



# OPERATION & SERVICE MANUAL



**Model: 11-2820-0000**  
**28.5 VDC Ground Power Unit**



08/2024 — Rev. 07

**For Spare Parts, Operations & Service Manuals or Service Needs**  
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05	05/2023	Modified 9.7 Engine/Alternator/Engine Mounting
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07	08/2024	Modified 1.6 Cold Weather Features, 2.3 Component Safety Features, 10.2 Recommended Spare Parts List

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## 1.0 PRODUCT INFORMATION

### 1.1 DESCRIPTION

Diesel Powered GPU, 28.5 VDC Output, Tier 4 final

### 1.2 MODEL & SERIAL NUMBER

Reference nameplate on unit

### 1.3 MANUFACTURER

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### 1.4 FUNCTION

The 11-2820-0000 Ground Power Unit (GPU), is a diesel powered unit designed to serve as a 28.5 volt DC power source for parked aircraft. It can provide 600 amps continuous for aircraft servicing, and up to 2000 amps peak for starting. The Current Limit (Soft Start) feature allows the user to select current limits for operations requiring current limit below the maximum output.

### 1.5 REQUIREMENTS

The GPU must run on ultra low sulfur Diesel Fuel only! The fuel filter is a disposable spin on type and must be changed every 500 hours of running time.

### 1.6 COLD WEATHER FEATURES

- 12 V, 900 CCA, AMG battery
- Automated glow plug control
- 120 VAC block heater
- Insulated engine enclosure for cold weather starting and sound dampening

## 2.0 SAFETY INFORMATION



**WARNING! CALIFORNIA PROPOSITION 65 – DIESEL ENGINES.** Diesel engine exhaust and some of its constituents are known by the State of California to cause cancer, birth defects, and other reproductive harm.

### 2.1 USAGE AND SAFETY INFORMATION

The GPU provides 28.5 Volts DC for performing aircraft service and maintenance.

To insure safe operations please read the following statements and understand their meaning. Also refer to your equipment manufacturer's manual for other important safety information. This manual contains safety precautions, which are explained below. Please read carefully.



**WARNING!** — Warning is used to indicate the presence of a hazard that **can cause severe personal injury, death, or substantial property damage** if the warning notice is ignored.

**CAUTION!** — Caution is used to indicate the presence of a hazard that **will or can cause minor personal injury or property damage** if the caution notice is ignored.

**2.2 EXPLANATION OF WARNING & DANGER SIGNS**

**WARNING! Accidental Starts!** Always turn off and lock out the battery switch before servicing this GPU. Only qualified service personnel may service this equipment. Read and understand the technical manual before servicing this equipment.



**WARNING! Rotating Parts!** Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the GPU with doors open or panels and guards removed.



**WARNING! Electrical Shock!** Caution: This GPU produces voltages and current sufficient to cause burns and death by electric shock! Always inspect cables and plugs for damage before use. Do not use if damaged. Always turn DC power to off before connecting or disconnecting cables. The human body has decreased resistance when wet; keep hands, feet and clothes dry when operating electrical equipment. Do not open doors or remove panels while the GPU is running. High current electrical components will be exposed. Always turn off and lock out the battery switch before servicing this GPU.



**WARNING! Hot Surfaces!** Engine components such as turbo chargers, exhaust pipes, and mufflers will remain hot after the engine has been shut down. Allow engine to cool before servicing.



**WARNING! Batteries!** Batteries give off flammable hydrogen gas and can explode if ignited. When servicing, do not allow arcing, sparks, or open flame near the battery. Acid and arcing from a ruptured battery can cause fires and additional damage.



**WARNING! Fuel Hazard!** Use only approved containers for transferring fuel. Shut down GPU before refueling. Fires and explosions can occur if the fuel tank is not grounded. Ground fuel tank before and during fuel transfer. Clean up all fuel spills immediately.



**WARNING! Carbon Monoxide!** Engine exhaust fumes can kill. If indoors, always pipe or vent exhaust fumes to a suitable exhaust duct. Never locate engine exhaust near air conditioner intake ducts.



**WARNING! CALIFORNIA PROPOSITION 65 – DIESEL ENGINES** Diesel engine exhaust and some of its constituents are known by the State of California to cause cancer, birth defects, and other reproductive harm.

**No Access for Unauthorized Persons!** Only qualified personnel may service this equipment.

**Read Operation Manual!** Read and understand the operation manual before using this equipment. Failure to follow operating instructions could result in death or serious injury.

**Read Technical Manual!** Read and understand technical manual before servicing.

**Lockout!** Shut down engine. Turn off and lockout battery switch before servicing. If working near the batteries or the battery switch, also disconnect the negative battery cable on all batteries (3 areas).

**Loud Noise Hazard!** Ear protection must be worn while operating this equipment.

**2.3 COMPONENT SAFETY FEATURES**

- Sheet metal panels
- Maintenance locks on doors
- Scrub brake system
- Three color beacon for running, warning, and fault conditions

**2.4 FUNCTIONAL SAFETY FEATURES**

- |                                   |                                      |
|-----------------------------------|--------------------------------------|
| • Emergency shut off switch       | • Over voltage protection circuit    |
| • Timed engine shut down          | • Cable interlock protection circuit |
| • Over current protection circuit | • Battery shut off switch            |

**2.5 PERSONAL PROTECTION EQUIPMENT**

- Safety glasses and ear protection must be worn when operating the GPU
- Additional equipment required by employer (gloves, vest, etc)

**2.6 SAFETY GUIDELINES**

- Operator must be properly trained prior to operating the GPU
- Pre-operation check must be performed before each use. (Refer to operating instructions)
- DC contactor must be OFF when connecting and disconnecting the cable from the aircraft
- Use emergency stop for emergency only. Normal shut down is accomplished by pressing power off. This allows the engine to cool for one minute at idle speed before shutting off. Unit will power down completely one minute after the engine shuts off
- Always shut the unit off, allow to cool, and turn the battery switch to OFF before performing service or maintenance. If working near the batteries or the battery switch, also disconnect the negative battery cable on all batteries (3 areas)

**2.7 GENERAL COMMENTS**

The GPU is intended to be operated by personnel trained in the proper use in conjunction with the aircraft maintenance manual.

The GPU must be used in accordance with the Technical and Operator Manuals and the intended aircraft.

**3.0 PREPARATION PRIOR TO FIRST USE****3.1 GENERAL**

Prior to operating the GPU, the user must become familiar with this Operator Manual.

**3.2 PRE-USE INSPECTION****CAUTION!**

**A pre-use inspection must be carried out prior to each use to ensure safe operation of the GPU. Failure to carry out these procedures listed below may result in severe damage to the GPU or prevent efficient operation.**

1. Unit..... Visually inspect outside of GPU for loose hardware, loose parts, frayed wires/cables and general appearance
2. Radiator..... Open radiator access door and remove radiator cap (cold only). Ensure that coolant is up to the bottom of the fill neck. Service as required
3. Engine Hoses..... Check integrity of hoses and clamps for tightness
4. Fuel Level..... Turn power on and check fuel level on fuel gauge. Top up as required with fuel
5. Engine ..... Inspect all fuel lines and fittings for traces of fuel leakage. Visually inspect cylinder block, oil pan, and valve covers for oil leakage
6. Oil Level ..... Remove dipstick to ensure oil level is at full mark. Replenish as required
7. Fan Belt..... Check belt for correct tension. Look for wear
8. Air Intake Filter ..... Ensure that filter inlet is not restricted
9. Tires ..... Check integrity of tires and tread wear and pressure
10. Brakes ..... Check for proper operation

**4.0 TRAINING****4.1 TRAINING REQUIREMENTS**

The employer of the operator is responsible for providing a training program sufficient for the safe operation of the GPU.

**4.2 TRAINING PROGRAM**

The employer-provided operator training program should cover safety procedures concerning use of the GPU in and around the intended aircraft at the intended aircraft servicing location.

**4.3 OPERATOR TRAINING**

The operator training should provide the required training for safe operation of the GPU.

**NOTE: Maintenance and Trouble Shooting are to be performed by a skilled and trained technician.**



**5.0 OPERATION**

**5.1 OPERATING PARAMETERS**

- The user shall use the GPU in accordance with the aircraft manufacturer's instructions.
- The user shall operate the GPU in accordance with the Operation and Service Manual.
- The employer of the operator shall provide all necessary training.

**5.2 NUMERICAL VALUES**

Model ..... 11-2820-0000  
 Serial Number ..... (See Nameplate on GPU)

**5.2.1 Physical**

Weight (Dry) ..... 3000 lbs (1361 kg)  
 Width ..... 66.25 in (168 cm)  
 Height ..... 61 in (155 cm)  
 Length ..... 96.5 in (245 cm)  
 Output Cable ..... 30 ft (9.14 m) long  
 Noise Level ..... 78 dBA at 3ft (1 m) from control panel

**5.2.2 Engine**

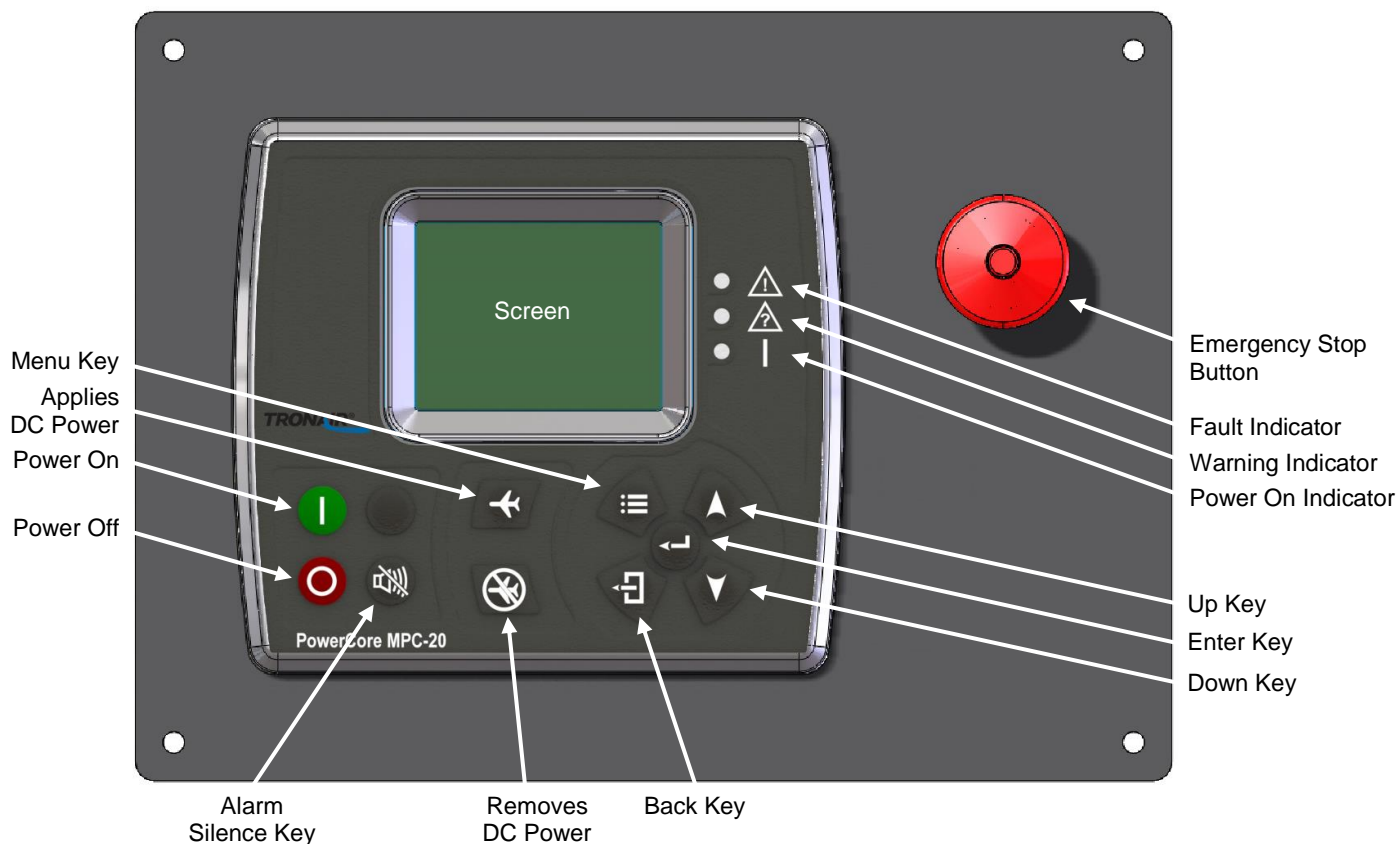
Doosan D24 ..... 2.4 Liter turbocharged after cooled, 4 cylinder, 4 stroke diesel engine  
 Horsepower ..... 68 hp (51 KW) at 1800 rpm  
 Electrical System ..... 12 volt, negative ground  
 Lubricating Oil ..... 2.4 gal (9.2 liters) w/filter  
 Coolant ..... 1 gal (3.7 liters)

**5.2.3 Alternator**

Marathon ..... Magna Plus 361PSL3161  
 Output Voltage ..... 21 volts AC, 6 phase  
 Output Power ..... 38 KW  
 Power Factor ..... 0.8  
 Ambient Temp °C ..... 40  
 Temperature Rise °C ..... 80  
 Speed ..... 1800 RPM  
 Frequency ..... 60HZ  
 Excitation ..... Externally regulated 66 volts DC, 4 amps  
 Insulation ..... Class F  
 Single Bearing ..... Sealed, pre-lubricated

5.3 LOCATION & LAYOUT OF CONTROLS

5.3.1 Control Panel (External)

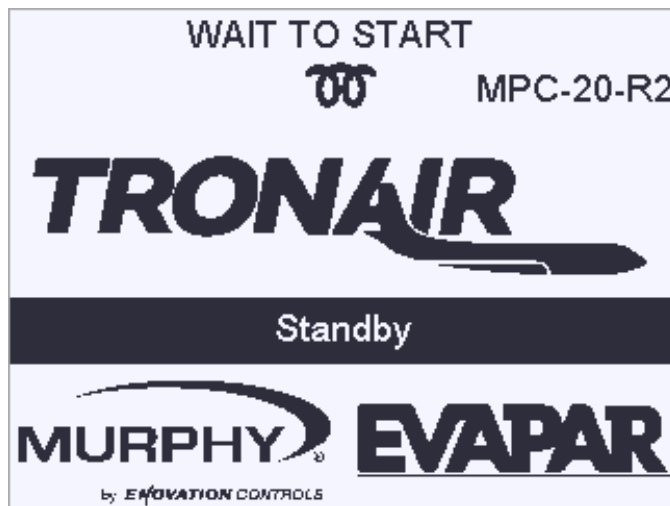


**OPERATOR BUTTONS**

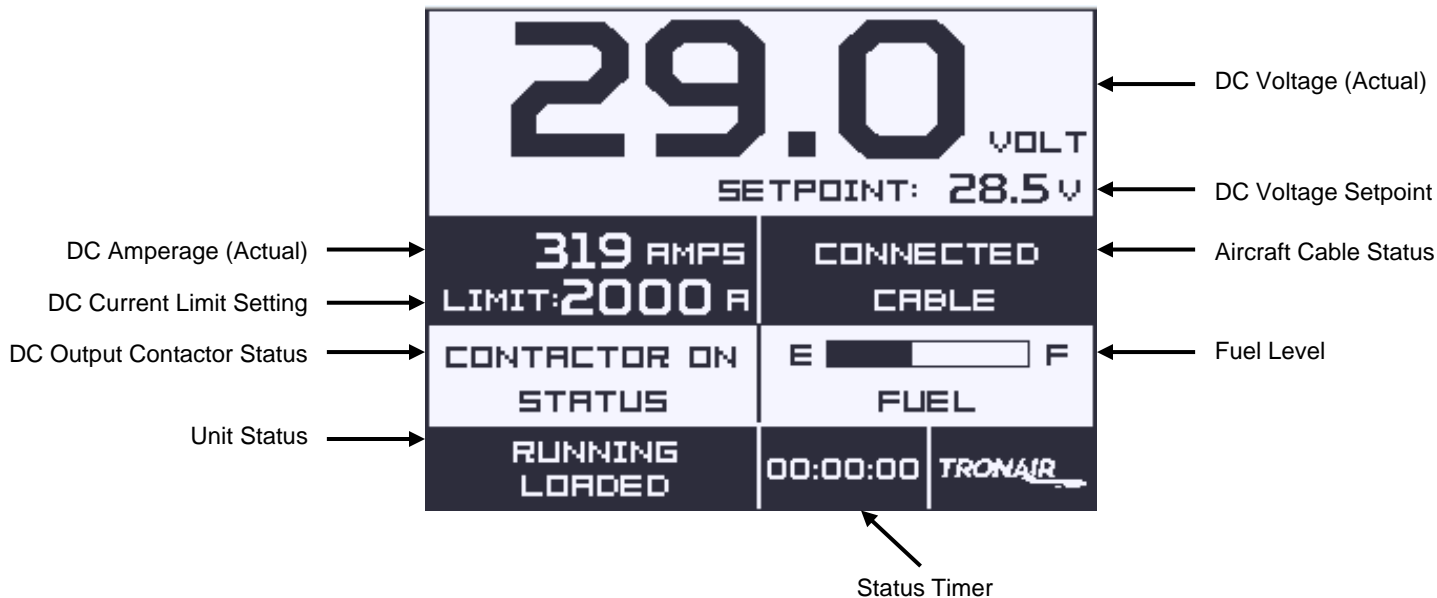
Description	Function
Power ON Position	Powers up unit, starts engine
Power OFF Position	Allows engine to idle for 1 minute before stopping, then 1 minute before unit powers down
Emergency STOP Button	Will immediately shut off power to the GPU and GPU will STOP <b>Use for emergency only</b>
Applies DC Power	Applies DC power to the aircraft cable
Removes DC Power	Removes DC power to the aircraft cable

