine remaining life in the other diodes. To avoid possible continued failures, it is recommended that the entire rectifier assembly be replaced rather than replacing individual diodes.

## SERVICE

### GENERAL

The service procedures given in this section are those which can reasonably be conducted on-site with a minimum number of special tools and equipment. Qualified maintenance personnel should conduct all service procedures. Replacement parts may be ordered through an authorized service center or directly from the factory.

### FIELD FLASHING

#### Restoring Residual Magnetism (not applicable on PMG equipped generators)

To restore residual magnetism to the generator, connect a 12 volt battery to the exciter field while the generator using the following procedure:

1. **Shutdown the generator set.** Remove the exciter field leads F+ and F- from the regulator.

### **CAUTION:**

**Failure to remove the exciter field leads from the automatic voltage regulator during flashing procedures may destroy the regulator.**

2. Connect the F+ and F- leads to the battery's corresponding positive and negative terminals. This should be done using an appropriate length of lead wire to separate the battery from the point of connection (batteries may explode when exposed to an electric arc). After 3 to 5 seconds, remove the F- lead. An inductive arc should result. If no arc is drawn, repeat the procedure.
3. Reconnect the F+ and F- leads to the regulator. Restart the generator and verify that terminal voltage is developed. If terminal voltage does not develop, repeat the field flashing procedure and / or consult the trouble shooting section.

## ***Bearing Removal***

Prior to performing this operation, it is suggested that the alternator's shaft be rotated until two of the main rotor poles are in a vertical position. Once the bearing bracket is backed out, the rotor will drop on the main stator core. Having the rotor in this position will limit the amount of rotor drop to that of the air gap. Visually inspect the bearing bore for damage or wear. If worn or damaged, replace prior to reassemble.

### **Opposite Drive End Bearing Bracket Removal.**

Prior to proceeding with bracket removal, disconnect exciter field leads F+ and F- from the automatic voltage regulator and ensure that they are free to move when the bearing bracket is removed. Remove the bearing bracket retaining bolts. Using a pair of screw drivers, wedge the bracket off the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame and will drop until the rotor is resting on the main stator core. Continue to pull the bracket free from the bearing. Visually inspect the bearing bore and o-ring (if equipped) for damage or wear. If worn or damaged, repair or replace prior to reassembly.

### **Drive End Bearing Bracket Removal, Two Bearing Units.**

Remove any drive arrangement from the generator shaft extension. Remove the bearing lock ring retaining screws. There is no o-ring in the drive end bearing bracket. The shaft extension must be supported before proceeding further. A hoist and sling, jack, or some other means of support with a capacity of 2 tons should be used.

Remove the bearing bracket retaining cap screws. Using a flat bladed screw driver or chisel, pry the bracket back from the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame. Lower the shaft extension until the rotor is resting on the main stator core.

Continue to pull the bracket free from the bearing. Visually inspect the bearing bore for damage or wear. If worn or damaged, sleeve or replace prior to reassembly.

Reassembly note: Before the bearing bracket is seated against the frame, a threaded rod may be used to help align the inner bearing cap with the bearing bracket.

## ***BEARING REPLACEMENT***

Using a bearing puller, remove the existing bearing. It is strongly recommended that the bearing be replaced any time it is removed from the shaft. **ALWAYS** install the same type and size bearing that was supplied as original equipment. Order by part number from the parts list, and include the unit serial number and part number when ordering. Heat the bearing to a maximum of 100°C (212°F) in an oven. Apply a thin coat of clean lubricating oil to the press-fit area of the rotor shaft. Using suitable heat resistant gloves, install the bearing over the end of the shaft until it seats against the shaft shoulder. The bearing should slide on the shaft and be seated without excessive force. Should the bearing bind on the shaft prior to being seated against the shoulder, a piece of tubing slightly larger than the press fit area can be used to drive the bearing to its final position. Using light taps with a soft mallet, apply pressure to the inner race only.

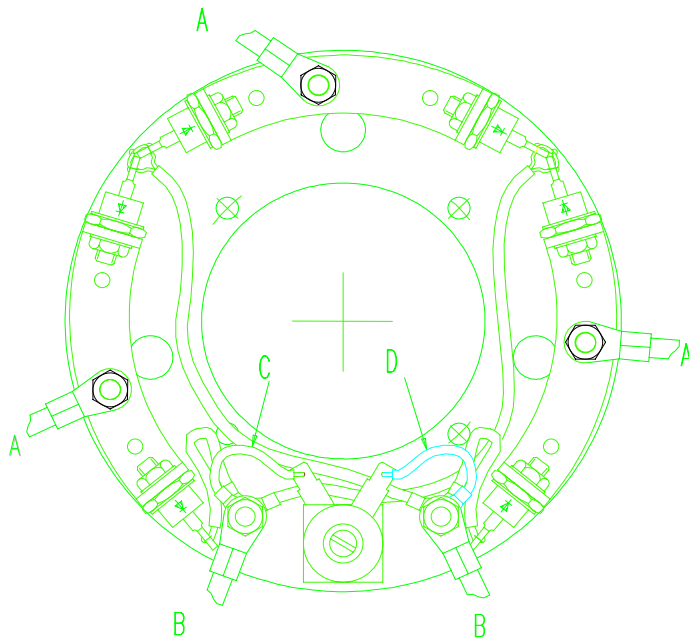
## ***Rectifier Assembly Removal***

The rectifier assembly cannot be removed until the opposite drive end bearing bracket and bearing have been removed (see bearing removal procedure). Remove the three exciter rotor leads from the heat sinks and the two main rotor leads from the main rotor posts (see Figures 4). Remove the screws securing the rectifier assembly and pull the assembly free from the shaft.

