GLOBAL
power technologies

Global*SolarHybrid*™

For Global*SolarHybrid*™ Models S-2025, S-2050, S-2075 S-2100, S-2150, S-3025, S-3050, S-3075 and S-3100

Operating Manual

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1 PRODUCT SAFETY INSTRUCTIONS

Throughout the manual there will be paragraphs proceeded by the text **WARNING**. It is imperative that the advice be adhered to, as failure to do so may result in personal injury or death, and/or possible damage to the equipment.

WARNING: The photovoltaic (PV) panels are producing power whenever they are exposed to light. The panels should be covered during installation and any maintenance.

Disconnects

Whenever working on any of the components in the system, always disconnect both breakers labelled with the component being worked on in the breaker box.

WARNING: Never turn off the battery power to the solar controller without first turning off the solar power to the solar controller. Battery power should always be turned off last and turned on first.

If the TEG disconnects are used to isolate the output of the TEG from the solar and batteries, the components within the control box will still remain live and energized while connected to the batteries and the solar system.

Battery Safety

Never place any type of battery into a sealed container. The battery box included in the system is a vented battery box.

Always use insulated tools and avoid making contact between battery posts with metal objects.

Always wear safety glasses when working around batteries. Explosive gases can cause blindness or injury. If battery acid comes into contact with skin, wash with soap and water. If acid comes into contact with eyes, flush eyes immediately with fresh water and get medical help fast.

Recycle the batteries when they are replaced. Contact Global Power Technologies (GPT) for recycling instructions.

TEG Operation

WARNING: Do not leave the site with the TEG system in LOCAL MODE and the TEG running.

The output voltage of the TEG electronics is set at a higher voltage to allow charging up to a higher voltage during colder temperatures. When in **REMOTE MODE**, the TCC board calculates when to stop the TEG based on the temperature compensation, and stops the TEG when that voltage has been reached. If left in **LOCAL MODE**, the batteries will be overcharged and the TEG will run continuously.

The TEG jumper clip, located in the control box, must be installed in one of the two operating positions on the terminal strip. Otherwise damage, to the generator can not be prevented. It must be in the Run position for normal operation.

SYSTEM VOLTAGE CAN EXCEED 30 VOLTS!

If electronic loads cannot tolerate more than 30V, a regulated DC-DC converter should be used. Call GPT for further guidance.

WARNING: DO NOT OPERATE THE SYSTEM WITHOUT THE TEMPERATURE SENSORS INSTALLED!

The temperature sensor allows the battery charging voltage to be adjusted based on the ambient temperature. Operating without the temperature sensor can potentially damage the batteries and the thermoelectric generator.

2 TECHNICAL TERMS

Thermoelectric Generator (TEG): A device that produces electrical power through the direct conversion of heat energy to electrical energy.

Power Unit: The hermetically sealed portion of the generator that contains the thermoelectric materials and the cooling fins.

Limiter-Converter (L/C): A specific electronic device attached between the generator and the system bus that converts one level of DC voltage to another, and limits the generator voltage level to a pre-determined maximum value.

Matched Load: A condition of load where the load voltage of the generator is one-half of the open circuit voltage and the load resistance is equal to the internal resistance of the generator.

Precision load: The precision resistor contained on the generator that provides the optimum load condition. The voltage across the resistor is defined as V_{set} and is used to analyze generator electrical performance. A precision resistor is not used on the 5060 model.

Rated Power: The amount of gross power a generator can produce at a specific ambient temperature. It is measured when the generator is placed in setup position and connected to the precision load.

Set-up Power: Power from the power unit for a specific ambient temperature. It is derived from voltage across a precision load, also known as V_{set}.

Set-up Voltage: V_{set} Voltage from the power unit for a specific ambient temperature, which is proportional to set-up power. Fuel flow to the burner is adjusted so that proper voltage exists, necessary temperature difference within the power unit maintained, to deliver required power. In the 5060 generator V_{set} equals open circuit voltage.

Open Circuit Voltage, Voc: The voltage at the terminals of a power unit when no appreciable current is flowing. 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 (Voc). The voltage will continue to climb from that level.

WARNING: In the case of the model 5120 do not allow Voc to exceed 13.5 volts, otherwise, the TEG can be damaged.
In the case of the model 5220 do not allow Voc to exceed 27.0 volts, otherwise, the TEG can be damaged.