5.3.2 Control Panel Screens

Power Up



Main Operating

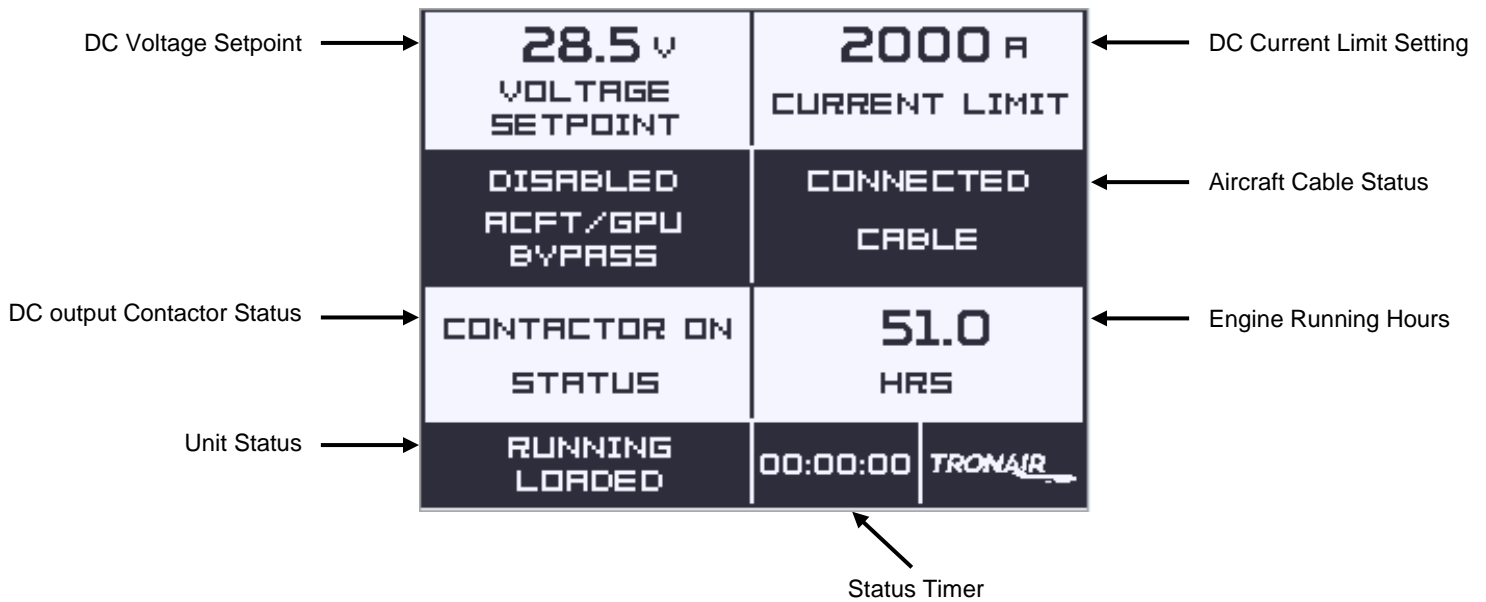


5.3.2 Control Panel Screens (continued)

### Engine Status

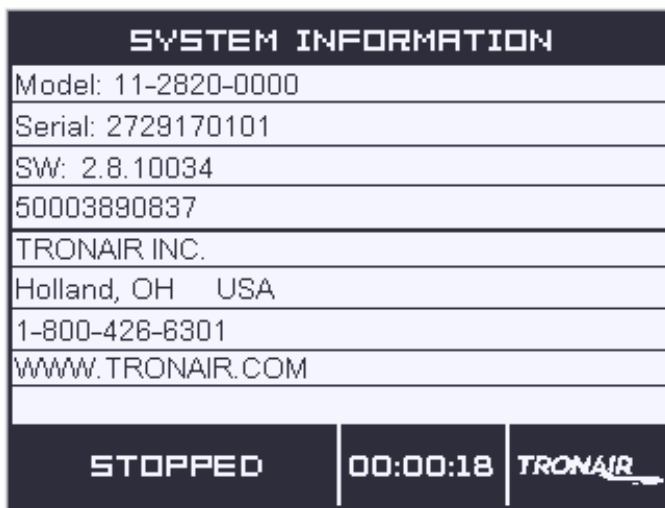


### Alternator Status



5.3.2 Control Panel Screens (continued)

### System Information



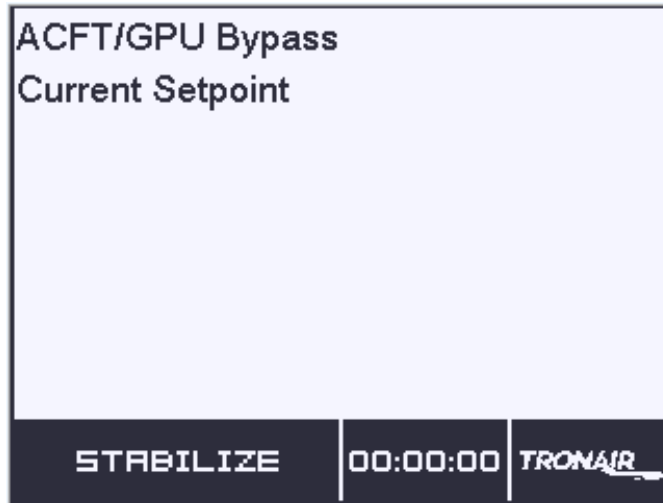
5.3.3 Control Panel Software Settings

1. To enter the software settings, press the Menu Key
2. Enter password **0000**, press Enter Key after each 0



5.3.3 Control Panel Software Settings *(continued)*

3. Select **ACFT/GPU Bypass**, press Enter Key



**CAUTION!**



The DC aircraft cable interlock is enabled when the third and smallest pin on the aircraft receptacle completes the circuit in the split pin connector. Under no circumstances should the split pin be bridged in order to switch on the DC.

**CAUTION!**



When the ACTF/GPU Bypass feature is in the enable mode the DC output cable will be live. Only trained, authorized personnel should use the equipment in this condition.

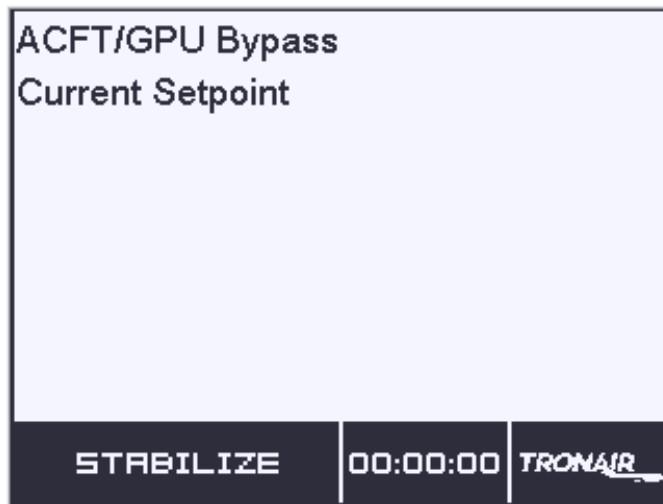
4. Select either **Disable** or **Enable**, press Enter Key

When Enabled, the ACTF/GPU Bypass feature allows the DC aircraft cable interlock feature to be overridden. The DC aircraft cable will be live when the DC Power key is pressed.

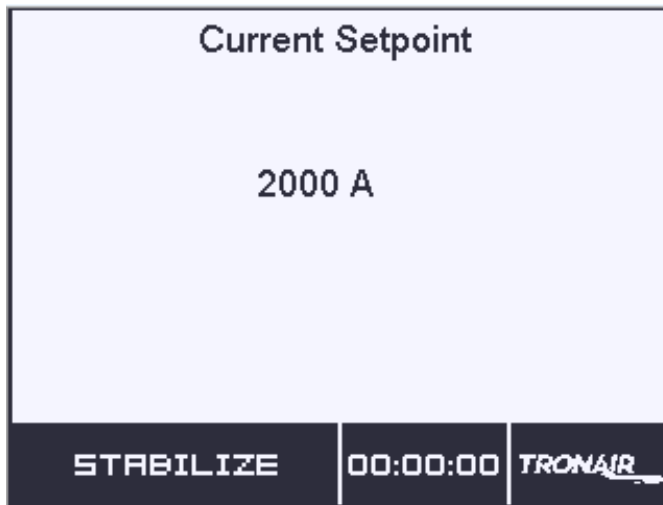


5.3.3 Control Panel Software Settings *(continued)*

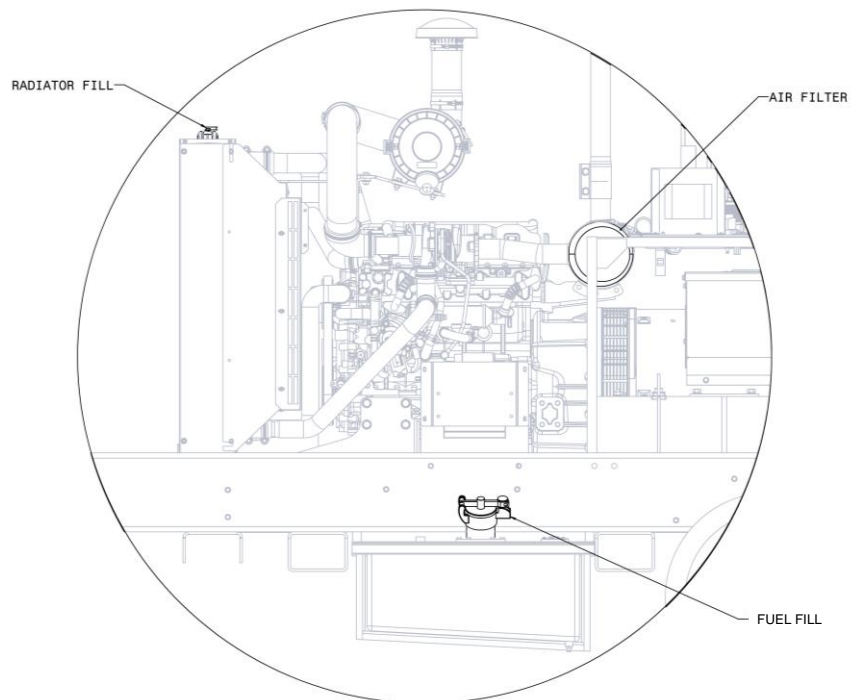
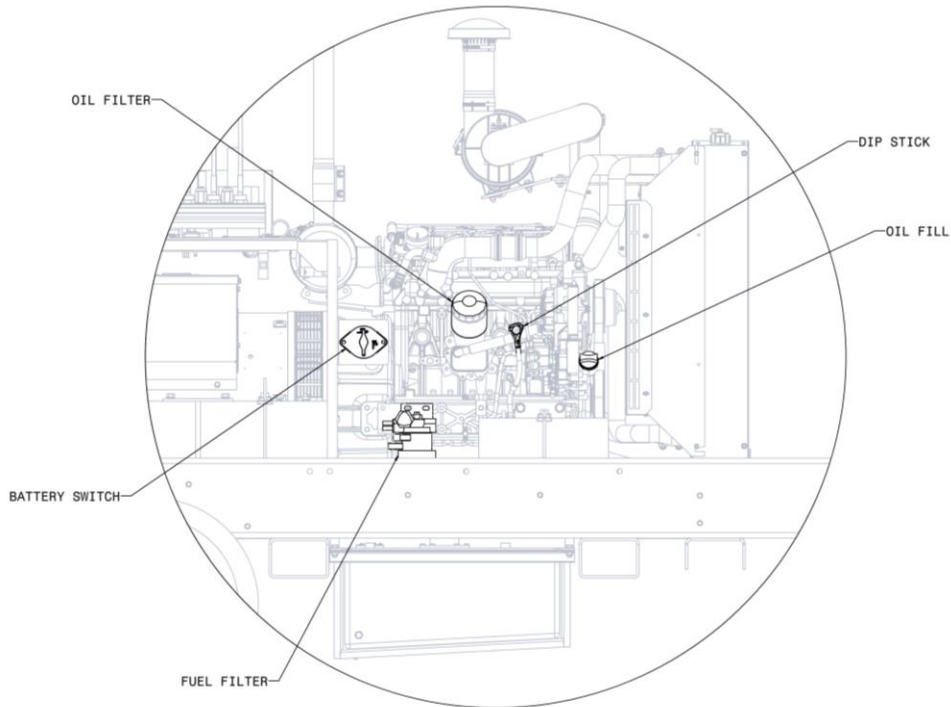
5. Select **Current Setpoint**, press Enter Key



6. Adjust the Current Limit (2000A should be used if no current limit is required), press Enter Key



5.3.4 Controls, Engine Compartment



Item	Description	Function
1	Battery Switch	Connects and disconnects unit Pos. 12 Volt battery cables. Must be in the ON position for unit to run. GPU is shipped with switch in the OFF position

## 5.4 START UP PROCEDURES

## 5.4.1 Pre-Use Inspection

**CAUTION!**

**A pre-use inspection must be carried out prior to each use to ensure safe operation of the GPU. Failure to carry out these procedures listed below may result in severe damage to the GPU or prevent efficient operation.**

1. Unit..... Visually inspect outside of GPU for loose hardware, loose parts, frayed wires/cables and general appearance
2. Tires ..... Check treads for wear and tires for pressure
3. Radiator Coolant .... Open radiator access door and remove radiator cap (cold only). Ensure that coolant is up to the bottom of the fill neck. Service as required
4. Engine Hoses ..... Check integrity of hoses and clamps for tightness
5. Fuel Level..... Turn power on and check fuel level on fuel gauge. Top up as required with fuel
6. Engine ..... Inspect all fuel lines and fittings for traces of fuel leakage. Visually inspect cylinder block oil pan and valve covers for oil leakage
7. Oil Level ..... Remove dipstick to ensure oil level is at full mark. Replenish as required
8. Fan Belt..... Check belt for correct tension. Look for wear
9. Brakes ..... Check for proper operation

## 5.4.2 Starting Sequence

The following sequence must be followed in the order shown:

1. The GPU battery disconnect switch must be selected to the ON position.
2. Press Power ON button. This will power up the unit.
3. Depending on air temperature the Wait To Start will display. Press Power ON button.
4. Engine will idle for 15 seconds, then go to operating speed.

**CAUTION!**

**Battery must be fully charged to supply sufficient voltage for starting.**

- If any warnings or faults display on screen respond accordingly.
- Unit should display  $28.5 \pm 0.1$  volts, and the current limit setting (2000 A default).

## 5.4.3 Supplying DC Power to the Aircraft

1. Connect 28.5 VDC cable to aircraft. Make sure that power plug is fully and correctly inserted into the aircraft receptacle.

**CAUTION!**

**Ensure that the current limit is in the correct setting for the aircraft to be started. Consult aircraft technical manual for proper switch setting. Severe aircraft engine damage can occur if incorrect setting is used.**

**Current limit setting (done in software) is only to be adjusted by competent maintenance personnel. Helicopters and some small jets and turbo prop aircraft will require a "limit" on peak power. Do not use soft start on hard start engines. Insure aircraft bypass is set to disable.**

2. Press the AIRCRAFT button. Display will say Contactor ON And Cable Connected.
3. The aircraft may now use DC power. During a start cycle, the DC voltage will fluctuate above and below 28.5 VDC. THIS IS NORMAL. The GPU will automatically compensate for the voltage drop in the cable to supply the starting voltage within specification at the aircraft receptacle. During the start, the Ammeter will show high amps initially and then quickly decay to show the continuing current draw.
4. Check all gauges for correct operation during the engine start cycle.
5. To shut down the GPU, press the power OFF button.
6. Unit will idle for 1 minute, then shut off.
7. Unit will automatically power down in 1 minute. Do not use emergency stop switch.
8. Stow DC plug and cable in cable tray.

## 5.4.4 Emergency Shut Down Procedure

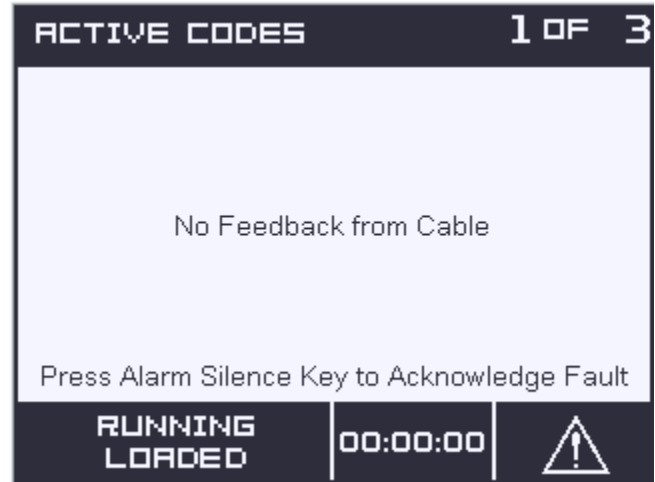
In the event an emergency shut down is necessary, press the emergency stop switch located on the operator panel. The Emergency Stop button is for emergencies only.

**CAUTION!**

Do not use for **normal** shut down. The Emergency Stop bypasses the timed cool down circuit and may cause engine damage.

## 5.5 INTERNAL FAULTS

- Contactor Off Feedback On
- No Feedback from Cable
- Contactor Off
- Over Voltage
- Over Current
- Under Voltage
- Rectifier High Temperature
- No Fuel
- Low Fuel Level
- Low Oil Pressure
- Under Speed
- High Engine Temp
- Over Crank
- Battery Not Charged
- Battery Weak
- Battery Low
- Battery High
- Emergency Stop Pressed



Internal Fault screen Example

**6.0 PACKAGING AND STORAGE****6.1 PACKAGING REQUIREMENTS**

1. Turn battery switch to OFF position
2. Drain fuel
3. Ensure fuel cap is secure
4. Securely fasten doors
5. Wrap for paint protection
6. Strap unit in truck or shipping container using 4 cargo straps. Hook one strap through each tie-down ring on the front

**NOTE: Use at least four (4) straps with a minimum 3,000 lb (136 kg) capacity each.**

**6.2 HANDLING**

The unit is designed to be lifted using a forklift.

**6.3 PACKAGING PROTECTION**

No special packaging material for cushioning or suspension is required for shipments within the continental United States.