## ***Diode Replacement***

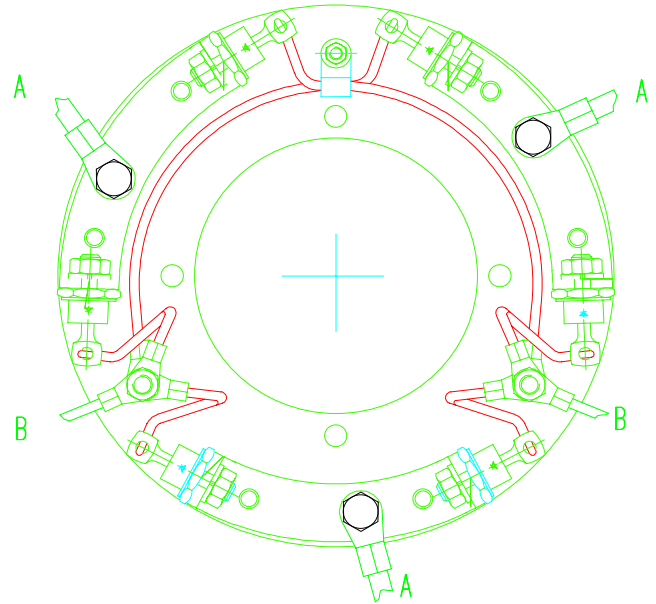
Prior to installing a replacement diode on the heat sink, apply a thin film of conductive heat sink compound around the base of the diode (do not coat the threads). When installing a diode on the heat sink, care should be taken not to over torque the retaining nut, which could cause damage to the device. Torque to 28 pound-inches. If not damaged, the existing diode lead wire may be unsoldered from the failed diode, and resoldered on the replacement.





### 430 FRAME

A - Exciter Rotor Lead, B - Main Rotor Lead, C - Red (+) Suppressor Lead, D - Black (-) Suppressor Lead



### 280 / 360 FRAME

**FIGURE 4: ROTATING RECTIFIER ASSEMBLY**

## RETURNED GOODS

Contact Marathon Electric Manufacturing Corporation for authorization before returning any product. We can not be responsible for any items returned without authorization.

### CAUTION

**Single bearing generators must have their rotor assembly properly secured to prevent damage during transit to the factory, or to an authorized service center.**

## TROUBLESHOOTING

This section is intended to suggest a systematic approach to locating and correcting generator malfunctions. The section is arranged according to the symptoms of the problem. The steps have been arranged in an attempt to do the easy

checks first and prevent further damage when troubleshooting a disabled machine.

The first step of troubleshooting is to gather as much information as is possible from operating personnel and individuals present during the failure. Typical information includes: how long the unit had been operating; what loads were on line; weather conditions; protective equipment that did or did not function. In addition, information as to the operating condition of the generator's prime mover is vital. Has the prime mover been maintaining constant speed? If not, have there been extended periods of under speed operation? Has the prime mover experienced an over-speed condition? If yes, what was the maximum speed, and how long did the unit operate at that elevated speed?

The generator speed should be maintained at rated nameplate value during all operating tests. The frequency of the generator depends upon rotational speed. Most regulators used with MagnaPLUS generators have built in under frequency protection such that if the speed is reduced more than 5%, the voltage will drop off rather rapidly with further reductions in speed.

## WARNING

HIGH VOLTAGES MAY BE PRESENT AT THE GENERATOR'S TERMINALS WHEN THE UNIT IS RUNNING. SOME ACCESSORY EQUIPMENT SUCH AS SPACE HEATERS MAY BE ENERGIZED FROM AN OUTSIDE POWER SOURCE WHEN THE UNIT IS AT REST. TOOLS, EQUIPMENT, CLOTHING AND YOUR BODY MUST BE KEPT CLEAR OF ROTATING PARTS AND ELECTRICAL CONNECTIONS. SPECIAL PRECAUTIONS MUST BE TAKEN DURING TROUBLESHOOTING SINCE PROTECTIVE COVERS AND SAFETY DEVICES MAY BE REMOVED OR DISABLED TO GAIN ACCESS AND PERFORM TESTS. BE CAREFUL. SERIOUS PERSONAL INJURY OR DEATH CAN RESULT FROM THESE HAZARDS. CONSULT QUALIFIED PERSONNEL WITH ANY QUESTIONS.