3 INTRODUCTION

The SolarHybrid system merges the power derived from the sun, captured by the solar system, and the dependability of the thermoelectric generator (TEG). The solar system works in parallel with the TEG system. While the solar system can produce enough power to supply the load and re-charge the battery, the TEG remains off and in stand-by. When the batteries discharge to a pre-set voltage monitored by the TEG electronics, the TEG will be started and the power from the TEG will be delivered to the load, if any additional power is available it will be delivered to the batteries.

ATTENTION: The system's negative bus is common and located in the control box. Each source's negative connection is wired to their own disconnect breaker in the breaker box, then wired to the common negative bus in the control box. The system is negatively grounded in the solar combiner box by the wire which connects the negative bus to the ground bus.

The solar system consists of the solar array mounted on a rack at the top of a pole, the combiner box, solar disconnect breakers, and solar controller. The solar panels may be wired in series to achieve the 24V system voltage, and the series strings may be wired in parallel to achieve the size capacity of the array. Each series string of solar panels are wired into a separate disconnect breaker in the combiner box. The combined solar array power is fed to the solar controller through disconnect breakers in the breaker box. The output power from the solar controller is fed to the system bus in the control box where the battery bank, load and TEG output are connected. See the solar panel installation **Section 5.3** for more details.

The battery system consists of the battery enclosure, terminal block in the battery enclosure, multiple interconnected batteries, and the battery disconnect breakers. The batteries may be wired in series to achieve the 24V nominal system voltage, and the series strings may be wired in parallel to achieve the size capacity of the system. The battery bank is wired to the system bus through disconnect breakers in the breaker box. See the battery installation **Section 5.6** for more details.

The TEG system consists of the generator and fuel system, the mounting hardware, and TEG Limiter/Converter electronics, TEG Charge Controller; Spark Ignition system, and the TEG disconnect breakers.

There are three electrical boxes: the control box, the breaker box, and solar combiner box. The control box and the breaker box are mounted on the side of the TEG cabinet. The solar combiner box is mounted with an additional bracket to the TEG mounting hardware during installation.

The breaker box contains breakers to isolate the positive and negative lines of each power source: TEG output power from the TEG Limiter/Converter electronics, Solar input power from the solar array to the solar controller, and the battery from the System Bus.
The solar combiner box contains breakers to individually disconnect the positive connection of each string of solar panels. A string is comprised of a single panel in 12V systems and two panels in series in a 24V system. The output of the breakers is connected to a PV positive bus, the solar panel negatives are connected to a PV negative bus, and all panels are bonded to the ground bus bar. A single wire is used to ground the negative bus to the ground bus, inside the combiner box to negatively ground the system.

The Control box contains the electronics required for the TEG, the solar controller, the system bus and load connection.

The TEG electronics consist of the TEG Charge Controller (TCC), Spark Ignitor (SI) module, TEG Limiter/Converter (L/C), limiter resistor, measurement shunt, and setup terminal strip.

The TEG Charge Controller (TCC) monitors the battery voltage and SCADA control signals or uses the on-board control switches to determine when the thermoelectric generator (TEG) should be started and stopped. The TCC board is powered by two battery sensing wires connected directly to the battery bank. This allows the generator electronics to start and stop based on this measured battery voltage, and will not be affected by the varying voltage drop that can occur across the battery charging wires.

The TCC board uses a temperature sensor to measure the temperature of the battery. The sensor is mounted to one of the battery posts near the center of the battery box. The TCC uses this reading to temperature compensate the charging voltage by stopping the TEG at the compensated value.

Temperature compensation is required because of the large range of temperatures the batteries are exposed to. Typically, battery charging voltages are given assuming the temperature is 25ºC. Any deviation below 25ºC will mean the batteries are not fully charged if the upper charging limit is unchanged, resulting in reduced battery capacity. Any temperature deviation above 25ºC can overcharge the battery resulting in permanent battery damage. To correctly adjust for changes in temperature, the temperature of the battery is measured and the effective battery charge limit is adjusted. In colder temperatures, the battery charging voltage is increased. In warmer temperatures, the battery charging voltage is decreased. The TEG turn off voltage will be temperature compensated from 25 ºC at a rate of 5.0 mV/(ºC) per battery cell. On a 12V system, this equates to 0.030 V/ºC. On a 24V system, this equates to 0.060 V/ºC. The TEG turn ON voltage does not change with temperature.

Spark Ignitor (SI) Module is responsible for the ignition sequence of the TEG, and is powered by the TCC board.