**6.4 LABELING OF PACKAGING**

Packaging should be labeled as follows: **DO NOT DROP  
THIS SIDE UP  
DO NOT STACK**

**6.5 STORAGE COMPATIBILITY****6.5.1 Short Term Storage (less than 3 months)**

The following steps are recommended if the unit is to be placed out of services for three months or less. The unit should be prepared for storage as soon as possible after being removed from service.

1. Make sure that the mixed coolant is adequate for the lowest anticipated temperatures during time of storage.
2. Add oil to the FULL mark level on dip stick.
3. Drain a small portion of fuel from fuel tank by using the drain valve. This will remove any water that may have accumulated on the fuel tank.

**NOTE: Do not drain the fuel system or crankcase.**

4. Install new fuel filters.
5. Fill fuel tank to capacity. A full fuel tank prevents moisture laden air from entering the tank during the cool periods.
6. Close all access doors to minimize build-up of foreign particles in the unit.
7. Store unit in a building that is dry.
8. If the storage area has high humidity levels, place moisture absorbing chemicals inside the unit.

### 6.5.2 Long Term Storage

Special precautions are necessary to protect the GPU from rust and corrosion. It is recommended that the unit be stored in a building that is heated during winter months. Moisture absorbing chemicals should be placed inside the unit in climates where there is excessive dampness. Parts of the diesel requiring special attention are given below. The unit should be prepared for storage as soon as possible after being removed from service.

1. Drain the cooling system. Flush with clean water. Refill with 50/50 mix of water and antifreeze or mix according to ratio for temperature as recommended in the Doosan Operation and Maintenance Manual.
2. Circulate the coolant by operating the engine until the normal operating temperature is reached.
3. Stop the engine.
4. Drain the engine crankcase. Reinstall the drain plug. Install new lubricating oil filter element. Refill with high quality lubricating oil as recommended in the Doosan Operation and Maintenance Manual.
5. Drain the fuel tank of contaminants, fuel/water. Add additives, fill with fuel, and operate the engine for about ten minutes.

**NOTE: Where biological contamination may be a problem, add a biocidal such as Biobor JF or equivalent to the fuel. Follow the biocidal manufacturer's concentration recommendations and observe all warnings and cautions.**

6. Remove the spin-on fuel filters, discard, fill new filters with fuel and reinstall on the engine.
7. Remove and clean battery terminals and cables with baking soda-water solution, rinse with fresh water. Do not allow the soda water to enter the battery. Add distilled water to the electrolyte, if necessary fully charge the battery. Store the battery in a cool dry place (never below 32°F, or 0 degrees C). Keep the battery fully charged and check the specific gravity of the electrolyte regularly.
8. Seal all engine openings, including the exhaust outlets with moisture resistant tape. Use cardboard, plywood, or metal covers where practical.
9. Tag engine Control Panel "DO NOT RUN, READY FOR STORAGE".

## 7.0 TRANSPORTATION

- Do not stack.
- Unit is designed to be lifted with a fork lift.
- Strap unit in truck or shipping container using 4 cargo straps. Hook one strap through each tie-down ring. Raise tow-bar into latch and block wheels.
- Weight: 3000 lbs (1361 kg)

**8.0 TROUBLE SHOOTING**

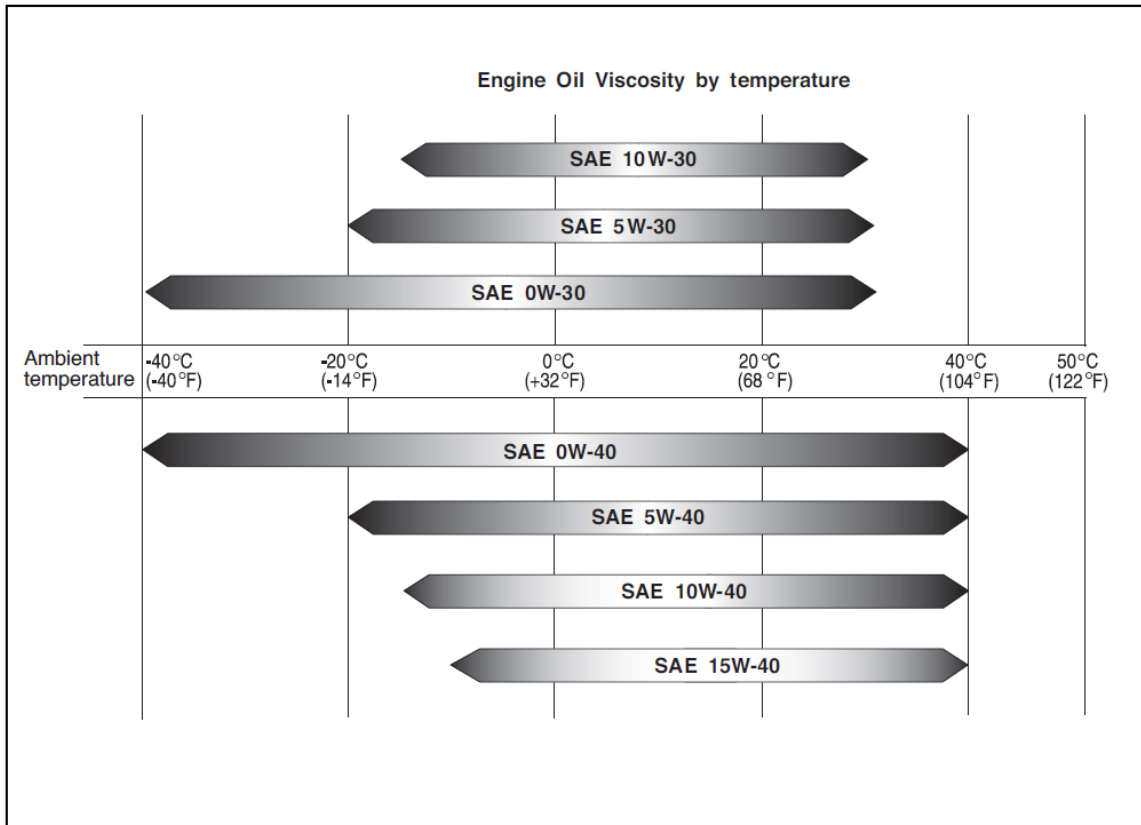
<b>FAULT</b>	<b>POSSIBLE CAUSE</b>	<b>SOLUTION</b>
No Power When "Power On" Switch is Pressed	Battery switch turned to off	Check, turn to on
	Loose battery terminals	Check, clean and tighten terminals
	Power ON switch inoperative	Check fuse one on ECU bracket
Contactor Off Feedback On	Contactor welded closed	Change DC output contactor
No Feedback from Cable	Damaged cable	Check continuity of Cable
	Not inserted fully into socket	Ensure cable is plugged all the way in
	Aircraft missing third pin	Change to GPU mode
Over Voltage	Large current drop	Consult Tronair
	AVR out of adjustment	Adjust volt adjustment on AVR
	Damaged AVR	Replace damaged AVR
Over Current	Exceeding current rating	Consult Tronair
	Current limit set to low	Raise current limit adjustment
Under Voltage	AVR out of adjustment	Adjust volt adjustment on AVR
Rectifier High Temperature	Rectifier overheat	Let GPU cool down by removing load
	Damaged temp switch	Check continuity and replace switch if faulty
No Fuel	Damaged fuel sending unit	Check sending unit resistance. If less than 4 ohms when unit is filled, replace
	No fuel	Fill with diesel until fault clears
Low Fuel Level	Low fuel	Fill with diesel until fault clears
	Damaged fuel sending unit	Check sending unit resistance. If less than 45 ohms when unit is filled, replace
Low Oil Pressure	Low oil/No oil	Check engine oil level and verify pressure using engine status screen. Add oil as necessary
High Engine Temp	Low coolant	Check coolant level when engine is cool. Add coolant as necessary
	Dirty radiator fins	Clean radiator of debris
	Broken fan belt	Replace
Over Crank	No fuel	Fill fuel tank
Battery Not Charged	Battery not charged	
Battery Weak	Loose battery connection	Check, clean and tighten terminals
	Low battery voltage	Check, using a multi meter, Charge or replace if necessary
Battery High	Bad alternator	Check alternator output voltage, replace if necessary
Emergency Stop Pressed	Emergency stop has been pushed	Pull emergency stop out

**9.0 MAINTENANCE**

As with all Ground Support Equipment it is very important to provide proper preventative maintenance and service. This will increase the service life of the diesel engine, which can be expected to operate for 30,000 hours without a major overhaul (this may vary according to local operating conditions.) The following specifies consumable service requirements:

**Fuel:** Ensure that the correct diesel fuel ASTM D 975 is used. Refer to the Doosan Operation and Maintenance Manual (provided as a supplement to this manual) for other allowable fuels.

**Engine Oil:** 15W-40 (API CH-4) is suitable for most operating temperatures. However, lower viscosity oils can be used to aid starting at temperatures below -20° C (-4° F). The engine requires the use of low ash oil. Refer to engine Operation and Maintenance Manual for oil and viscosity recommendations.



**CAUTION!**



Do not over fill the engine as damage may occur. Always use the engine oil level dipstick to ensure the correct level. Always use the same brand of engine oil. When topping up the oil level always prevent dirt from entering by cleaning around the oil filler prior to filling. The engine oil level should be checked every 10 hours of operation.

**9.0 MAINTENANCE** *(continued)*

**Cooling System:** Use 50/50 ethylene glycol and diethylene glycol mixture. Refer to section 4 of the Deutz Operation and Maintenance Manual (provided as a supplement to this manual) for anti-freeze and water quality recommendations. Must meet ASTM D3306-00A Standard.

Ambient Temperature (°C)	Coolant (°C)	Antifreeze (%)
Above -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

**Filters:** Fuel/water filter .....Change every 500 hours or 6 months  
 Engine oil filter .....Change every 500 hours or 6 months with oil change  
 Air cleaner filter.....Check daily. Change when clog indicator shows clogged  
 Fuel filter.....Change every 500 hours or 6 months

**9.1 GENERAL (DAILY CHECKS)**

1. Unit..... Visually inspect outside of GPU for loose hardware, loose parts, frayed wires/cables and general appearance.
2. Radiator..... Open radiator access door and remove radiator cap (cold only). Ensure that coolant is up to the bottom of the fill neck. Service as required.
3. Engine Hoses..... Check integrity of hoses and clamps for tightness.
4. Fuel Level..... Turn power on and check fuel level on fuel gauge. Top up as required with fuel.
5. Engine ..... Inspect all fuel lines and fittings for traces of fuel leakage. Visually inspect cylinder block oil pan and valve covers for oil leakage.
6. Oil Level ..... Remove dipstick to ensure oil level is at full mark. Replenish as required.
7. Fan Belt..... Look for wear and cracking.
8. Air Intake Filter ..... Ensure that plugged filter indicator shows clean, if not, replace air filter. Check again once unit is running.
9. Doors..... Check that all doors are securely latched before driving or starting



9.2 SHORT TERM PREVENTIVE MAINTENANCE SCHEDULE

It is recommended to change the engine oil and filter after the first 50 hours of operation.

The following table is provided as a guide to for frequent service intervals. The Doosan Operation and Maintenance Manual (provided as a supplement to this manual) provides engine service interval information for daily, 250 hour, 500 hour, 1000 hour and 2000 hour intervals. See the Doosan Operation and Maintenance Manual.

**Regular Inspection table**

maintain the engine with optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

**General Conditions**

Regular inspection and replacement according to the recommended regular inspection table allows you to

( ◦ : Inspection and Adjustment, • : Replacement)

Check Points	Daily	Inspection interval (x 1,000 hours)									
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Coolant system											
State of connection between cooler and coolant hose	◦										
Capacity and state of coolant <sup>a</sup>	◦	Replace every 1,200 hours <sup>b</sup>									
Cooling fan belt tension	◦										
Lubrication system											
Lubricating device and oil leakage	◦										
Capacity and condition of engine oil <sup>cd</sup>	◦	•	•	•	•	•	•	•	•	•	•
Engine oil filter	◦	•	•	•	•	•	•	•	•	•	•
Fuel system											
Fuel line and connection unit	◦										
Fuel volume	◦										
Water draining from water separator	◦										
Fuel injection time		Inspect and adjust if required									
Injector		Inspect and adjust if required									
Compression pressure		Inspect and adjust if required									
Intake/Exhaust system											
Air cleaner	◦	Clean and replace if required									
Throttle body cleaning	◦										
Intake line and connection unit	◦										
Exhaust line and connection unit	◦										
Emission state	◦										
Cylinder head											
Intake/Exhaust valve gap state			◦		◦		◦		◦		◦
Electric system											
Battery charging state	◦										
Various electric units	◦										

- a. Replenish coolant if required.
- b. Check coolant every 500 hours to maintain the concentration of antifreeze and additives.
- c. Replace it every 500 hours after the first 50 hours (Tier-4).
- d. Replace it every 250 hours after the first 50 hours (Tier-3).



9.3 DAILY CHECKS

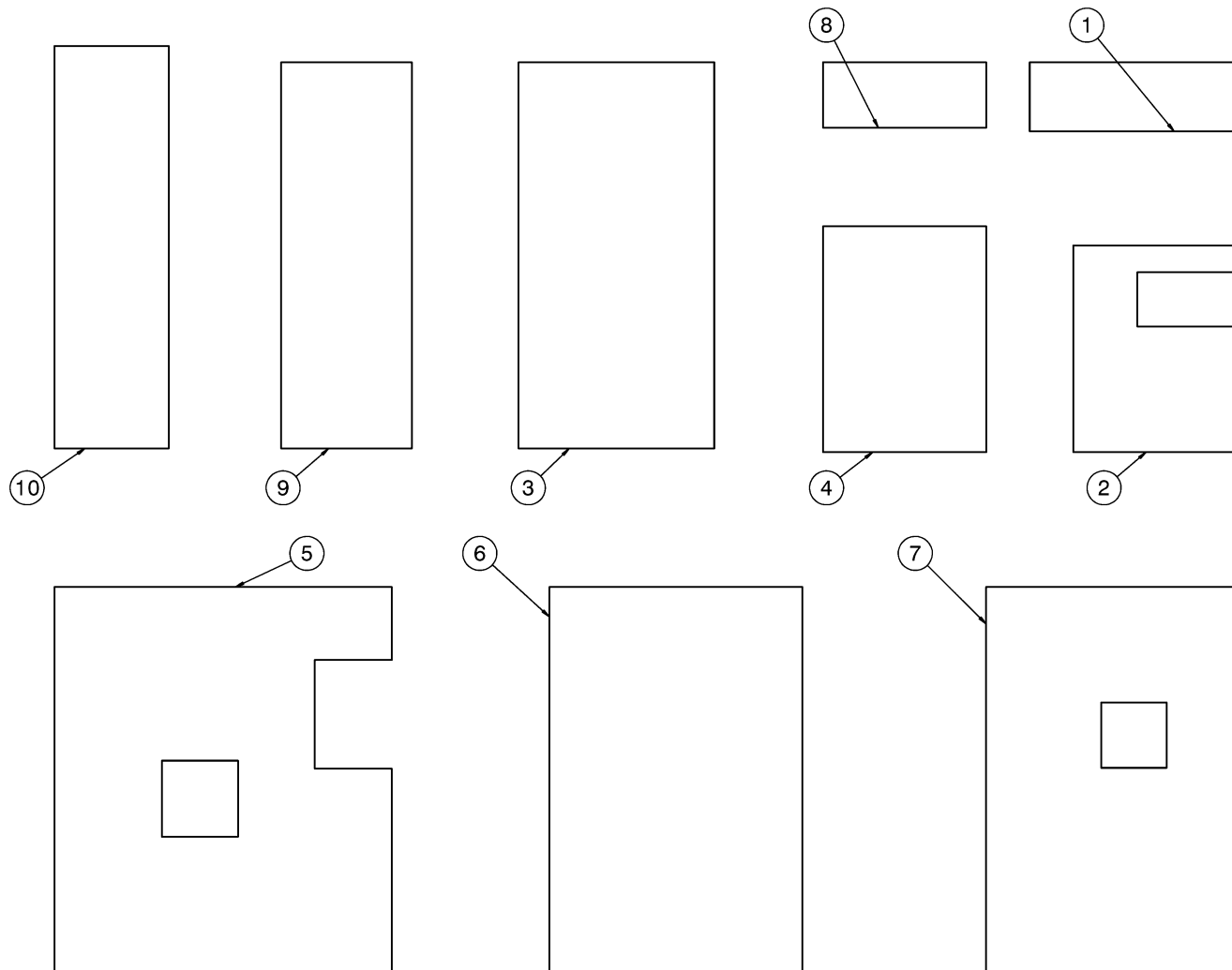
1. Unit..... Visually inspect outside of GPU for loose hardware, loose parts, frayed wires/cables and general appearance.
2. Radiator..... Open radiator access door and remove radiator cap (cold only). Ensure that coolant is up to the bottom of the fill neck. Service as required.
3. Engine Hoses..... Check integrity of hoses and clamps for tightness.
4. Fuel Level..... Turn power on and check fuel level on fuel gauge. Top up as required with fuel.
5. Engine ..... Inspect all fuel lines and fittings for traces of fuel leakage. Visually inspect cylinder block oil pan and valve covers for oil leakage.
6. Oil Level ..... Remove dipstick to ensure oil level is at full mark. Replenish as required.
7. Fan Belt..... Check belt for correct tension. Look for wear.
8. Air Intake Filter ..... Ensure that air filter is not plugged.
9. Doors..... Check that all doors are securely latched before driving or starting

Reference Sections **9.2 – 9.14** for Parts Lists, Descriptions and Illustrations