### **GENERATOR PRODUCES NO VOLTAGE**

CAUSE	CHECK AND REMEDY
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for loose connections, open circuits, grounds, and short circuits.
Loss of residual	Flash the field. Refer to field flashing in the service section. If the generator is equipped with a PMG, field flashing is not necessary -- check regulator fuse and input power from the PMG.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator protection operating	Adjust regulator. Consult regulator manual.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

### **GENERATOR PRODUCES LOW VOLTAGE, NO LOAD**

CAUSE	CHECK AND REMEDY
Underspeed operation	Check speed using a tachometer or frequency meter.
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for grounds, open circuits and short circuits.
Loss of regulator power	Check regulator fuse and input power. Input power is produced by the generator's residual voltage or from an optional PMG.
Regulator adjustment	Adjust regulator settings. Consult regulator manual.
Regulator incorrectly connected	Review the generator connection diagram or reference the regulator manual.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

## **GENERATOR PRODUCES LOW VOLTAGE WHEN LOAD APPLIED**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Excessive load	Reduce load. The load on each leg should be evenly balanced, and rated current should not be exceeded on any leg.
Large motor starting or low load power factor	Motor starting currents are too large for the generator. When starting multiple motors, sequence the motors and start the largest motors first. Reduce lagging power factor load.
Driver speed droop or belt slip	Check driver. If belt driven, check belt tension. Check under frequency setting on regulator. Under frequency voltage roll-off may be activated.
Reactive droop	If the generator is equipped for parallel operation, some droop is normal as reactive load increases. When operating as a single unit, the parallel CT can be shorted to eliminate this effect. Refer to Regulator manual.
Line drop	If voltage is proper at generator terminals but low at load terminals, increase external wire size.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.

## **GENERATOR PRODUCES FLUCTUATING VOLTAGE**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Fluctuating engine speed	Check engine and governor systems for malfunctions. Check load for fluctuation.
Regulator stability	Adjust Regulator stability. Refer to Regulator manual.
Regulator external rheostat	Replace defective or worn rheostat. Use shielded cable to minimize electrical noise.
Defective rectifier assembly	Check assembly for loose connections. Test the diodes as specified in the test section.
Loose terminal or load connections	Improve connections both mechanically and electrically.
Defective regulator	Replace regulator.

## **GENERATOR PRODUCES HIGH VOLTAGE**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Faulty metering	Check voltage with separate meter at generator terminals.
Incorrect connections	Verify generator connections. Refer to drawings supplied with the generator or connection diagrams in this manual.
Regulator adjustments	Adjust regulator. Consult regulator manual.
Leading power factor	Check the power factor of the load. If power factor is leading, change load configuration. Excessive leading power factor (capacitors) can cause voltage to climb out of control.
Incorrect regulator connection	Verify regulator voltage sensing is connected correctly. Consult regulator manual.
Defective regulator	Replace regulator.

## **GENERATOR BUILDS VOLTAGE FROM STARTUP, THEN GOES TO LOW (RESIDUAL) VOLTAGE**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Regulator protective circuit operating	Check indicators on regulator. Correct problems and adjust regulator as is required. Refer to regulator manual.

## **GENERATOR IS OVERHEATING**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Generator is overloaded	Reduce load. Check with ammeter and compare with nameplate rating.
Clogged ventilating screens	Clean air passages.
High room temperature or altitude	Improve ventilation or reduce load.
Insufficient circulation of cooling air	Generator location and enclosure design must provide adequate airflow and minimize recirculation of hot air.
Unbalanced load	The load on each leg should be as evenly balanced as possible and should not exceed rated current on any one leg.

## **GENERATOR PRODUCES MECHANICAL NOISE**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Defective bearing	Replace bearing.
Loose or misaligned coupling	Tighten, realign, or replace coupling.
Belt slap or loose guards	Check belt tensioning. Check belt guard fasteners.

## **EQUIPMENT RUNS NORMALLY ON UTILITY POWER, BUT WILL NOT RUN ON GENERATOR**

<b>CAUSE</b>	<b>CHECK AND REMEDY</b>
Distorted voltage waveform	Analyze load. Excessive SCR (thyristor) loading will cause distortion. Some equipment may be sensitive to distorted waveforms. Refer to Marathon Electric.
Improper generator voltage or frequency	Check nameplates of devices comprising the load. Compare required voltage and frequency with that of the generator. Adjust driver speed and/or generator voltage as necessary to match generator output to load requirements.

**CAUTION:** Compare required voltage, frequency, and kVA with generator nameplate to ensure adequate generator capacity. If in doubt, consult Marathon Electric for information regarding generator capacity.

## SPECIFICATIONS

MODEL / FRAME SIZE	EXCITER RESISTANCE	
	STATOR	ROTOR
281, 282, 283, 284	23.0	.120
361, 362, 363 -- three phase	23.5	.120
361, 362, 363 -- dedicated single phase	23.0	.135
431, 432, 433 -- three phase	20.33	.076
431, 432 -- dedicated single phase	18.0	.105