The TEG Limiter/Converter (L/C) consists of a shunt type voltage limiter and limiter resistor that helps protect the power unit and a DC/DC converter for stepping up the input voltage to the desired output voltage. There is a blocking diode in series with the positive output for reverse current protection to prevent current from flowing back through the converter to the TEG.

The 50mV/50A shunt is in-line with the output of the converter and is located before the reverse current protection diode. A voltmeter set to read mV can be used to measure the amount of current being pulled from the converter output. The mV reading is equivalent to the Amps delivery through the shunt.

The TEG terminal strip is used to switch between running configuration and the maintenance/setup configuration. When the jumper clip is placed in the Setup position, a precision load is connected to the generator power unit, to allow the operator to configure the fuel/air requirements based on ambient temperature and location. See the TEG Power Output Evaluation Section 8 for more details. When the jumper clip is placed in the Run position, the limiter/converter electronics are connected to the generator power unit, to allow power generated to be converted to the nominal system voltage and delivered to the system bus.

ATTENTION: Always ensure the jumper clip is in the Run position when leaving the site.

The solar charge controller regulates the voltage from the solar panels to the charge voltage for charging the batteries. The solar controller detects day and night conditions, and handles this condition internally without using blocking diodes in the charging lines. The second temperature sensor is used to temperature compensate the solar charging voltage for the same reason the TCC used its sensor. The two sensors use different methods for measuring the temperature and both need to be connected to their respective controller for correct operation.

The load terminal block is for connecting the customer load. Two 20A single pole breakers are wired in between the system bus terminal block and the load terminal block for use as a load disconnection.

3.1 Solar Theory of Operation[2]

Photovoltaics (PV) is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. These free electrons are captured, resulting in an electric current and used as electricity when connected to an electric load.

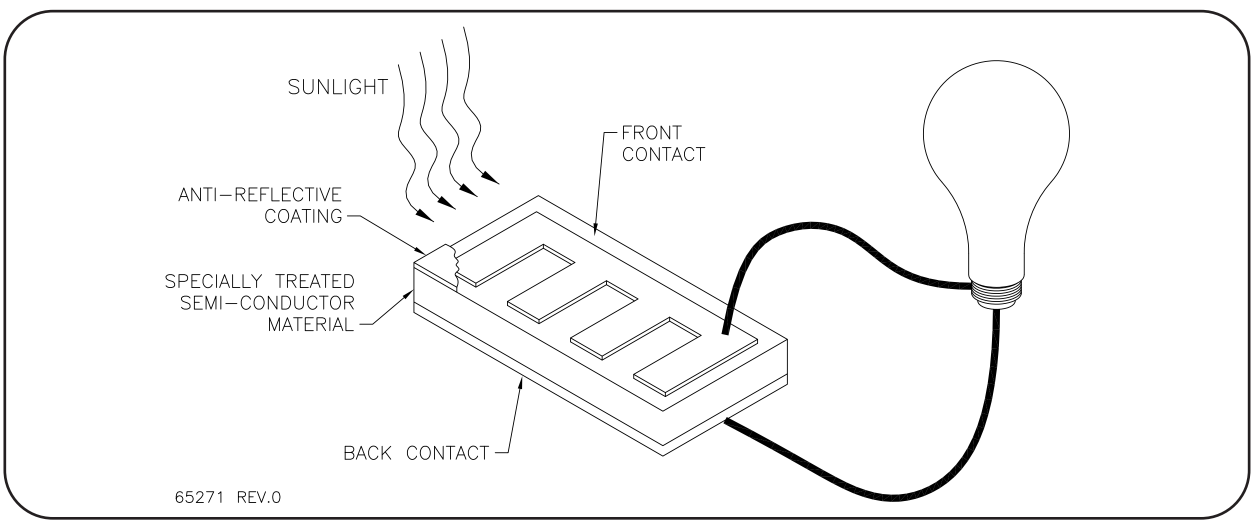


Figure 3-1 Photovoltaic Cell - Basic Operation

Figure 3-1 illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials used in the microelectronics industry. In solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. When an electric load is attached to the positive and negative sides, the electrons can be captured in the form of an electric current.

A number of solar cells, electrically connected to each other and mounted in a support structure or frame, is called a photovoltaic module. Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. The current produced is directly dependent on how much light strikes the module.

Multiple modules can be wired together to form an array, and in general, the larger the area of a module or array, the more electricity will be produced. PV modules and arrays produce direct-current (DC) electricity.

3.2 TEG Theory of Operation

A thermoelectric generator (TEG) produces electrical power through the direct conversion of heat energy into electrical energy.