9.4 SOUNDFOAM

**NOTES:**

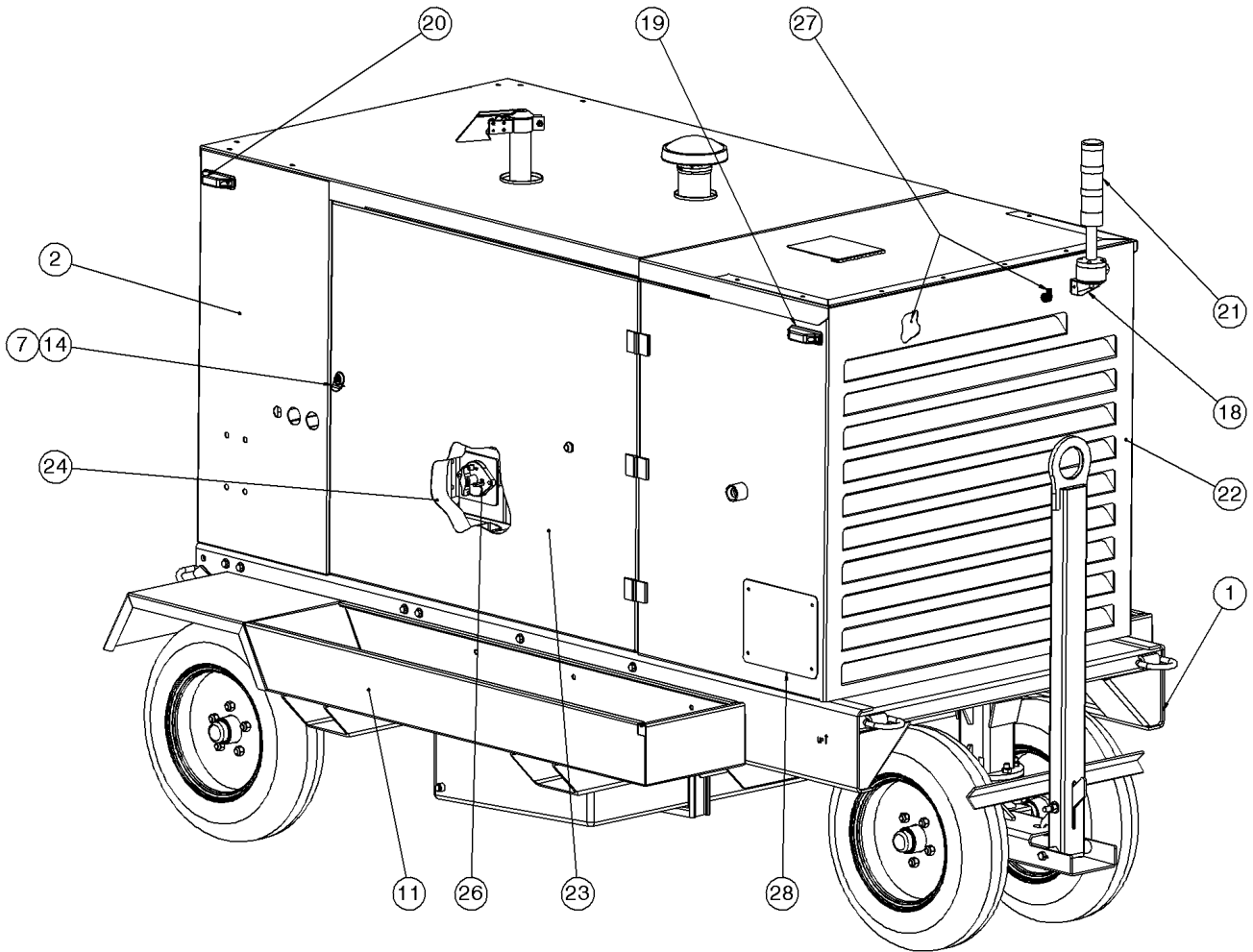
1. All panels to be 2" thick
2. Panels are sound foam M
3. Finish is black matte film and MDK adhesive



**4. Panels drawn with adhesive side shown**

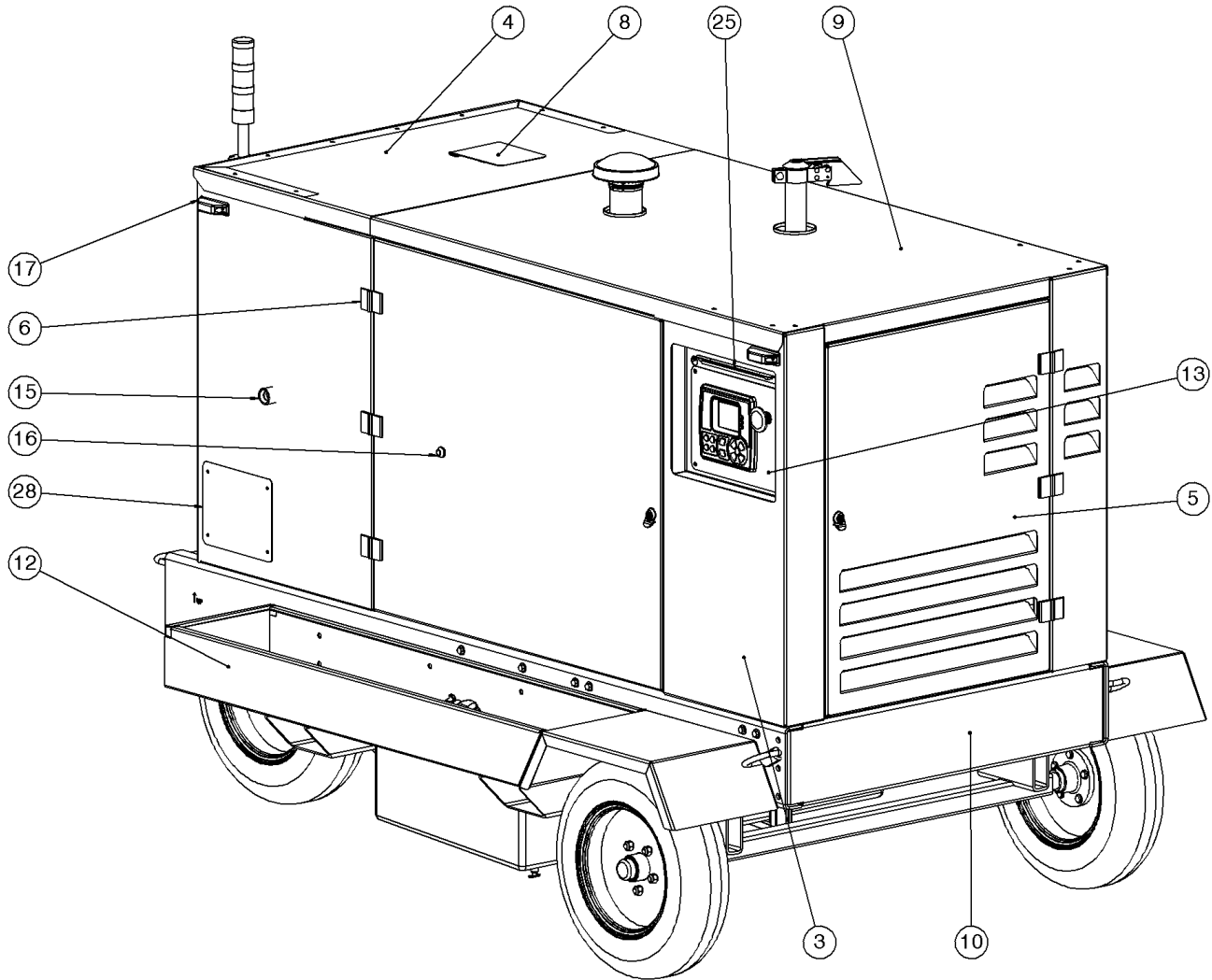
Item	Part Number	Description	Qty
1	K-5176-A	Soundproofing, Back Panel	1
2	K-5176-B	Soundproofing, Fire Extinguisher Bottom	1
3	K-5176-C	Soundproofing, Doors	4
4	K-5176-D	Soundproofing, Control Panel	1
5	K-5176-E	Soundproofing, Top Panel Middle	1
6	K-5176-F	Soundproofing, Top Panel Rear	1
7	K-5176-G	Soundproofing, Top Panel Front	1
8	K-5176-H	Soundproofing, Fire Extinguisher Top	1
9	K-5176-J	Soundproofing, Louver Pre-Fan Side	2
10	K-5176-K	Soundproofing, Louver Post-Fan Side	2

9.5 EXTERNAL COMPONENTS



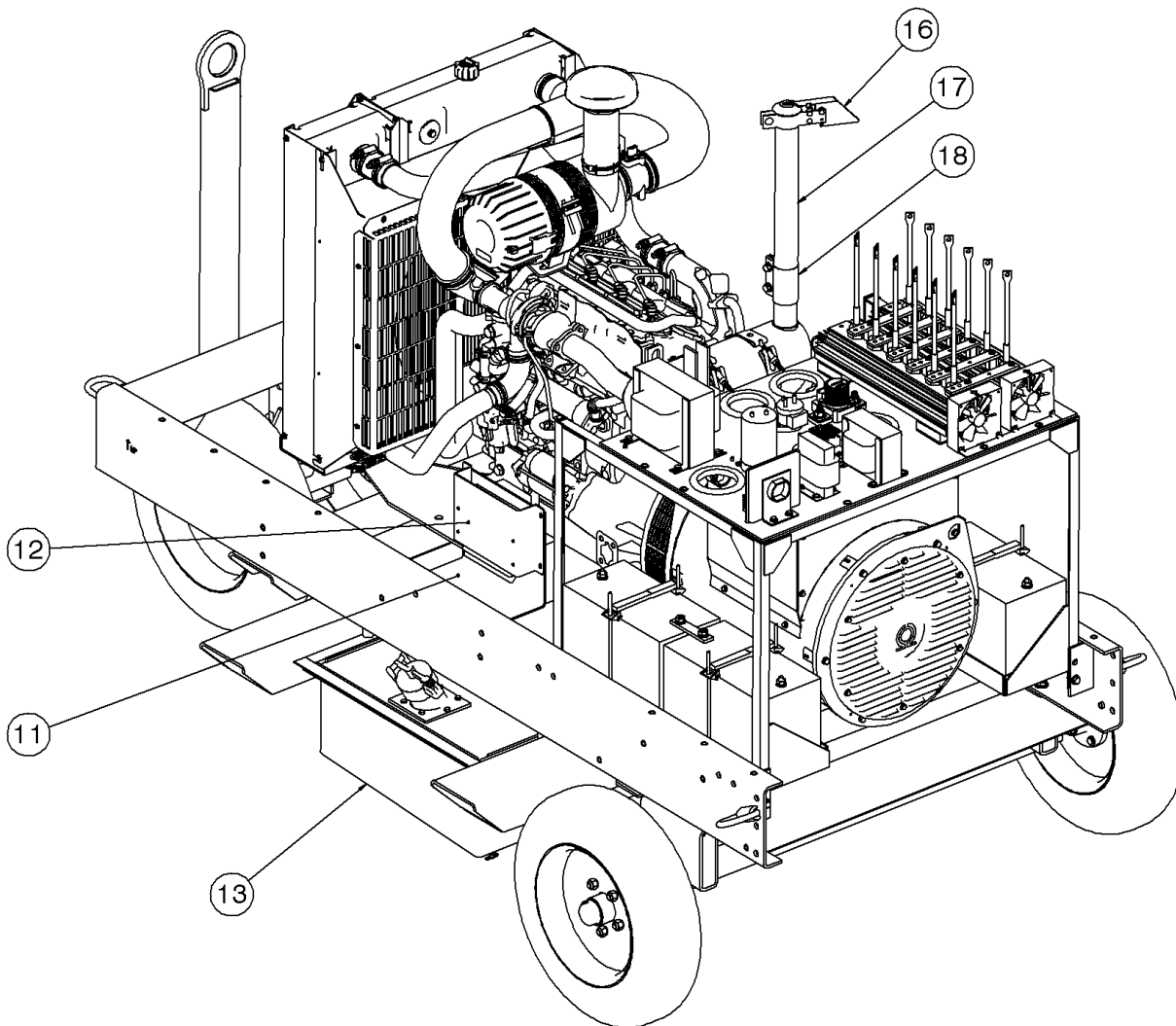
Item	Part Number	Description	Qty
1	Z-9167	GPU CHASSIS ASSEMBLY	1
2	S-3011-01	LOUVER, BACK LEFT	1
7	H-2884	DOOR, LATCH	3
11	S-2411	SIDE, TRAY RT	1
14	H-2915	PULL, TAB	3
18	EC-1794	BOX, VERTICAL MOUNTING JUNCT	1
19	EC-2709	BASE, BLACK FOR 169 LED LIGHT	4
20	EC-2708	LED, 12V RED	2
21	EC-2984	LIGHT, TOWER GRN, AMBR, RED, 12V	1
22	Z-9279	WELDMENT, 28V LOUVER	1
23	Z-9278	DOOR, ENGINE LONG	2
24	K-5176	KIT, SOUNDPROOFING	1
26	EC-2700	SWITCH, DISCONNECT	1
27	H-1721-01	CLAMP, ELECTRICAL	2
28	S-3274	PANEL, ACCESS	2

9.5 EXTERNAL COMPONENTS (continued)



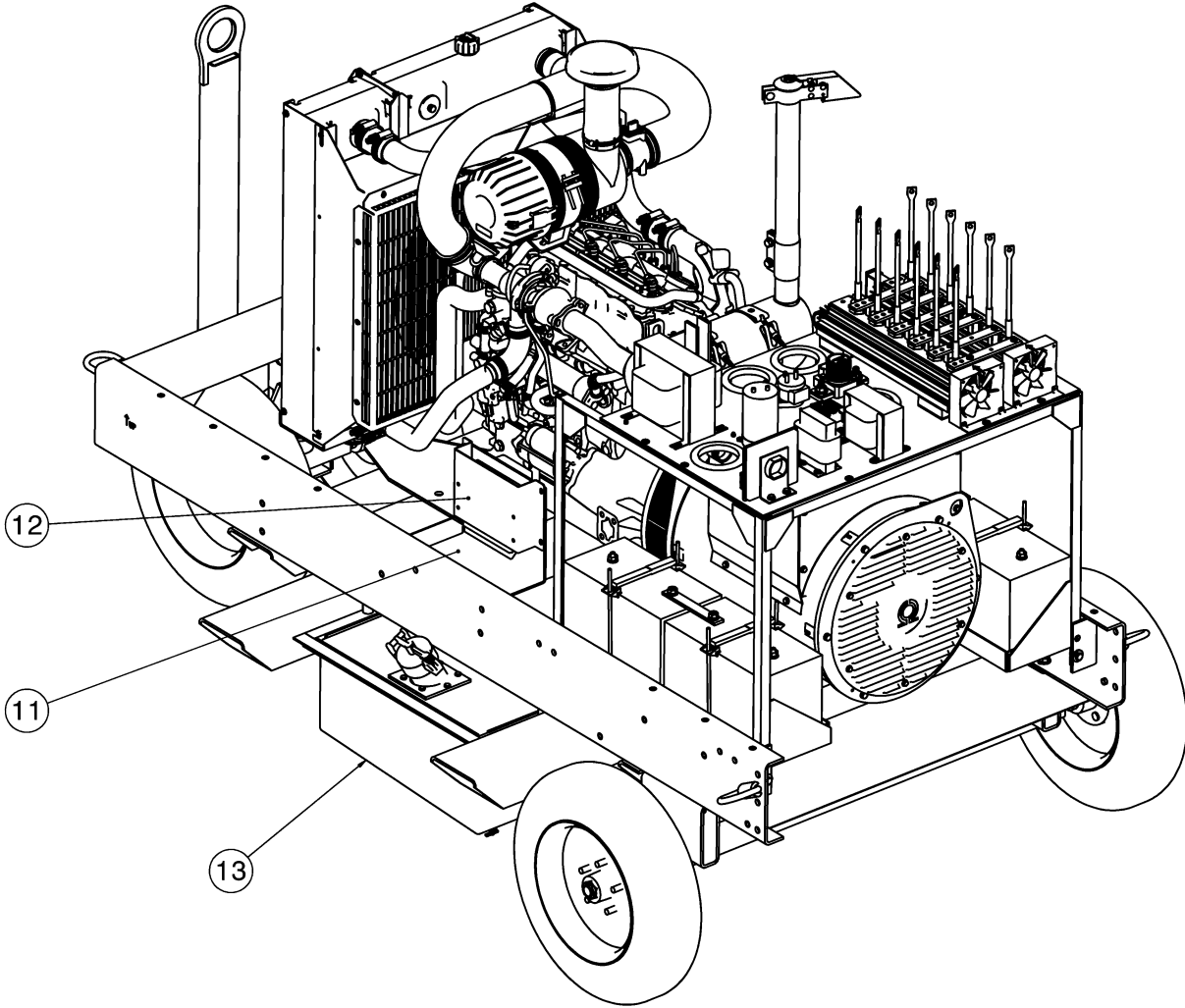
Item	Part Number	Description	Qty
3	Z-9229	WELDMENT, CONTROLS PANEL	1
4	S-3014	PANEL, TOP FRONT	1
5	Z-9230	WELDMENT, LOUVER DOOR	1
6	H-2827	HINGE, DOOR	9
8	Z-6168-00	LID, RADIATOR ACCESS (P)	1
9	Z-9231	WELDMENT, TOP REAR	1
10	J-6341	MEMBER, REAR CROSS	1
12	S-2410	SIDE TRAY, LEFT	1
13	EC-3441-285	PANEL, CONTROLS	1
15	H-3697	RUBBER DOOR HOLDER	2
16	H-3697 MALE	RUBBER DOOR HOLDER	2
17	EC-2707	LED, 12V AMBER	2
25	EC-3010	LIGHTS ASSY, PANEL LED	1