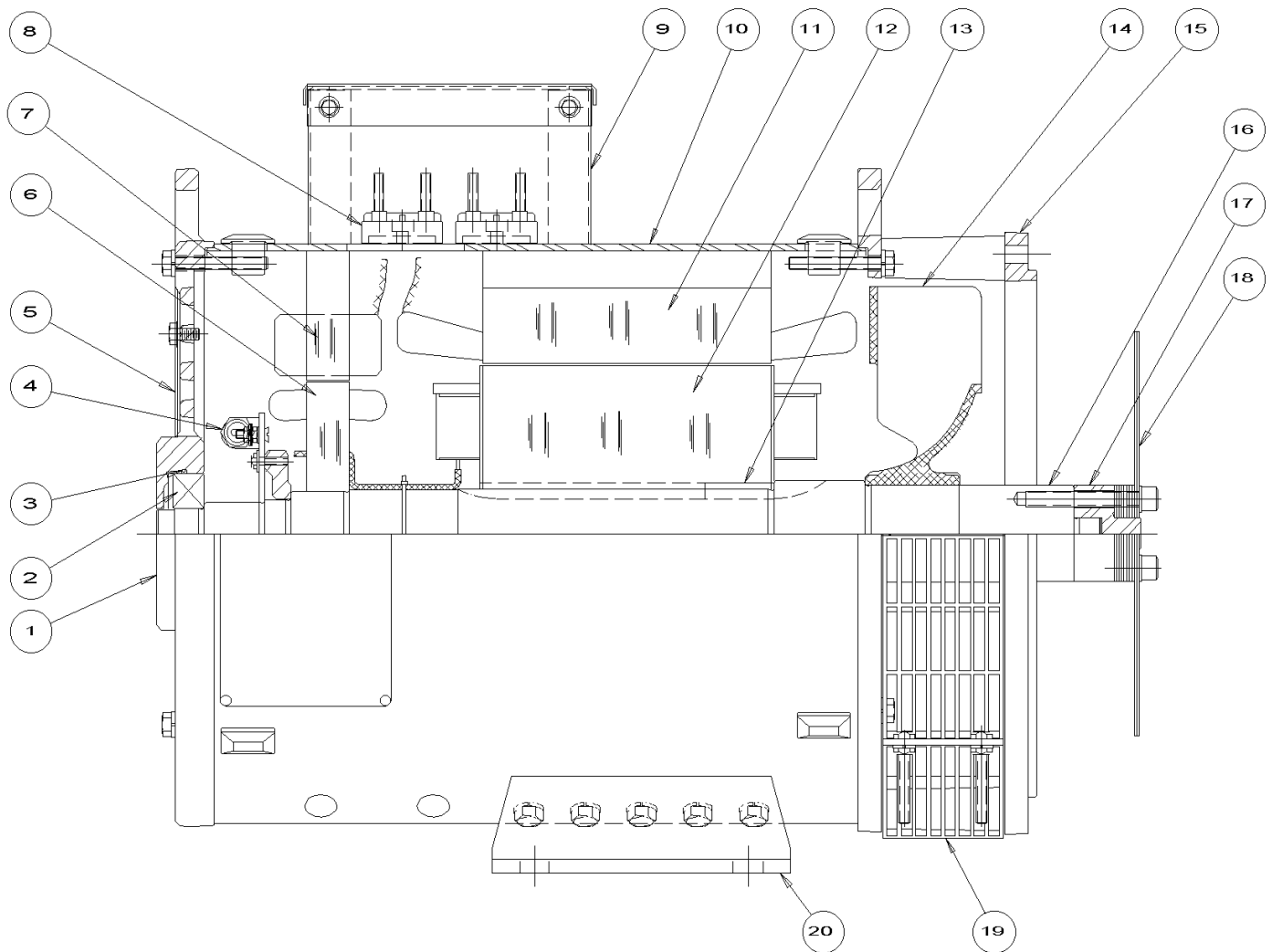
MODEL	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ	NO LOAD TERMINAL VOLTAGE WITH 12 VDC FIXED EXCITATION	
	STATOR*	ROTOR		HIGH WYE / 60 HZ	HIGH WYE / 50 HZ
281PSL1500	4.20	.400	11.0	485	400
281PSL1501	4.15	.400	11.0	490	404
281PSL1502	3.20	.439	9.0	528	435
282PSL1503	2.00	.470	10.4	500	415
282PSL1504	1.51	.512	11.3	490	400
282PSL1505	1.00	.575	10.1	515	415
283PSL1506	.681	.654	11.0	495	400
283PSL1507	.480	.758	12.0	480	390
284PSL1508	.346	.875	12.0	480	375
361PSL1600	.381	.750	11.8	485	400
361PSL1601	.264	.810	12.5	475	385
361PSL1602	.181	.990	14.1	460	370
362PSL1604	.138	1.05	12.2	480	380
362PSL1606	.0980	1.20	10.8	500	405
363PSL1607	.0692	1.37	12.2	475	380
431PSL6202	.0214	.8114	15.1	440	360
431PSL6204	.0477	.6373	13.6	455	385
431PSL6206	.0371	.6793	13.82	455	370
431PSL6208	.0133	.715	12.20	475	390
432PSL6210	.0214	.8114	15.1	440	360
432PSL6212	.0226	.8656	14.1	445	385
433PSL6216	.01215	1.0672	16.2	425	345
433PSL6220	.01214	.9743	15.6	430	350

\* Stator resistance measured line to line in a high wye connection.

DEDICATED SINGLE PHASE	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS / 60 HZ
	STATOR	ROTOR	
281PSL1511	1.420	.381	8.3
281PSL1512	1.106	.395	8.1
281PSL1513	.632	.430	8.7
282PSL1514	.436	.450	9.2
282PSL1515	.240	.520	9.7
283PSL1516	.160	.620	13.3
284PSL1517	.0918	.760	12.2
284PSL1518	.0610	.857	16.6
361PSL1611	.0695	.750	17.5
361PSL1612	.0434	.857	16.1
361PSL1613	.0369	.926	13.6
362PSL1615	.0191	1.20	17.0
363PSL1617	.0119	1.35	23.0
431PSL1811	.0248	.516	9.9
431PSL1813	.0129	.615	13.8
432PSL1814	.00931	.643	15.1
432PSL1815	.00723	.852	11.2