This is done by joining two dissimilar, thermoelectric materials at one end and then heating the junction end to a higher temperature than the other end. This creates a voltage across the cooler end. If the temperature difference is maintained, electrical power can be delivered to a load placed in this circuit.

The TEG voltage varies according to the temperature difference at the thermocouple junction. The hot side of the thermocouples is maintained at an elevated temperature by a burner which operates on propane, or natural gas. The cold side of the thermocouples is maintained at a lower temperature by the cooling fins which transfer the heat to the surrounding air. This temperature difference is controlled by adjusting the amount of fuel supplied to the burner.

The 5120 and 5220 TEG's are supplied with a precision load resistor that provides the optimum load condition when running the generator in the setup position. The 5060 TEG is run open circuit instead of with a precision resistor. The setup position is used for both adjusting the TEG for proper operation and evaluating its performance. The fuel flow to the burner is adjusted so that the proper voltage exists in this setup position. At this condition the TEG is operating at the intended temperature and is delivering maximum power.

The TEG is supplied with a protective device which prevents the generator power unit voltage from rising above the protective limiter set value. This is required because under no load or slightly loaded conditions the hot junction temperature could increase beyond the safe operating range.

TEG Model	5060	5120	5220
Protective Limiter Setting	10V	10V	16V

In summary, the TEG produces electrical power when a temperature difference is maintained between the hot and cold junctions of the thermocouples. This temperature difference, and therefore the amount of power produced, depends on the rate at which fuel is supplied to the burner and the ambient temperature.

With the fuel flow held constant, the effect of temperature on the operation of the TEG causes a reduction in power when operating in ambient temperatures higher than the specified ambient value for gross power, up to a maximum ambient temperature of 65.5ºC (150ºF). Conversely, an increase in power occurs when operating at ambient temperatures lower than specified.

TEG Model	**5060**	**5120**	**5220**
Gross power at a specified ambient temperature	60W @ 24ºC	120W @ 24ºC	220W @ 20ºC
Temperature effect: power reduction per increase in temperature	0.18W / ºC	0.36W / ºC	0.8W / ºC

• Maximum allowable ambient temperature for operation is 65ºC (150ºF).

3.3 Battery Theory of Operation[4]

A lead-acid battery is an electrical storage device that uses a reversible chemical reaction to store energy. It uses a combination of lead plates or grids and an electrolyte consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and back again. The electrolyte of lead-acid batteries is hazardous to your health and may produce burns and other permanent damage if you come into contact with it.

Batteries are typically built for specific purposes and they differ in construction accordingly. Broadly speaking, there are two applications that manufacturers build their batteries for: Starting and Deep Cycle.

- Starter batteries are meant to get internal combustion engines going. They have many thin lead plates which allow them to discharge a lot of energy very quickly for a short amount of time. They do not tolerate being discharged deeply, as the thin lead plates needed for starter currents degrade quickly under deep discharge and re-charging cycles, causing irreversible damage after a few complete discharges.

- Deep Cycle batteries have thicker lead plates that make them tolerate deep discharges better. They cannot dispense charge as quickly as a starter battery making them less suitable for starting engines, but can be used if bigger deep-cycle batteries are used. The thicker lead plates usually mean a longer life span. A heavier battery for a given group size, usually indicates thicker lead plates, and the battery will better tolerate deep discharges.

- Battery types come in several different configurations. Lead acid can be either the sealed or open variety.

- Deep-Cycle Flooded cells usually have removable caps that allow you to replace any electrolyte that has evaporated over time - the open variety.

- Sealed Flooded Cells have electrolyte that cannot be replenished.

- Valve-Regulated Lead Acid (VRLA) batteries remain under constant pressure of 1-4 psi. This pressure helps the recombination process under which 99+% of the Hydrogen and Oxygen generated during charging are turned back into water.

    - Gel batteries feature an electrolyte that has been immobilized using a gelling agent like fumed silica.
    - AGM batteries feature a thin fiberglass felt that holds the electrolyte in place like a sponge

The State of Charge describes the percentage (%) of charge in a battery. It is an indication of the depth of discharge: 100% charge is equal to 0% depth of discharge. The exact voltage to battery state of charge correlation is dependent on the temperature of the battery as well as the current draw. At a no load condition, cold batteries will show a lower voltage when full than hot batteries. This is one of the reasons why quality charging systems use temperature probes on batteries.