9.6 ENGINE/ALTERNATOR/ENGINE MOUNTING



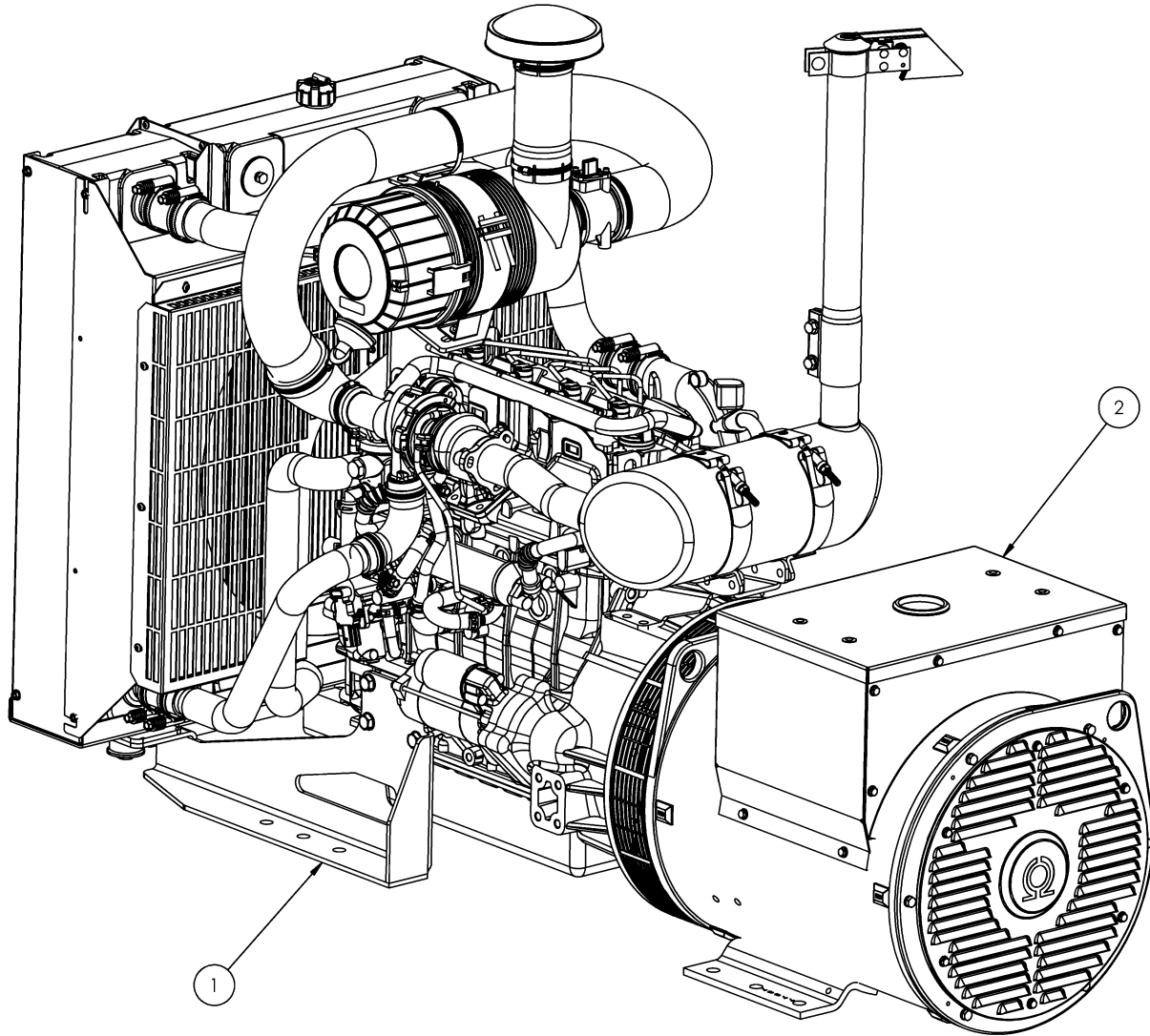
Item	Part Number	Description	Qty
1	Z-9232	GPU CHASSIS	1
2	TS-2665-01	TUBE, MOUNTING	1
3	TS-2664-01	TUBE, MOUNTING	1
5	Z-9233	ASSEMBLY, ENGINE/ALTERNATOR	1
6	Z-9208	ASSEMBLY, SHELF	1
7	Z-9217-01	WELDMENT, STARTER BATTERY TRAY	1
8	EC-3149	BATTERY, 12 VOLT	1
9	H-4005	TIE-DOWN, BATTERY	1
10	H-4025	FUEL FILTER	1
15	S-3018-01	BRACKET, FUEL FILTER SUPPORT	1
16	H-4192	CAP, RAIN 2"	1
17	TR-2505	TUBE, EXHAUST	1
18	394-098	CLAMP, MUFFLER	1

9.6 ENGINE/ALTERNATOR/ENGINE MOUNTING (continued)



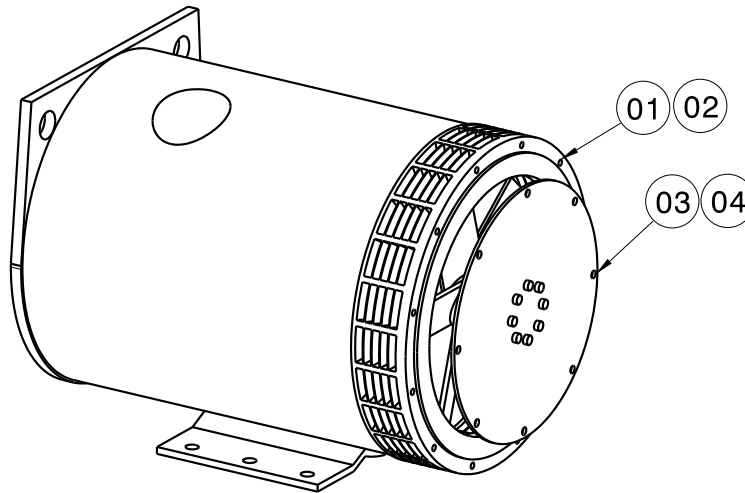
Item	Part Number	Description	Qty
4	H-4028	VMC ISOLATOR	4
11	S-3019-01	BRACKET, ECU SUPPORT	1
12	EC-2982	FUSE HOLDER, ECU	1
13	Z-9243	ASSEMBLY, FUEL TANK	1
14	J-6369-01	SPACER, ENGINE MOUNT	4
15	S-3018-01	BRACKET, FUEL FILTER SUPPORT	1

9.6 ENGINE/ALTERNATOR/ENGINE MOUNTING (continued)



Item	Part Number	Description	Qty
1	H-4024	ENGINE	1
2	EC-3093	ALTERNATOR	1

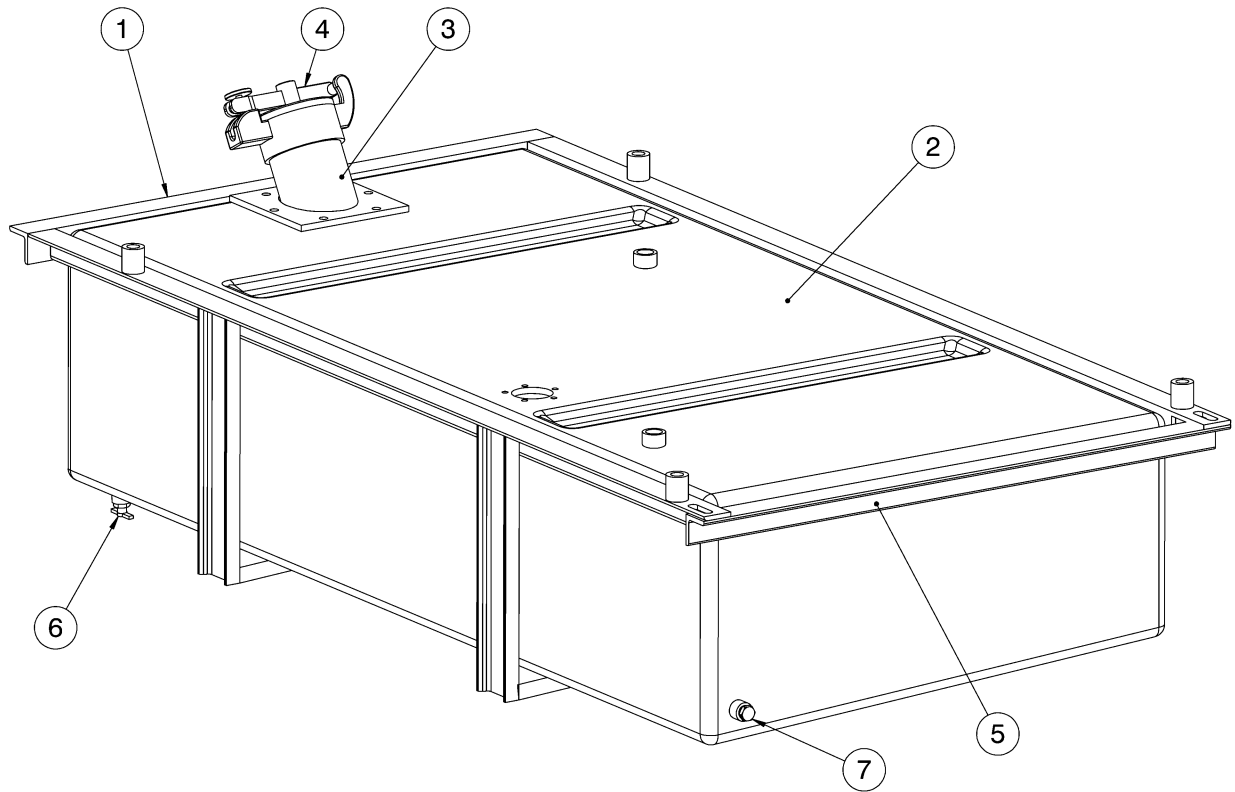
9.7 ALTERNATOR



EC-2046  
38 KW ALTERNATOR

Item	Part Number	Description	Qty
1	G-1420-107010	Bolt, Hex Head Grade 8, 3/8" - 16 x 1 Long	8
2	G-1513-1070N	Flatwasher, 3/8" Hardened	8
3	G-1514-M100R	Lockwasher, M10	18
4	G-1533-100035	Bolt, Hex Head, M10 x 35 mm	10

9.8 FUEL TANK AND FRAME



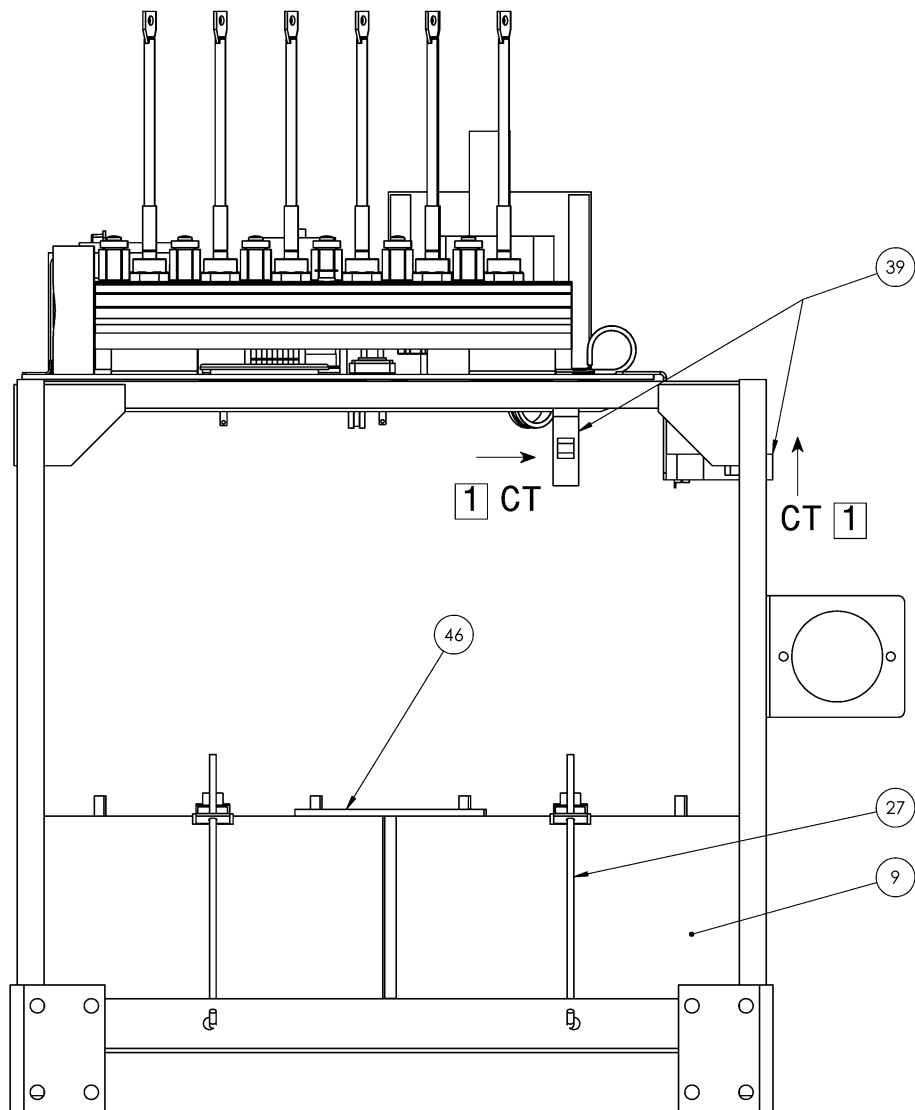
Item	Part Number	Description	Qty
1	Z-7773-01	WELDMENT, FUEL TANK CAGE	1
2	H-4196	FUEL TANK	1
3	Z-7756	WELDMENT, FUEL NECK	1
4	15253	FILL CAP LESS SCREEN (GREEN)	1
5	A-1279-01	ANGLE, SUPPORT	1
6	N-2783-02	DRAIN, COCK	1
7	N-2206-03-SS	PLUG, HEX HEAD	1





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9.9 RECTIFIER/CONTACTOR/BATTERY SWITCH/OUTPUT CABLE (continued)

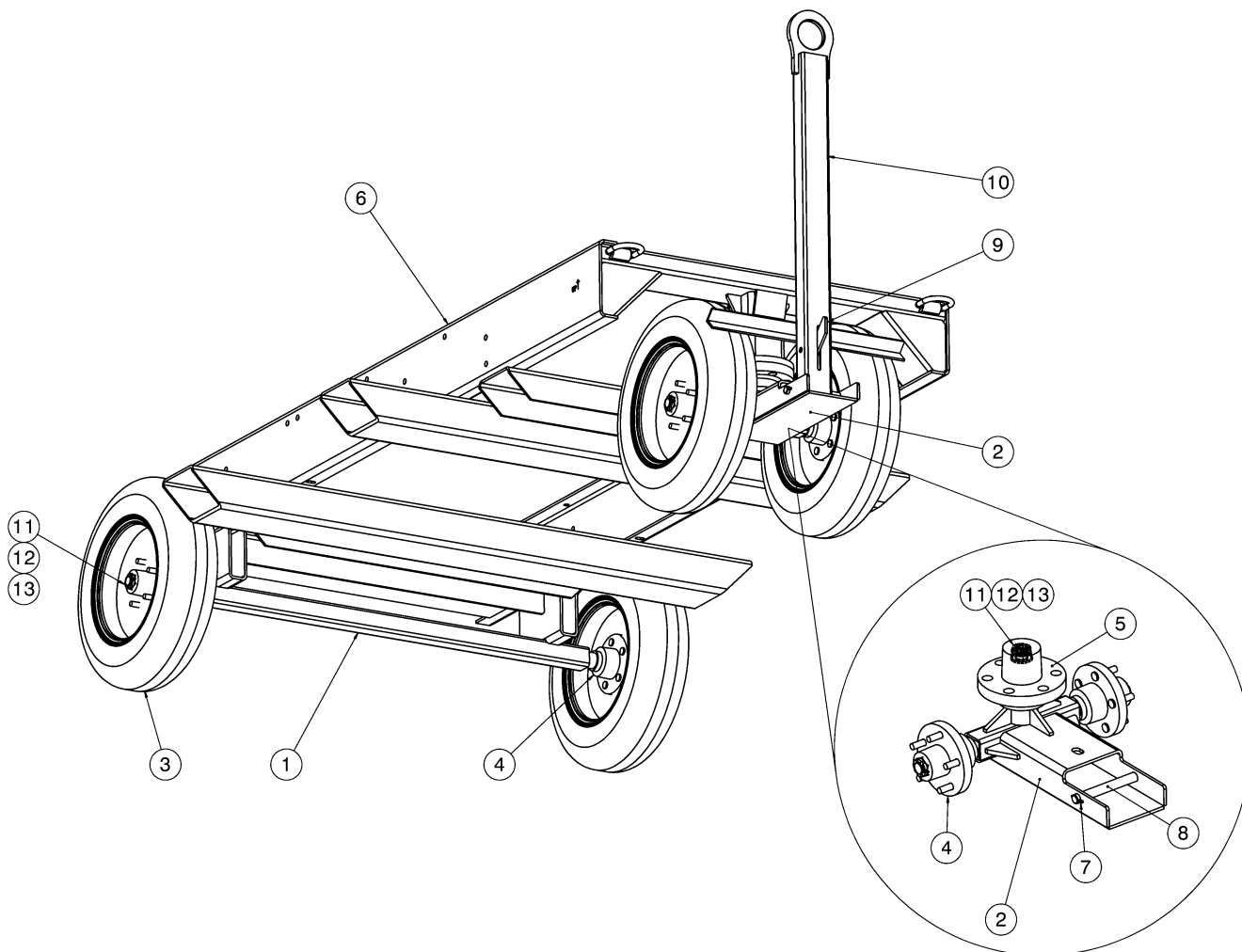


NOTE: **1** Align arrows on Item 21 (CT) per drawing.

