⚠ WARNING

FIRE OR EXPLOSION HAZARD

Failure to follow safety warnings exactly could result in serious injury, death, or property damage.

- **Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance.**
- **WHAT TO DO IF YOU SMELL GAS**
  - **Do not try to light any appliance.**
  - **Do not touch any electrical switch; do not use any phone in your building.**
  - **Leave the building immediately.**
  - **Immediately call your gas supplier from a neighbor's phone. Follow the gas supplier's instructions.**
  - **If you cannot reach your gas supplier, call the fire department.**
- **Installation and service must be performed by a qualified installer, service agency or the gas supplier.**

⚠ WARNING

FIRE, EXPLOSION, AND ASPHYXIATION HAZARD

Improper adjustment, alteration, service, maintenance, or installation can cause serious injury or death.

Read and follow installations and precautions in User's Information Manual provided with this appliance. Installation and service must be performed by a qualified service agency or the gas supplier.

WARNING: For outdoor use only.

NOTICE TO INSTALLER: These instructions shall be left with the consumer.

NOTICE TO CONSUMER: You must read all instructions in the manual and must keep all manuals for future reference.

⚠ AVERTISSEMENT

RISQUE D'INCENDIE OU D'EXPLOSION

Si les consignes de sécurité ne sont pas suivies à la lettre, cela pourrait entraîner une utilisation dangereuse, la mort, de graves blessures ou des dommages matériels.

- **Ne pas entreposer ni utiliser d'essence ou d'autres vapeurs et liquides inflammables à proximité de cet appareil ou n'importe quelle application.**
- **QUE FAIRE SI UNE ODEUR DE GAZ EST DÉTECTÉE**
  - **Ne mettre en marche aucun appareil.**
  - **Ne toucher aucun interrupteur électrique; ne pas utiliser de téléphone dans le bâtiment.**
  - **Quitter le bâtiment immédiatement.**
  - **Appeler immédiatement le fournisseur de gaz en utilisant le téléphone d'un voisin. Suivre les instructions du fournisseur de gaz.**
  - **Si le fournisseur de gaz n'est pas accessible, appeler le service d'incendie.**
- **Installation et l'entretien doivent être effectués par un installateur ou une entreprise d'entretien qualifié, ou le fournisseur de gaz.**

⚠ AVERTISSEMENT

RISQUE D'INCENDIE, D'EXPLOSION ET D'ASPHYXIE

Si un réglage, une modification, une réparation, en entretien ou l'installation est effectué de façon inadéquate, cela pourrait causer de graves blessures ou la mort.

Lire et suivre les instructions et les précautions fournies dans le manuel de l'utilisateur accompagnant cet appareil. L'Installation et l'entretien doivent être effectués par un installateur ou une entreprise d'entretien qualifié, ou le fournisseur de gaz.

AVERTISSEMENT: Utiliser uniquement à l'extérieur.

AVIS À L'INSTALLATEUR: Ces instructions doivent être remises au consommateur.

AVIS AU CONSOMMATEUR: Vous devez lire toutes les instructions du manuel et conserver tous les manuels pour référence future.

S-8500 THERMOELECTRIC GENERATOR

Operating Manual

Intertek
4008107

CSA/ANSI 13.1:22

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64131 Rev3

TABLE OF CONTENTS

1 ABOUT THIS MANUAL

1.1 WARNINGS & CAUTIONS

WARNINGS

Throughout this manual, paragraphs preceded by the text WARNING, it is imperative that the advice in these paragraphs be adhered to, as failure to do so may result in personal injury or death and possible damage to the equipment.

CAUTIONS

Throughout this manual, paragraphs preceded by the text CAUTION, it is imperative that the advice in these paragraphs be adhered to, as failure to do so may result in damage to the equipment.

WARNING: The installation must conform with local codes or, in the absence of local codes, with CSA B149.1 or ANSI Z223.1/NFPA 54, and CSA B149.2 or NFPA 58, as applicable.

WARNING: The Thermoelectric Generator, when installed, must be electrically grounded in accordance with local codes or, in the absence of local codes, with CSA C22.1 or NFPA 70.

CAUTION: The Thermoelectric Generator and its individual shut-off valve must be disconnected from the gas supply piping system during any pressure testing of that system at test pressures in excess of 3.5 kPa (0.5 psi).

The Thermoelectric Generator must be isolated from the gas supply piping system by closing its individual manual shut-off valve during any pressure testing of the gas supply piping system at test pressures equal to or less than 3.5 kPa (0.5 psi).

WARNING: Keep the Thermoelectric Generator area clear and free from combustible materials, gasoline and other flammable vapors and liquids. Maintain minimum clearances specified in this manual.

WARNING: The Thermoelectric Generator consists of sub-systems that combust gaseous fuel and others that consume excess power through resistors, all of which can pose high surface temperature hazards. Operators and service personnel should avoid indicated areas of the generator to avoid burns or clothing ignition when in operation or cooling down.

WARNING: Any guard or other protective device removed for servicing the Thermoelectric Generator must be replaced prior to operating the appliance.

WARNING: Installation and repair should be performed by a qualified service person. The Thermoelectric Generator should be inspected before use and at least annually by a qualified service person. More frequent cleaning may be required as necessary. It is imperative that the control compartment, burners and circulating air passageways of the appliance be kept clean.

WARNING: Do not use this Thermoelectric Generator if any part has been under water. Immediately call a qualified service technician to inspect the appliance and to replace any part of the control system and any gas control which has been under water.

WARNING: The Thermoelectric Generator must be mechanically installed according to the instructions contained within this manual. The Generator has a mass of 273kg (603 lbs), a high center of gravity, and a low tipping angle of 11 degrees from vertical. The Generator must be securely bolted to a mounting pad or platform when assembled. See Appendix B.

WARNING: Inspect and check all gas connections for leaks using a commercially available liquid leak detection fluid after installation or service to any part of the fuel system. Remedy any fuel system leaks prior to starting the Thermoelectric Generator.

WARNING: This device contains electrical, and gas related safety devices as identified throughout this manual. Tampering or rendering inoperative any of these safety devices may result in personal injury or death and possible damage to the equipment and is not permitted under any circumstances.

WARNING: The Thermoelectric Generator is designed to combust gaseous fuels which will result in combustion products of heat, carbon dioxide and water vapor and may contain traces of Carbon Monoxide, unburnt Hydrocarbons and Nitrous Oxides. Emissions from combustion will depend on generator set-up and operation as well as the composition of the gas feed. It is imperative that these instructions be followed, and that gas supplied meets Global Power Technologies' gas specification.

CAUTION: The Thermoelectric Generator consists of some parts constructed from sheet metal. Every effort is made to ensure that edges have been deburred when manufactured, sharp edges may still exist. Caution must be exercised when handling and use of gloves is advised.

WARNING: *CONDENSATE FROM REGULATOR IS VERY HIGH-RISK OF BEING FLAMMABLE.*

When draining condensate from regulator, ensure it is removed from cabinet and is a safe distance from ignition sources.

If there is a concern about liquids in the fuel line, it is suggested that the customer install a regulator drain line to remove condensate to a safe location away from ignition sources.

Condensate collecting/pooling/splashing/etc. inside the TEG cabinet creates a dangerous fire hazard. Contact GPT for assistance with fuel conditioning options to remove liquids from fuel line supply.

CAUTION: If a hose assembly is used to connect the Thermoelectric Generator to the gas supply piping system, inspect the hose assembly before each use of the Thermoelectric Generator.

The hose assembly must be replaced prior to the appliance being put into operation if there is evidence of excessive abrasion or wear, or if the hose is damaged.

The replacement hose assembly shall be that specified by the manufacturer.

CAUTION: Properly locating the hose out of pathways where people may trip over it or in areas where the hose may be subject to accidental damage.

1.2 GENERAL INFORMATION

This manual provides instructions for the installation, operation, performance, basic maintenance and troubleshooting of the model S-8500 Thermoelectric Generator (TEG), a device that produces electrical power through the direct conversion of heat energy to electrical energy.

Appendices provide reference details for the Technical Specifications, Wiring diagrams and electrical schematics, Parts lists, and Options.

WARNINGS and ***CAUTIONS*** are important to understanding any limitations of the device placed on its installation and operation in a safe manner as is intended by the design.

2 INSTALLATION

Sites where Thermoelectric Generators are placed vary greatly and are unique. Instructions for preparing the installation here are for a single model S-8500 TEG. Please contact your Global Power Technologies (GPT) representative for more information on custom solutions.

Tools Required

See Appendix E Service and Installation Tools.

2.1 SITE PREPARATION

The site should be prepared in advance of the arrival of the TEG. The Model S-8500 is designed for General Area use and Outdoor Applications. No shelter is required for the operation of this TEG.

Mount the TEG to a level and sturdy stable base capable of supporting the 273 kg (603 lb.) mass of the TEG. Bolt down the TEG using 1/2-13 bolts of material suitable for the environment. See Appendix B Overall Weight & Dimensions for mounting hole locations.

WARNING: Installation of this appliance at altitudes above 2000 ft (610 m) shall be in accordance with local codes or, in the absence of local codes, CSA B149.1 or ANSI Z223.1/NFPA 54, and CSA B149.2 or NFPA 58, as applicable.

WARNING: Maintain a minimum clearance horizontally of 450 mm (18 inches) from the TEG on all four sides to combustible walls. DO NOT use a combustible roof above the TEG. Consult with GPT for using non- combustible roofing and its required clearances.

2.2 UNPACKING

Unpack the TEG from its shipping crate, keep the crate until the TEG is operational. Locate and identify the following items that were shipped with the S-8500 TEG main assembly, and any options kit assemblies that would have been shipped with the order, in particular Cathodic Protection or DC/DC converter panels.

- 1 Rain cap
- 1 Stand kit (See Appendix F, Figure 20 for details)
- 1 Ball Valve and nipple
- 2 Spare 3 A fuses
- Thread sealant

WARNING: Inspect the TEG for damage which may have occurred during shipping. Report any damage as soon as possible. Some damage may make the generator inoperable. Consult with GPT before operating a damaged TEG.

2.3 ASSEMBLY

1. Assemble the stand as shown in parts list using the hardware specified in Appendix F, Figure 20. The mounting brackets must be square before the final tightening of the fasteners. Squaring of the stand can be accomplished by measuring corner to corner across the top and adjusting the frame until these measurements match

closely.

2. Mount the stand kit on the installation platform using 1/2-13 anchor bolts.
3. Dismantle the crate.
   - If using a spreader bar during lifting; use spreader bar and chains or cables connected to shackles in each of the two lifting lugs to lift the TEG.
   - If not using a spreader bar during lifting; remove rain cap, exhaust stack, and rope gasket (B1/B2/B3 in Appendix F Figure 15) to be able to reach the lifting lugs on the TEG. This is required to prevent damage to the exhaust stack during lifting. Use chains or cables connected to shackles in each of the two lifting lugs to lift the TEG.

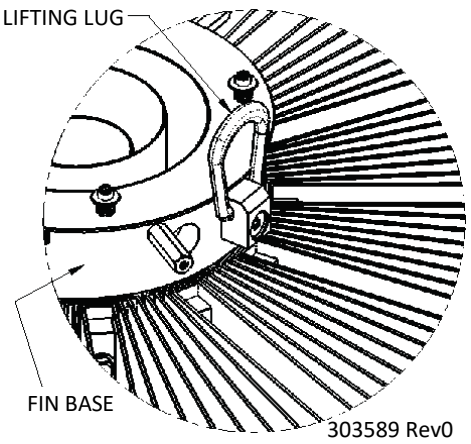


Figure 1 Location of lifting lug

4. Line up the holes on the stand with the holes on the TEG. Use specified fasteners to assemble the TEG on the stand (A17 through A19 in Appendix F, Figure 14).
5. If removed, reinstall the exhaust rope gasket (B3) inside the groove in the exhaust assembly (B2). Refit the exhaust assembly (B2 & B3) and fit the rain-cap (B1 in Appendix F, Figure 15) with fasteners B10, through B13 in Appendix F, Figure 15.

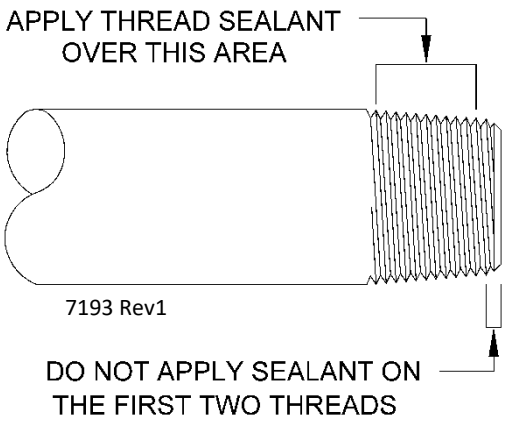


Figure 2 Applying thread sealant

6. Remove the packaging that supports the resistor assembly (A3) folded up for transport and loosen the two hinge fasteners, lift, and then rotate down the resistor assembly so that it is positioned vertically and retighten the hinge fasteners to lock the assembly in place. Refer to Appendix C Figure 10.
7. Apply thread sealant to the fuel line kit as per Figure 2. The fuel line kit includes the manual shut-off valve and 1/4 NPT nipple (A7 and A8 in Appendix F, Figure 14).
8. Install and tighten the fuel line kit to 1/4 NPT elbow (C14 in Appendix F, Figure 16) in the fuel system.

2.4 CONNECTING THE FUEL SUPPLY

Connect the fuel supply to the 1/4 in. female NPT fuel inlet manual shut-off valve:

1. Remove the protective cap or plugs.
2. Apply thread sealant to the fuel line threads as per Figure 2.

Note: Thread sealant is recommended. Sealant must be approved for use with gaseous fuels. Tape is not recommended.

3. Connect the fuel line and test all joints for leaks using a commercial leak detector fluid such as Snoop®.

4. Inspect the fuel lines and fittings to be sure they are free of foreign material.
5. Purge fuel lines of all air.

WARNING: ***CONDENSATE FROM REGULATOR IS VERY HIGH-RISK OF BEING FLAMMABLE.***

When draining condensate from regulator, ensure it is removed from cabinet and is a safe distance from ignition sources.

If there is a concern about liquids in the fuel line, it is suggested that the customer install a regulator drain line to remove condensate to a safe location away from ignition sources.

Condensate collecting/pooling/splashing/etc. inside the TEG cabinet creates a dangerous fire hazard. Contact GPT for assistance with fuel conditioning options to remove liquids from fuel line supply.

2.5 FUEL CONSIDERATIONS

Fuel must be either natural gas or propane vapor and dependent on the model ordered. Check the TEG data plate for the fuel type. Do not use a different type of fuel than indicated.

CAUTION: Do not exceed the data plate for pressure rating. If the fuel supply pressure will vary greatly, the use of an additional primary regulator is recommended to hold the input pressure relatively constant.

Propane/LPG Gas Supply Considerations

If remote Propane/LPG gas supply system is used, consider the following:

Location: Propane/LPG tanks and cylinders must be located outdoors in a well-ventilated area, at least 3 meters (10 ft) from the TEG unless directed otherwise by the local authority having jurisdiction.

Mounting: Each tank or cylinder must be set on a firm, level, waterproof base, located on firm ground at grade level. The base must extend at least 300 mm (1 ft) from all sides of the tank or cylinder, must be designed to support the weight of the tank or cylinder and is subject to approval by the local authority having jurisdiction. To prevent remote cylinders from tipping over, they shall be secured by brackets, straps, or carriers designed and manufactured to withstand calculated loading in any direction equal to at least four times the weight of the filled cylinder.

Connection: Tanks and cylinders are to be equipped with flexible connections to offset any movement affecting the piping or tubing.

2.6 CONNECTING CUSTOMER LOAD

Bring the customer load wires through the provided hole (H1 in Figure 3) nearest to the terminal block in the bottom of the Electrical Assembly using appropriate cable connectors for the wire or cable being used. Allow enough wire to connect to the terminal block TB-1, terminals 3(+) and 4(-). Grounding and bonding connections may be made to TB-1, terminal 5. Refer to Appendix D, Figure 12.

WARNING: Use supply wires with copper diameter no smaller than 8 AWG wire, and a minimum temperature rating of 90°C.

3 OPERATION

3.1 BEFORE STARTING

The operator should familiarize him/herself with the major sub-systems and location of key components using Appendix F, Parts List, understand the TEG Specifications and have read the manual prior to starting the TEG.

1. **CALCULATE THE TARGET POWER FOR THE CURRENT AIR TEMPERATURE AND ALTITUDE BEFORE STARTING THE TEG. REFER TO SECTION 5. Record on the performance log at the end of this manual.**
2. Inspect the TEG for mechanical damage and remedy if found. If excessive damage is found contact Global Power Technologies (GPT).
3. Check that the fuel system connections are tight and have been checked for leaks.
4. Check the electrical connections to the customer terminal block are tight and correctly connected.
5. Check that the resistor assembly has been rotated down to the operating position.
6. Check that the TEG has been properly grounded and bonded to the site ground.
7. Remove the left and right cabinet panels by turning the 1/4 turn fasteners counterclockwise.
8. Inspect the air shutter for cleanliness and open to 50%.
9. Ensure the pressure gauge vent plug, located on top of gauge, is open (raised position), as required to measure the correct fuel pressure.
10. Open the main electrical enclosure and prop open the door using the slide latches on the top of the enclosure.
11. Check that the internal battery has been connected, that the battery fuse is in place and intact.
12. Turn the customer load circuit breaker to the "OFF" position.

3.2 TEG START-UP

1. Supply fuel and open the manual shut-off valve.

Note: Pressure gauge vent plug must be open to measure the correct fuel pressure.

2. Observe the fuel pressure at the pressure gauge. Refer to the data plate for the nominal fuel pressures for Natural Gas and Propane.
3. Unless otherwise instructed, the TEG should be started at the nominal fuel pressure. Pressure may be adjusted to rated values by turning the screw on the pressure regulator, see Figure 7.

If the Remote Start (TEG Controller) option has been installed, refer to Appendix I – Options for starting instructions.

4. Opening the manual shut-off valve causes the Spark Ignition (SI) module to spark and the pilot solenoid valve to open as indicated by LED L1 on the SI Controller module, see Figure 3.
5. Three ignition trials are made.
6. If unsuccessful on all three attempts, the SI will go into Lockout mode. The red Lockout light on the SI Controller board, LED L5 will turn on and the SI will be

powered down.

7. To reset the SI Controller board after a Lockout, wait 10 seconds after the red light turns on, then press the SI Controller's on-board reset switch S1. If the pressure switch is still closed, the SI module will turn on and another three ignition trials will be made.
8. 60 seconds after successful ignition of the pilot burner, the main burner solenoid valve is turned on, as indicated by LED L2 on the SI Controller and the TEG will rapidly heat-up and start to produce power.

Note: The ignition system contains a 6 V, 5.0 Amp-hour rechargeable battery pack and a battery charger. A new fully charged battery pack provides approximately 120 minutes of operating time at 25 ºC. Completely discharged battery pack will take approximately 20 hours of TEG operation to regain 100% charge as long as the output load is not overloading the TEG and the Customer Load circuit breaker is "ON". The battery will NOT charge if the Customer Load circuit breaker is in the "OFF" position.

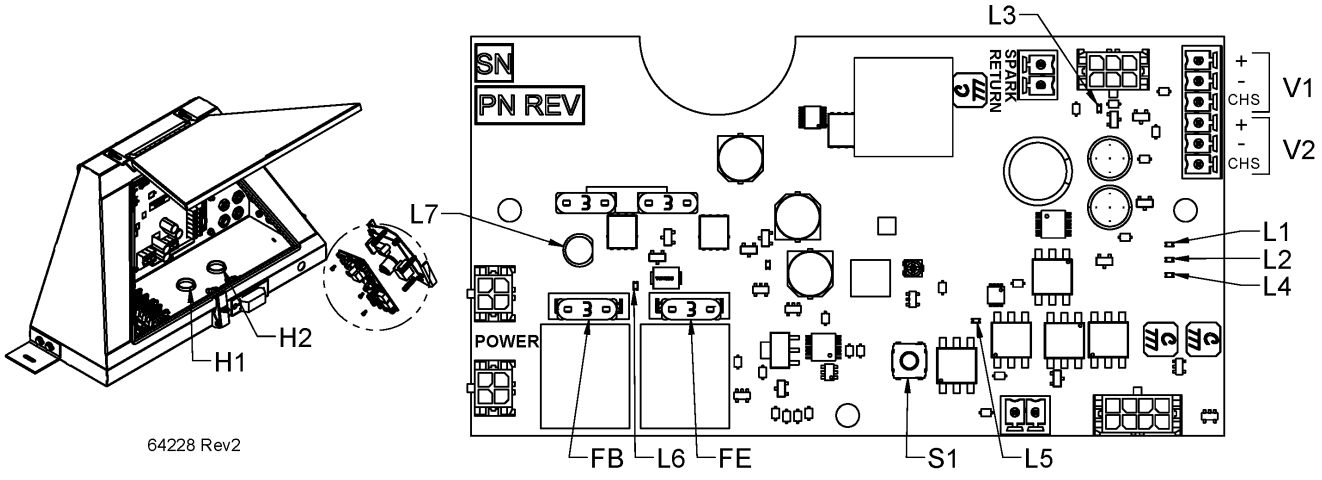


Figure 3 SI Controller Interface

3.3 POWER OUTPUT EVALUATION

During first time operation and following any maintenance, perform the following procedure. Refer to the target setup power calculation performed before starting the TEG. Factory settings of the fuel pressures are shown on the data plate. Note factory air shutter setting as shipped, (marking air shutter setting is advised).

1. Wait about 30 minutes after ignition before making any changes to the output voltage and/or combustion.
2. Loosen the air shutter retaining screw.
3. Open the air shutter to about 25% greater than factory setting as shipped.
4. Measure and if needed adjust output voltage
   a. Connect a DC voltmeter +/- leads to M1 (+) / M2 (-) measurement points of the High-Power Limiter (HPL) respectively. See Appendix H.
   b. Press switch S4 (ADJ) until L1 (OV) LED starts flashing
   c. Meter is displaying a scaled reading of the Output Voltage (2.7V reading = 27.0V).
   d. If the output voltage reading is the desired output voltage, proceed to step 5

e. If the output voltage reading is not the desired output voltage, press switch S1 (DN) to decrease the setting or switch S2 (UP) to increase the setting in steps of 0.05V as needed to set the desired voltage.