VRLA batteries are susceptible to reduced life and performance due to overcharging. When these batteries are overcharged, oxygen and hydrogen produced is forced out of the pressure relief valves, drying out the battery.

Undercharging the batteries cause sulfate to build up on the positive plate, reducing the power available from the battery and impeding recharging the battery. This can also reduce the life and performance of the battery.

Battery capacity, known as the amp-hour capacity (Ah), is the amount of useable energy stored in the battery at a nominal voltage. Storage capacity is added when batteries are wired in parallel but not in series; the voltages are added when wires in series but not in parallel. The available capacity partly depends on how quickly the battery is charged or discharged. It is measured at a rate of discharge over time; the C/20 rate is a rate of discharge that will leave the battery empty in 20 hours. The available capacity is non-linear: if it is discharged faster than the C/20 rate, there will be less capacity, and a slower discharge, will show greater capacity. Battery capacity is also affected by temperature. The capacity is reduced as the temperature decreases, and it increases as the temperature increases.

Higher temperatures also reduce the life of the battery. The life is reduced by 50% for every 8ºC above 25ºC. If a battery with a 10-year service life is held at a constant temperature of 33ºC, the service life will be reduced to 5 years.

There is a limit to the number of cycles the battery can be subjected to. The deeper the discharge cycle, the fewer cycles can be tolerated by the battery which also reduces the life of the battery.

This system uses VRLA Gel Electrolyte Batteries in the battery bank. Each of the two charging systems, solar and TEG, utilizes its own temperature sensor.

4 IDENTIFICATION

Hybrid System Models

Model	Power Level	TEG Model	PV Array Size (W)	# of PV Panels	# of Batteries in System and per Battery Box
S-2025	25W	5060	270	2	2
S-2050	50W	5060	540	4	4
S-2075	75W	5120	540	4	6
S-2100	100W	5120	810	6	8
S-2150	150W	5220	1080	8	12 (2x6-Battery Box)
S-3025	25W	5060	270	2	4
S-3050	50W	5060	540	4	6
S-3075	75W	5120	810	6	8
S-3100	100W	5120	1080	8	12 (2x6-Battery Box)