## 9.9 RECTIFIER/CONTACTOR/BATTERY SWITCH/OUTPUT CABLE (continued)

Item	Part Number	Description	Qty
1	Z-9209-01	WELDMENT, SHELF	1
2	EC-1656	BATTERY, 12 VOLT	4
3	EC-2045	RECTIFIER, 28VDC 6-PHASE	1
4	EC-2395	CHOKE	1
5	EC-2968	TRANSFORMER, SINGLE PHASE	1
6	EC-2970	VOLTAGE REGULATOR	1
7	EC-2971	RELAY, 500A 12VDC	1
8	J-6312-01	BRACKET	4
9	S-3003-01	MOUNTING BRACKET, ARV	1
10	H-4005	TIE-DOWN, BATTERY	4
11	EC-2979	RESISTOR, 10 OHM, 100W, 5%	1
12	H-3480	CLAMP, MOUNTING CAPACITOR	1
13	S-3001	PLATE, SHELF	1
14	EC-2981	BRACKET, RESISTOR	2
15	EC-2397	CAPACITOR	1
16	EC-2967	TRANSFORMER, 3 PHASE	1
17	H-4027	GROMMET, RUBBER 4.75OD x 3.5ID	4
18	EC-3004	FAN, GPU RACK	2
19	S-3070-01	BRACKET, FANS	1
20	EC-3006	CONTACTOR 600 AMP 12 VDC	1
21	EC-3008	SPLIT CORE HALL EFFECT DC CURRENT SENSOR	2
22	EC-2083	TERMINAL BLOCK, 4 COND (LT GRAY)	9
23	13070	ANCHOR DINRAIL END	2
24	EC-1895-005.37	RAIL, DIN	1
25	EC-2072	JUMPER, 2 CONDUCTOR	1
26	S-3074-01	BRACKET, CURRENT SENSOR	1
27	H-1721-08	CLAMP, ELECTRICAL	3
28	J-6402	BUSBAR, BATTERY CONNECT	2
29	K-5181	ELECTRICAL HARNESS	1

9.10 SUB ASSEMBLY COMPONENTS



Item	Part Number	Description	Qty
1	Z-9178	WELDMENT, REAR AXLE	1
2	Z-9179	WELDMENT, FRONT AXLE	1
3	H-4000	TIRE, GPU CHASSIS	4
4	H-3424	HUB	4
5	H-3200	HUB	1
6	Z-9191	WELDMENT, FRAME	1
7	G-1301-02	1/8" Cotter Pin	2
8	R-2096	PIN, TOWBAR	1
9	J-3427	LEVER	1
10	Z-9193	WELDMENT, TOWBAR RAIL	1
11	G-1230-01	NUT, AXLE 1"	5
12	G-1283	WASHER, SPINDLE	5
13	G-1301-05	PIN, 5/32 X 1.5" LG. COTTER	5
1	Z-9178	WELDMENT, REAR AXLE	1

**10.0 PROVISION OF SPARES****10.1 SOURCE OF SPARE PARTS**

Spare parts may be obtained from the manufacturer:

**TRONAIR, Inc.**1 Air Cargo Pkwy East  
Swanton, Ohio 43558 USA

Telephone: (419) 866-6301 or 800-426-6301

Fax: (419) 867-0634

E-mail: sales@tronair.com

Website: www.tronair.com

For Spare Parts, Operations & Service Manuals or Service Needs:  
Scan the QR code or visit Tronair.com/aftermarket**10.2 RECOMMENDED SPARE PARTS LISTS**

Reference the following page(s) for Replacement Parts and Kits available.

Recommended Spares:

H-5260.....	V-Belt
EC-1934 .....	28.5 VDC Output Cable
EC-3149 .....	Battery
EC-3680 .....	Alternator
H-4000.....	Wheel/Tire
H-5262.....	Oil Filter
H-5263.....	Fuel Filter Element
H-5264.....	Secondary Air Element
H-5265.....	Primary Air Element
H-5266.....	Injector Assembly
H-5267.....	EGR Valve
H-5268.....	Starter
H-5269.....	Water Pump
H-5270.....	Thermostat
H-5271.....	Auto Tensioner

**11.0 IN SERVICE SUPPORT**

Contact Tronair, Inc. for technical services and information. See Section 1.3 – Manufacturer.

**12.0 GUARANTEES/LIMITATION OF LIABILITY**

Tronair products are warranted to be free of manufacturing or material defects for a period of one year after shipment to the original customer. This is solely limited to the repair or replacement of defective components. This warranty does not cover the following items:

- Parts required for normal maintenance
- Parts covered by a component manufacturers warranty
- Replacement parts have a 90-day warranty from date of shipment

If you have a problem that may require service, contact Tronair immediately. Do not attempt to repair or disassemble a product without first contacting Tronair, any action may affect warranty coverage. When you contact Tronair be prepared to provide the following information:

- Product Model Number
- Product Serial Number
- Description of the problem

If warranty coverage is approved, either replacement parts will be sent or the product will have to be returned to Tronair for repairs. If the product is to be returned, a Return Material Authorization (RMA) number will be issued for reference purposes on any shipping documents. Failure to obtain a RMA in advance of returning an item will result in a service fee. A decision on the extent of warranty coverage on returned products is reserved pending inspection at Tronair. Any shipments to Tronair must be shipped freight prepaid. Freight costs on shipments to customers will be paid by Tronair on any warranty claims only. Any unauthorized modification of the Tronair products or use of the Tronair products in violation of cautions and warnings in any manual (including updates) or safety bulletins published or delivered by Tronair will immediately void any warranty, express or implied.

The obligations of Tronair expressly stated herein are in lieu of all other warranties or conditions expressed or implied. **Any unauthorized modification of the Tronair products or use of the Tronair products in violations of cautions and warnings in any manual (including updates) or safety bulletins published or delivered by Tronair will immediately void any warranty, express or implied and Tronair disclaims any and all liability for injury (WITHOUT LIMITATION and including DEATH), loss or damage arising from or relating to such misuse.**



**13.0 APPENDICES**

APPENDIX I Wiring Diagram – INS-2372

APPENDIX II Alternator Operation & Maintenance Manual – Magnaplas 361

APPENDIX III Declaration of Conformity

**Additional Documents**

See Doosan for DM24 Operation & Maintenance Manual



## **APPENDIX I**

### **Wiring Schematic (INS-2372)**



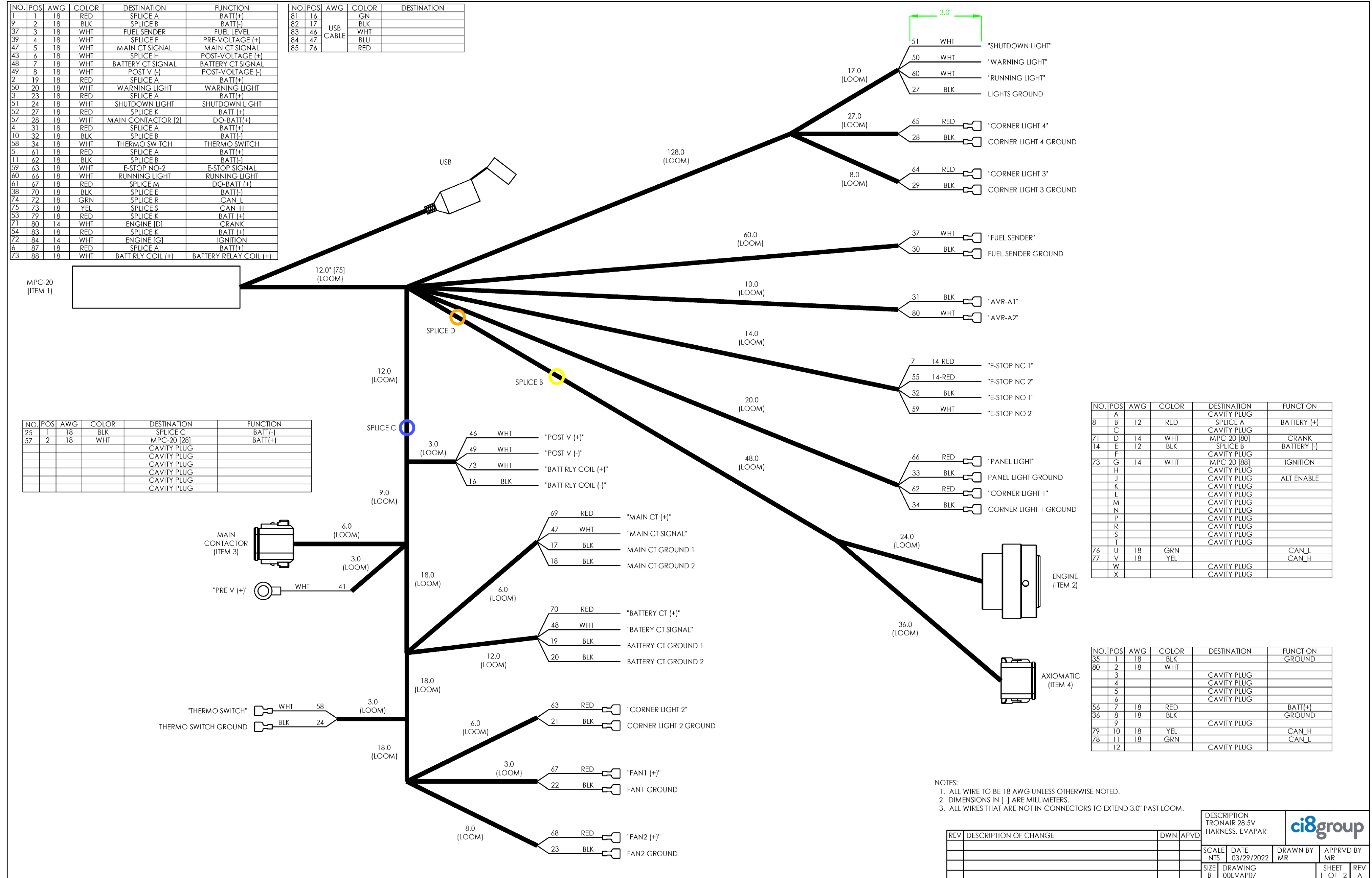


THIS DRAWING IS THE PROPERTY OF TRONAIR, INC. IT IS FURNISHED TO YOU FOR CONFIDENTIAL INFORMATION PURPOSES ONLY AND IS NOT TO BE DISCLOSED TO ANYONE OR REPRODUCED OR USED FOR MANUFACTURING PURPOSES WITHOUT THE EXPRESS WRITTEN PERMISSION OF TRONAIR, INC.

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
1	1	18	RED	SPLICE A	BATT(+)
2	2	18	BLK	SPLICE B	BATT(-)
37	3	18	WHT	FUEL SENDER	FUEL LEVEL
39	4	18	WHT	SPLICE F	PRE-VOLTAGE (+)
47	5	18	WHT	MAIN CT SIGNAL	MAIN CT SIGNAL
43	6	18	WHT	SPLICE H	POST-VOLTAGE (+)
48	7	18	WHT	BATTERY CT SIGNAL	BATTERY CT SIGNAL
49	8	18	WHT	POST V (-)	POST-VOLTAGE (-)
2	19	18	RED	SPLICE A	BATT(+)
50	20	18	WHT	WARNING LIGHT	WARNING LIGHT
3	23	18	RED	SPLICE A	BATT(+)
51	24	18	WHT	SHUTDOWN LIGHT	SHUTDOWN LIGHT
52	27	18	RED	SPLICE K	BATT (+)
57	28	18	WHT	MAIN CONTACTOR [2]	DO-BATT(+)
4	31	18	RED	SPLICE A	BATT(+)
10	32	18	BLK	SPLICE B	BATT(-)
58	34	18	WHT	THERMO SWITCH	THERMO SWITCH
5	61	18	RED	SPLICE A	BATT(+)
11	62	18	BLK	SPLICE B	BATT(-)
59	63	18	WHT	E-STOP NO-2	E-STOP SIGNAL
60	66	18	WHT	RUNNING LIGHT	RUNNING LIGHT
61	67	18	RED	SPLICE M	DO-BATT (+)
38	70	18	BLK	SPLICE E	BATT(-)
74	72	18	GRN	SPLICE R	CAN L
75	73	18	YEL	SPLICE S	CAN H
53	79	18	RED	SPLICE K	BATT (+)
71	80	14	WHT	ENGINE [D]	CRANK
54	83	18	RED	SPLICE K	BATT (+)
72	84	14	WHT	ENGINE [G]	IGNITION
6	87	18	RED	SPLICE A	BATT(+)
73	88	18	WHT	BATT RLY COIL (+)	BATTERY RELAY COIL (+)

NO.	POS	AWG	COLOR	DESTINATION
81	16		GN	
82	17		BLK	
83	46		WHT	
84	47		BLU	
85	76		RED	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
25	1	18	BLK	SPLICE C	BATT(-)
57	2	18	WHT	MPC-20 [28]	BATT(+)
				CAVITY PLUG	
				CAVITY PLUG	
				CAVITY PLUG	
				CAVITY PLUG	
				CAVITY PLUG	
				CAVITY PLUG	



NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
8	A	12	RED	CAVITY PLUG	BATTERY (+)
	B			SPLICE A	
	C			CAVITY PLUG	
71	D	14	WHT	MPC-20 [80]	CRANK
14	E	12	BLK	SPLICE B	BATTERY (-)
	F			CAVITY PLUG	
73	G	14	WHT	MPC-20 [88]	IGNITION
	H			CAVITY PLUG	
	J			CAVITY PLUG	ALT ENABLE
	K			CAVITY PLUG	
	L			CAVITY PLUG	
	M			CAVITY PLUG	
	N			CAVITY PLUG	
	P			CAVITY PLUG	
	R			CAVITY PLUG	
	S			CAVITY PLUG	
	T			CAVITY PLUG	
76	U	18	GRN		CAN L
77	V	18	YEL		CAN H
	W			CAVITY PLUG	
	X			CAVITY PLUG	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
35	1	18	BLK		GROUND
80	2	18	WHT		
	3			CAVITY PLUG	
	4			CAVITY PLUG	
	5			CAVITY PLUG	
	6			CAVITY PLUG	
56	7	18	RED		BATT(+)
36	8	18	BLK		GROUND
	9			CAVITY PLUG	
79	10	18	YEL		CAN H
78	11	18	GRN		CAN L
	12			CAVITY PLUG	

- NOTES:  
 1. ALL WIRE TO BE 18 AWG UNLESS OTHERWISE NOTED.  
 2. DIMENSIONS IN [ ] ARE MILLIMETERS.  
 3. ALL WIRES THAT ARE NOT IN CONNECTORS TO EXTEND 3.0" PAST LOOM.

REV	DESCRIPTION OF CHANGE	DWN	APVD	DESCRIPTION TRONAIR 28.5V HARNESSES, EVAPAR	
SCALE	DATE	DRAWN BY	APPRVD BY		
SIZE	DRAWING				

MADE FROM	N/A
MATERIAL	N/A
FINISH	N/A
THIRD ANGLE PROJECTION	
SCALE	1:1
SIZE	C
DO NOT SCALE DRAWING	

BREAK ALL SHARP EDGES AND CORNERS INTERPRET PER ASME Y14.5-2009  
 DIMENSIONS IN INCHES AND TOLERANCES PER BELOW UNLESS OTHERWISE SPECIFIED:  
**DIMENSION INCH [mm]:**  
 .X [X] ± .1 [3]  
 .XX [X] ± .03 [0.8]  
 .XXX [XX] ± .010 [0.25]  
 .XXXX [XXX] ± .0030 [0.076]  
**FRACTION INCH [mm]:**  
 1/XX [1/X] ± 1/16 [1.6]  
**ANGULAR DEGREE [RADIAN]:**  
 X [XXX] ± .5 [0.01]

**TRONAIR** AIRCRAFT GROUND SUPPORT EQUIPMENT

DWN BY: NGL CKD BY: DATE: no/tc/heck

**SCHEMATIC, ELECTRICAL**

**INS-2372** REV

WEIGHT: LB SHEET 2 OF 3

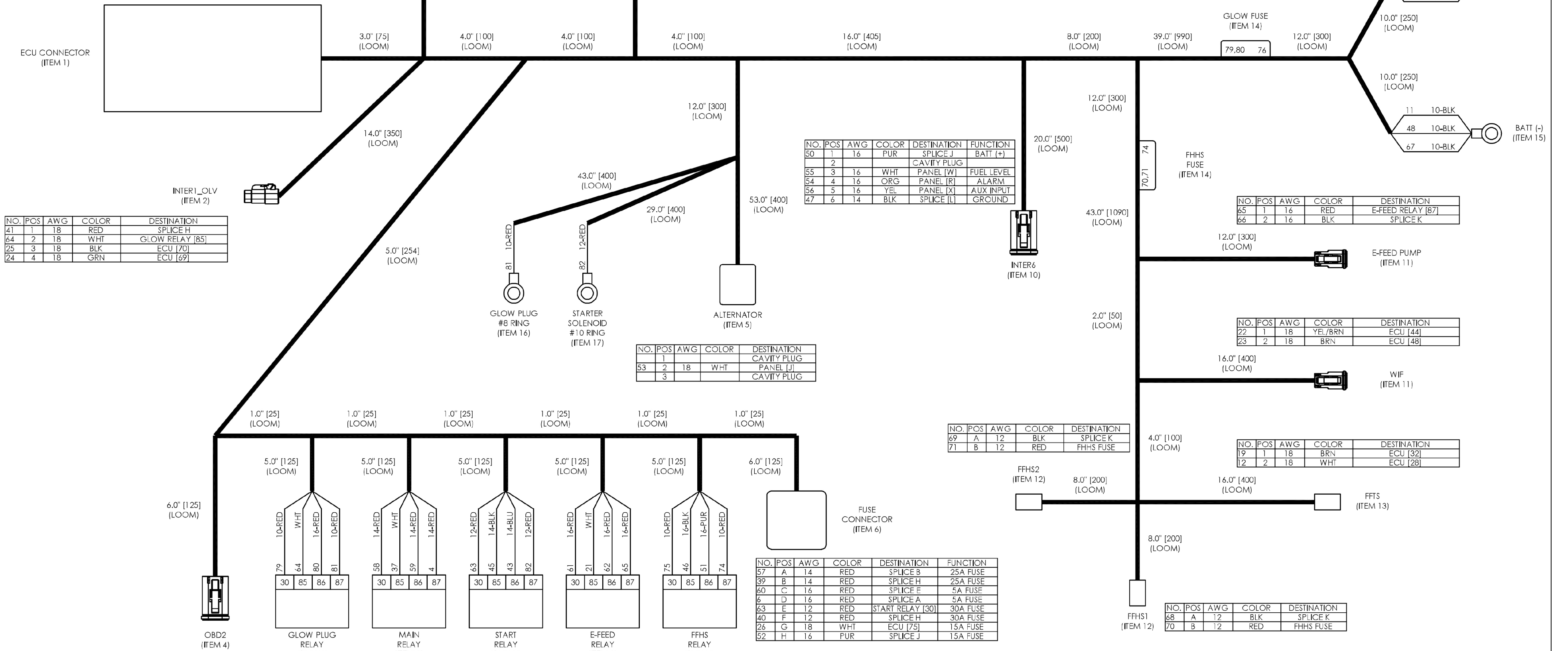
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NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
1	1	14	RED	SPLICE A	BATT (+)
2	3	14	RED	SPLICE A	BATT (+)
3	5	14	RED	SPLICE A	BATT (+)
7	2	14	BLK	SPLICE C	BATT (-)
8	4	14	BLK	SPLICE C	BATT (-)
9	6	14	BLK	SPLICE C	BATT (-)
12	28	18	WHT	FFTS [2]	
13	30	18	YEL	SPLICE F	CAN1_H
14	31	18	GRN	SPLICE N	CAN1_L
19	32	18	BRN	FFTS [1]	
20	35	18	WHT	PANEL [H]	PARKING BRAKE
21	40	18	WHT	E-FEED RELAY [85]	E-FEED RELAY (-)
22	44	18	YEL/BRN	WIF [1]	
23	48	18	BRN	WIF [2]	
24	69	18	GRN	INTER1_OLV [4]	
25	70	18	BLK	INTER1_OLV [3]	
26	75	18	WHT	FUSE CONNECTOR [G]	ECU ENABLE
27	76	18	WHT/RED	INTER3_MAF [4]	
28	79	18	WHT	INTER3_MAF [2]	
30	80	18	GRN	SPLICE G	CAN2_L
29	81	18	YEL	SPLICE P	CAN2_H
35	86	18	GRN	INTER3_MAF [1]	
36	87	18	YEL/BRN	INTER3_MAF [3]	
37	88	18	WHT	MAIN RELAY [85]	MAIN RELAY (-)