# PARTS LIST – SINGLE BEARING

## Typical Generator Cross Section

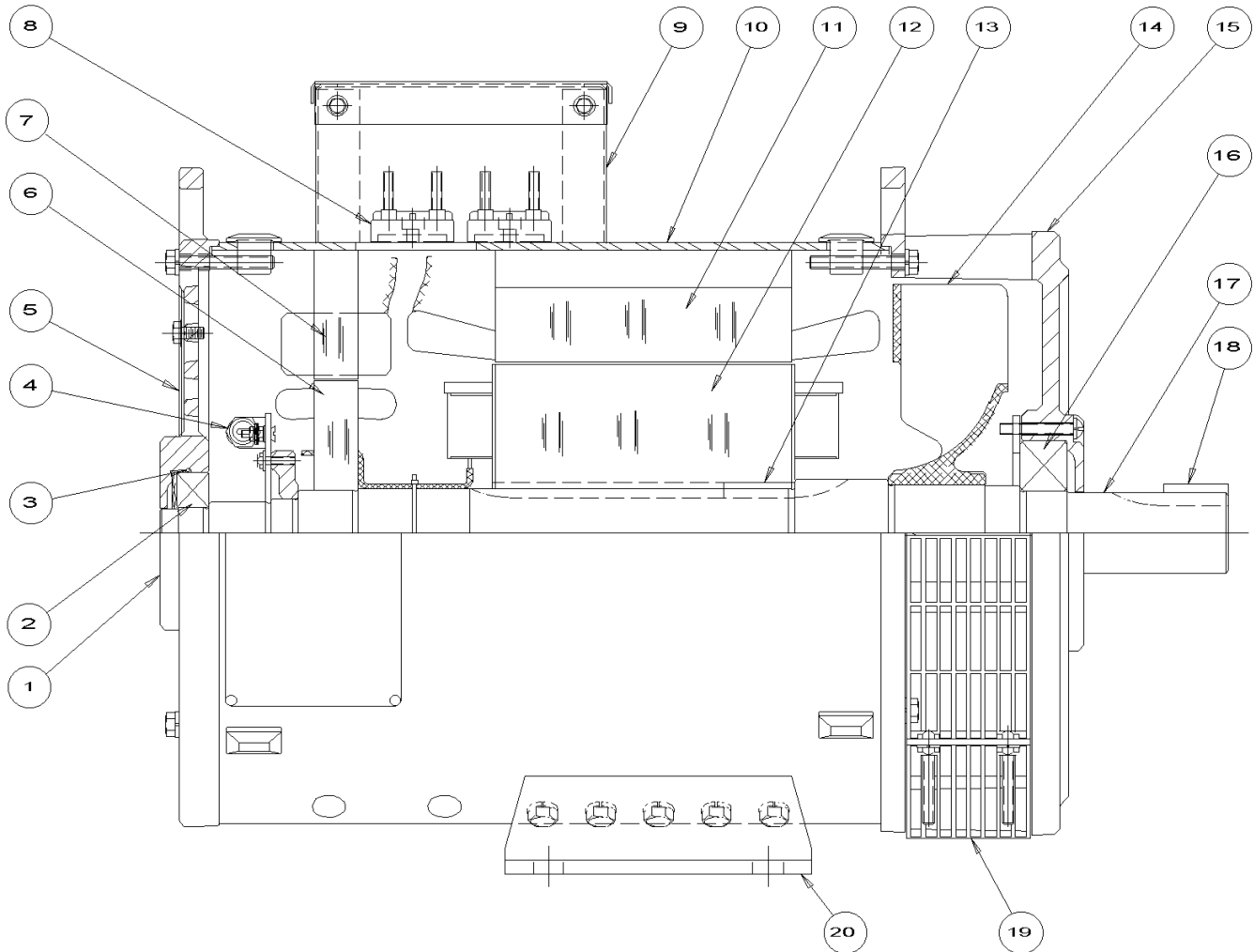


Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 360 & 430 frames)	11	Main Stator
2	Bearing	12	Main Rotor
3	O-ring (280 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Screen (280 frame only)	15	Mounting Adapter (SAE)
6	Exciter Rotor	16	Shaft
7	Exciter Stator	17	Drive Hub
8	Link Board (terminal block)	18	Drive Disk (SAE)
9	Conduit Box	19	Exhaust Screen (drip cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 280 frame MagnaPlus. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

# PARTS LIST – DUAL BEARING

## Typical Generator Cross Section



Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 360 & 430 frames)	11	Main Stator
2	Bearing (nondrive end)	12	Main Rotor
3	O-ring (280 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Screen (280 frame only)	15	End Bracket (drive end)
6	Exciter Rotor	16	Bearing (drive end)
7	Exciter Stator	17	Shaft
8	Link Board (terminal block)	18	Key
9	Conduit Box	19	Exhaust Screen (drip cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 280 frame MagnaPlus. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

# **RULES FOR SAFE TRAILER OPERATION**

## **CAUTION – Before you start:**

- Make sure vehicle is capable of towing the load.
- Be sure hitch capacity is equal to or greater than the load when mounted on the vehicle.
- See that hitch ball rated capacity is equal to or greater than the load.
- Make sure your safety chain(s) is rated equal to or greater than twice the maximum gross trailer weight rating of your trailer.
- It is against the law to carry passengers in the back of any trailer.
- Reduce weight in car trunk and rear seat areas by the amount of tongue weight of your trailer.
- Any alterations or changes made to the trailer void any express or implied warranties on the trailer or towing equipment.