4.1 System Components

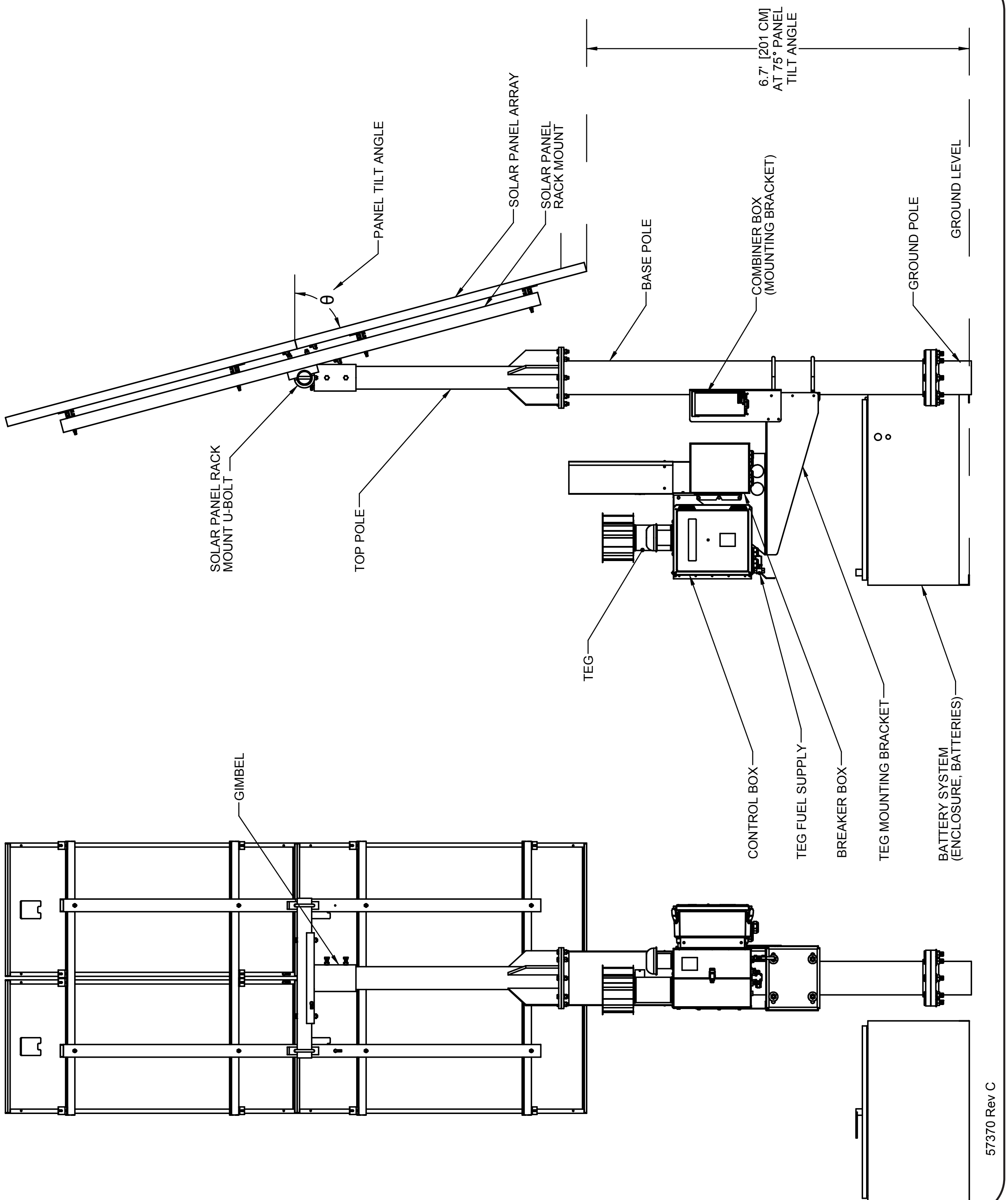


Figure 4-1 System Components

4.2 Control Box Components