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
35	1	18	GRN	ECU [86]	
28	2	18	WHT	ECU [79]	
34	3	18	YEL/BRN	ECU [87]	
27	4	18	WHT/RED	ECU [76]	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
38	A	12	RED	SPLICE H	BATTERY (+)
C				CAVITY PLUG	
43	D	14	BLU	START RELAY [86]	CRANK
44	E	12	BLK	SPLICE L	BATTERY (-)
				CAVITY PLUG	
49	G	14	PUR	SPLICE J	IGNITION
20	H	18	WHT	ECU [35]	PARKING BRAKE
53	J	18	WHT	ALTERNATOR [2]	ALT ENABLE
34	K	18	GRN	SPLICE G	CAN2_L
33	L	18	YEL	SPLICE P	CAN2_H
	M			CAVITY PLUG	
	N			CAVITY PLUG	
	P			CAVITY PLUG	
54	R	16	ORG	INTER6 [4]	ALARM O/P
	S			CAVITY PLUG	
	T			CAVITY PLUG	
18	U	18	GRN	SPLICE N	CAN1_L
17	V	18	YEL	SPLICE F	CAN1_H
55	W	16	WHT	INTER6 [3]	FUEL LEVEL
56	X	16	YEL	INTER6 [5]	AUX INPUT

NOTES:  
 1. ALL WIRE TO BE 18 AWG UNLESS OTHERWISE NOTED.  
 2. DIMENSIONS IN [ ] ARE MILLIMETERS.  
 3. YELLOW AND GREEN CAN WIRES TO BE TWISTED.



NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
41	1	18	RED	SPLICE H	
64	2	18	WHT	GLOW RELAY [85]	
25	3	18	BLK	ECU [70]	
24	4	18	GRN	ECU [69]	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
50	1	16	PUR	SPLICE J	BATT (+)
2				CAVITY PLUG	
55	3	16	WHT	PANEL [W]	FUEL LEVEL
54	4	16	ORG	PANEL [R]	ALARM
56	5	16	YEL	PANEL [X]	AUX INPUT
47	6	14	BLK	SPLICE [L]	GROUND

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
1				CAVITY PLUG	
53	2	18	WHT	PANEL [J]	
3				CAVITY PLUG	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
69	A	12	BLK	SPLICE K	
71	B	12	RED	FHHS FUSE	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
57	A	14	RED	SPLICE B	25A FUSE
39	B	14	RED	SPLICE H	25A FUSE
60	C	16	RED	SPLICE F	5A FUSE
6	D	16	RED	SPLICE A	5A FUSE
63	E	12	RED	START RELAY [30]	30A FUSE
40	F	12	RED	SPLICE H	30A FUSE
26	G	18	WHT	ECU [75]	15A FUSE
52	H	16	PUR	SPLICE J	15A FUSE

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
68	A	12	BLK	SPLICE K	
70	B	12	RED	FHHS FUSE	

NO.	POS	AWG	COLOR	DESTINATION	FUNCTION
5	1	16	RED	SPLICE A	BATT (+)
10	2	16	BLK	SPLICE C	BATT (-)
15	3	18	YEL	SPLICE F	CAN1_H
16	4	18	GRN	SPLICE N	CAN1_L
31	5	18	YEL	SPLICE P	CAN2_H
32	6	18	GRN	SPLICE G	CAN2_L

REV	DESCRIPTION OF CHANGE	DWN	APVD

DESCRIPTION DOOSAN DM01 / 02 HARNESS, TRONAIR EC-3425, EVAPAR				<b>ci8group</b>	
SCALE NTS	DATE 03/12/2024	DRAWN BY MR	APPRVD BY MR	SHEET 1 OF 2	REV A

MADE FROM N/A	BREAK ALL SHARP EDGES AND CORNERS INTERPRET PER ASME Y14.5-2009
MATERIAL N/A	DIMENSIONS IN INCHES AND TOLERANCES PER BELOW UNLESS OTHERWISE SPECIFIED:
FINISH N/A	<b>DIMENSION INCH [mm]:</b> .X [X] ± .1 [3] .XX [X.X] ± .03 [0.8] .XXX [X.XX] ± .010 [0.25] .XXXX [X.XXX] ± .0030 [0.076]
THIRD ANGLE PROJECTION	<b>FRACTION INCH [mm]:</b> 1/XX [1/X] ± 1/16 [1.6] <b>ANGULAR DEGREE [RADIAN]:</b> X [XXX] ± .5 [0.01]
SCALE: 1:1	SIZE <b>C</b>
DO NOT SCALE DRAWING	

<b>TRONAIR</b>		AIRCRAFT GROUND SUPPORT EQUIPMENT	
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SCHEMATIC, ELECTRICAL			
INS-2372		REV	
WEIGHT: LB	SHEET 3 OF 3		





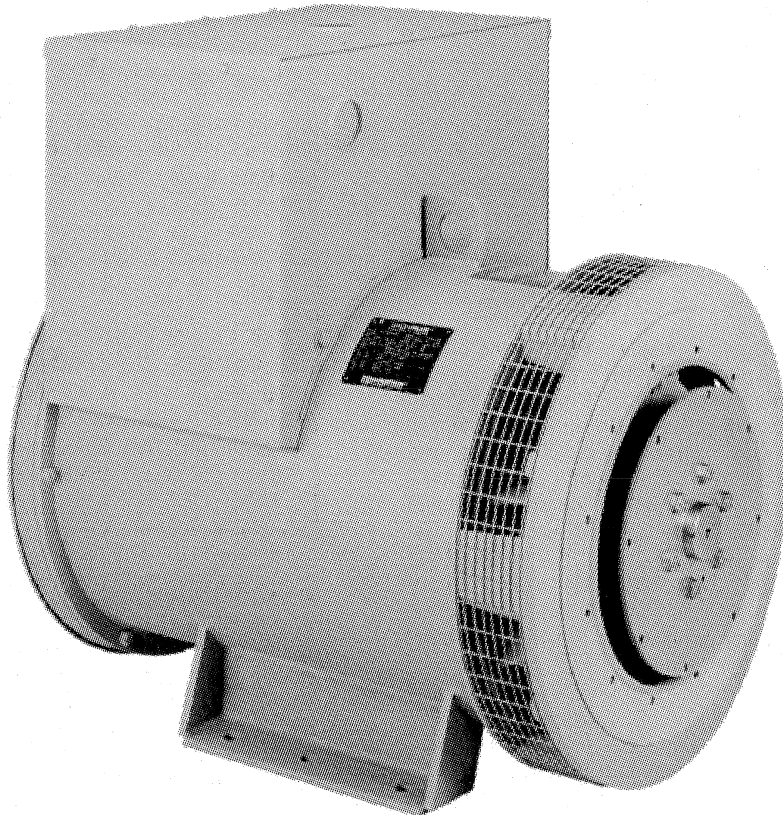
## APPENDIX II

### Alternator Operation and Maintenance Manual (Magnaplus 361)



# MAGNAPLUS® GENERATOR

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



Marathon Electric Mfg. Corp.  
A Subsidiary of Regal-Beloit Corp.  
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 **MARATHON**  
**ELECTRIC**

*A Subsidiary of Regal-Beloit Corporation*

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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 are 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.

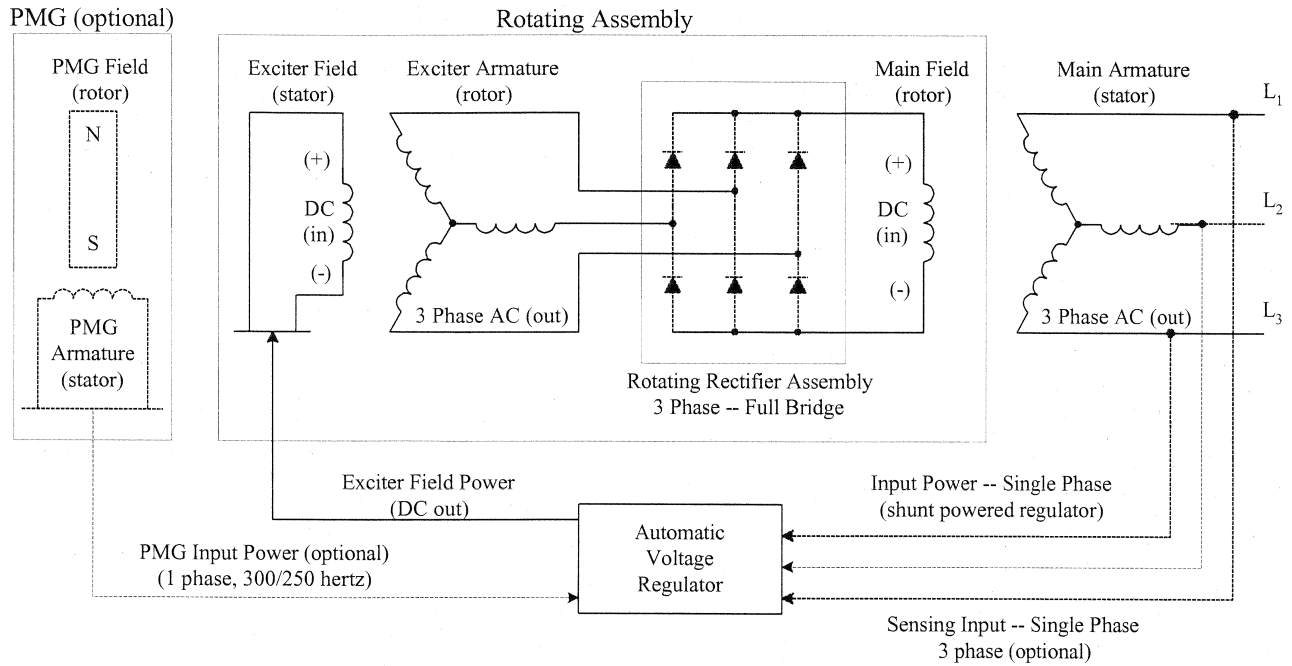
**WARNING**

**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.**

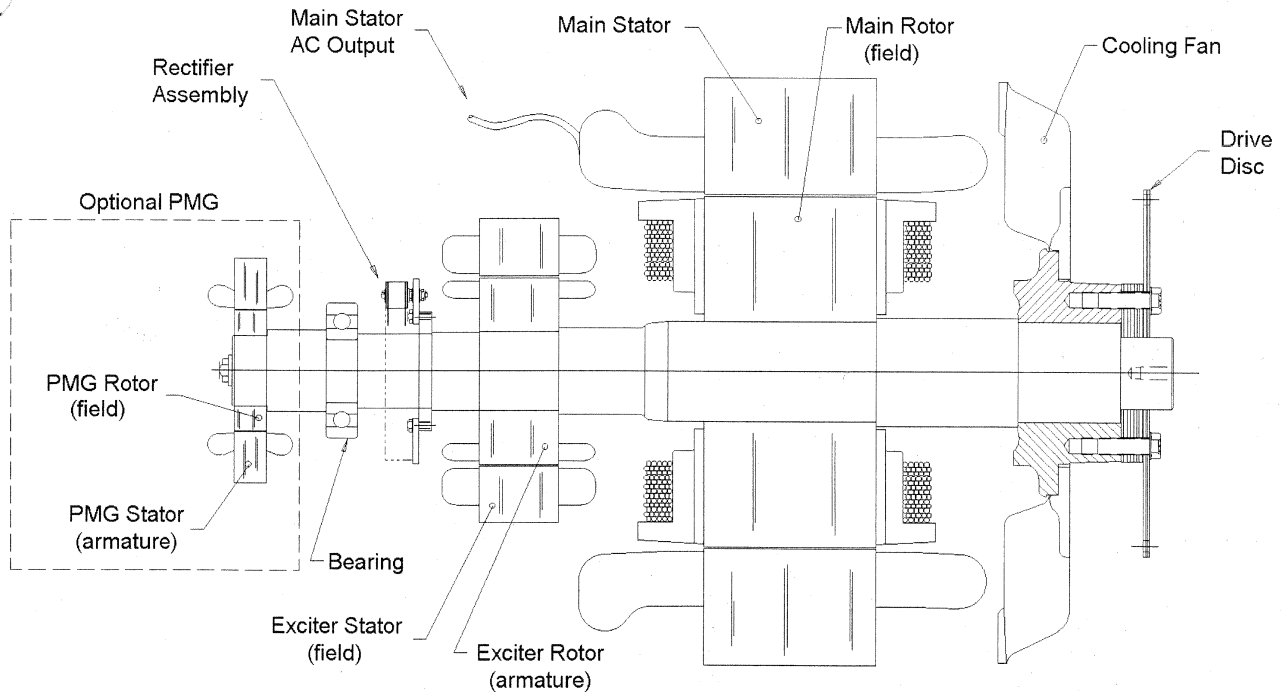
**STORAGE**

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, 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. The generator's terminal voltage is changed by adjusting the regulator's reference set point. Consult the regulator manual for specific adjustment and operating instructions.

### MOTOR STARTING

When a motor is started, a large surge of current is drawn by the motor. 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 wave form of the generator. This creates additional heat in the generator windings and may cause the generator to over-heat. Problems which 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 bolt holes 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, increase 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 end play specifications and measurement procedures. If end play 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 either 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 vibration 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.

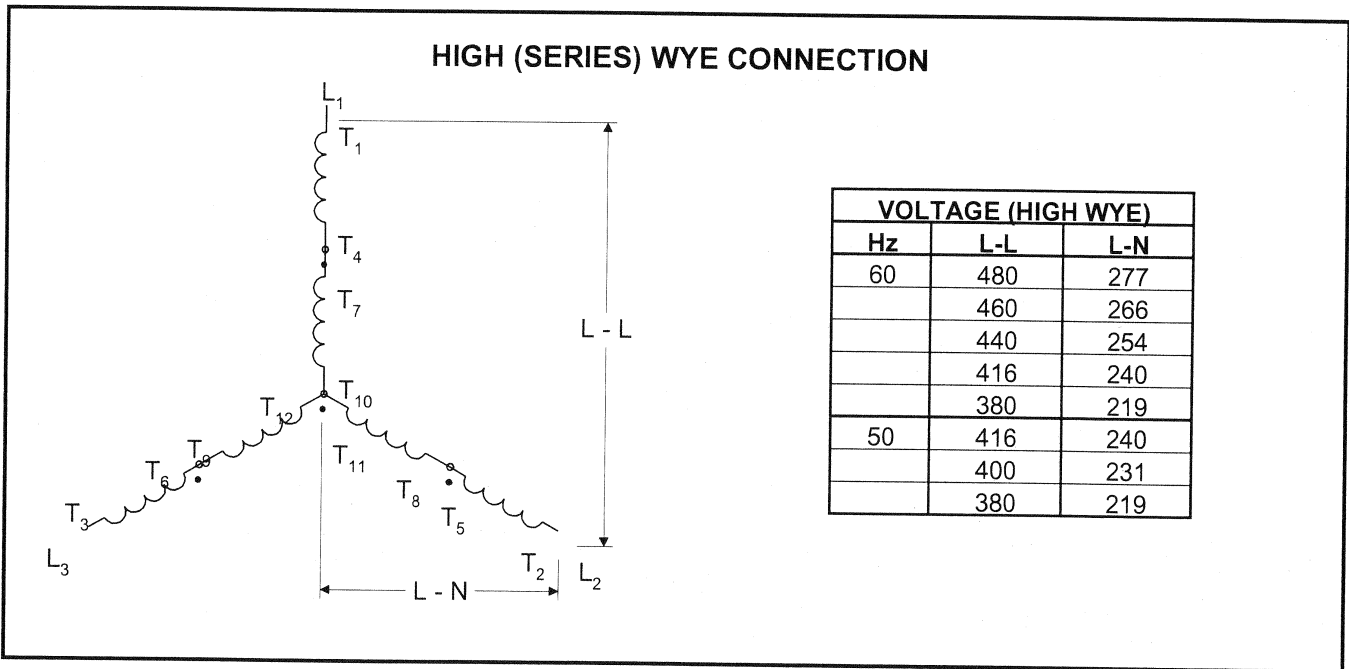
The generator conduit box construction allows cable entry from multiple sides. A hole saw or other appropriate tool may be used to provide for conduit entrance. Protect the

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.