## **SELECTING THE PROPER TOWING EQUIPMENT**

When selecting the proper towing equipment, the two most important factors that must be considered are the M.G.T.W. (Maximum Gross Trailer Weight) and the Tongue Weight. The M.G.T.W. is the total weight of the trailer plus the payload in the trailer. The tongue weight is the downward pressure exerted at the coupler.

The easiest way to measure the gross trailer weight is to place the loaded trailer on a vehicle scale making sure that the scales are supporting the entire weight of the loaded trailer.

The easiest method for measuring tongue weight (up to 300 lbs.) is to place the trailer tongue on a set of bathroom scales making sure the trailer is level. For heavier tongue weights, place a board across the bathroom scales and a solid object of the same thickness as the scales with a piece of pipe between each. The trailer tongue should be level and in its normal towing position. Multiply the scale reading by three (3) to obtain the tongue weight. Tongue weight should be 10% of trailer weight and not over 10% of M.G.T.W.

## **TOWING VEHICLE**

Make sure the vehicle you are using to tow the trailer is capable of towing the weight. Check the vehicle Owner's Manual for towing capability of the towing vehicle or contact the car dealer for this information.

<b>Hitch Class</b>	<b>Maximum Towing Cap.</b>	<b>Maximum Tongue Wt.</b>	<b>Normally Installed</b>
Sub Class I	1000 Lbs.	100 Lbs	Foreign or U.S. Sub-compact vehicles
Class I	2000 Lbs.	200 Lbs.	Compact Vehicles
Class II	3500 Lbs.	300 Lbs.	Mid-size & Full Size Vehicles
Class III	5000 Lbs. Plus	500 Lbs. Plus	Full Size Vehicles, Pick-up Truck



## **ELECTRICAL TRAILER WIRING**

All trailers must have taillights, brake lights and turn signals connected in with the towing vehicle's electrical system. It is also recommended that a heavy-duty turn signal flasher be installed since the trailer lights place an extra load on the car flashers.

## **TOWING HEAVY TRAILER LOADS**

1. Trailer brakes – In all cases refer to your Vehicle Owner's Manual and the Trailer Operating Manual to be certain you have an adequate braking system to handle the vehicle/trailer combination. Also, state requirements, road and weather conditions and grade of road, etc. should be taken into consideration when assessing the need for trailer brakes.
2. Additional equipment – the following items may be helpful for towing heavy loads. Consult your vehicle Owner's Manual for recommended towing accessories.
  - (A) Overload Springs
  - (B) Overload or air shocks
  - (C) Transmission Oil Cooler
  - (D) Engine Oil Cooler
  - (E) Coolant recovery System
  - (F) Heavy Duty Fan
  - (G) Side View Mirrors
  - (H) Sway Control

## **SAFE DRIVING**

- (1) Loading Trailer – The trailer should be loaded so that the downward tongue weight is approximately 10% of the gross trailer weight.
- (2) Driving – The following precautions should be taken when towing a trailer:
  - (A) Following and stopping distance – the rule of thumb for the minimum distance that should be maintained between you and the preceding car is one car and trailer length for every 10 MPH you are traveling. The distance should be increased accordingly depending on road and weather conditions. Avoid sudden stops if possible.
  - (B) Passing – Accelerating and passing should be done slowly to allow extra distance for passing. Signal well in advance when passing and returning to the proper lane.
  - (C) Turning – Drive slightly beyond normal turning power to avoid running over curbs and soft shoulders.
  - (D) Uphill and Downhill Grades – Reduces speed and use a lower transmission gear for steep or long up or down hill grades.
  - (E) Parking –
    - Avoid parking on uphill or downhill grades
    - Place transmission in "PARK"
    - Apply parking brake.
    - Use wheel chucks.
  - (F) Trailer Sway – If trailer sways, reduce speed; apply trailer brakes rather than car brakes to control sway. If excessive sway persists, consult your local dealer for help.

## **SAFETY CHECKS**

The following items should be checked before each use and once every 100 miles of towing:

- (1) Check lighting to be sure stop, tail and turn signals are working properly. Replace any broken lenses, reflectors or bulbs.
- (2) Check wires for good connections and possible fraying or wearing of insulation.
- (3) Check and properly maintain the trailer, hitch, ball and coupler.
- (4) Inspect hitch and ball for damage in every day use. Ball or hitch can be damaged in parking, hitting curbs, dragging when crossing ditches or railroad tracks.
- (5) Check and properly tighten all bolts on trailer, hitch, ball and coupler (including wheels).
- (6) Check safety chains for wear and do not allow them to drag on ground.
- (7) Towing vehicle tires – check tires for wear and proper inflation (Consult Vehicle Owner's Manual for proper level of inflation of tires for towing a trailer).
- (8) Trailer Tires– Check tires for wear and proper inflation. If it becomes necessary to change a tire, replace only with a tire of the same size rating and capacity.
- (9) Carry emergency flares and fire extinguisher (required in some states).
- (10) Carry extra light bulbs and fuses.
- (11) Wheel bearings should be checked and replaced after the first 100 miles, and every 4000 miles thereafter or at least once a year. Wheel bearing grease or a good grade of multi-purpose grease should be used for packing wheel bearings. If you don't know how to repack your wheel bearing, take your trailer to a garage for advice.
- (12) Vehicle maintenance – For proper vehicle maintenance while towing a trailer, refer to your Vehicle Owner's Manual and manufacturer's specifications.