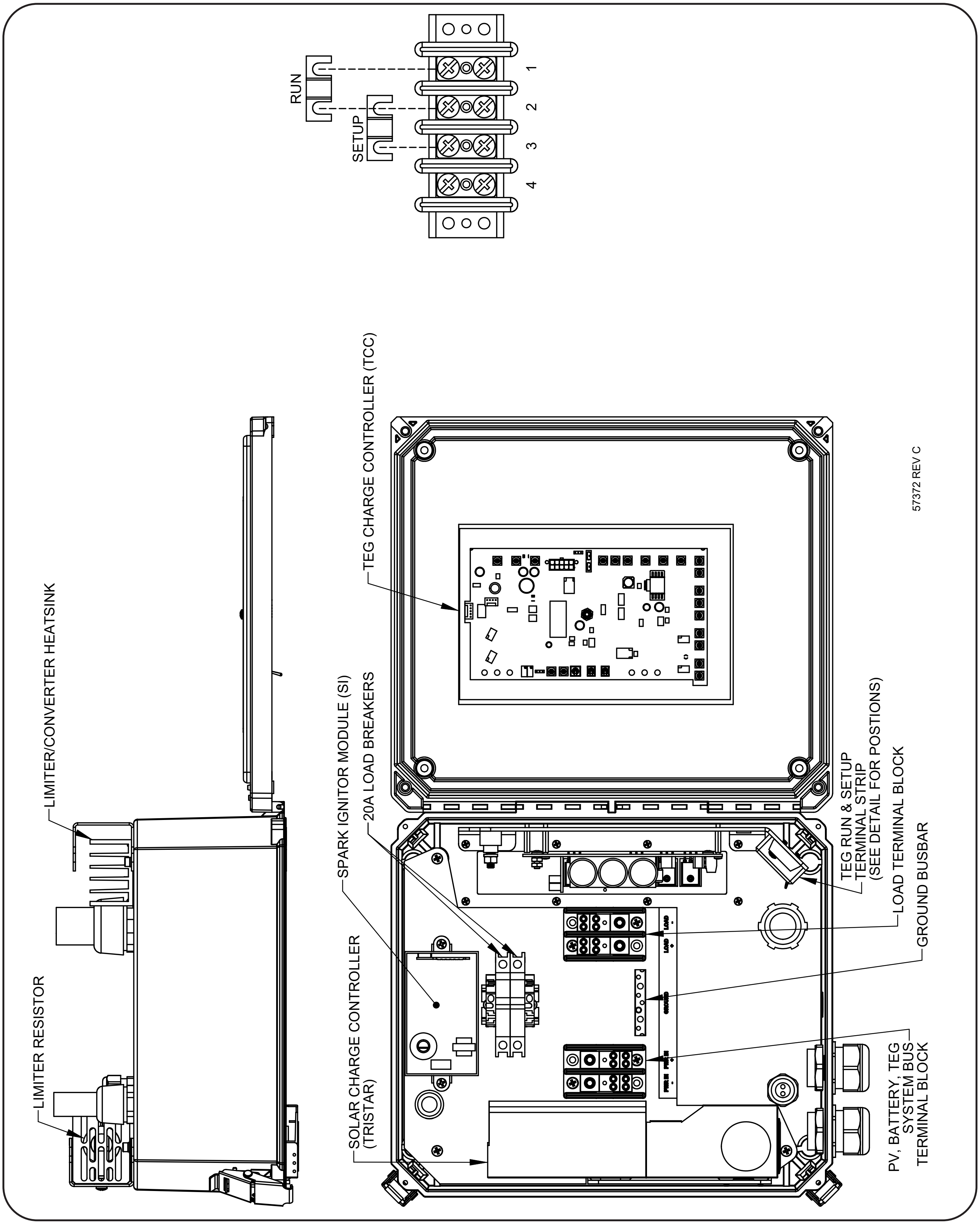


Figure 4-2 Control Box Components

4.3 TCC Components

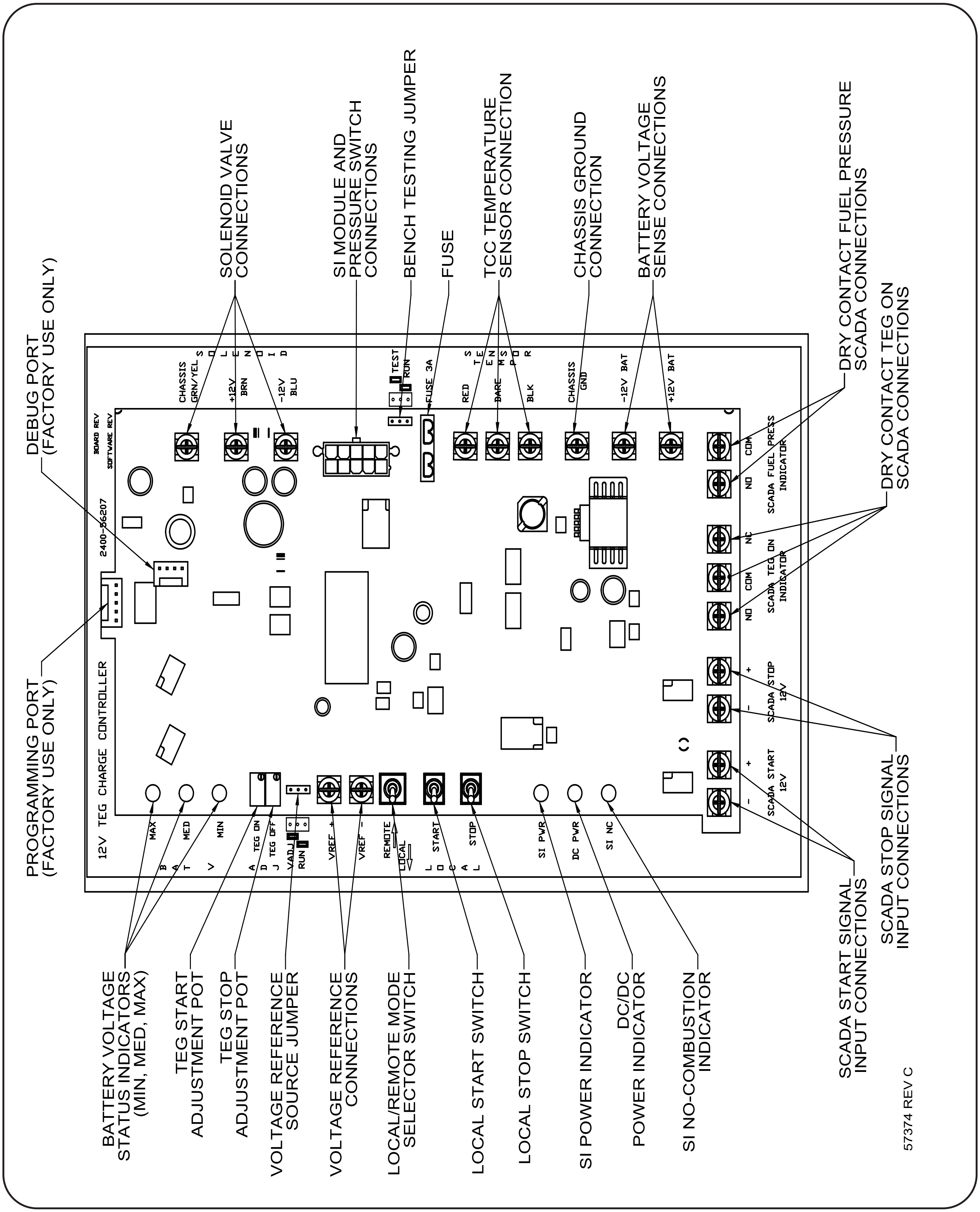