5. Measuring the power
   a. Connect the DC voltmeter +/- leads to M1 (+) / M2 (-) measurement points of the HPL
   b. Press switch S3 (DIS), to cycle through display options, until LED L4 (OP) is illuminated
   c. Meter should display a scaled reading of the TEG power (5.5V reading = 550W)
6. Monitor the measured power while the TEG is heating up to ensure the target setup power is not exceeded.
7. If the measured power level rises more than 10 Watts above the target setup power, reduce the fuel pressure in 6.8 kPa (1 psi) increments and allow the TEG to stabilize for 15 minutes between adjustments.

Note: Pressure gauge vent plug must be open to measure the correct fuel pressure.

8. The TEG has stabilized once there is about 5 Watts difference between two 15-minute readings. This is typically about an hour after starting.

Note: The TEG power will likely have not reached the target setup power at this point

9. Adjusting Air Shutter

   Decrease the air shutter opening until the maximum power unit output is observed. Allow the TEG to stabilize between air shutter adjustments, approximately 15 minutes. Lock the air shutter in place once the maximum power has been reached. When the power starts to decrease slightly, reverse the last air shutter adjustment. This should be the optimum setting.

Note: Optimum air shutter adjustment results in a peak point in power. Any adjustments from this point will result in a decrease of power. The power falls off quicker if the combustion is fuel rich compared to fuel lean, therefore it is better to be slightly air rich.

10. Adjusting fuel pressure

Note: Pressure gauge vent plug must be open to measure the correct fuel pressure.

   a. If the measured power is **ABOVE** the target setup power, **decrease** the fuel pressure by 3.5 kPa (0.5 psi) increments
   b. If the measured power is **MORE than 10 Watts BELOW** the target setup power, increase the fuel pressure by 3.5 kPa (0.5 psi) increments
   c. Allow the TEG to stabilize for 15 minutes between power measurements and adjustments.

WARNING: Under no circumstances should the fuel pressure exceed 97kPa (14psi) for Natural Gas, or 172 kPa (25psi) for Propane . Do not adjust fuel pressure to achieve power greater than the target set up power.

11. Re-adjusting Air Shutter
   a. Decrease the air shutter in increments of 5% to 10% and allow the TEG to

stabilize for 15 minutes between power measurements and adjustments. This will cause the power to increase between adjustments.

b. When the power starts to decrease slightly, reverse the last air shutter adjustment. This should be the optimum setting.

NOTE: Optimum air shutter adjustment results in a peak point in power. Any adjustments from this point will result in a decrease of power. The power falls off quicker if the combustion is fuel rich compared to fuel lean, therefore it is better to be slightly air rich.

12. If the measured power is still ABOVE the target setup power, reduce the fuel pressure to reach the target power. This will leave the combustion slightly air rich as desired.

NOTE: Incorrect air shutter setting may result in power loss, unburnt hydrocarbons, and/or carbon monoxide emissions greater than 50ppm. Soot may be visible on the exhaust and rain cap.

3.4 LEAVING THE SITE

1. Make sure the TEG performance is as required for the load and that the TEG is operating normally.
2. Make sure the Customer Load circuit breaker is in the "ON" position.
3. Close the main electrical panel lid.
4. Replace the pyramid stand panels using the 1/4 turn fasteners (1/4 turn clockwise).
5. Ensure there are no combustible materials within 46 cm (18 inches) from the TEG.

3.5 SHUT-DOWN

Shut off the manual fuel shut-off valve.

If the Remote Start (TEG Controller) option has been installed, refer to Appendix I - Options for shut-down instructions.

4 PERFORMANCE

4.1 UNDERSTANDING THE DATA PLATE

The Data Plate is located on the inside rear of the pyramid cabinet on one of the pyramid stand legs, see Figure 10. The data plate includes vital information about the generator. These are the conditions achieved at the Global Power Technologies (GPT) manufacturing facility before shipping. Customer site conditions typically vary from factory conditions, resulting in a different target setup power from the data plate.

Model Number: The model number on the Data Plate is interpreted as follows:

S-8500 ( ) - ( ) – ( ) – ( )

Fuel Type:
L = Propane
N = Natural Gas

Output Voltage:
12, 24, or 48 Volts

SS = Stainless Steel Fuel System

CP = Cathodic Protection Interface
RS = Remote Start

Serial Number: This is a unique number assigned by GPT to provide traceability.
Fuel Input Rating: This is the fuel energy input rate of the TEG.
Inlet Pressure: This is the maximum permitted fuel supply pressure range.
Fuel Type: 'NATURAL GAS' (CH_4) or 'PROPANE' (C_3H_8).
Orifice Size: The size of orifice specific for the fuel type indicated.

IMPORTANT:	Each type of fuel requires a specific orifice, therefore use only the fuel indicated.

NOTE:	If butane is used, the fuel type will indicate propane. This is because the energy content of propane and butane are nearly equal; therefore, they require the same orifice.

Output Rating: This is the output voltage range and power to customer load.
Factory Settings: The power output at ambient temperature, voltage across the precision load, and manifold fuel pressure that were measured during factory performance test at elevation of the factory are recorded as factory settings. This information is provided for reference only because the manifold fuel pressure is adjusted to obtain the desired power at customer site.

4.2 POWER UNIT POWER CURVE

The Thermoelectric Generator converts heat to direct current electricity via a thermopile power unit. This power unit has a fixed internal resistance in a range of 1.0 to 1.3 Ohms.

The maximum power is delivered when the load resistance closely matches that of the power unit. Voltage and current can be plotted together to show a power curve for the TEG.

WARNING: Do NOT adjust the device outside of the absolute maximum ratings as listed in Appendix B. Increasing fuel pressure or output power beyond these limitations will result in damage to the power unit, additional cost to the customer, the TEG being out of service for a period of time, and possible injury.

The amount of power that can be drawn from the TEG is primarily dependent on the heat input and the cooling system. The heat input is fixed via combustion of fuel and the cooling is provided by the fin base, fins, and fin duct, all of which work together. Cooling is affected by ambient temperature, humidity, wind, and altitude.

The following chart shows the gross power output of the thermoelectric power unit prior to power conditioning and without consideration of ambient conditions.

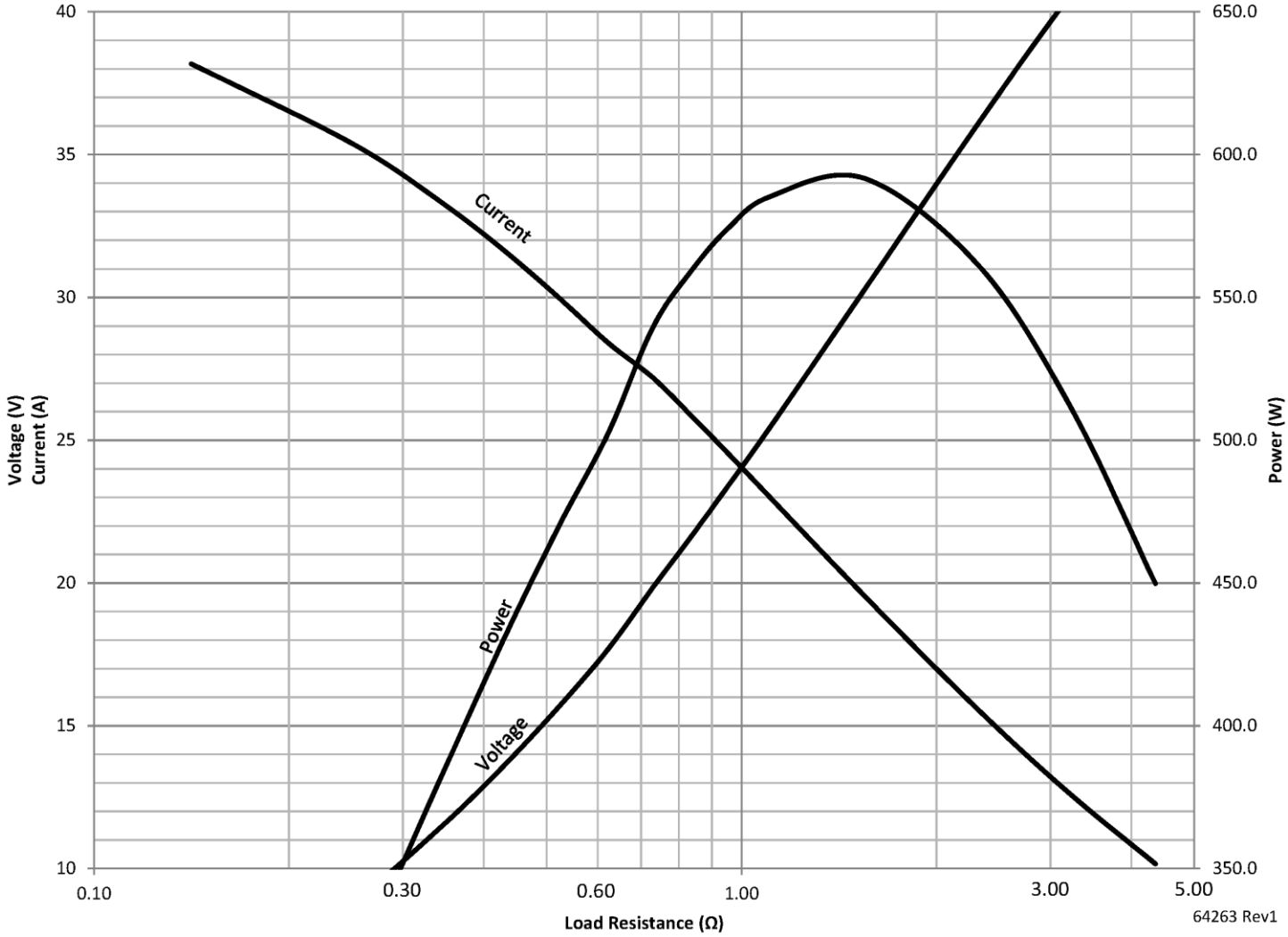


Figure 4 Thermoelectric Power Unit Power Curve

Ambient temperature

As temperature increases Power output will drop by about 1.4 W per ^{O}C above 25 ^{O}C. This is important when setting up the TEG or checking performance as the maximum power that can be achieved will vary. The following chart should be used to determine the expected maximum power under the given ambient temperature condition.

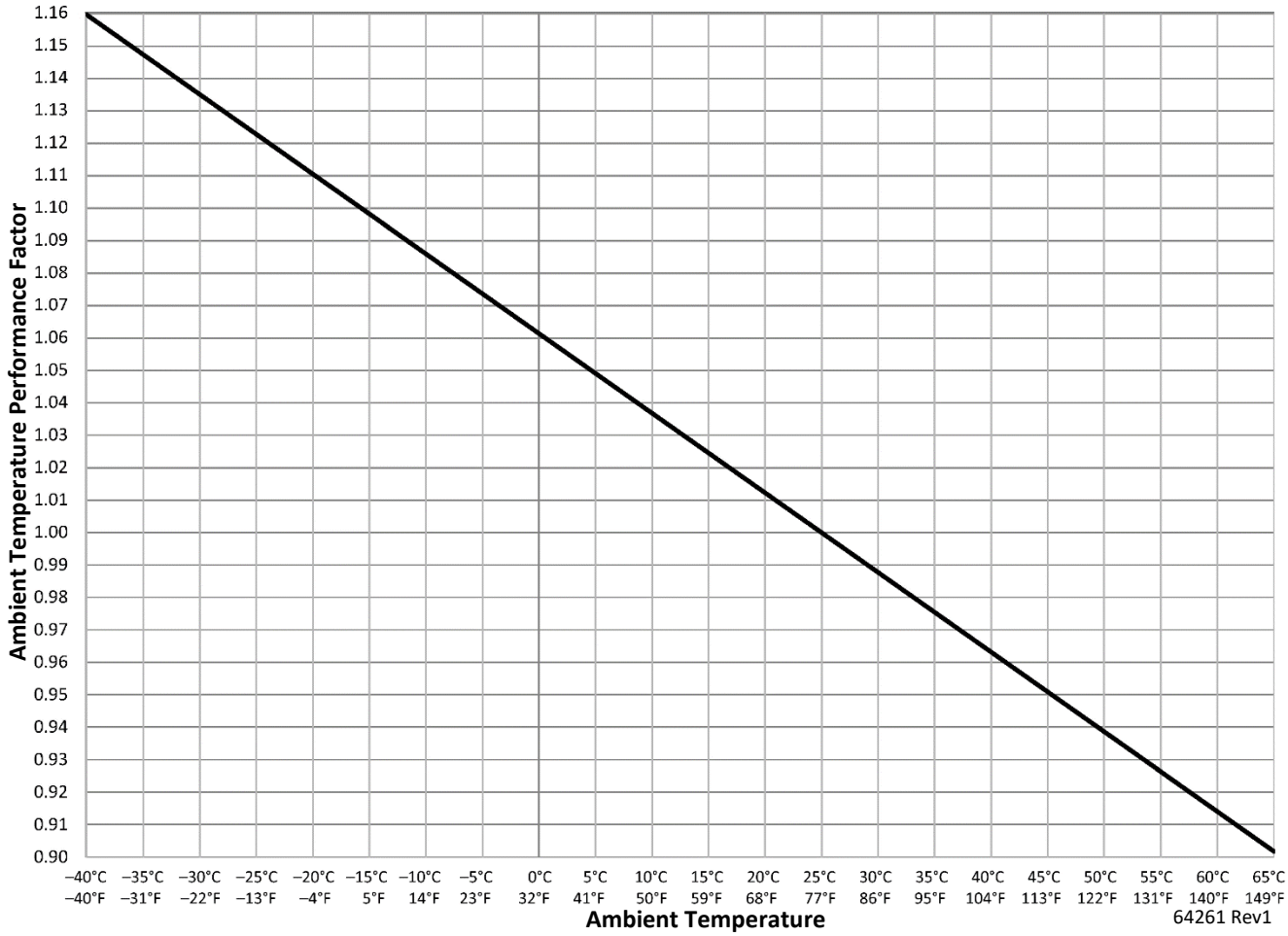


Figure 5 Thermoelectric Power Unit Ambient Temperature Derate Curve

Humidity

The cooling system will be more effective as humidity increases. As humidity can rarely be controlled at a particular site, it will not be considered further.

Wind

The cooling system is designed to generally be unaffected by wind because the external duct creates a natural chimney type draft. As wind can rarely be controlled at a particular site, it will not be considered further.

Altitude

With increasing altitude, the air becomes less dense and the ability of the cooling system to transfer heat to the air less effective. Further adjustments will need to be made to the air intake shutter, opening more with increased altitude, to provide sufficient oxygen

to the burner for full combustion of the fuel. GPT's manufacturing facility sits at 750 m above sea level. Performance will increase at lower altitudes. At sea level, the performance will improve by about 5% (545W output). At 3000 m, the performance may be up to 15% lower (450 W output). The following chart shows the power multiplication factor as a function of altitude Above Sea Level (ASL).

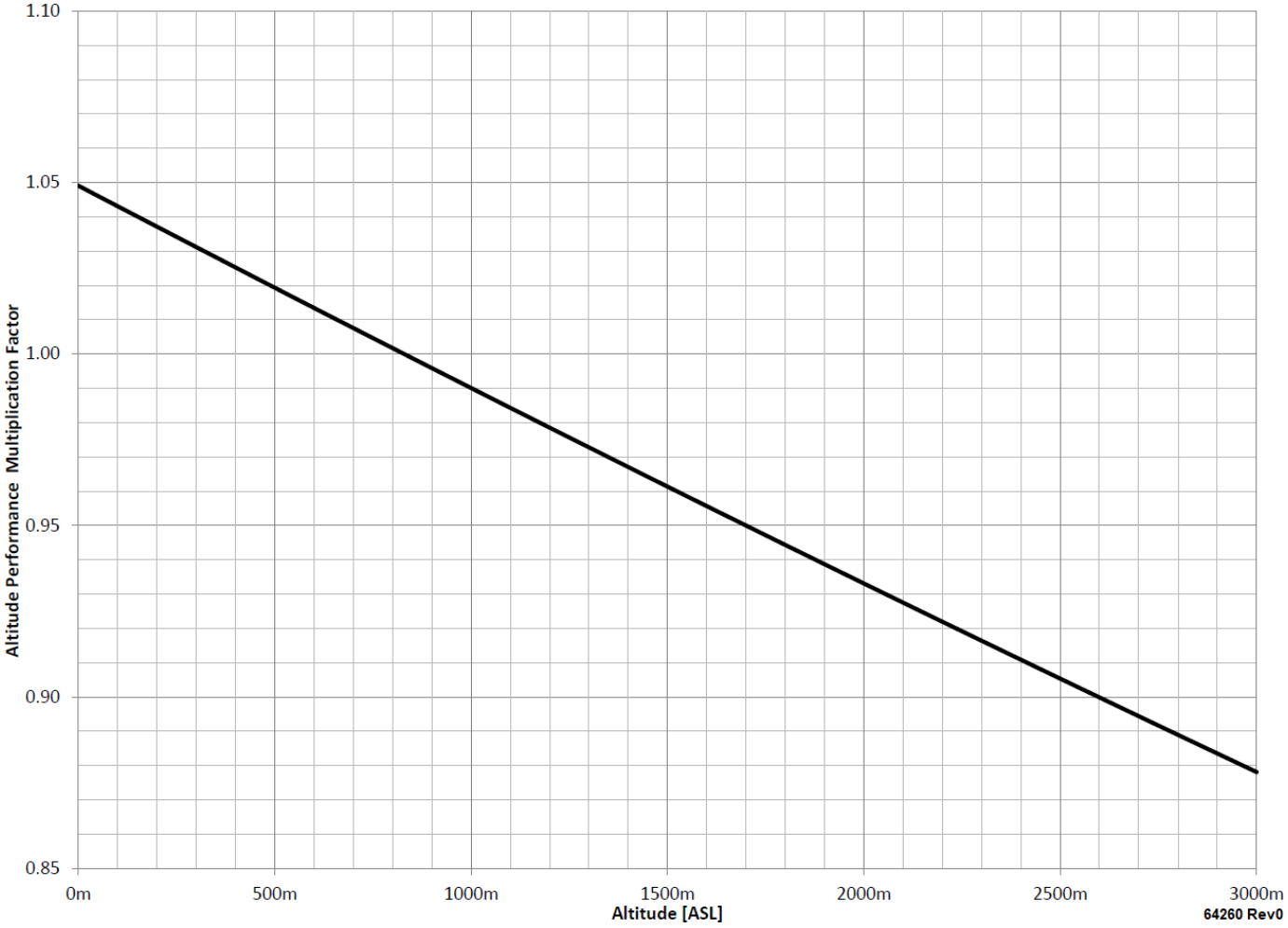


Figure 6 Thermoelectric Power Unit Altitude Derate Curve

4.3 TARGET SET-UP POWER CALCULATION

Calculate the target setup power as follows:

Target power (W) = Data Plate Power (W) x Temperature Factor x Altitude Factor

Example:

Target Power of a unit with Factory Power of 525 W at 35°C ambient and 1000 m altitude = 525 W x 0.975 x 0.990 = 506.7 W

Note: Customer available power is the target setup power minus the power losses of the system.

4.4 CUSTOMER POWER OUTPUT

The S-8500 TEG incorporates protective electronics modules designed to maintain optimum

conditions, protect the power unit, and regulate the output voltage.

If no customer load is attached to the TEG or the Customer Load circuit breaker is "OFF" during normal operation, the electronics act to draw a load on the power unit as well as to maintain the output voltage set by the operator.

WARNING: Disconnecting the electronics can result in overvoltage conditions which can cause damage to the customer load. Prolonged open circuit conditions can also lead to permanent damage of the power unit due to overheating of the internal components. The electronics should never be tampered with and if damage is suspected, contact GPT for replacement parts and service instructions.

The power expected at the output of the TEG needs to account for the power losses within the system. Power losses come from interconnections as well as power required to run the High-Power Limiter, the solenoid valves, the spark ignitor module and controller and any additional options that may have been added. These electronics have been designed to draw as little power as possible but are required for safe and reliable operation. Tampering with the electronics will potentially damage the TEG, leading to the unit being out of service and requiring repair.

The nominal power required by the TEG control system is 20 Watts. This may vary but will increase by up to 3 Watts when the internal battery is being recharged.

Calculate the expected power at the customer output terminals as follows:

Output power [W] = Target Setup Power (W) - Control System Power Losses [W]

Example:

Previously setup TEG (Target Setup Power = 539W) at 55 ^{O}C and sea level (0 m ASL) = 539 W - 23 W = 516 W

5 PERIODIC BASIC MAINTENANCE

The TEG requires periodic basic maintenance to provide the expected continuous and steady operation. The maintenance interval depends on the site conditions (fuel purity, environment, etc.) and must be established based on-site records. Based on field experience, the recommended periodic basic maintenance interval is once a year.

In addition, a power output evaluation should be performed and recorded based on Section 4.3 prior to basic periodic maintenance. Additional maintenance might be required if the output power is significantly lower than the target power, in which case contact the Customer Service Department at Global Power Technologies (GPT). The following sections explain the required basic maintenance for TEG sub-systems.

5.1 FUEL SYSTEM

WARNING: ***CONDENSATE FROM REGULATOR IS VERY HIGH-RISK OF BEING FLAMMABLE.***

When draining condensate from regulator, ensure it is removed from cabinet and is a safe distance from ignition sources.

If there is a concern about liquids in the fuel line, it is suggested that the customer install a regulator drain line to remove condensate to a safe location away from ignition sources.

Condensate collecting/pooling/splashing/etc. inside the TEG cabinet creates a dangerous fire hazard. Contact GPT for assistance with fuel conditioning options to remove liquids from fuel line supply.