## **TRAILER LIGHT KIT WIRING INSTRUCTIONS**

Connect the wires of the short trunk connector to the vehicle wiring. Connect the brown wire to the tail light wire, the yellow wire to the left-hand stop and turn, and the green wire to the right-hand stop and turn wire. Attach the white ground wire to the vehicle frame. If vehicle has rear turn signals separated from stoplights, you will need an Anderson 5403 electronic converter.

### **TRAILER LIGHT MOUNTING AND CONNECTION**

Mount the light with license window on the left rear of the trailer with side marker to the outside of the trailer. Mount the light without license window on the right rear of the trailer with side marker to the outside. Mount the license bracket with the left-hand light.

Using frame clips, mount each half of the harness down each side of the trailer, with yellow and brown wires down left side and green and brown wires down right side. Connect yellow and brown wires to left side and green and brown wires down right side. Connect yellow and brown wires to left-hand light by stripping harness ends 3/8" and inserting yellow wire into hole marked "Stop and Turn (yellow)". Insert brown wire into hole marked "Tail (brown)". (Extra holes are spares for auxiliary use.) Connect green and brown harness ends to the right-hand light in the same manner. Attach white ground wire to trailer tongue or frame.

Mount the front side marker lights in the area shown. Attach wire to brown harness wire with 3M Scotchlok connector. (Kits 540,545, 547).

Mount the three red marker lights to rear of trailer making sure that the lamps are no less than 6" and no more than 12" from center of lamp to center of lamp. (Kit 547)

After lamps are mounted, use 3M Scotchlok connectors to connect all three leads together and then plug into the extra hole marked brown in the back of taillight (either side).

**NOTE:** Smaller holes above or below circuit holes on all lights are relief holes to be used for removal of wires. By inserting nail or paper-clip into these small holes the strain on the wires can be relieved so they can be moved.

Connect harness plug to trunk connector plug. Turn on car headlights – both tail and all four side markers should come on. The brighter stoplights should come on only when the brake pedal is depressed, or when turn signal is activated, (Key must be in "on" position.) If lights do not light, check all ground connections. If turn signals do not operate properly, check connections between vehicle wiring and trunk connector.

**NOTE:** All lights used in these kits comply with D.O.T. standards. Some kits do not contain all of the lights needed to meet vehicle requirements.

### **Limited Warranty**

Unless otherwise provided, Baldor generators are warranted against defects in Baldor workmanship and materials for a period of time as set forth in the Warranty Period chart below. If a Baldor product is defective due to Baldor workmanship or materials and the defect occurs during the warranty period, then Baldor will either repair the product or replace it with a new one, whichever Baldor believes to be appropriate under the circumstances. Service for warranty issues regarding any Baldor Generators Products Warranty is available by contacting Baldor Generators' Customer Service Department in Oshkosh, Wisconsin. A list of Baldor's generator repair facilities may be obtained by contacting Baldor Generators at: Customer Service, Baldor Generators, 3815 Oregon Street, Oshkosh, Wisconsin 54902, 920-236-4200 (telephone), 920-236-4219 (facsimile). All Baldor products requiring warranty service shall be transported or shipped freight pre-paid, at the risk of the party requiring warranty service, to a Baldor Generator repair facility, or to Baldor Generators' Customer Service Department in Oshkosh, Wisconsin. Written notification of the alleged defect in addition to a description of the manner in which the Baldor generator is used, and the name, address and telephone number of the party requiring warranty service must be included. Baldor is not responsible for removal and shipment of the Baldor product to the service center or for the reinstallation of the Baldor product upon its return to the party requiring warranty service. Customers who are unable to take or ship the Baldor product to a Baldor Generator repair facility, or who desire a repair to be made by other than a Baldor Generator repair facility, should contact Baldor Generators' Customer Service Department at 920-236-4200. Baldor, in advance of such service, must approve a repair by anyone other than a Baldor Generator repair facility in writing. Problems with Baldor products can be due to improper maintenance, faulty installation, non-Baldor additions or modifications, or other problems not due to defects in Baldor workmanship or materials. If a Baldor Generator repair facility determines that the problem with a Baldor product is not due to defects in Baldor workmanship or materials, then the party requesting warranty service will be responsible for the cost of any necessary repairs. Parties requiring warranty service not satisfied with a determination that a problem is outside of warranty coverage should contact Baldor Generators' Customer Service Department at 920-236-4200 for further consideration. EXCEPT FOR THE EXPRESSED WARRANTY SET FORTH ABOVE, BALDOR GENERATORS DISCLAIMS ALL OTHER EXPRESSED AND IMPLIED WARRANTIES INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY. NO OTHER WARRANTY, EXPRESSED OR IMPLIED, WHETHER OR NOT SIMILAR IN NATURE TO ANY OTHER WARRANTY PROVIDED HEREIN, SHALL EXIST WITH RESPECT TO THE GOODS SOLD UNDER THE PROVISIONS OF THESE TERMS AND CONDITIONS. ALL OTHER SUCH WARRANTIES ARE HEREBY EXPRESSLY WAIVED BY THE BUYER. UNDER NO CIRCUMSTANCES SHALL BALDOR GENERATORS BE LIABLE OR RESPONSIBLE IN ANY MANNER WHATSOEVER FOR ANY INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES, OR ANTICIPATED PROFITS RESULTING FROM THE DEFECT, REMOVAL, REINSTALLATION, SHIPMENT OR OTHERWISE. This is the sole warranty of Baldor Generators and no other affirmations or promises made by Baldor Generators shall be deemed to create an expressed or implied warranty. Baldor Generators has not authorized anyone to make any representations or warranties other than the warranty contained herein.