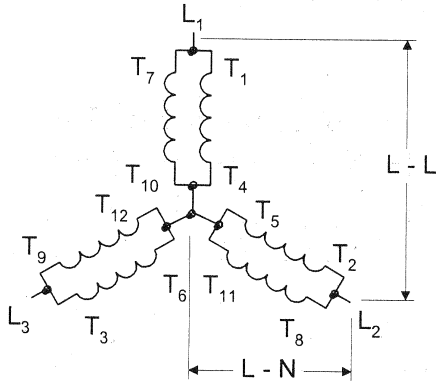
All MagnaPLUS generators are equipped with link boards (terminal strips) for both internal and external connections. All connections made to the studs of the link board should be made with high quality ring terminals. Ring terminal sizes are: 6 mm (280 Series Frames) and 10 mm (360 and 430 Series Frames). 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

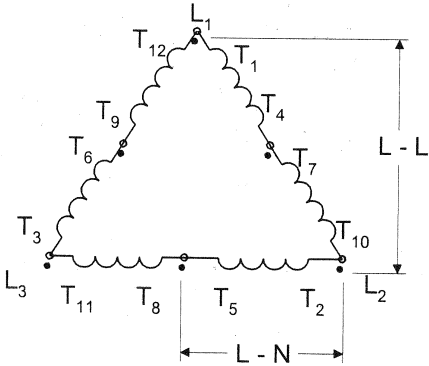


### LOW (PARALLEL) WYE CONNECTION



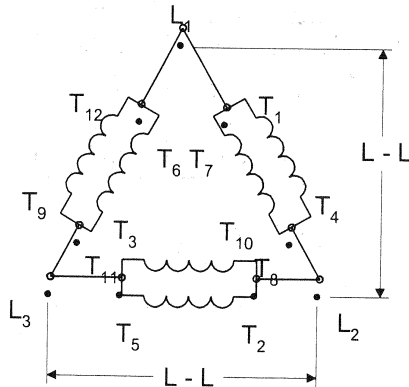
VOLTAGE (LOW WYE)		
Hz	L-L	L-N
60	240	139
	230	133
	220	127
	208	120
	190	110
50	208	120
	200	115
	190	110

### HIGH (SERIES) DELTA CONNECTION



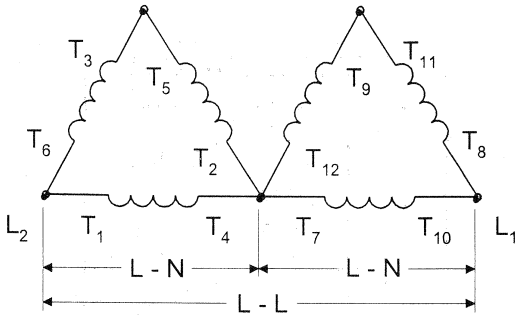
VOLTAGE (HIGH DELTA)		
Hz	L-L	L-N
60	277	139
	240	120
50	240	120
	220	110
	200	100

### LOW (PARALLEL) DELTA CONNECTION



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

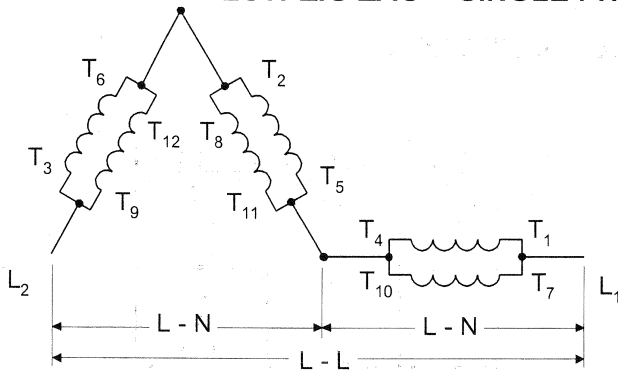
### DOUBLE DELTA -- SINGLE PHASE CONNECTION



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.

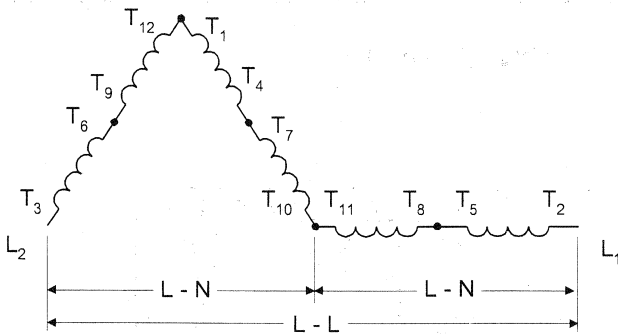
### LOW ZIG ZAG -- SINGLE PHASE (PARALLEL) CONNECTION



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.

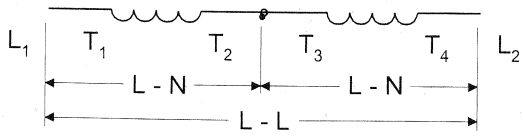
### HIGH ZIG ZAG -- SINGLE PHASE (SERIES) CONNECTION



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 HIGH VOLTAGE - SERIES CONNECTED



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

**THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. 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 air flow 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

**THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. 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 bench mark reading, it is an indication of problems in either 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. The method selected will be influenced by winding wetness and situation limitations.

### 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. This process can be accelerated by enclosing the unit with a covering and inserting additional heating units. 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 which 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

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. 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 which can be checked using an ohm meter: exciter stator, exciter rotor, main stator and main rotor. Each of these components are comprised of various windings which 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 ohm meter 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.

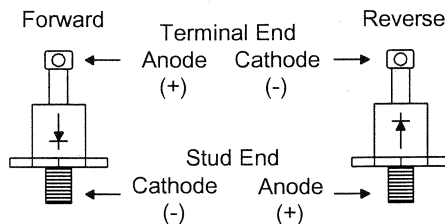


FIGURE 3: DIODE POLARITY

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. All service procedures should be conducted by qualified maintenance personnel. 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

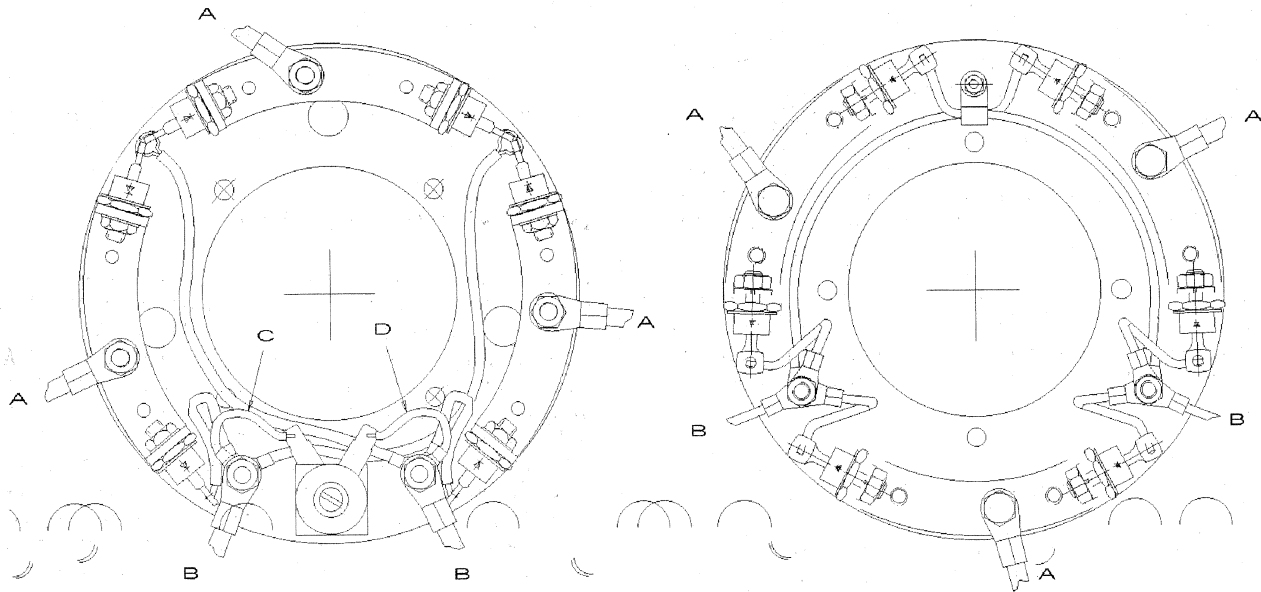
Using a bearing puller, remove the existing bearing. It is strongly recommended that the bearing be replaced any time the it is removed from the shaft. **ALWAYS** install the same type and size bearing that was supplied as original equipment. Order by part number from the parts list, and include the 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

### 280 / 360 FRAME

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

**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 iransit 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  
CHECK AND REMEDY**

**CAUSE**

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  
CHECK AND REMEDY**

**CAUSE**

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

CAUSE	CHECK AND REMEDY
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

CAUSE	CHECK AND REMEDY
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

CAUSE	CHECK AND REMEDY
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  
CHECK AND REMEDY**

**CAUSE**

Regulator protective circuit operating

Check indicators on regulator. Correct problems and adjust regulator as is required. Refer to regulator manual.

**GENERATOR IS OVERHEATING  
CHECK AND REMEDY**

**CAUSE**

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 air flow 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  
CHECK AND REMEDY**

**CAUSE**

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 SET  
CHECK AND REMEDY**

**CAUSE**

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 name plates 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

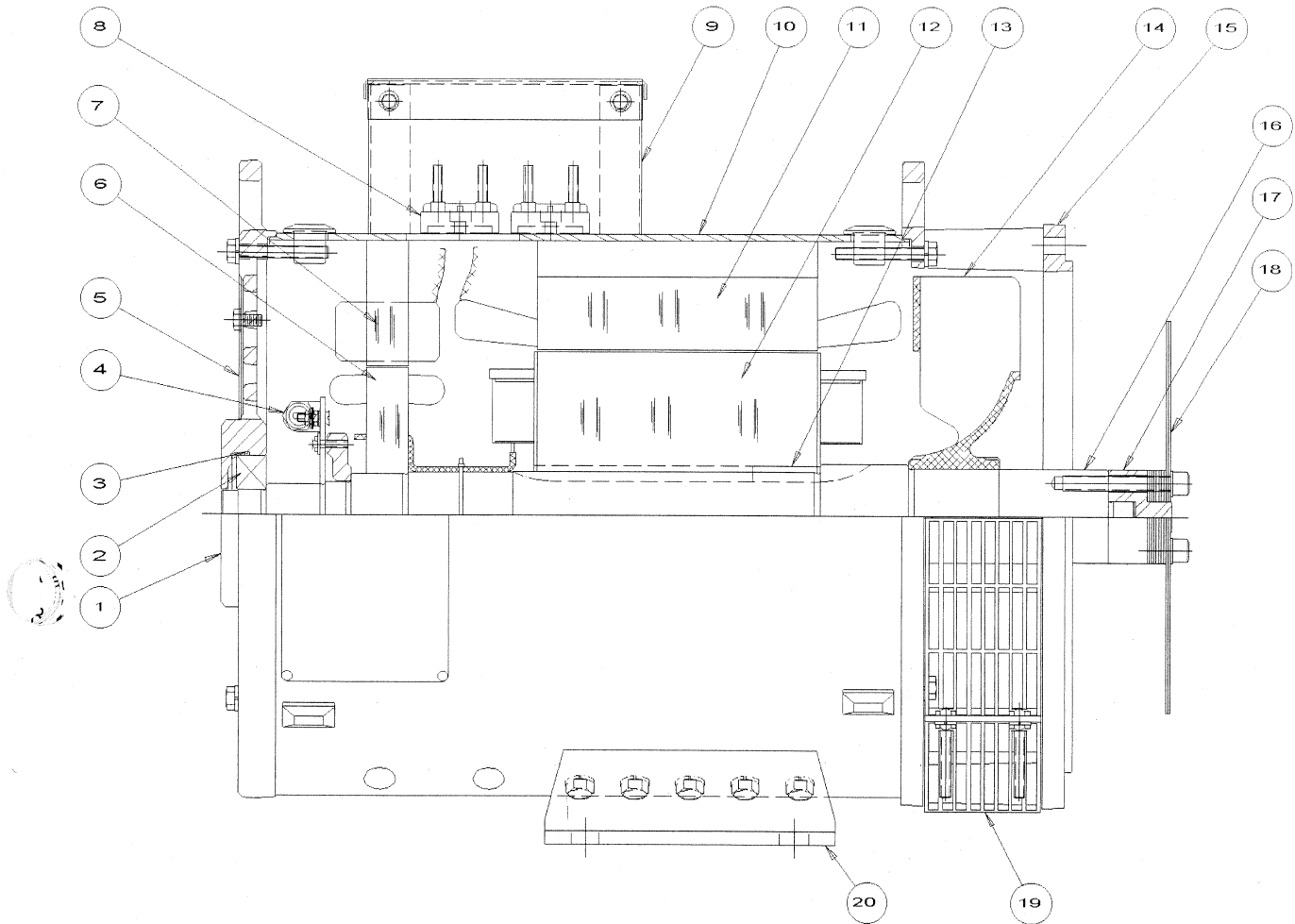
MODEL / FRAME SIZE	EXCITER RESISTANCE	
	STATOR	ROTOR
281, 282, 283, 284	23.0	.120
361, 362, 363 -- three phase	23.5	.120
361, 362, 363 -- dedicated single phase	23.0	.135
431, 432, 433 -- three phase	20.33	.076
431, 432 -- dedicated single phase	18.0	.105

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

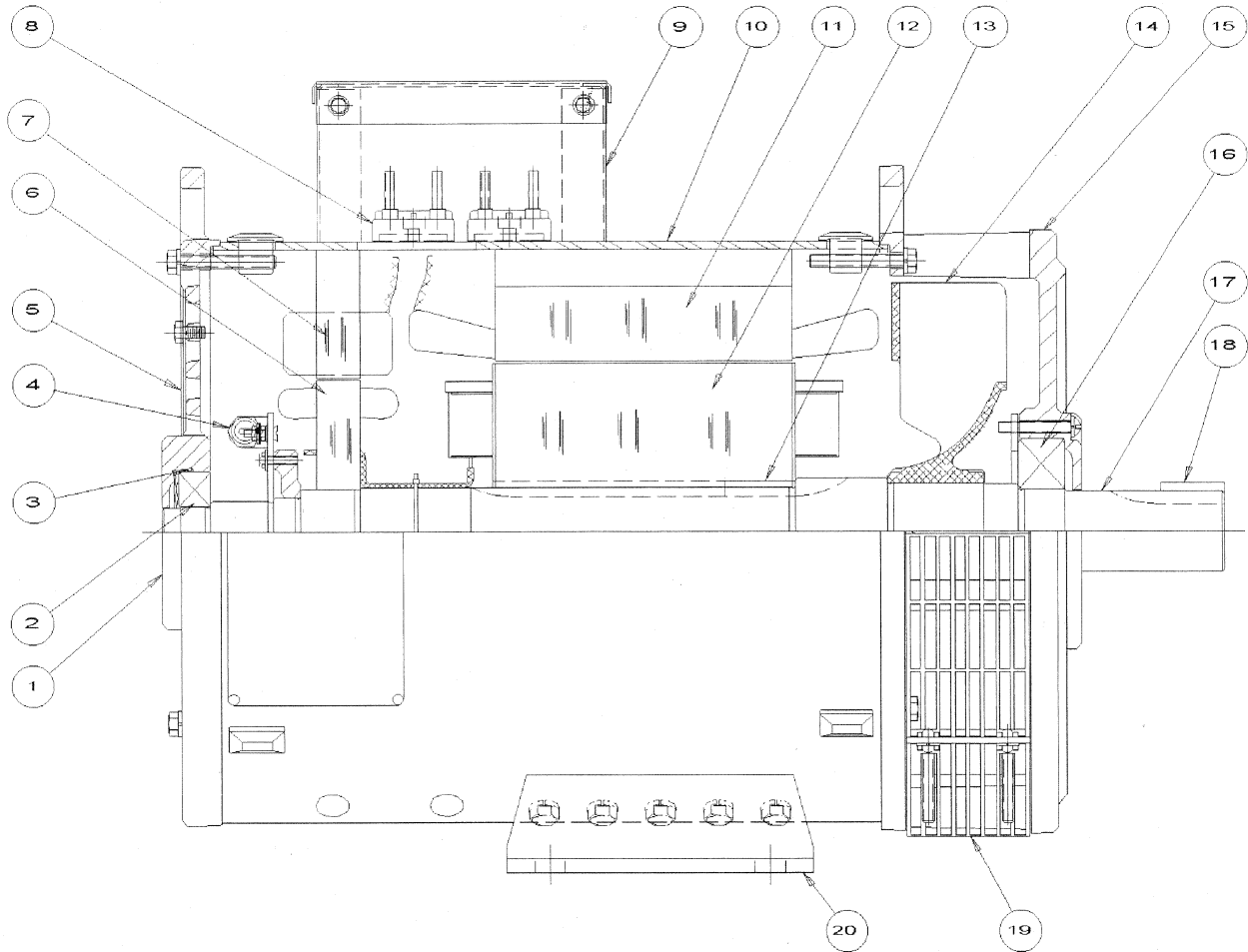
## PARTS LIST – SINGLE BEARING Typical Generator Cross Section



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.



## **APPENDIX III**

### **Declaration of Conformity**





# EU Declaration of Conformity

**Model Number(s)** 11-2820-0000

**Product Type/Name:** Diesel Ground Power Unit

**Serial Number(s):** Enter serial number(s)

**Declaration:** Tronair has assessed the equipment described above against the Essential Health and Safety Requirements of one or more Directives. Based on this assessment, the equipment described above is deemed to comply with the directive(s) listed below.

This declaration of conformity is issued under the sole responsibility of the manufacturer.

**Directives:** European Machinery Directive 2006/42/EC

<b>Standards:</b>	prEN 1915-1:1995	General requirements – Part 1: Basic Safety
	prEN 982:1996	Safety of machinery - Hydraulics
	prEN 60204-1:1997	Safety of machinery - Part 1: Basic Safety
	HFFA/JIC T2.24.1-1990	Hydraulic Fluid Power-- Systems Standard for Stationary Industrial Machinery
	ISO 4021:1997	Hydraulic fluid power
	ARP 1247B	Aircraft ground support equipment – General requirements
	NFPA 70/NEC 1999	National electric code

**Markings:**



**The technical documentation for the machinery is available from:**

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**Identification of person empowered to sign on behalf of the Manufacturer:**

*Patrick Finch*  
Quality Assurance Representative

Enter a date  
Date