WARNING: Check for fuel leaks after any fuel system service.

Note: Pressure gauge vent plug must be open to measure the correct fuel pressure.

Follow these steps to drain the Sediment Bowl:

1. Shut off the fuel supply and allow TEG to cool; approximately 1 hour.
2. Open the drain cock located on the underside of the TEG cabinet, any impurities will drain through the cock.
3. Close drain cock.
4. Leak check the drain cock.

5.1.1 Fuel Filter Replacement

See Figure 7, follow these steps to remove the fuel filter:

1. Shut off the fuel supply and allow TEG to cool.
2. Drain the sediment bowl by opening the drain cock.
3. Remove the four screws from the bottom of the regulator.

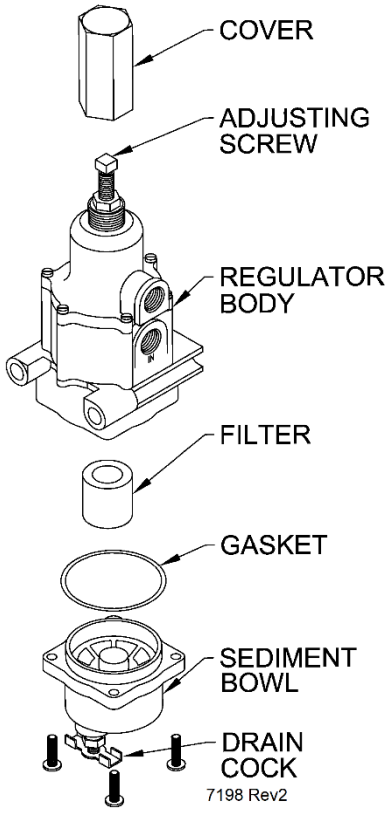


Figure 7 Fuel filter servicing

4. Remove the filter, and gasket.

Follow these steps to install the fuel filter:

1. Install the filter, and gasket onto the sediment bowl.
2. Carefully replace the bottom of the regulator making sure the filter and gasket are in their proper position.
3. Align the sediment bowl with the regulator body, replace the four screws and tighten.
4. With the fuel pressure on, leak check all regulator joints and fuel connections using a commercial leak detector.

5.1.2 Fuel Orifice Inspection

Follow these steps to inspect the fuel orifice, see Appendix F, Figures 17 & 18:

1. Shut off the fuel supply and allow TEG to cool; approximately 1 hour.
2. Disconnect the fuel line from the solenoid valve.
3. Disconnect the other end of the fuel line from the orifices on the main and pilot line.
4. Remove the orifice fitting from the spark post and main venturi.
5. Visually check each orifice hole. It should be free from any obstructions. Replace it if necessary. Use magnifying glass to aid with visual inspection.
6. Connect the orifice fittings back on the spark post and venturi. Both orifice fittings (on the main venturi and spark post) only need to be finger tight when reassembling the parts.

   CAUTION: Always use the same size orifice as was removed.

   (See Appendix F - Parts list)
7. Connect the fuel line to solenoid valve and orifice, then tighten the fuel line fittings.
8. Leak check all connections using a commercial leak detector.

5.2 BURNER MAINTENANCE

Burner internals are maintenance free for most applications. If the required power still cannot be achieved after servicing the fuel system, air filter and checking the cooling fins then it may be necessary to check and service the burner internals. The procedures below give the steps for inspecting the burner components.

Follow these steps to remove the burner:

1. Shut off the fuel supply to the TEG and allow it to cool.

WARNING: The burner reaches extreme temperatures. The TEG must cool for at least 3 hours or more, otherwise personal injury will result during handling. Always be cautious when beginning maintenance since parts may not yet have cooled sufficiently to handle.

2. Disconnect the supply fuel line and fuel inlet valve.
3. Disconnect the solenoid wire terminal connections and the pressure switch wire connections.
4. Remove the ignition cable assembly and associated green wire from the electrode assembly. See Appendix F, Figure 17.
5. Remove the venturi, electrode assembly, spark post assembly and venturi

wye based on Figure 17, Appendix F.

6. Disassemble the burner based on Appendix F, Figure 15.
7. Follow these steps to inspect the burner:
   a. Check the main venturi. If it looks severely corroded, it should be replaced.
   b. Check the spark post assembly. If the tip is showing black deposits, remove the spark electrode, clean the tip using a soft wire brush, clean residues and check for material degradation.
   c. Check the air intake is not being blocked.
   d. Check the flame holder in the burner for debris, warpage, misalignment, etc. Replace if required.
8. Reinstall the burner. Tighten the three burner screws (B9 in Appendix F, Figure 15) to get a 16mm (5/8") gap between the two mounting plates (B7 and B8)
9. Continue to reinstall parts in the reverse order of disassembly.

Note: Both orifice fittings, on the main venturi and spark post, only need to be finger tight when reassembling the parts.

10. Before re-starting the TEG, leak check all fuel connections.

5.3 SI SYSTEM MAINTENANCE

5.3.1 Follow these steps to check the spark electrode:

1. Remove the spark electrode by loosening the fitting nut at the bottom of the spark post and sliding the electrode out, (see Appendix F, Figure 17).
2. Inspect the electrode for any cracks in the ceramic rod. If any cracks are found the electrode must be replaced.
3. Inspect the electrode tip for corrosion, debris build up or impurities formed on the electrode tip. If electrode tip is corroded or excessive impurities have formed, the electrode must be replaced.
4. Fully insert the electrode, and then pull it back until the ceramic rod extends the correct distance below the spark post fitting. For Natural Gas the correct distance is 34 mm (1.35"); for Propane the correct distance is 26.7 mm (1.05"). Check the TEG data plate for the fuel type.

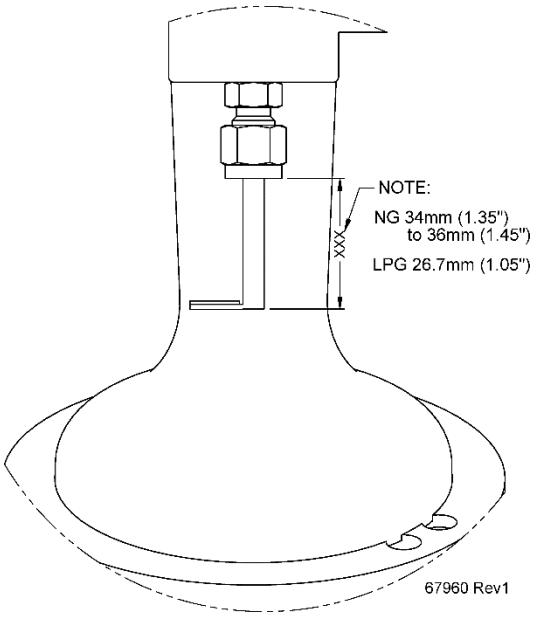


Figure 8 S-8500 Electrode Position

5. Tighten the fitting nut only until it is snug. Ensure the ceramic rod remains at the previously specified distance.
6. Loosen or remove the wire connectors from the pressure switch and then short circuit the two wires. Sparking should occur in the combustion chamber (making a clicking noise).

5.3.2 Battery

Follow these steps to check the battery voltage:

1. Open the front of the electronics box.
2. Locate the battery, see Appendix F, Figure 18
3. Disconnect the connector with the brown and white wires from the battery to remove the battery from the system.
4. Measure the Battery Voltage between the +/- test points on the battery interconnect board assembly. The voltage should be greater than 6 V.
5. If the voltage is less than 6 V the battery assembly needs recharging or replacing.

5.3.3 Check the Operation of the Ignition Control Module and Spark Generation

1. Verify that the ceramic rod protrudes the correct distance, see 5.3.1.
2. Start the TEG.
3. If sparking occurs, the ignition control module is functioning.
4. If no sparking occurs, verify on the SI Controller board that the SI Power indicator light is turn on, (see Appendix G, Table 4). If it is on, check that the two boards are connected with good contact, otherwise replace the SI module.

5.3.4 Check the spark return path for the SI module

1. Verify the Green wire in the Ignition cable assembly is connected to the Spark post assembly.
2. Verify that the green wire in the Ignition cable assembly is connected to the SI module SPARK RETURN (See Appendix G, Figure 22).
3. Both connections are required for the SI module to properly detect flame recognition. See wiring diagrams Appendix D, Figures 13 and 14 for reference.

5.3.5 Pressure Switch

Follow these steps to check the pressure switch:

1. Remove the two wires from the pressure switch and connect a multi-meter across the pressure switch terminals, set to measure resistance (ohms).
2. If there is no fuel pressure in the system, check the resistance measured across the switch is near infinity, which indicates the switch is open.
3. Provide fuel pressure to the switch by opening the manual shut-off valve.
4. Check that the resistance measured across the switch is near zero, which indicates the switch is closed. Replace the pressure switch if necessary.

Note: Switch should close at pressures above 13.8 kPa (2 psi).

5. Remove fuel pressure from the switch by closing the manual shut-off valve and use a wire to join the two removed pressure switch wires together. This will cause the system to attempt a start which will release the trapped fuel.
6. If the Remote Start (TEG Controller) option has been installed, refer to Appendix I - Option for starting instructions to release the trapped fuel.
7. Check the resistance measured across the switch is near infinity, which indicates the switch is opened. Replace the pressure switch if necessary.

Note: Switch should open at pressures below 6.9 kPa (1 psi).

8. The SI controller must recognize that there is fuel available by the closed pressure switch condition before it will power the SI module.

5.3.6 Solenoid Valve

1. If at the beginning of a sparking cycle, the solenoid is not heard to click open, no fuel can flow. Unplug the solenoid valve connector at the solenoid, see Appendix F, Figure 16, item C5-A. Measure the voltage between the blue and brown wires; it should be around 12 V when the SI module is sparking. If it is, check the solenoid.
2. Check the resistance of the 12V solenoid valve. Replace the solenoid valve if the resistance is not within 65 ohm +/- 20%.
3. If the voltage between the blue and brown wires is not around 12V, measure the voltage on the solenoid connector of the SI Controller board, between the blue and brown wires (V1 +/-) when the SI module is sparking and the pilot solenoid valve indicator L1 is on. See Figure 22. If it is, replace the solenoid wiring harness. If it isn't, replace the SI module.
4. The main solenoid valve turns on 60 seconds after the pilot valve. The same process can be used for the main valve. Reference Appendix F, Figure 16, item C5 and Figure 3.

5.4 COOLING SYSTEM

For optimum performance, make sure the top of the cooling fins remains free of debris, such as leaves, that would prevent air flow. No further cleaning of the cooling system should be required. Should the fins become caked with dust or mud, it may be necessary to remove the dust and mud by the most appropriate method at hand, such as using compressed air, a long soft brush or use of water spray.

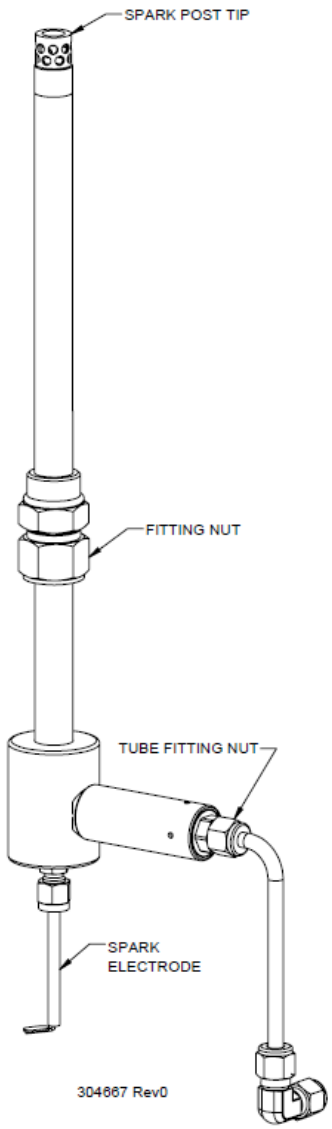
Addendum to 64131 Rev3 (S-8500 Manual)

5.5 SPARK POST ASSEMBLY

The spark post requires periodic inspection to evaluate its condition and to ensure proper TEG operation.

Follow these steps to remove the spark post assembly:

1. Shut off the fuel supply to the TEG and allow it to cool.
2. Remove the spark ignition cable from the spark electrode and unscrew the green grounding wire.
3. Disconnect the spark post assembly from the fuel line by loosening the tube fitting nut connected to the pilot fuel orifice.
4. Loosen the fitting nut connecting the shaft of the spark post to the TEG. Loosening the bottom nut is preferred for ease of reinstallation.
5. Pull the spark post assembly out of the TEG. Twist the assembly if required.



Once removed, the spark post assembly should be properly inspected for any degradation or damage. Specifically, inspect the spark post tip for any erosion or cracks, as well as any excess deposits that may have formed. If any damage is seen, please replace the spark post assembly.

Install the spark post assembly in the TEG by following these steps:

1. Push the spark post assembly into the TEG.
2. Tighten the fitting nut on the shaft of the spark post assembly to secure it to the TEG.
3. Connect the spark post assembly to the fuel line by tightening the tube fitting nut onto the pilot fuel orifice.
4. Screw on the green grounding wire to the spark post base, and attach the spark ignition cable to the spark electrode.

6 TROUBLESHOOTING

Problem	Probable Cause	Possible Solution	Lookup Section
Burner does not ignite	Air in fuel line	Purge fuel lines of air or attempt restarting the TEG.	*Installation*
	Supply gas Pressure too low	Increase the gas supply pressure to the TEG	*Installation*
	Fuel filter dirty	Drain the regulator sediment bowl	*Maintenance*
		Replace the fuel filter	*Maintenance*
	Fuel pressure adjustment incorrect	Adjust the TEG fuel pressure	*Operation & Performance*
	Fuel orifice plugged	Replace the fuel orifice	*Maintenance*
	Fuel orifice size incorrect	Replace the fuel orifice	*Maintenance*
	Air-shutter adjustment incorrect	Adjust the air-shutter	*Operation & Performance*
	SI system faulty	Maintain the SI system	*Maintenance*
Burner will ignite but will not continue to burn	Supply gas pressure too low	Increase the gas supply pressure to the TEG	*Installation*
	Fuel filter dirty	Drain the regulator sediment bowl.	*Maintenance*
		Replace the fuel filter	*Maintenance*
	Fuel pressure adjustment incorrect	Adjust the TEG fuel pressure	*Operation & Performance*
	Fuel orifice plugged	Replace the fuel orifice	*Maintenance*
	Fuel orifice size incorrect	Replace the orifice with one of the correct size	*Maintenance*
	Air shutter adjustment incorrect	Adjust the air-shutter	*Maintenance*
	SI system faulty	Maintain the SI system	*Performance*

TROUBLESHOOTING *continued*

Problem	Probable Cause	Possible Solution	Lookup Section
Low output power	Setup power incorrect	Determine required setup power for present ambient temperature at site and adjust	*Performance*
	Airflow past cooling fins insufficient	Clean the cooling fins of any debris	*Maintenance*
	Fuel filter dirty	Drain the regulator sediment bowl	*Maintenance*
	Fuel orifice plugged	Replace the fuel orifice	*Maintenance*
	Fuel orifice size incorrect	Replace the orifice	*Maintenance*
	Fuel pressure adjustment incorrect	Adjust TEG fuel pressure	*Operation & Performance*
	Air-shutter adjustment incorrect	Adjust air-shutter	*Performance*
	High Power Limiter damaged	Replace the High-Power Limiter electronics	*Contact GPT*
	Power unit damaged	Contact GPT	*Contact GPT*
Output power is too high	Fuel pressure adjustment incorrect	Adjust the TEG fuel pressure	*Operation & Performance*
Output voltage is too high	High Power Limiter adjustment incorrect	Adjust the High-Power Limiter electronics	*Operation*
	High Power Limiter damaged	Replace the High-Power Limiter electronics	*Contact GPT*
Low output voltage	High Power Limiter adjustment incorrect	Adjust the High-Power Limiter	*Operation*
	Overloaded TEG	Reduce customer load	*Performance*

APPENDIX A: TECHNICAL TERMS & DEFINITIONS

High Power Limiter: Protective electronics modules designed to maintain optimum conditions, protect the power unit, and regulate the output voltage.

Open Circuit Voltage: Voltage at the terminals of the power unit when no current is flowing through the power unit, i.e., open circuit, which is related to the temperature across the thermoelectric materials inside the power unit.

When a power unit lead is suddenly disconnected, breaking the circuit to the load, the voltage measured across the power unit leaps up to a new value. This is known as the momentary open circuit voltage (V_{oc}).

Power Unit (PU): The hermetically sealed portion of the TEG that contains thermoelectric materials.

Rated Power: Model S-8500 TEG produces 520 W when operating in an ambient temperature of 20 ºC (68 ºF).

Set-up Voltage: V_{set}: Voltage from the power unit for a specific ambient temperature when the power unit is operated in a known state, which is proportional to set-up power. Fuel flow to the burner is adjusted so that proper voltage and necessary temperature difference within the power unit are maintained, delivering the required power.

APPENDIX B: TECHNICAL SPECIFICATIONS

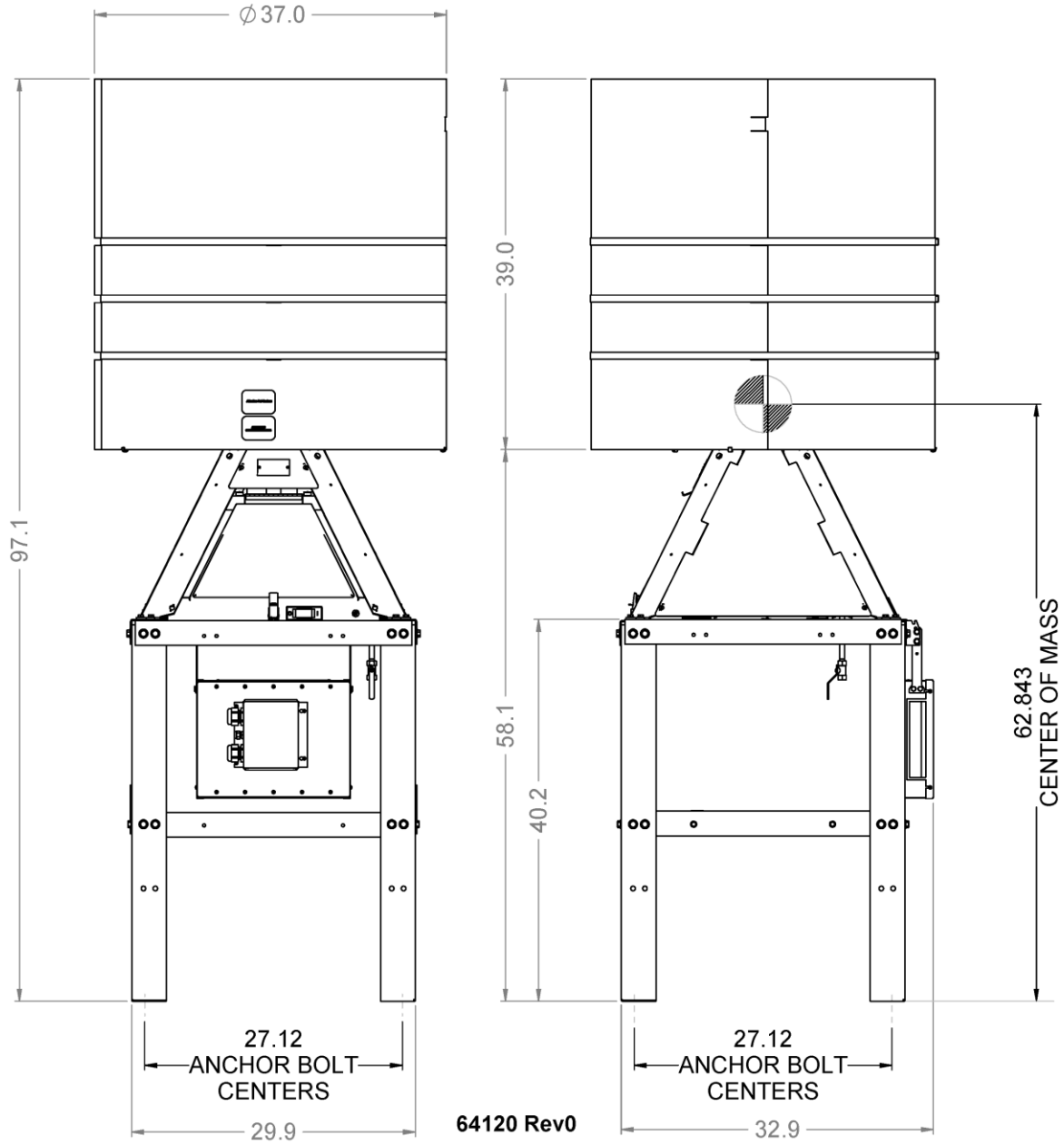


Figure 9 Overall Dimensions, Centre of Mass, and Anchor bolt pattern

Overall Diameter (Footprint)	940 mm (37.0 in)
Depth - Support Base	840 mm (32.9 in.)
Width - Support Base	760 mm (29.9 in.)
Height	2466 mm (97.1 in.)
Net Weight	273 kg (603 lbs)
Shipping Weight	415 kg (916 lbs)
Mounting Holes	689 mm × 689 mm (27.12 in. × 27.12 in.)

Table 1 Overall Dimensions, Weight, and Anchor bolt pattern

Parameter	Limit	Value [Unit]
Fuel Supply Pressure	Maximum	344 kPa (50 psi)
	Minimum (Natural Gas)	103 kPa (15 psi)
	Minimum (Propane)	165 kPa (24 psi)
Ambient Temperature (Operation)	Minimum	-40ºC (-40ºF)
	Maximum	55ºC (130ºF)
Ambient Temperature (Storage)	Minimum	-55ºC
	Maximum	65ºC
Wind Loading	Maximum (Operation)	112 kmh (70 mph) Structural integrity
	Maximum (Structural)	200 kmh (120 mph) Some damage to panels expected
Altitude above sea level (ASL)	Maximum	3000 m (9850 ft)
Load Current	Maximum	28 A
Load Transient	<30%	50% Load step
	<50%	100% load step
Design Life	>15 Years	
Start Cycles	>150	

Table 2 Absolute Maximum & Minimum Ratings

CAUTION: Under severe wind loading conditions some damage to sheet metal parts can be expected. In such cases, inspect for damage prior to being returned to operation. If excessive damage is found contact GPT.