### **Warranty Period**

<b>Generator Series</b>	<b>Labor*</b>	<b>Parts</b>
Portable Products (Premier, Powerchief, DG Series, K Series)	1 Year	3 Years
Towable Products (TS)	1 Year or 3,000 Hours Whichever comes first	3 Years or 3,000 Hours Whichever comes first
3600 RPM Standby Systems (Some AE Models)	1 Year or 1,000 Hours Whichever comes first	3 Years or 1,000 Hours Whichever comes first
1800 RPM Standby Systems (Some AE Models, DLC, GLC)	1 Year or 3,000 Hours Whichever comes first	3 Years or 3,000 Hours Whichever comes first
Industrial Standby Systems	1 Year or 1,000 Hours Whichever comes first	2 Years or 1,000 Hours Whichever comes first
Industrial Prime Power Systems	1 Year or 1,000 Hours Whichever comes first	1 Year or 1,000 Hours Whichever comes first
International	1 Year or 1,000 Hours Whichever comes first	1 Year or 1,000 Hours Whichever comes first

## **Limited Warranty** Continued

### Notes for Warranty Period:

1. Labor coverage for warrantable repairs is provided for the applicable period not to exceed published rates as contained in the Baldor Generators Warranty Policy. Mileage is allowed only for permanent installations not to exceed published rates as contained in the Baldor Generators Warranty Policy.
2. Proof of purchase date is required for all Portable and Towable products to qualify for any warranty consideration. Serial number and model number will be required for all warranty work.
3. For all other products, a Start-up Inspection Form / Warranty Registration must be completed in its entirety and submitted to Baldor Generators within 30 days of start-up to qualify for any warranty consideration.

### **Owner's Responsibilities:**

The owner is obligated to operate and maintain the generator in accordance with the recommendations published by Baldor Generators in the Operator's Manual for the generator. The owner is responsible for the costs associated with maintenance and any adjustments that may be required.

The owner is responsible for payment of any of the following expenses that might be incurred as a result of a failure under the terms of this warranty:

1. Rental equipment used to replace the equipment being repaired.
2. Telephone or other communication expenses.
3. Living and travel expenses of persons performing service, except as specifically included within the terms of specific warranty.
4. The premium costs for overtime labor requested by the owner.
5. All parts transportation costs.

All warranty claims must be submitted to a Baldor Generator repair facility prior to the expiration of the warranty period. Baldor Generators shall have no responsibility or liability for any defect, latent or otherwise, discovered after the expiration of the warranty period provided herein. Extended warranties are available for certain Baldor products. These warranties are described in Baldor's catalog and other sales literature. Extended warranties are subject to the terms and conditions of this Limited Warranty as modified by the additional terms of the extended warranty.

### **Limitations:**

Baldor Generators is not responsible for the repair of generators required because of normal wear, accident, misuse, abuse, improper installation, lack of maintenance, unauthorized modifications or improper storage.

**Normal Wear:** This warranty will not cover repair where normal use has exhausted the life of a part or generator. It should be remembered that the service life of any generator is dependent on the care it receives and the conditions under which it has to operate. Some applications are very often used in dusty or dirty conditions, which can cause what appears to be excessive wear. Such wear, when caused by dirt, dust, grit or other abrasive material, which has entered the generator because of improper maintenance, is not covered by Warranty.

For all product lines, the engine manufacturer warrants engine systems. Contact Baldor Generators for current engine warranties.

#### Owner's Responsibilities:

The owner is obligated to operate and maintain the generator in accordance with the recommendations published by Baldor Generators in the Operator's Manual. The owner is responsible for the costs associated with maintenance and any adjustments that may be required.

The owner is responsible for payment of any of the following expenses that might be incurred as a result of a failure under the terms of this warranty:

1. Rental equipment used to replace the equipment being repaired.
2. Telephone or other communication expenses.
3. Living and travel expenses of persons performing service, except as specifically included within the terms of specific warranty.
4. The premium costs for overtime labor requested by the owner.
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No person is authorized to give any other warranties or to assume any other liabilities on Baldor Generators' behalf unless made or assumed in writing by an officer of Baldor Generators and no person is authorized to give any warranties or assume any other liability on behalf of the seller unless made or assumed in writing by the seller.

Major components, such as engines, used in Baldor Generators' generator sets that are not manufactured by Baldor Generators are specifically excluded from Baldor Generators coverage and are covered separately by their respective manufacturers. Warranty terms and policies of excluded products are included with their owners information package supplied with each product.

**WARNING:**  
**CALIFORNIA PROPOSITION 65 WARNING:**  
Engine exhaust from this product contains chemicals known to the state of California to cause cancer, birth defects and other reproductive harm.

**WARNING:**  
**CALIFORNIA PROPOSITION 65 WARNING:**  
Diesel engine exhaust and some constituents are known to the state of California to cause cancer, birth defects and other reproductive harm.

**WARNING:**  
**CALIFORNIA PROPOSITION 65 WARNING:**  
Battery posts, terminals and related accessories are known to the state of California to cause cancer, birth defects and other reproductive harm.