Parameter	Value	Notes
Output Power	520 W @ 24 V	At 20^{O}C 750m ASL at output terminals including reverse current diode losses at beginning of life.
Start-up time	15 Minutes to 80% Rated Power	Nominal
Output Voltage Adjustment	24 to 30 V	24 V model factory set to 27.0V
Power Derate Factor	-1.4 W/ºC	Above 25 ºC
Power Degradation	<0.2%/Year	Nominal @ 20 ºC
Reverse Current Protection	Yes	Via output diode
Overload Protection	Yes	Voltage fold-back
Maximum Output Current	28 A	Protected by 30 A Circuit Breaker
Output Connections	Screw type terminal block, #10 studs. Wire copper diameter no smaller than 8 AWG. Hole for up to 1” conduit connector.	
Output Voltage Regulation	<1%	% of Set-point
Output Voltage Temperature Drift	+/- 0.03%/ºC	
Output Voltage Ripple	<1%	% of Set-point
Fuel Consumption	50.4 Sm^3/day (1780 Sft^3/day) 1000 BTU/Sft^3 (37.7 MJ/Sm^3)	Natural Gas
	76.0 liters/day (20.1 US gal/day)	Propane
Fuel Connection	1/4” FNPT	
Temperature Compensated Battery Charging (TCBC)	Yes, when enabled	
System Station Battery Type	Lead-Acid, 12 cells	Valve Regulated, Absorbed Glass Mat or Flooded Type
Temperature Compensation Range	-20 ºC to +45 ºC	
Temperature Compensation Factor	-5.5 mV/ºC / 240cell	Nominal factor
Voltage Sense Relay (VSR)	Two	Each with single Normally Open (NO), Normally Closed (NC) contacts,16-28 AWG Wire
VSR1 Adjust	20 to 32 V	Factory set to 23.0 V

Parameter	Value	Notes
VSR2 Adjust	20 to 32 V	Factory set to 28.5 V
VSR Contact Rating	1 A	@ 30 VDC
Voltage Limiter User Interface	Yes	Via Digital Multimeter
Voltage Measurement Accuracy	+/- 1.5%	% of Set-point
Current Measurement Accuracy	+/- 2.0%	% of Set-point
Power Measurement Accuracy	+/- 2.5%	% of Set-point
Emissions	<50 ppm CO <30 ppm NOX	Nominal correct air / fuel set-up
Acoustic Signature	<75 dB(A)	@ 1 m distance
Humidity	100% Condensing	Up to 10 mm/ min
Seismic	Rated Zone 4	
Primary Materials of Construction	Cabinet & Duct 304 SS Cooling system 1100 & 6061 Series Aluminum Fuel System contains Stainless and Brass fittings	

Table 3 Absolute Maximum & Minimum Ratings (24V model)

STANDARD SPECIFICATION FOR GASEOUS FUEL

Gaseous fuels supplied to Global Power Technologies' Thermoelectric Generators:[1]

1. Shall not contain any particulates larger than 30 µm diameter, including but not limited to sand, dust, gums, crude oil, and impurities.
2. Shall not have a hydrocarbon dew point in excess of 0ºC (32ºF) at 170 kPa_g (25 psi_g).
3. Shall not contain more than 115 mg/Sm^3 [2] (approx. 170 ppm) of H_2S [3].
4. Shall not contain more than 60 mg/Sm^3 (approx. 88 ppm) of Mercaptan Sulphur.
5. Shall not contain more than 200 mg/Sm^3 (approx. 294 ppm) of total Sulphur.
6. Shall not contain more than 10% [CO_2] and/or [N_2] by volume, nor vary more than ±1% [CO_2] and/or [N_2] during operation.
7. Shall not contain more than 120 mg/Sm^3 of water vapor.
8. Shall not contain more than 1% by volume of free oxygen.
9. Shall have a nominal gross heating value of:
   a) Natural Gas: 37 MJ/Sm^3 (1,000 BTU/Sft^3 [2]) [1]
   b) Propane/LPG: 93 MJ/Sm^3 (2,500 BTU/Sft^3) [1]
   c) Butane: 123 MJ/Sm^3 (3,300 BTU/Sft^3) [1]
10. Shall not exceed 60ºC (140ºF) in temperature.

NOTE:

[1] For gaseous fuels outside of these specifications, please contact Global Power Technologies.

[2] Sm^3 = Standard cubic meter, Sft^3 = Standard cubic foot, of gas at 101.325 kPa (1 atm) and 15ºC (NIST).

[3] Contact local representative or Global Power Technologies if H_2S concentration is greater than 170 ppm.

APPENDIX C: INSTALLATION CLARIFICATIONS

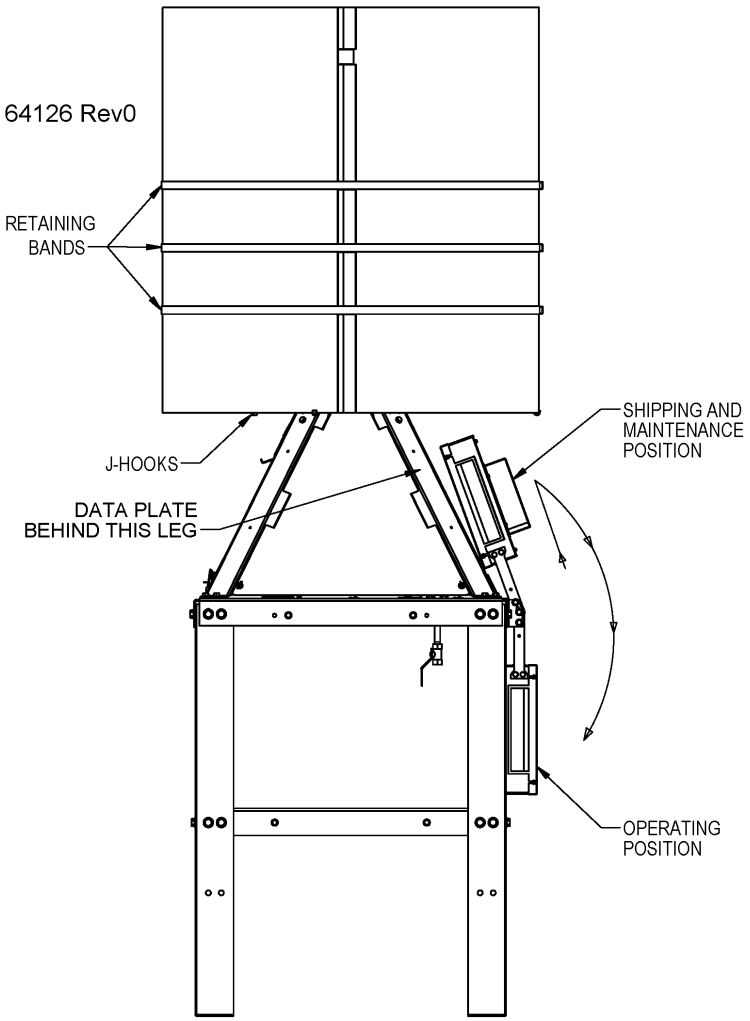


Figure 10 Locating resistor assembly

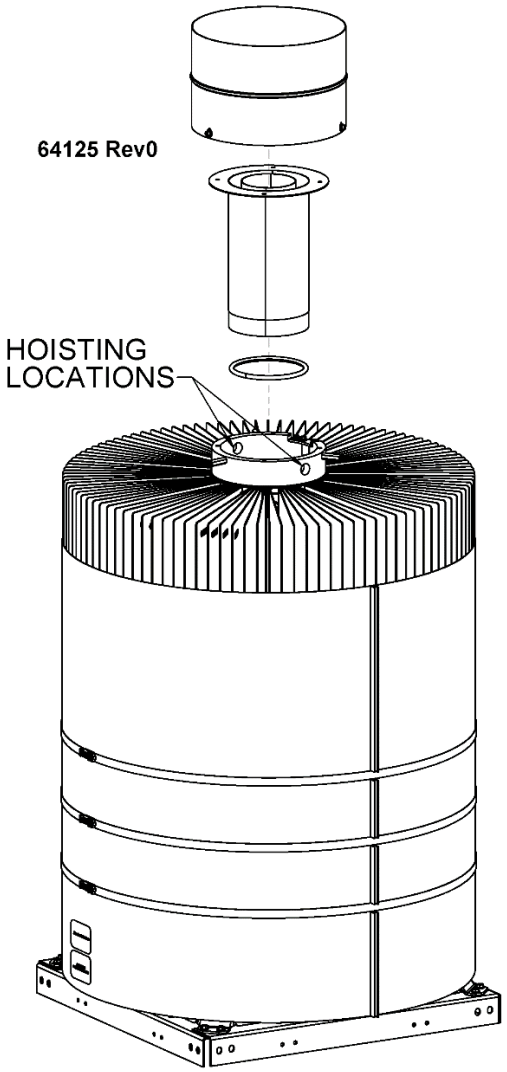


Figure 11 Location of hoisting points

APPENDIX D: ELECTRICAL SCHEMATICS & CONNECTIONS

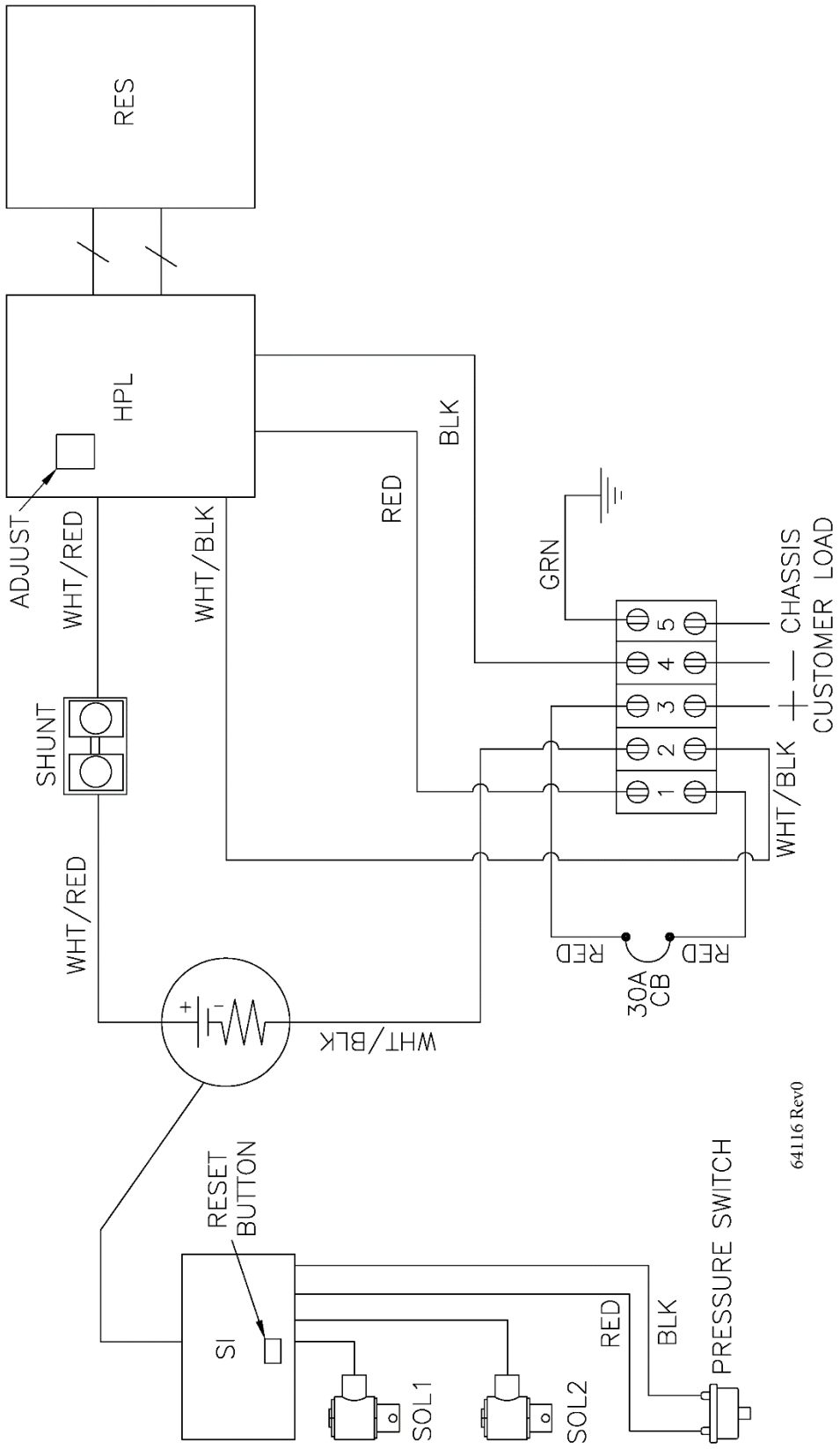


Figure 12 Basic wiring diagram

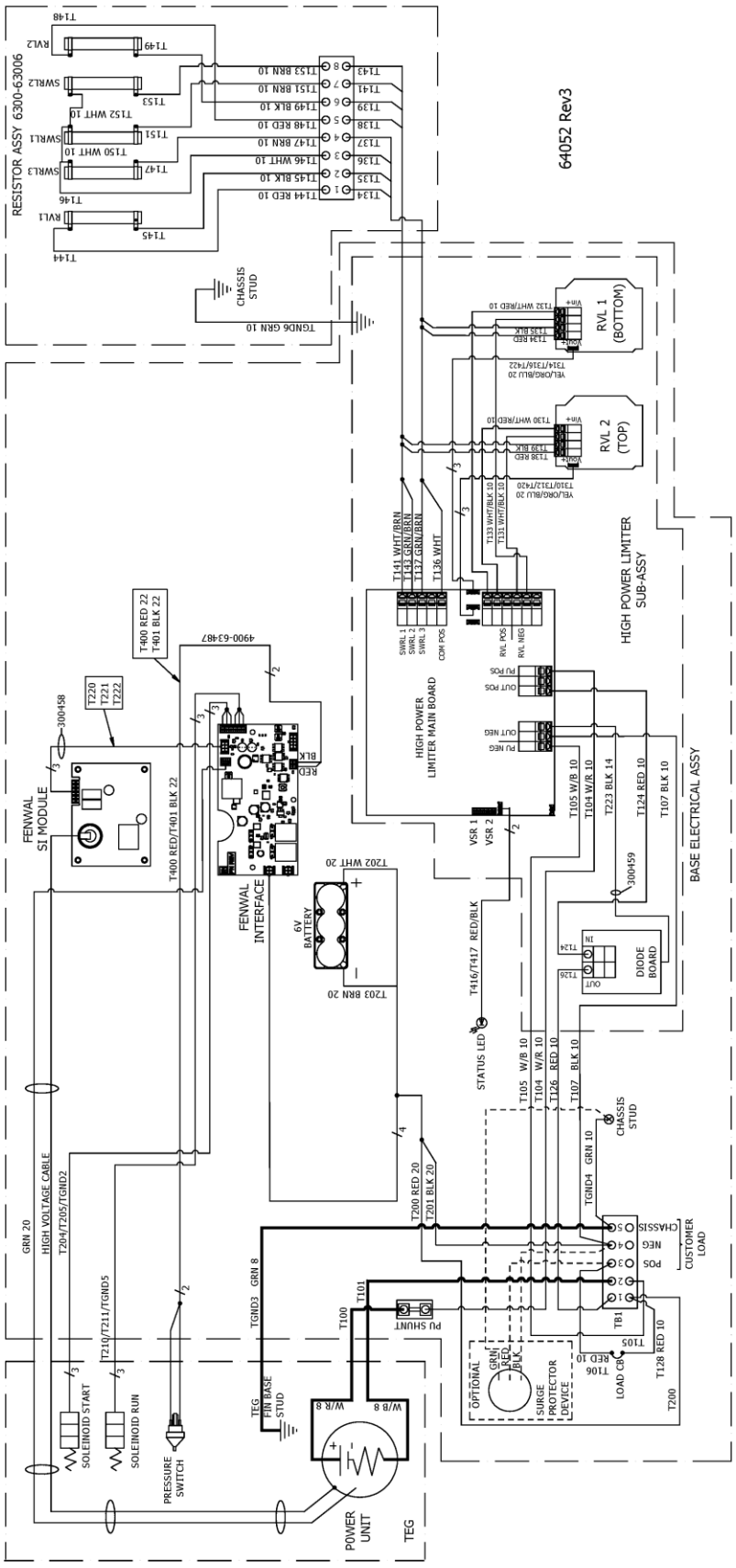


Figure 13 Detailed wiring diagram - Base TEG

APPENDIX E: SERVICE AND INSTALLATION TOOLS

Tools required for service:

- 1 DC Voltmeter, 30V Accurate to 1%
- 1 3/16” hex key (Allan key)
- 2 7/16” wrench
- 2 1/2” wrench
- 2 9/16” wrench
- 1 5/8” wrench
- 1 11/16” wrench
- 1 7/8” wrench
- 1 1” wrench
- 2 Adjustable wrenches, that will open to 16 mm (5/8 in.)
- 1 Flat head screwdriver
- 1 Phillips head screwdriver
- 1 1.8 m (6 ft) step ladder (for any service requiring inspection of the rain cap or exhaust)

Additional tools required for installation:

- 1 Lifting device capable of lifting 273kg (603lbs) under expected weather conditions
- 2 shackles
- 1 Lifting strap, chain, or cable
- 4 Bolts & nuts, #1/2-13 for mounting
- 1 Tape measure

APPENDIX F: MODEL S-8500 PARTS LIST

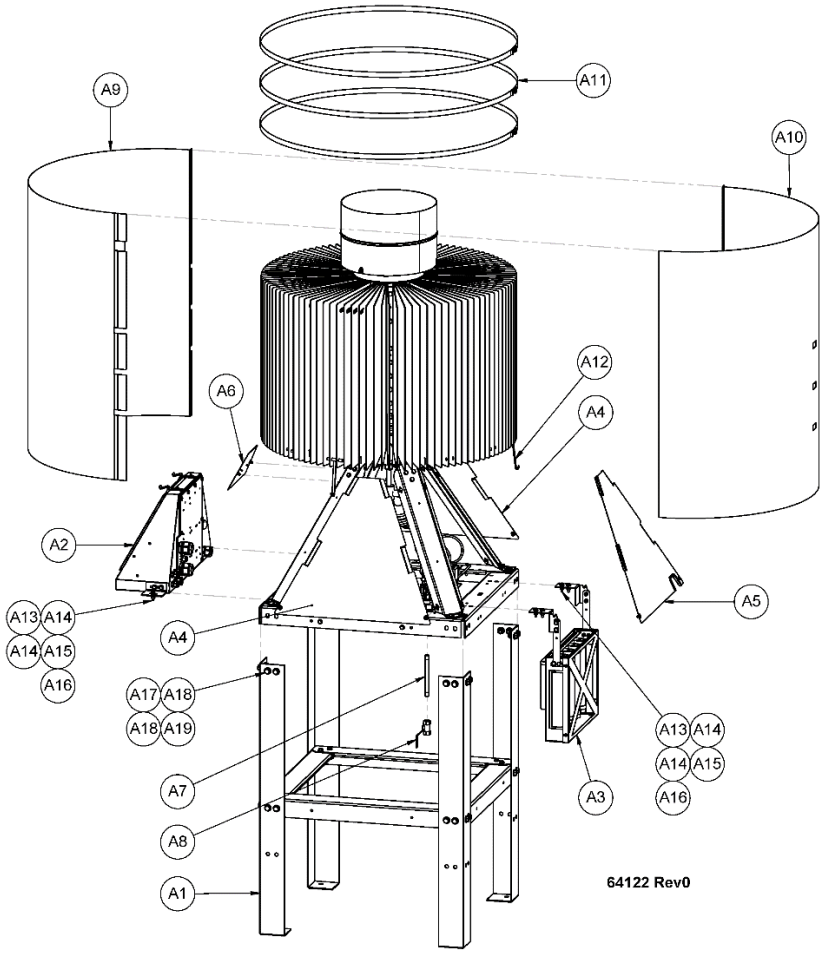


Figure 14 Major sub-assemblies' overview

Item	Part No.	Description
A1	63335	STAND KIT, S-8500
A2	63005	ELECTRICAL BOX ASSY, 24V, S-8500
A3	63006	RESISTOR BOX ASSY, S-8500
A4	63162	PANEL ASSY, CABINET, S-8500
A5	63163	PANEL ASSY, CABINET, W/SLOT, S-8500
A6	63161	PANEL ASSY, UPPER, CABINET, S-8500
A7	62069	NIPPLE, ¼ NPT X 6" LG. BRASS
A8	24653	VALVE, BALL, ¼ NPT, BRASS
A9	62349	FIN DUCT, OUTER HEM & OVERLAP, S-8500
A10	62348	FIN DUCT, INNER HEM, S-8500
A11	62350	CLAMP, BAND, 0.75" WIDE, 36.00-36.35" DIA
A12	62351	J-HOOK, 304 SS, MOUNTING HOOK, FIN DUCT, S-8500
A13	3094	SCREW, HEX HD, ¼-20 X 0.75" LG, SS
A14	557	WASHER, FLAT, ¼", SS
A15	541	WASHER, LOCK, SPRING, ¼, SS
A16	611	NUT, HEX, ¼-20, SS
A17	62789	SCREW, HEX HD, 7/16-14 X 1.0" LG, SS
A18	63336	WASHER, FLAT, 7/16", HARDENED, SS
A19	62790	NUT, HEX, 7/16-14, SS

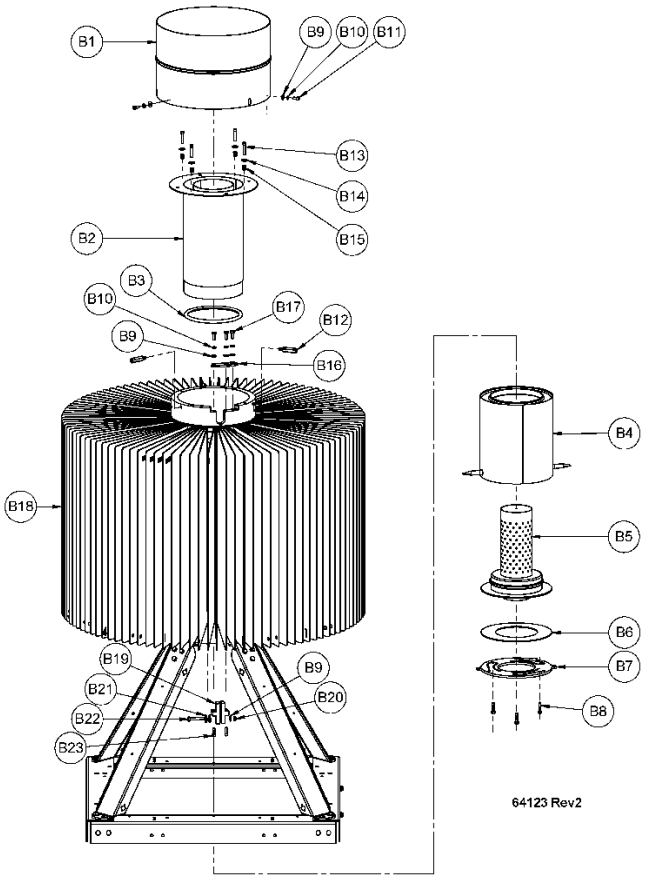


Figure 15 Major sub-assemblies' overview

Item	Part No.	Description
B1	62340	RAIN CAP ASSY, S-8500
B2	61915	EXHAUST STACK ASSY, S-8500 (LPG and NG units made before June 2020)
	300461	EXHAUST STACK ASSY, N, S-8500 (NG units made after June 2020)
B3	5545	EXHAUST GASKET, 8550
B4	8912	POWER UNIT, S-8500, CUSTOMER SERVICE
B5	62331	BURNER ASSY, S-8500
B6	62361	MOUNTING PLATE, UPPER, BURNER, S-8500
B7	62339	MOUNTING PLATE, LOWER, BURNER, S-8500
B8	64208	SCREW, HEX HD, 1/4-20 X 1.25, FULL THRD
B9	557	WASHER, FLAT, 1/4" SS
B10	541	WASHER, LOCK, SPRING, 1/4, SS
B11	266	SCREW, CAP, SOC, 1/4-20 X 1/2 SS
B12	63457	STANDOFF, RAIN CAP, S-8500
B13	1835	SCREW, CAP, SOC, 1/4-20 X 1.25", SS
B14	5578	WASHER, FLAT, 5/16", SS
B15	5576	SPRING, SPAE-NAUR, 610-403
B16	63459	BRACKET, STIFFENER, FIN BASE, S-8500
B17	3094	SCREW, CAP, HEX-HD, 1/4-20 X 3/4 LG, SS
B18	62360	FIN BASE ASSY, S-8500
B19	100108	CLAMP, FIN BASE, S-8500
B20	300230	NUT, HEX, LOCK, FLEX-TOP, 1/4-20, SS
B21	100141	WASHER, DISC SPRING, 1/4, 1989LB, 17-7 PH
B22	72368	SCREW, HEX 1/4-20X1.75 316SS F593G
B23	70839	SCREW, SOC 1/4-20X0.75, FULL THD, 316SS

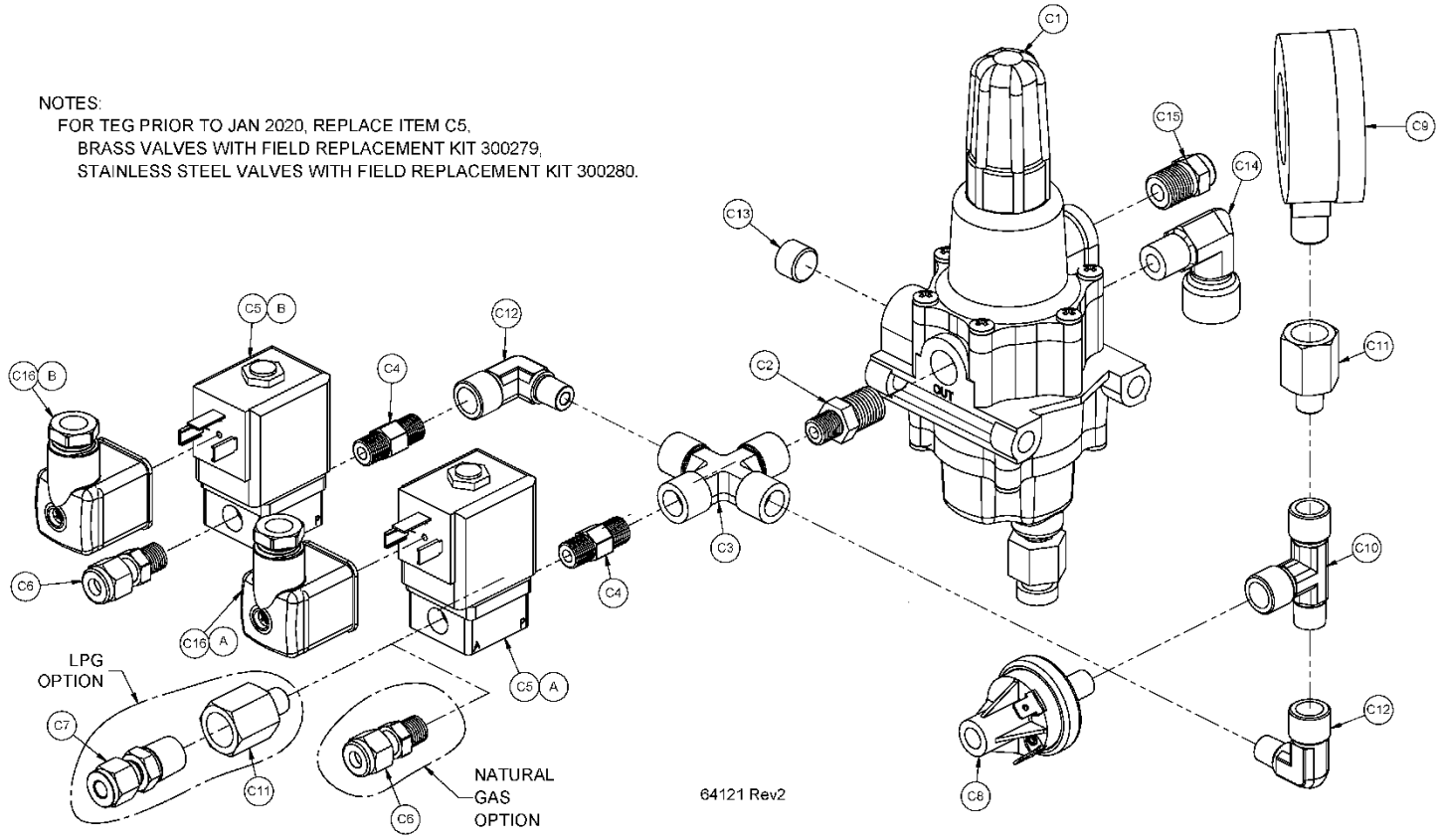


Figure 16 Fuel system overview

Item	Part No.	Description
C1	66048	REGULATOR, FISHER 67CFR, 0-35 PSI, NACE
C2	21108	NIPPLE, HEX REDUCING, 1/4 X 1/8 NPT, SS
C3	50865	CROSS, 1/8 FNPT
C4	7996	NIPPLE, HEX, 1/8 NPT
C5	72158	VALVE BODY, SOLENOID, BRASS
	72282	VALVE BODY, SOLENOID, SS
C6	20977	CONNECTOR, 1/4 TB X 1/8 MNPT
C7	5550	SNUBBER, NAT.GAS, B4SMA-400L
C8	6471	SWITCH, PRESSURE 1.6 PSI
C9	59564	GAUGE, PRESSURE, 0-30 PSI
C10	21109	TEE, STREET, 1/8 NPT, SS, SS-2-ST
C11	51600	REDUCER, 1/4 FNPT X 1/8 MNPT, SS
C12	50289	ELBOW, STREET, 1/8 NPT, SS
C13	58949	PLUG, 1/4” NPT X 7/8” STEEL
C14	21569	ELBOW, STREET 1/4 NPT, BRASS
C15	63181	BREATHER VENT, 1/4 NPT, 316 SS
C16	72322	CABLE PLUG, SOLENOID VALVE, TYPE 2518

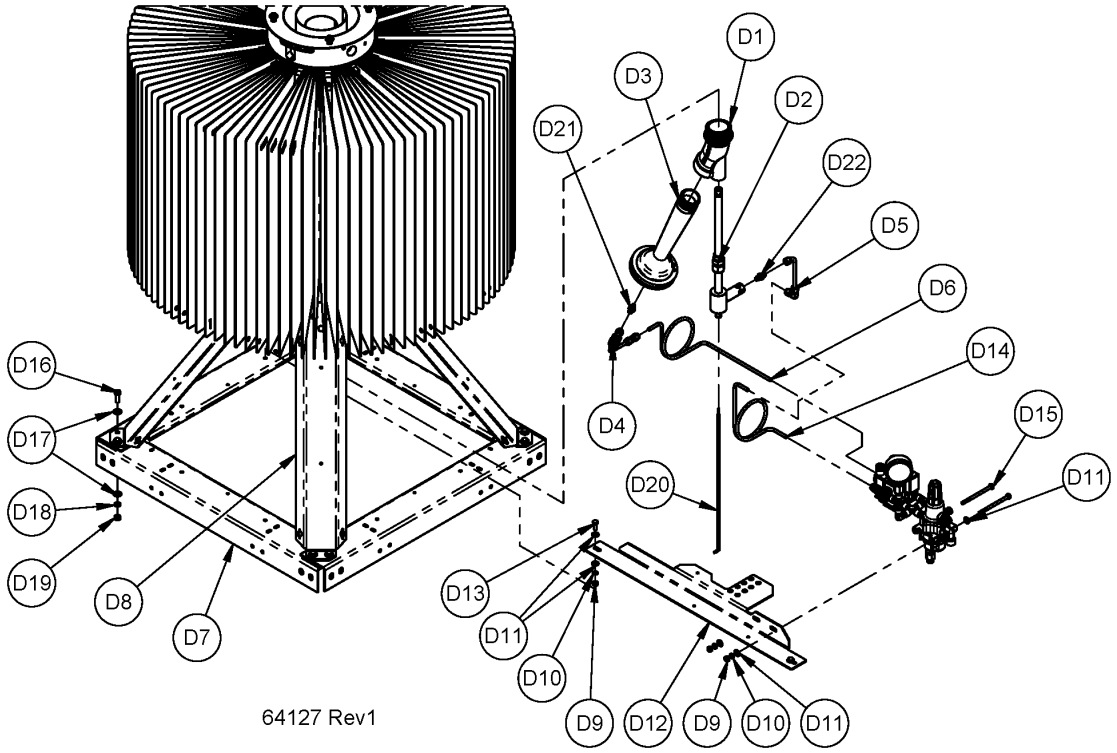


Figure 17 Upper stand assembly and air / fuel system placement

Item	Part No.	Description
D1	62166	VENTURI WYE, CAST, S-8500
D2	63101	SPARK POST ASSEMBLY, S-8500 (LPG and NG units made before Jun 2020)
	300441	SPARK POST ASSEMBLY, N, S-8500 (NG units made after Jun 2020)
D3	63456	VENTURI, NPSH MACHINED,1-1/2" , S-8500
D4	63188	ORIFICE TUBE ASSEMBLY, S-8500
D5	63339	FUEL LINE ASSY, AIR MIXER, S-8500
D6	68097	FUEL LINE, SOLENOID TO VENTURI, W/NUT & FERRULES, S-8500
D7	62336	MOUNTING ANGLE, UPPER, STAND, S-8500
D8	62345	LEG, COOLING SYSTEM MOUNT, S-8500
D9	611	NUT, HEX, 1/4-20, SS
D10	541	WASHER, LOCK, SPRING, 1/4, SS
D11	557	WASHER, FLAT, 1/4”, SS
D12	63070	MOUNTING BRACKET, FUEL SYSTEM, S-8500
D13	3094	SCREW, HEX HD, 1/4-20 X 3/4, SS
D14	68098	FUEL LINE, SNUBBER TO SPARK POST, W/NUT & FERRULES, S-8500
D15	22520	SCREW, HEX HD, 1/4-20 X 3.75” SS
D16	62823	SCREW, HEX HD, 5/16-18 X 1.0” LG, SS
D17	5578	WASHER, FLAT, 5/16”, SS
D18	25648	WASHER, LOCK SPRING, 5/16, SS
D19	5579	NUT, HEX, 5/16-18, SS
D20	62951	ELECTRODE ASSY, SI, S-8500
D21	63454	ORIFICE ASSY, 0.056, S-8500 (for NG)
	22585	ORIFICE ASSY. 0.035 DIAMETER (for LPG)
D22	688	ORIFICE, 6, 0.0185” (for NG units made before June 2020)
	685	ORIFICE, 3, 0.0085” (for NG units made after June 2020)
	686	ORIFICE, 4, 0.0145 (for LPG)

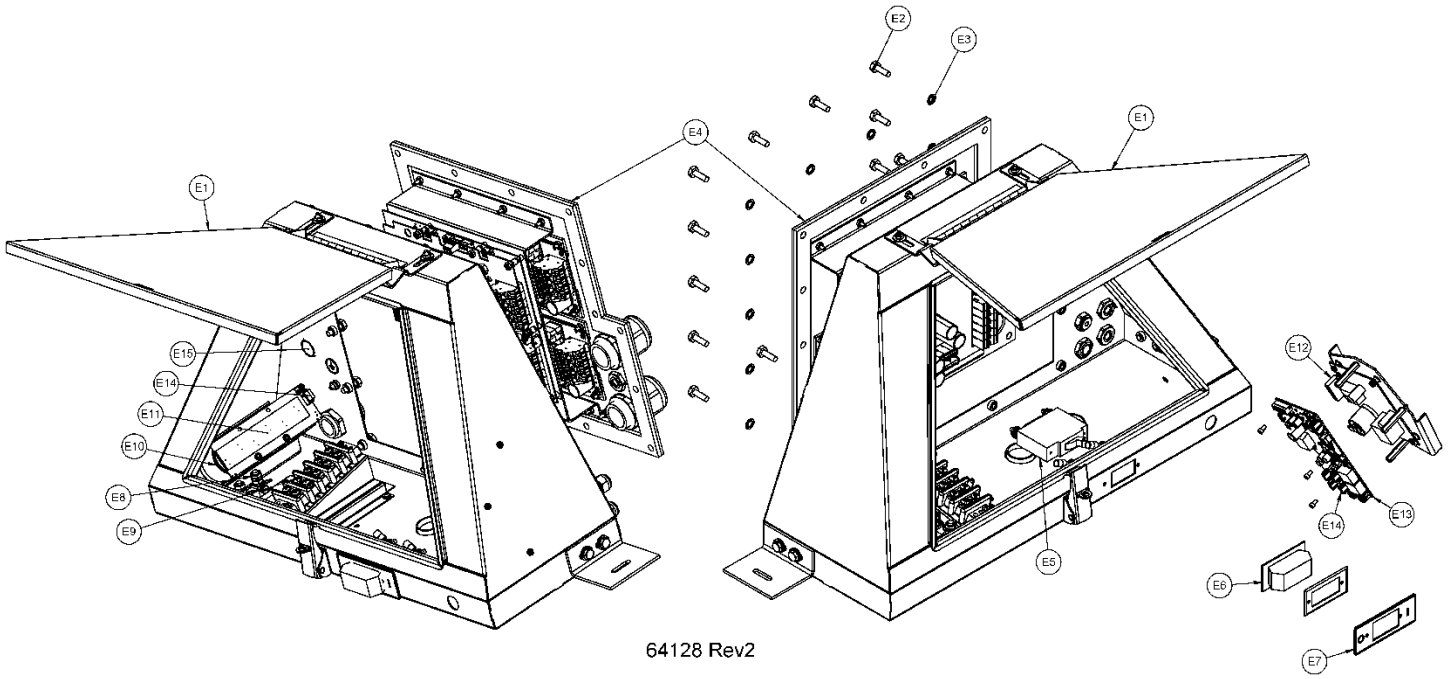


Figure 18 Main electrical enclosure

Item	Part No.	Description
E1	62963	ENCLOSURE ASSY, ELECTRONICS, S-8500
E2	56828	SCREW, CAP, HEX, 1/4-20 X 1/2” LG, SS
E3	470	WASHER, LOCK, INT, 1/4”, SS
E4	62398	HIGH POWER LIMITER ASSY, S-8500,
E5	284	CIRCUIT BREAKER, 30 AMP, 1-POLE
E6	64064	BOOT, CIRCUIT BREAKER, 1-POLE, CLEAR
E7	62416	LABEL, LAMACOID, BREAKER, S-8500
E8	29722	SHUNT, 50 mV. 50 AMP, LA-50-50
E9	29141	TERMINAL BLOCK, 5 POSITION, KULKA 603-5
E10	62422	BATTERY, 2V 5.0 AH
E11	62587	PCB ASSY, X-CELL BATT INTERCONNECT, 6V
E12	69005	SI MODULE, FENWALL, S-1100
E13	300065	PCBM, FENWALL, SI INTERFACE, S-8500
E14	66222	FUSE, 3 AMP, 32V VIOLET MINI ATM
E15	57826	SURGE SUPPRESSOR, 48VDC (OPTION)
NOT SHOWN		
	56980	SENSOR, TEMPERATURE, TRISTAR TS-RTS (OPTION)

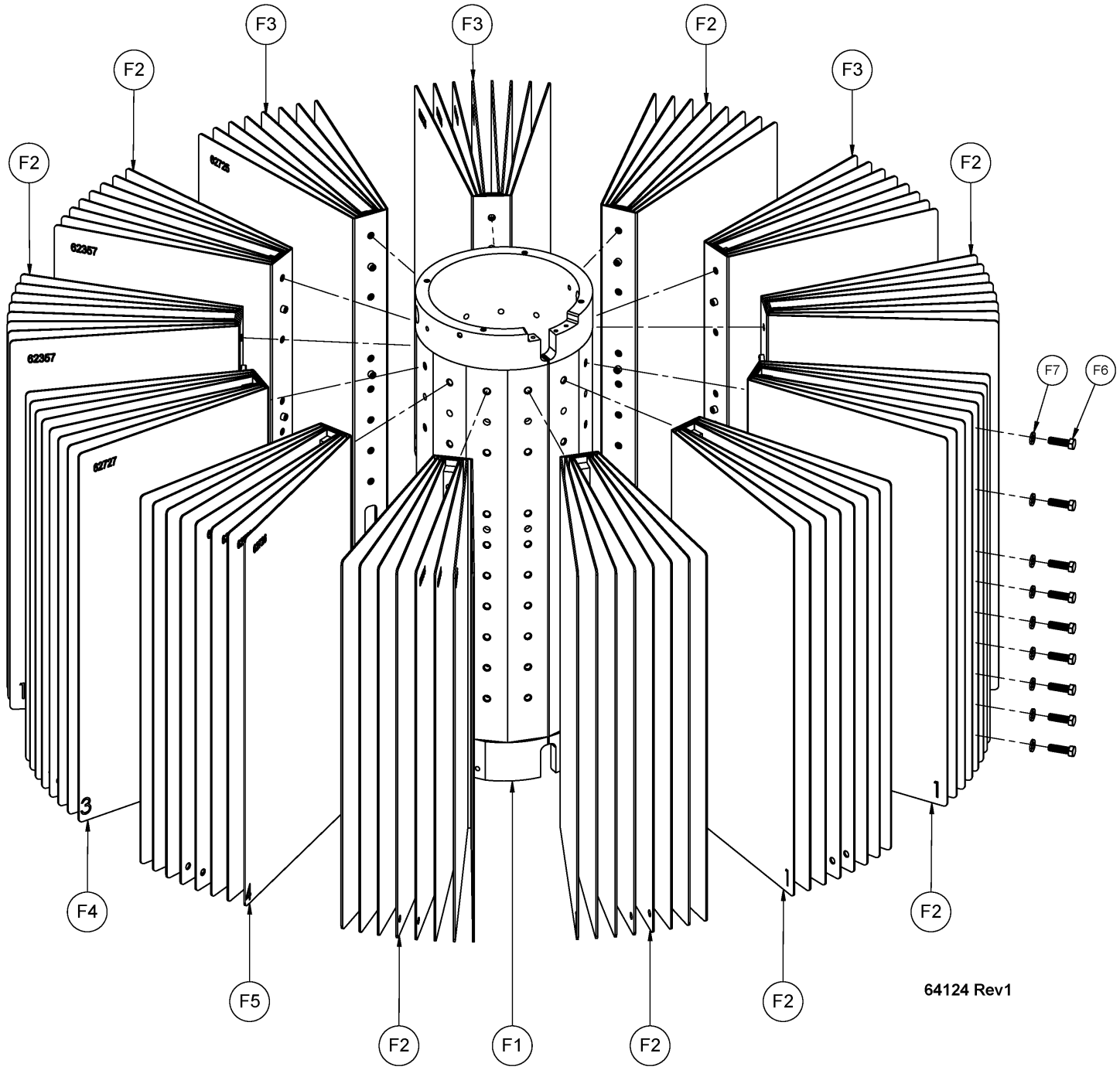


Figure 19 Cooling Sub-System

Item	Part No.	Description
F1	62353	FIN BASE, MACHINED, S-8500
F2, F3, F4, F5	71975	FIN ASSY KIT, S-8500
F6	2390	SCREW, HEX HD, 3/8”-16 x 1.5”,SS
F7	100082	WASHER, DISC SPRING, 3/8”, 4822LB, 17-7 SS

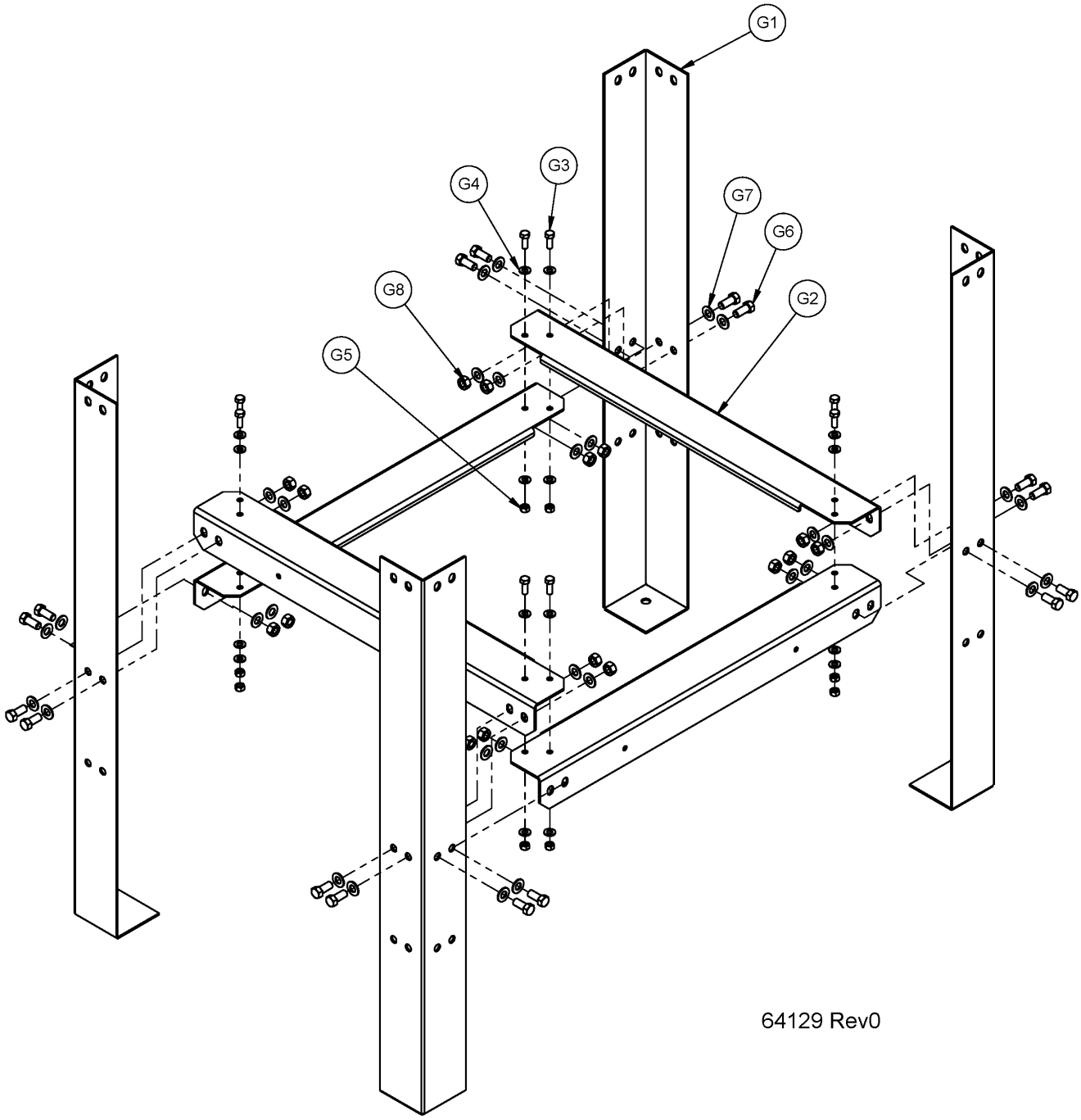


Figure 20 Lower stand assembly

Item	Part No.	Description
G1	62338	LEG, STAND, S-8500
G2	62337	MOUNTING ANGLE, LOWER, STAND, S-8500
G3	62822	SCREW, HEX HD, 5/16-18 X 0.875” LG, SS
G4	5578	WASHER, FLAT, 5/16”, SS
G5	5579	NUT, HEX, 5/16-18, SS
G6	62789	SCREW, HEX HD, 7/16-14 X 1.0” LG, SS
G7	63336	WASHER, FLAT, 7/16”, HARDENED, SS
G8	62790	NUT, HEX, 7/16-14, SS

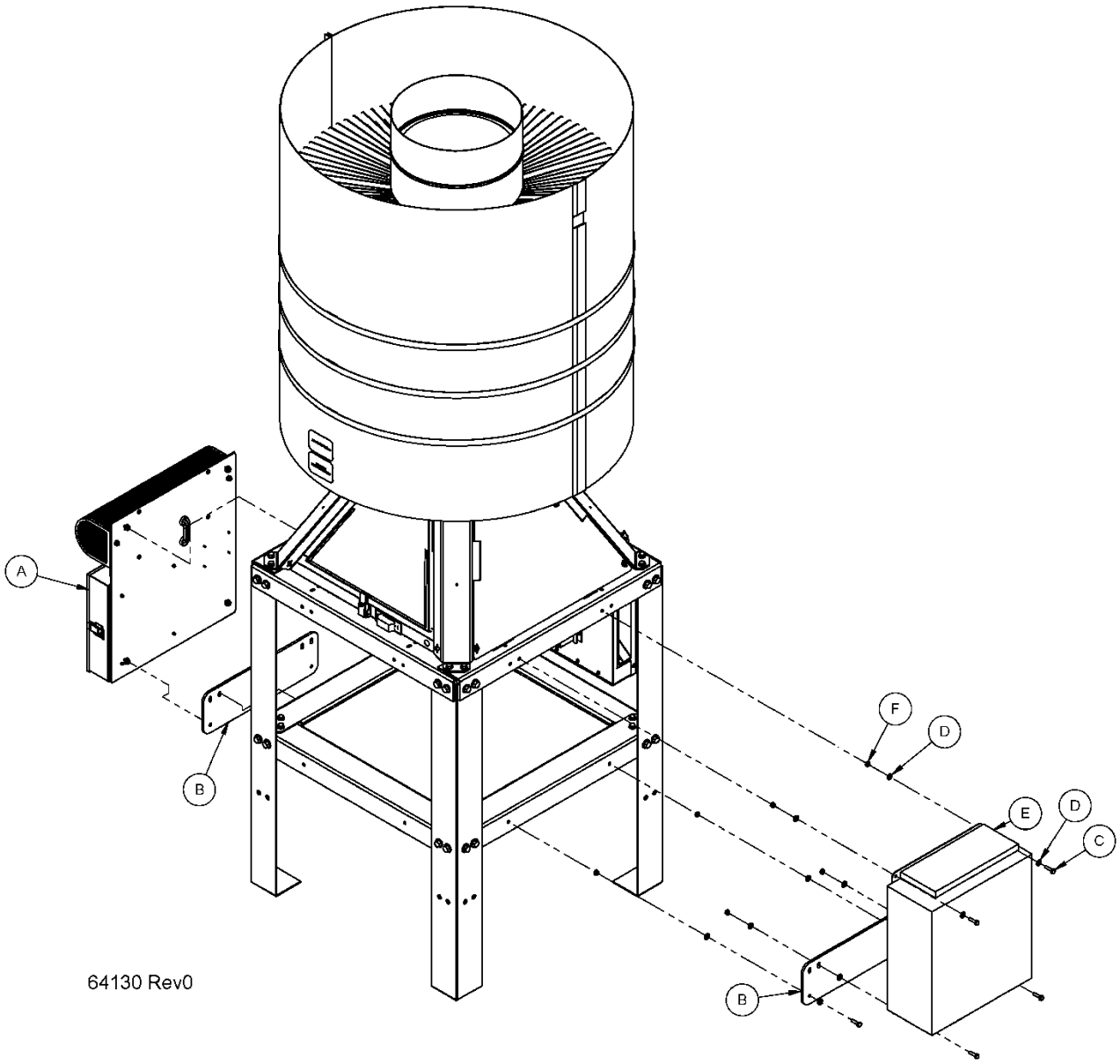


Figure 21 Options assembly

Item	Part No.	Description
A	64175	CP PANEL ASSY, S-8500-12, 30V-50A
	64174	CP PANEL ASSY, S-8500-24, 30V-30A
	64176	CP PANEL ASSY, S-8500-48, 90V-30A
B	65205	PLATE, MOUNTING, CP PANEL/CONVERTER, S-8500
C	20953	SCREW, HEX HD, 1/4-20 X 1.0” LG, 316 SS
D	22023	WASHER, FLAT, 1/4, 316 SS
E	20497	DC CONVERTER PANEL, 24/12V, 500W
	64166	DC CONVERTER PANEL, 24/48V, 500W
F	611	NUT, HEX, 1/4-20, SS
NOT SHOWN		
	64105	WIRING ASSY, TEG TO CP PANEL, S-8500
	64106	WIRING ASSY, TEG TO DC/DC PANEL, S-8500
	64107	WIRING ASSY, DC/DC TO CP PANEL, S-8500

APPENDIX G: SPARK IGNITION SYSTEM

The Spark Ignition System consists of the following parts:

- Spark Electrode
- Ignition Cable
- Pressure Switch
- Solenoid Valves
- Ignition Control Module (SI Module)
- SI Controller Board
- Battery Pack

Note: The certified Ignition Control Module (SI module) is responsible for the ignition sequence and control of the fuel valve and spark generation.

Refer to section 3.2 - TEG Start-Up for details on the SI system operation.

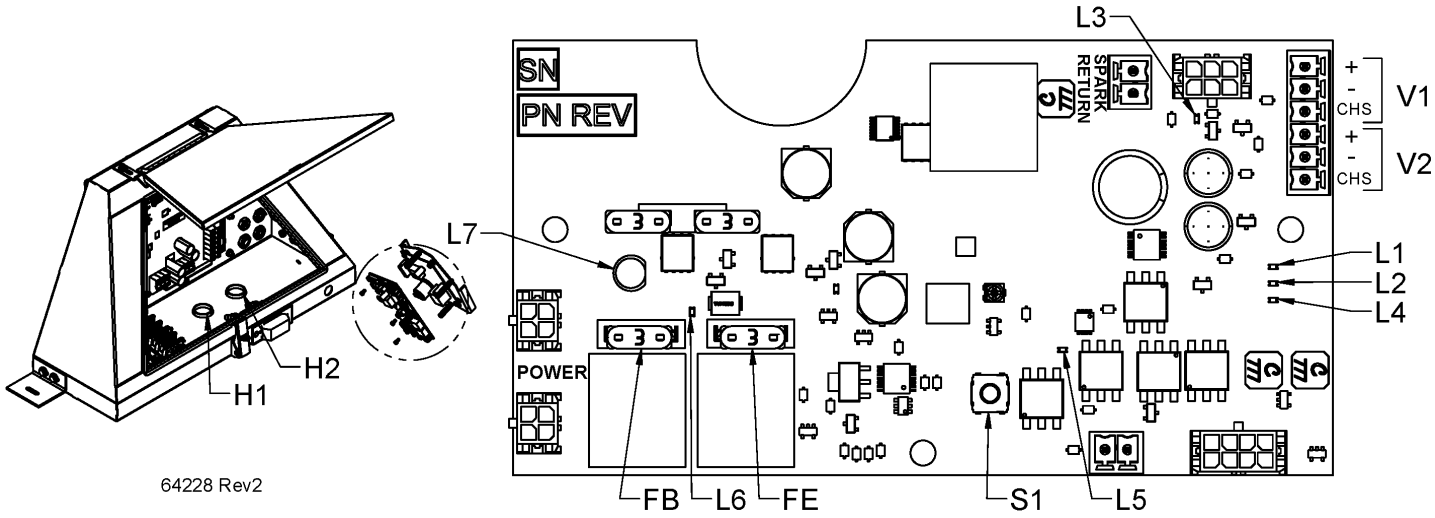


Figure 22 SI Controller Interface Diagram

Interface	Operation
S1 Switch	Reset Switch
L1 Indicator (Green)	Pilot/Start Solenoid valve indicator (Fig F-3 - Solenoid valve C5-A)
L2 Indicator (Green)	Main/Run Solenoid valve indicator (Fig F-3 - Solenoid valve C5-B)
L3 Indicator (Green)	SI module power indicator
L4 Indicator (Yellow)	SI Module No-Combustion signal indicator
L5 Indicator (Red)	Lockout indicator
L6 Indicator (Red)	Voltage supply blown fuse indicator
L7 Indicator (Red)	Battery supply blown fuse indicator (Blinks dimly)
FE Fuse	TEG supply fuse
FB Fuse	SI battery supply fuse
V1 Connections	Pilot/Start Solenoid valve connector (pos/neg/chassis)
V2 Connections	Main/Run Solenoid valve connector (pos/neg/chassis)

Table 4 SI Controller Interface

APPENDIX H: HIGH POWER LIMITER ELECTRONICS

The High-Power Limiter (HPL) is a solid state switched mode shunt regulator. The circuit monitors the TEG output voltage and adjusts the current through a series of resistors to maintain a constant user-selectable voltage. The HPL is attached across the TEG output in parallel with the customer load.

High Power Limiter (HPL) User interface

The High-Power Limiter has a simple on-board user interface, with text labels on the front panel for button and LED identification.

The User Interface has four main parts:

1. One analog voltage meter signal output port for external voltage meter reading
2. Four user buttons for parameter selecting and adjusting
3. Five user LEDs indicating parameter selected
4. Two sets of voltage sensing relays (VSRs), with dry contacts (NO/NC/COM) output

To read parameters from the analog voltage meter port, the user will need a multimeter or a DC voltage meter with a minimum range of 30 Vdc, and a minimum accuracy of 1%.

Analog voltage meter port: 2 voltage measurement points (+ and -)

Analog voltage meter port voltage signal range: 0.0 V to 9.9 V

The multimeter will read a DC voltage which is scaled as:

1. Voltage, 0.1 V/Volt (e.g., a 27.0 Volt output will read as 2.70 V)
2. Power, 0.01 V/Watt (e.g., a 500 W output will read as 5.00 V)
3. Current, 0.1 V/Amp (e.g., a 20.0 A output will read as 2.00 V)

Status LED

The status LED (See Figure 23) indicates the regulation status of the High-Power Limiter.

- The status LED will flash slowly if the output voltage is below the Output voltage set point by more than 1.0V (Low Output Voltage)
- The status LED will be solid if the output is within the output Voltage set point +/- 1.0V (Within regulation)
- The status LED will flash quickly if the output voltage is more than 1.0V above the output voltage set point. (High Output Voltage)

See section 7 – Troubleshooting, for possible causes of high or low output voltage.

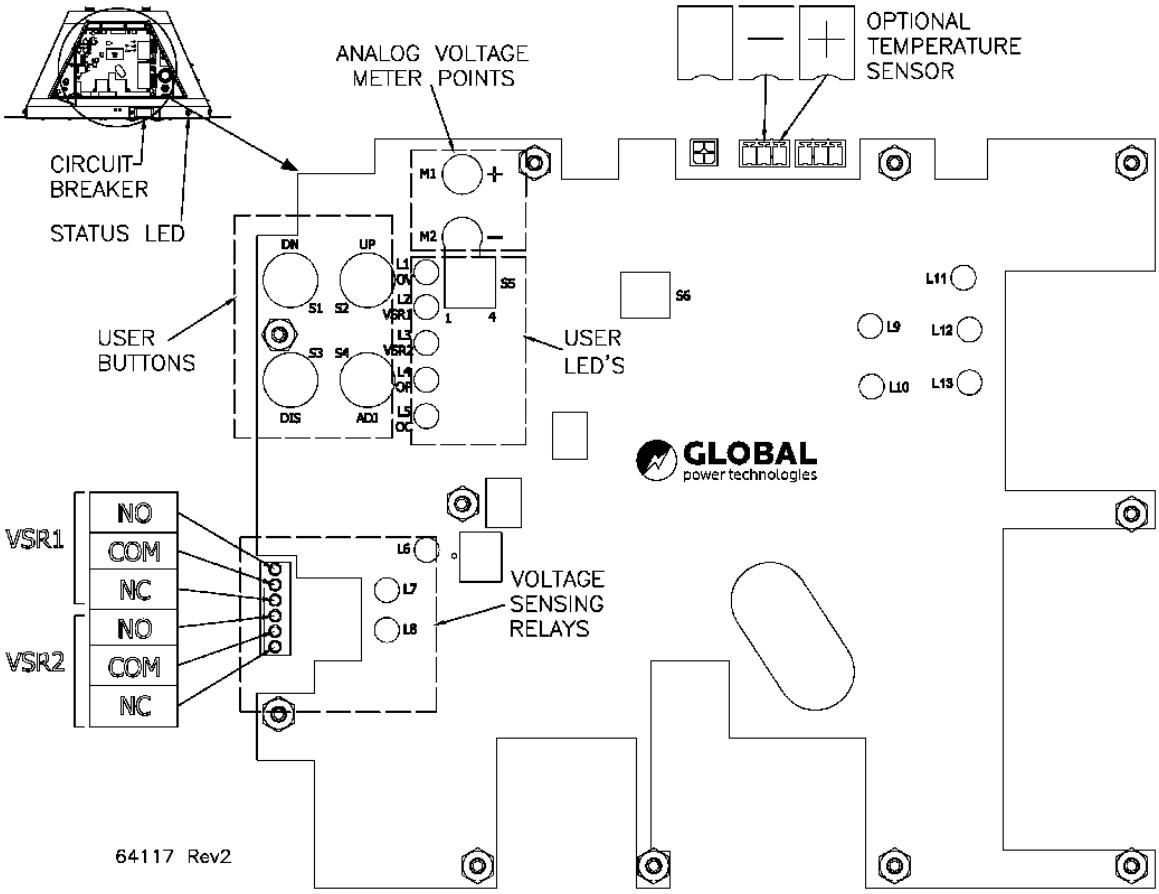


Figure 23 High Power Limiter Interface

Interface	Operation
M1 (+)	Meter output Positive
M2 (-)	Meter output Negative
S1 Switch - DN	Decrease selected parameter
S2 Switch - UP	Increase selected parameter
S3 Switch - DIS	Select display parameters
S4 Switch - ADJ	Select adjustment Parameters
S5 Switch	Mode select
L1 Indicator (Green) - OV	Solid: Meter output displays output voltage Blinking: Output voltage adjustment active
L2 Indicator (Green) - VSR1	Solid: Meter output displays VSR1 voltage set point Blinking: VSR1 set point adjustment active
L3 Indicator (Green) - VSR2	Solid: Meter output displays VSR2 voltage set point Blinking: VSR2 set point adjustment active
L4 Indicator (Green) - OP	Solid: Meter output displays TEG output power
L5 Indicator (Green) - OC	Solid: Meter output displays TEG output current
L6 Indicator (Green)	Heartbeat LED. Blinks to indicate HPL is running
L7 Indicator (Green)	Solid: Indicates output voltage is above VSR1 set point and VSR1 is Energized
L8 Indicator (Green)	Solid: Indicates output voltage is above VSR2 set point and VSR2 is energized
L9, L10 Indicators (Red)	Solid: Protective Limiter is engaged. Indicates a failure state
L11, L12, L13 Indicator (Yellow)	Switched resistor 1, 2, and 3 respectively are active

Table 5 HPL INTERFACE

Display Parameters

The High-Power Limiter has the ability to display 5 different parameters:

1. Output Voltage L1 (OV)
2. VSR1 Set Point (VSR1 Voltage) L2 (VSR1)
3. VSR2 Set Point (VSR2 Voltage) L3 (VSR2)
4. Power Unit Output Power (PU Output Power) L4 (OP)
5. Power Unit Output Current (PU Output Current) L5 (OC)

To view any of these parameters follow the steps below:

1. Connect a DC voltmeter +/- leads to M1(+) / M2(-) measurement points respectively. Ensure the voltmeter is in the correct range and has better than 1% accuracy.
2. Press switch S3 (DIS) to cycle through display options, until the LED for the required parameter is illuminated.

Output Voltage Adjustment

Adjustment of the output voltage should not be attempted until the TEG is set up and operating normally according to the TEG Operating Instructions.

1. Ensure the Customer Load circuit breaker is in the "OFF" position
2. Check all electrical connections
3. Connect a DC voltmeter +/- leads to M1 (+)/ M2 (-) measurement points respectively.
4. Press switch S4 (ADJ) until L1 (OV) LED is Illuminated and flashing
5. Press switch S1 (DN) to decrease setting and switch S2 (UP) to increase setting in steps of 0.05 V, as needed to the required voltage (reminder, e.g., a 27 Volt output voltage will read as 2.7 V on the multimeter)
6. If setup is complete, turn the Customer Load circuit breaker to the "ON" position

CAUTION*: Be aware the High-Power Limiter input and output voltage will follow operator's adjustment operation, and will change accordingly during adjustment*

Setting Voltage Sensing Relays

The High-Power Limiter is equipped with two standard VSRs. The VSR will Energize and the LED illuminate when the voltage rises above a user selectable voltage (L7 for VSR1 and L8 for VSR2). Each Relay provides a normally open, and a normally closed contact. See Figure 22 In order to change the VSR voltage set point.

1. Connect a DC voltmeter +/- leads to M1 (+) / M2 (-) measurement points respectively.
2. Press switch S4 (ADJ) until the L2 (VSR1) or L3 (VSR2) LED is Illuminated and flashing.
3. Press switch S1 (DN) to decrease setting and switch S2 UP to increase setting in steps of 0.1 V, as needed to the required voltage (reminder, e.g., a 27 Volt output voltage will read as 2.7 V on the multimeter).

CAUTION: Be aware the VSR relays might energize or de-energize with adjustment.

Temperature Compensated Battery Charging

The High-Power Limiter has two operating modes controlled by a DIP Switch S5 as shown in Table 6

S5-1	S5-2	S5-3	S5-4	MODE
OFF	OFF	OFF	OFF	Power Supply (normal operation)
ON	OFF	OFF	OFF	Temperature Compensated Battery Charging
X	ON	X	X	Reserved - Do not use
X	X	ON	X	Reserved - Do not use
X	X	X	ON	Reserved - Do not use

Table 6 High Power Limiter Operating Modes

When Temperature Compensated Battery Charging (TCBC) mode is selected, the output voltage set point will be automatically adjusted according to the battery temperature.

An optional temperature sensor must be connected to the socket on the High-Power Limiter, see Figure 22, for temperature compensation mode to work correctly. The temperature sensor should also be attached to one of the posts of the station battery.

WARNING: **TCBC operation for 24V system only. Always disconnect the temperature sensor, the battery and load before adjusting the output set point for the value required at 25°C. It is factory set to charge 12 cells (24V nominal) lead acid battery system (factory set to 27.0V at 25°C). Please contact Global Power Technologies (GPT) for more information on custom solutions.**

APPENDIX I: OPTIONS

The following standard Model S-8500 configurations have been released. Please consult your GPT representative for customized reliable remote power solutions not listed here.

Model Number	Part Number
S-8500N-12	8534
S-8500N-24	8530
S-8500N-48	8538
S-8500N-12-RS	8535
S-8500N-24-RS	8531
S-8500N-48-RS	8539
S-8500N-12-CP	8542
S-8500N-24-CP	8544
S-8500N-48-CP	8546
S-8500L-12	8536
S-8500L-24	8532
S-8500L-48	8540
S-8500L-12-RS	8537
S-8500L-24-RS	8533
S-8500L-48-RS	8541
S-8500L-12-CP	8543
S-8500L-24-CP	8545
S-8500L-48-CP	8547

Table 7: Standard S-8500 Part Numbers

APPENDIX I1: REMOTE START OPTION

The Remote Start Board (also known as the TEG Controller) provides a method of starting, stopping, and monitoring the TEG either locally or remotely, using on-board buttons, SCADA signal interfacing, or system measurements.

The operation of the Remote Start Board is fully covered in the Remote Start Operating Manual (PN 302254). This manual is included with every Remote Start S-8500 TEG and is also available on GPT's website in the Document Archive.

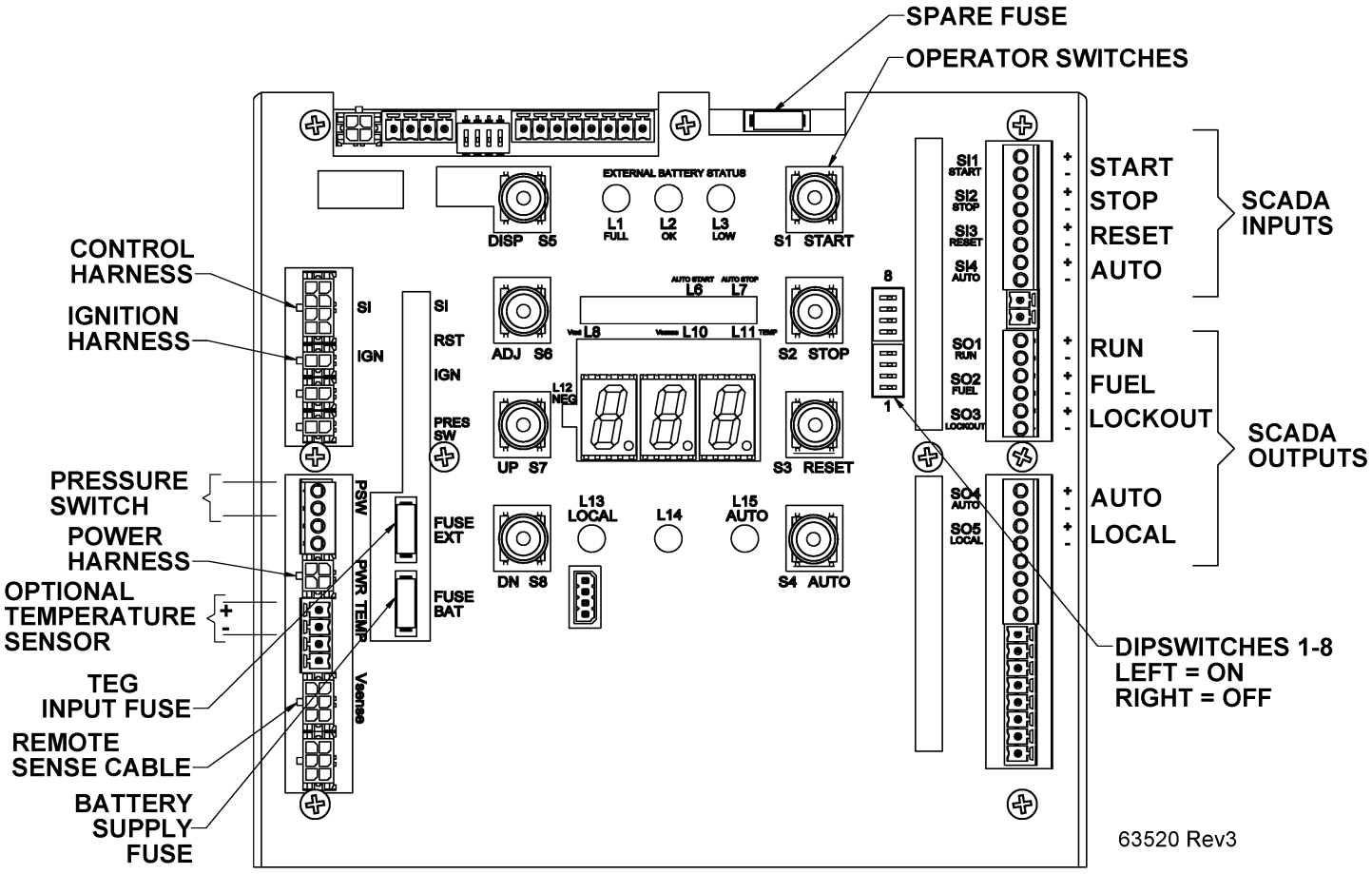


Figure 24 Remote Start Board – Diagram

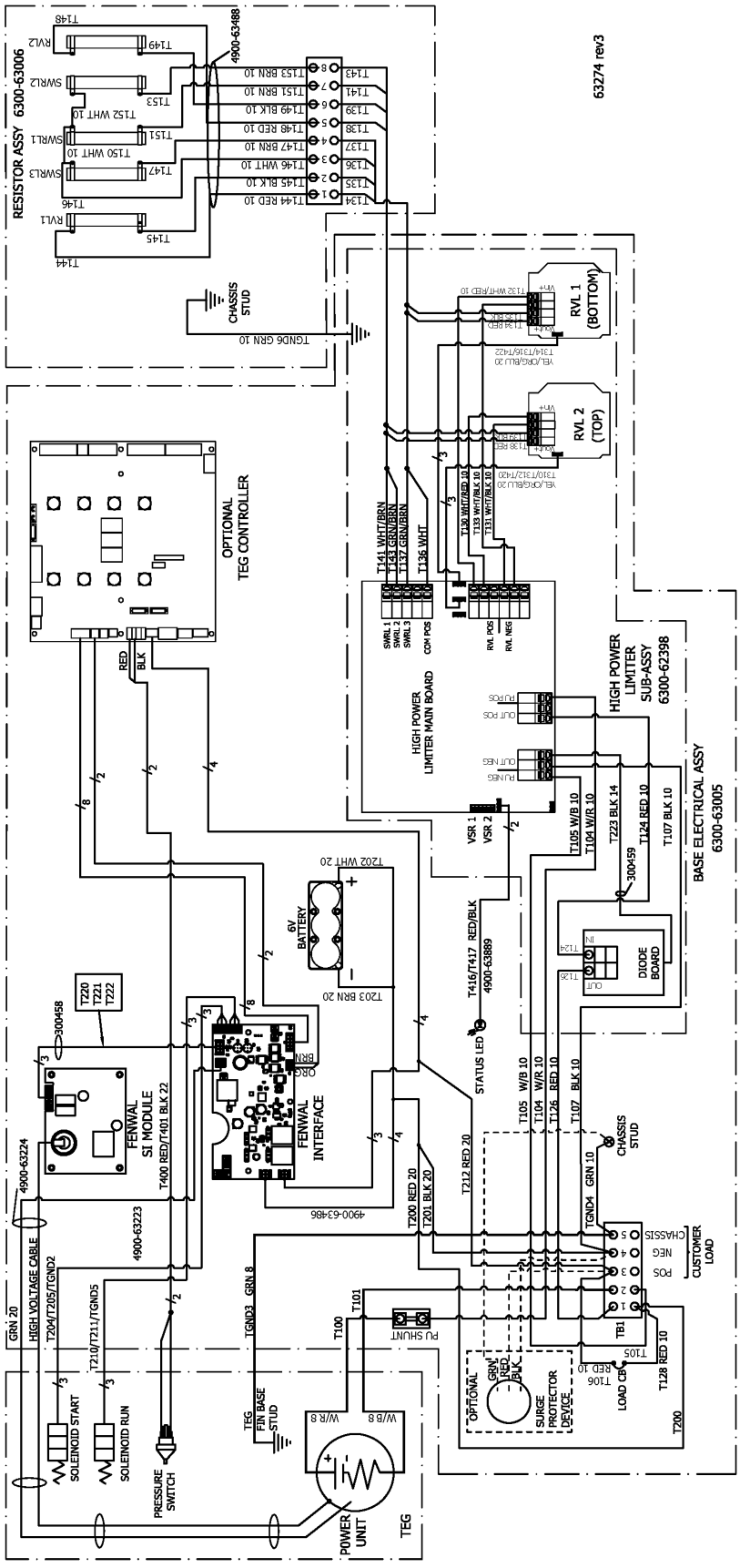


Figure 25 Detailed wiring diagram - 24V Remote Start

APPENDIX I2: CATHODIC PROTECTION INTERFACE

The Cathodic Protection (CP) Interface System provides for adjustment and monitoring of power to the CP load. The anode and cathode cables enter the cabinet at the bottom and connect directly to the heavy-duty terminal block. Refer to Figure 26 for locations and descriptions of the major components of the CP interface cabinet.

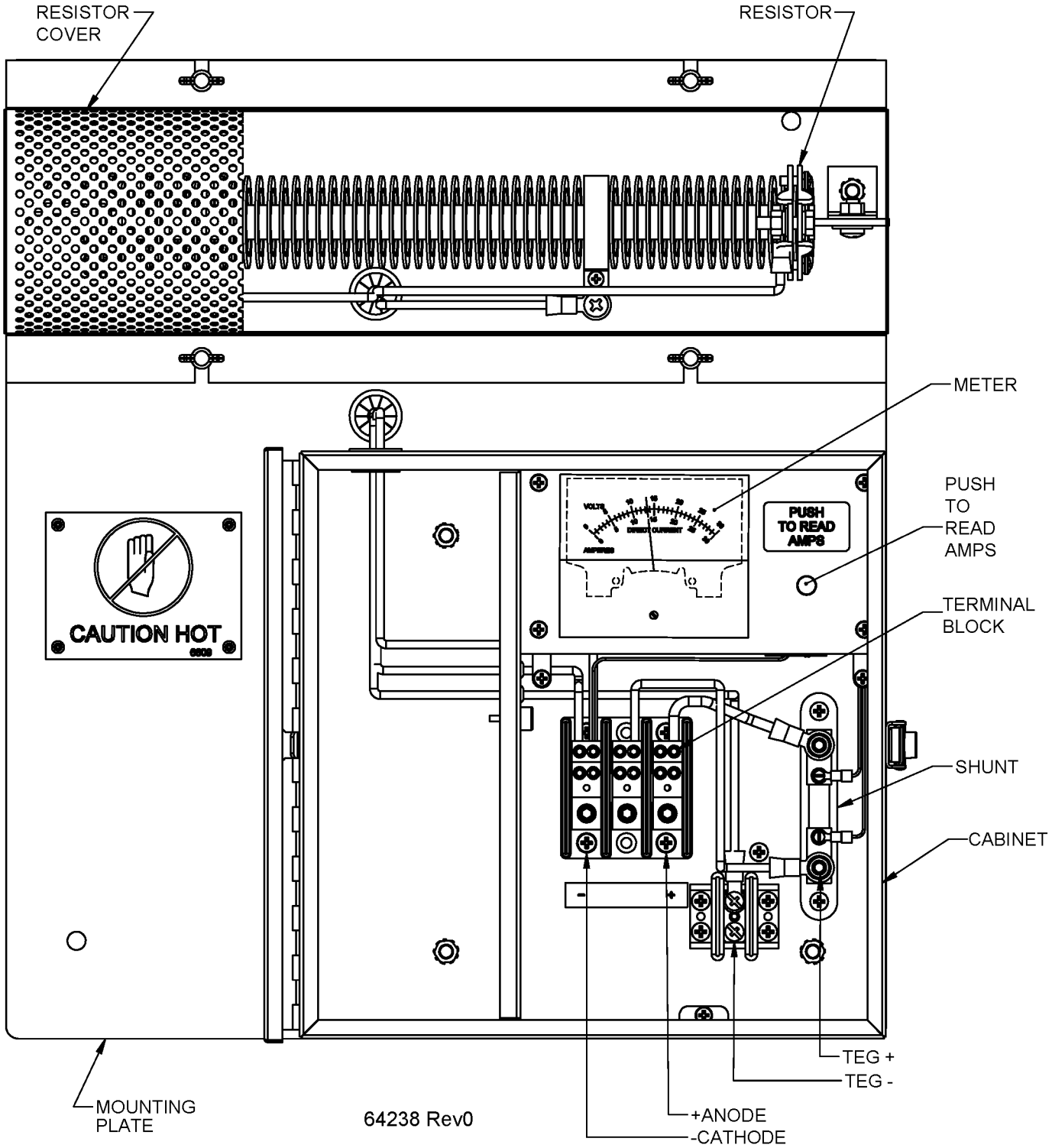


Figure 26 Cathodic Protection Interface Panel

METER & CURRENT SHUNT

The dual scale meter displays voltage at the terminal block, and current when the PUSH TO READ AMPS button is depressed. The meter is accurate to ±3% of full scale (50 mV) and is weatherproof. A shunt is used to measure the current to the terminal block. The voltage drop across the shunt is proportional to the current flowing through it. The current shunt is rated at 30 Amps = 50 mV for 24V and 48V systems, and 50 Amps = 50mV for 12V systems.

SERIES

By connecting the large power resistor (1000W for 12V & 24V systems, 752W for 48V system) in series with the CP load the maximum allowable power may be delivered to the CP load with the current and hence pipe to soil voltage controlled. This is achieved by moving the tap to the left side of the resistor. To reduce power to the CP load, slide the tap to the right.

PARALLEL

By connecting the large power resistor in parallel with the TEG smaller levels of power may be delivered to the CP load with the current and hence pipe to soil voltage controlled and sometimes required to reduce hot spots on the CP anode. With the tap located at the right side of the resistor the output power will be zero. As the tap is moved to the left the power to the CP load is increased. The change from series to parallel configuration is made by moving the wire coming from the right side of the 1000 Watt resistor, from the left position to the center position of the heavy duty terminal block.

FOR PARTS LIST - SEE APPENDIX F, Figure 21

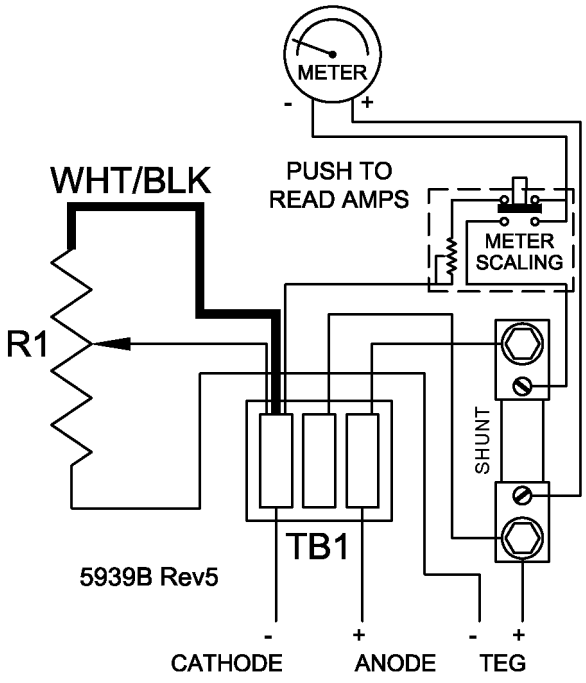


Figure 27 CP Interface System, Series Wiring Diagram

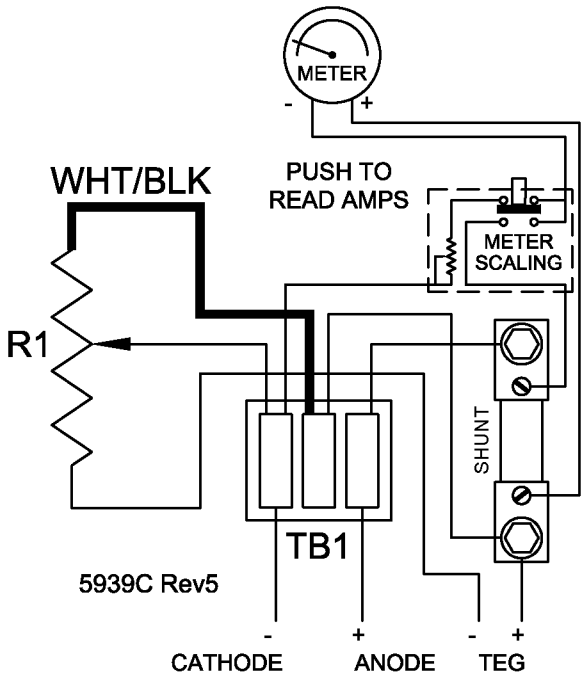


Figure 28 CP Interface System, Parallel Wiring Diagram

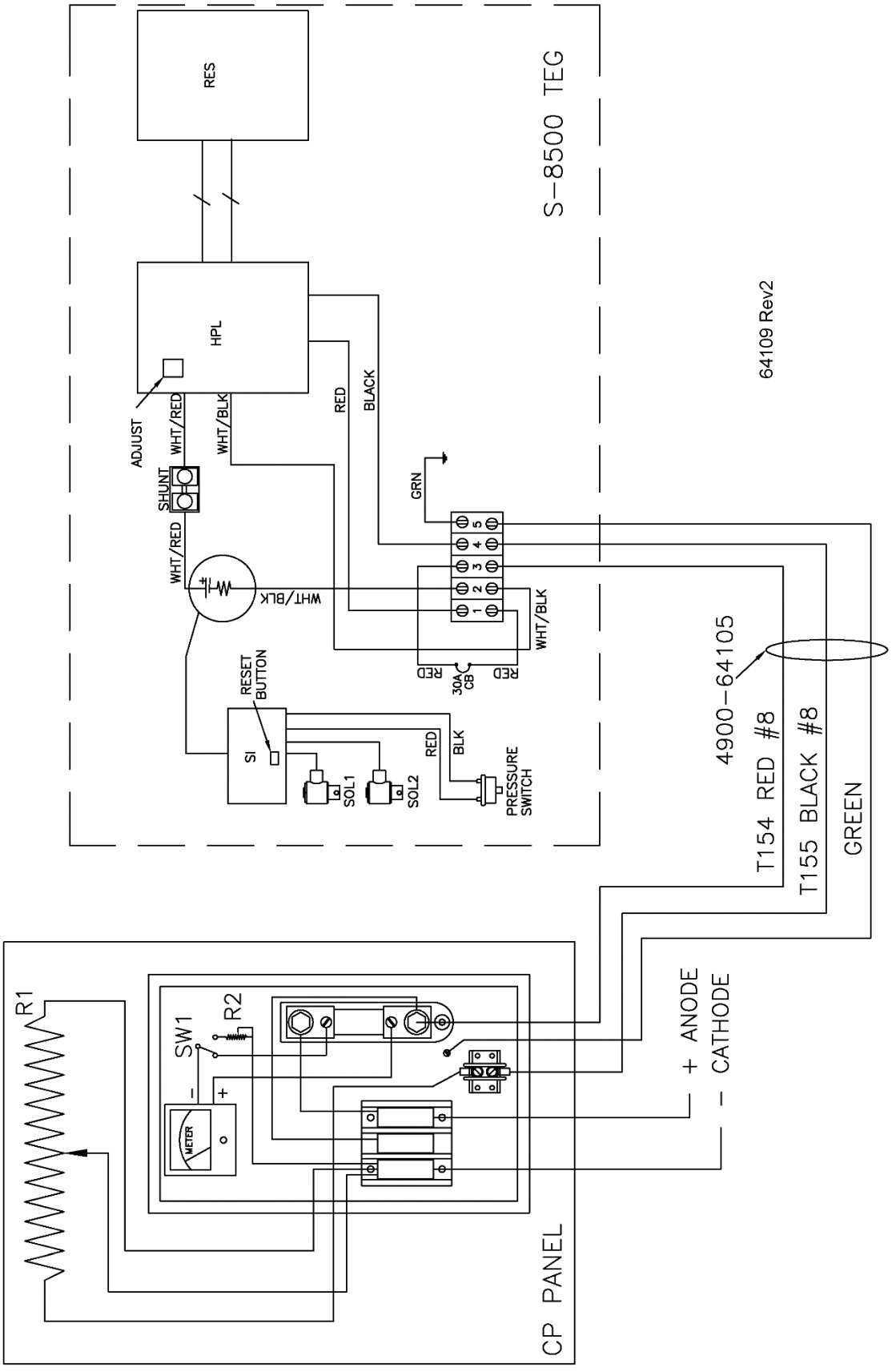


Figure 29 CP Panel wiring schematic

APPENDIX I3: DC/DC CONVERTER SYSTEM

The DC/DC Converter options convert the standard nominal 24 V TEG output to either nominal 12 V or nominal 48 V depending on the option selected. The following is a list of Specifications for each option.

PARAMETER	12 V OPTION	48 V OPTION	NOTES
Output Power	460 W	460 W	At 20^{O}C, 750m ASL. Includes reverse current diode losses. At beginning of life (BOL)
Output Voltage/Current	12 VDC @ 40 A	48 VDC @ 10 A	
Voltage Adjustment Range	11.4 V to 12.6 V	47 V to 57 V	
Load Regulation	±1.5%	±1.5%	From 10% to Full Load
Output Ripple	30 mV RMS	50 mV RMS	20 MHz BW
Temperature Range	-40 ºC to +50 ºC	-40 ºC to +50 ºC	

Table 8 12 V and 48 V Option Specifications

CONNECTION

Mount the DC/DC Panel as per Appendix F - Figure 21.

To connect the DC/DC Converter to the TEG, install the conduit and connect wires as per Figures 30 and 31. Connect the user load to output (+) and (−) as shown in Figure 29. The connection requires a ring terminal for a #10 stud. The GND connection is a #10 screw on the left-hand side of the unit.

WARNING: Use supply wires with copper diameter no smaller than 8 AWG wire, and a minimum temperature rating of 90°C.

NOTE: If the CP option is installed connect user load as instructed in Appendix I2

OPERATION

For optimal performance of the DC/DC converter, set the High-Power Limiter output to 30V. See Section 4 for how to set the TEG output voltage.

To adjust the output voltage of the DC/DC Converter measure the voltage across Output (+) and (−) then adjust the voltage adjustment pot until the desired voltage is reached. See Figure 30.

FOR PARTS LIST- SEE APPENDIX F- FIGURE 21

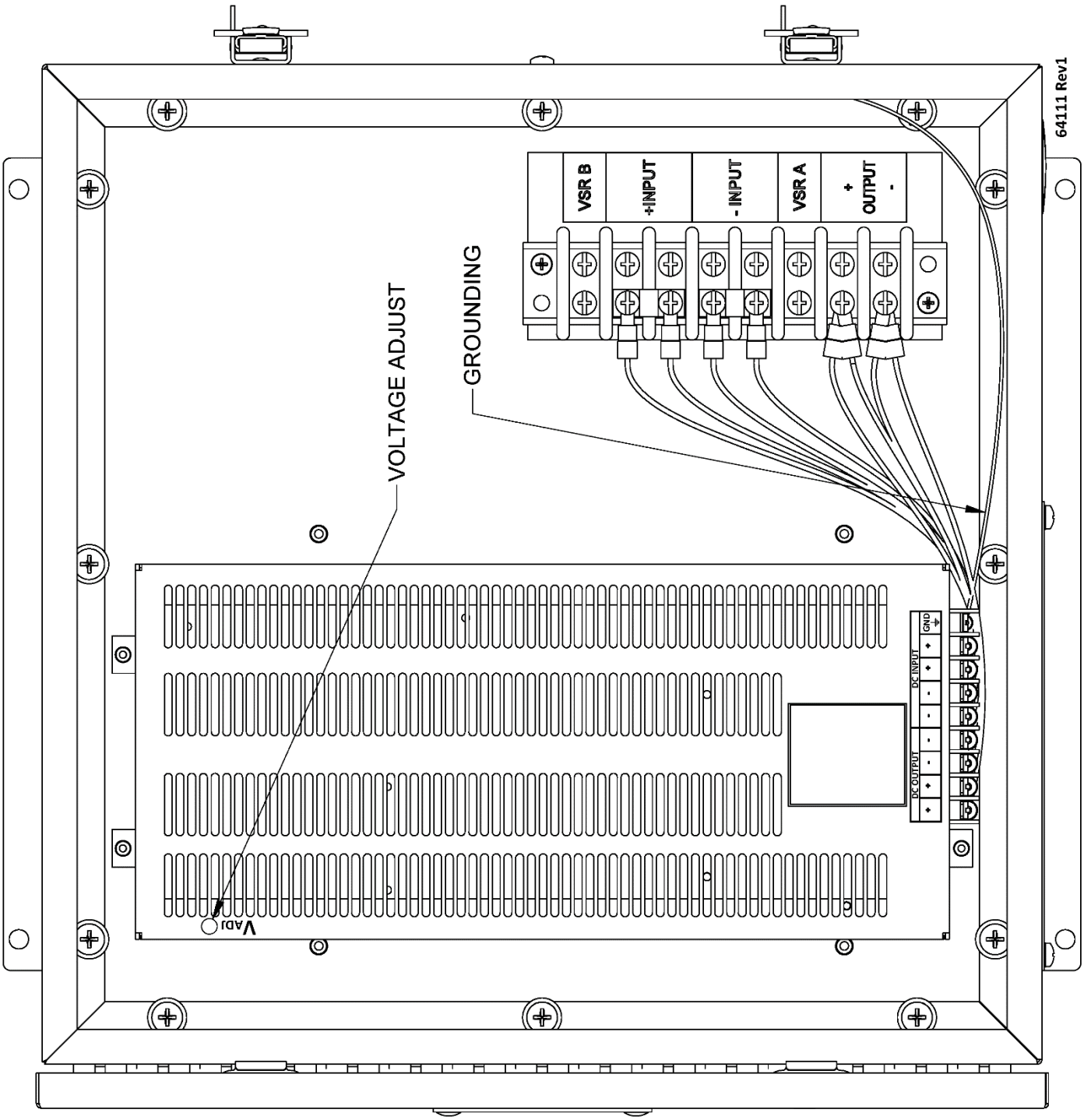


Figure 30 DC/DC Converter Connections

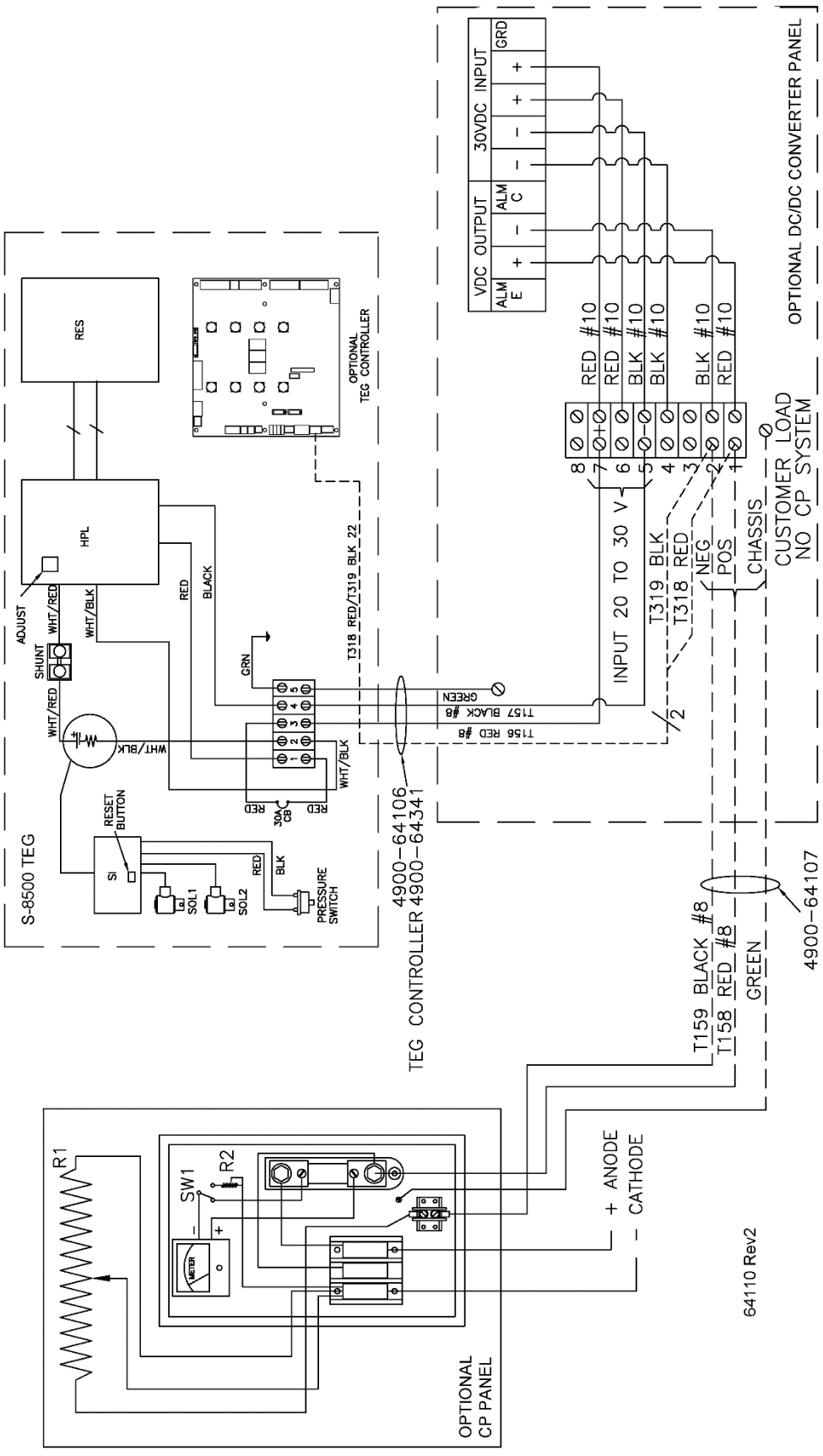


Figure 31 DC/DC Converter with CP Panel wiring schematic

APPENDIX J: BATTERY CHARGING OPERATION

Correct setup of the TEG system is required to charge the station battery optimally for the specific application. Over or undercharging station batteries can severely limit their operating life and may limit the overall system's ability to provide reliable remote power.

Lead acid batteries require higher charging voltages at lower temperatures and conversely lower charging voltages at higher temperatures for optimum charging; this is the effect of temperature compensated battery charging (TCBC). If the battery system is exposed to temperatures outside of 20-30ºC, change the power electronics mode to TCBC and connect the required optional battery temperature sensor to the power electronics and mount it on one of the battery posts.

The sensor measures the thermal temperature of the battery; it most often is not the same as the ambient temperature because the battery is in use. The output charging voltage will be adjusted automatically using this measured temperature. The sensor is required for TCBC to be effective. (See Appendix H for the location to connect the sensor to the power electronics)

The TCBC mode can only be used for lead acid batteries. Note that there are multiple types of lead acid batteries, which may require different charging voltages for the given application.

WARNING: Always refer to battery manufacturer specifications for the required application's charging voltages, depth of discharge versus battery life data, and capacity versus temperature data.

WARNING: If the required temperature sensor is not used, which will adjust the output charging voltage, then the battery may not be ideally charged according to the manufacturer's specifications.

Note that as batteries age with use and cycling, the time to charge will likely increase and should be considered in the application.

WARNING: Always disconnect the output from the TEG (load and station battery) prior to making changes to the output voltage set point.

Charging Mode Applications

If the TEG is not in a float or cycle charging application, then the default operation is fixed voltage power supply mode. **This is the default factory mode setting; it provides a regulated output voltage.**

The TEG output charging voltage to be set will depend on either a float charging or cycle charging application.

Float Charging

A float charging application is when the TEG system will be running continuously or for long extended periods of time. The output voltage needs to be set to the float charging voltage, which is lower than cycle charging voltage. The remote start is an option for remote SCADA controlled starting and stopping of the TEG, in addition to

on-site local operation; Auto functionality should be turned off since it is a cycling function. An example of float charging would be when the TEG is run continuously over the winter season.

Cycle Charging

A cycle charge application is when the TEG system provides periodic charging to the battery system. The output voltage needs to be set to the cycle charging voltage, which is higher than float charging voltage. The remote start option is necessary, with Auto functionality turned on to start the TEG at a set starting voltage associated with the battery depth of discharge and to stop the TEG at a voltage associated with the amount of battery capacity recharged. Connect a second temperature sensor to the TEG Controller board and also mount it on one of the battery posts. The stop voltage set point is compensated by temperature, since battery capacity is affected by temperature. The remote start option can also be used for remote SCADA controlled operation and on-site local operation. Auto functionality operates when the TEG Controller board is in the remote mode; see Appendix I1 for more operation details.

WARNING: If the second temperature sensor is not used, which will adjust the auto stop voltage, then the battery may not be ideally charged according to the manufacturer's specifications.

The TEG can be either the primary charger in a TEG only system, or it may be the secondary charger in hybrid system. The TEG output voltage is set to the cycle charging voltage in either case.

The Auto Start voltage is typically set to the same value in either system; the TEG will be started when the battery voltage has discharged down to this voltage. The life of the battery is affected by the depth of discharge. If the auto start voltage set point is too high, this will result in the TEG starting often.

The difference between a primary and secondary charger behavior is set by the Auto Stop set point in the TEG Controller. The setting is application specific. The Auto stop voltage is typically set higher for applications where the TEG is the primary charger, usually near to the cycle charging voltage. The Auto stop voltage is typically set to recharge up to a lower capacity of the battery instead of full capacity when the TEG is the secondary charger. The TEG will be stopped when the battery voltage charges up to this voltage.

The stop voltage is a charging voltage not a direct representation of the state of charge. The battery voltage will settle to a resting state when left without charging or discharging; to measure the state of charge of a battery it must rest for a minimum of four hours before measuring the voltage.

WARNING: If the auto stop voltage set point is set too low, this will result in an increased number of charge cycles and will likely lower the battery and TEG life. The higher the auto stop voltage, the longer the TEG will operate before turning off.

WARNING: Always set the Auto stop voltage set point to be at least 0.5V below the output voltage, otherwise the TEG will

likely run continuously. If the maximum achievable voltage output from the power electronics is lower than the temperature compensated stop voltage, then the TEG will run continuously until the temperature rises to undo this condition. This is often the case at cooler temperatures, see Table 3 for the effect of temperature compensation.

An example of cycle charging would be when the TEG is a secondary charger in a hybrid system and provides backup charging in when the primary charging system is unable to charge the battery.

WARNING: If the TEG is used in a battery charging application, the operating mode must be changed to TCBC in combination with the required optional temperature sensor(s) for proper TCBC operation. If left in power supply mode or without the temperature sensor(s), the battery may not be charged according to the manufacturer's specifications.

The following table shows the factory default settings, and initial recommended guidelines for a default lead-acid battery systems:

	12V System*	24V System				48V System**			
	Output Voltage	Auto Start	Output Voltage	Auto Stop	TCBC	Auto Start	Output Voltage	Auto Stop	Comments
Factory Settings: PS/TCBC	12.0	Auto OFF	27.0	Auto OFF	Off	Auto OFF	54.1	Auto OFF	Default: Power Supply mode (PS)
Float Charging	n/a	Auto OFF	27.0	Auto OFF	Turn ON	Auto OFF	54.1	Auto OFF	Use temperature sensor to HPL
Cycle Charging: TEG only	n/a	24.4 ~50% SOC	28.8	28.3 ~85% SOC	Turn ON	n/a	n/a	n/a	Turn Auto On 24V: Use two temperature sensors
Cycle Charging: Secondary charger	n/a	24.4 ~50% SOC	28.8	27.2 ~80% SOC	Turn ON	48.8 ~50% SOC	57** (max)	54.4 ~80% SOC	Turn Auto On 24V: Use two temperature sensors 48V: One temperature sensor to Remote Start
Absolute Maximums	12.6	22	32	30	---	44	57	60	

Table 9 Battery Charging Application

Settings TCBC: Temperature Compensated Battery Charging

* S-8500-12V – Not applicable for battery charging; it is intended for CP applications. The 12V DC/ DC converter is a tightly regulated converter with minimal adjustment. Ensure Auto functionality is OFF.

** S-8500-48V – The DC/DC converter has no temperature compensated output (TCBC does not apply); it is intended for CP applications and power supply only float charging applications. It is not recommended as a primary charger in a cycling application, due to the limitation of the maximum output voltage.

It can be used in a limited function in a multi-charger cycling application. The output voltage should be set to the maximum to allow the TEG Controller board with the external temperature sensor to control the operation between +5 to +50ºC. The TEG will run continuously for temperatures below +5ºC.

CAUTION: If Auto is turned off, reset the output voltage to the float charging voltage. See the effect of temperature compensation in table 8.

Effects of temperature compensation

The following table shows the effects of temperature compensation on a nominal set point at 25ºC, dependent upon the changing application and system voltage. Adjust these values as per the battery manufacturer's specification.

If the battery system is in a controlled environment, use the associated application charging voltage value shown for the controlled temperature, and do not enable temperature compensation.

Lead Acid Battery temperature compensation is applied using 5.5mV/ºC/2V-cell.

	24V System			48V System		
Temp ºC	Float Volts	Cycle Volts	Secondary: auto stop	Float Volts	Cycle Volts	Secondary: auto stop
50	25.4	27.2	25.6	50.8	54.3	51.1
45	25.7	27.5	25.9	51.5	55.0	51.8
40	26.0	27.8	26.2	52.1	55.6	52.4
35	26.3	28.1	26.5	52.8	56.3	53.1
30	26.7	28.5	26.9	53.4	56.9	53.7
25	27.0	28.8	27.2	54.1	57.6	54.4
20	27.3	29.1	27.5	54.8	58.3	55.1
15	27.7	29.5	27.9	55.4	58.9	55.7
10	28.0	29.8	28.2	56.1	59.6	56.4
5	28.3	30.1	28.5	56.7	60.2	57.0
0	28.7	30.5	28.9	57.4	60.9	57.7
-5	29.0	30.8	29.2	58.1	61.6	58.4
-10	29.3	31.1	29.5	58.7	62.2	59.0
-15	29.6	31.4	29.8	59.4	62.9	59.7

Table 10 Effects of Temperature Compensation

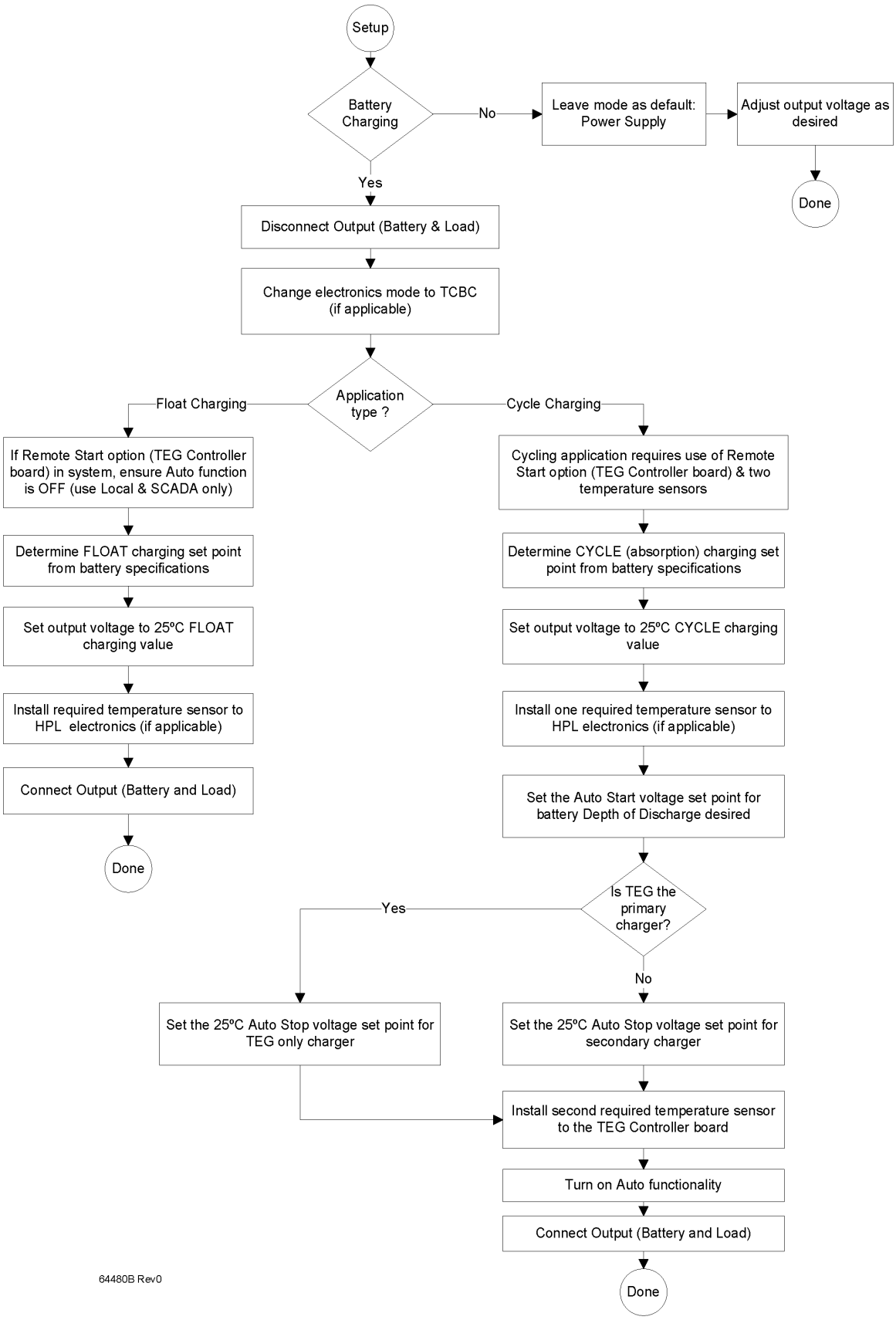


Figure 32: Flowchart, Battery Charging Application Setup

APPENDIX K: TEG PERFORMANCE LOG

MODEL NO: _____

TEG SERIAL NO: _____

FUEL TYPE: _____

DATE	TIME	AMBIENT TEMP (°C)	TARGET POWER (W)	FUEL PRESSURE (psi)	TEG OUTPUT VOLTAGE (V)	TEG OUTPUT CURRENT (A)	TEG OUTPUT POWER (W)	MAINTENANCE REMARK

APPENDIX K: TEG PERFORMANCE LOG

MODEL NO: _____

TEG SERIAL NO: _____

FUEL TYPE: _____

DATE	TIME	AMBIENT TEMP (°C)	TARGET POWER (W)	FUEL PRESSURE (psi)	TEG OUTPUT VOLTAGE (V)	TEG OUTPUT CURRENT (A)	TEG OUTPUT POWER (W)	MAINTENANCE REMARK