Figure 4-3 TCC Components

4.4 L/C Components

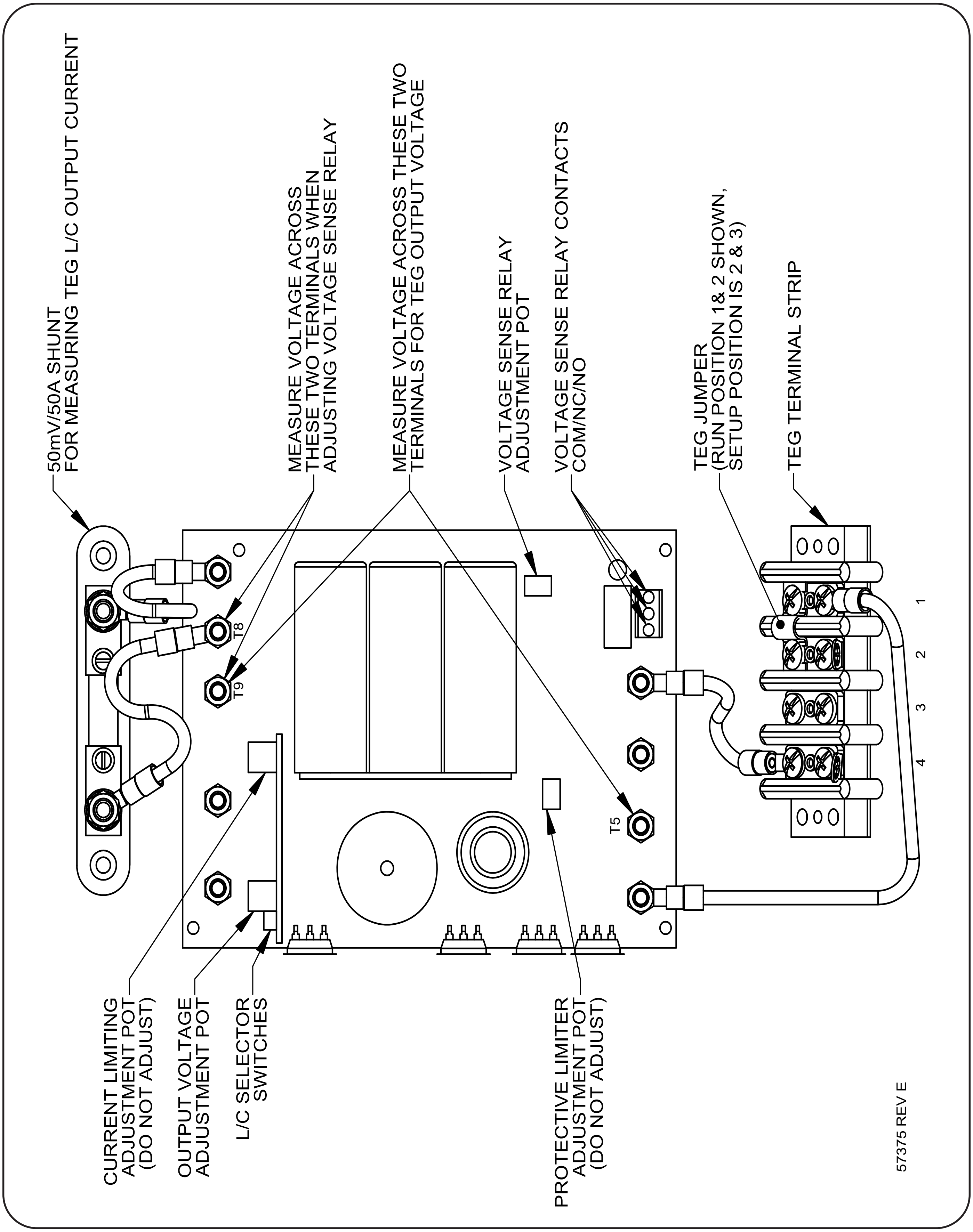


Figure 4-4 L/C Components

4.5 Solar Controller Components

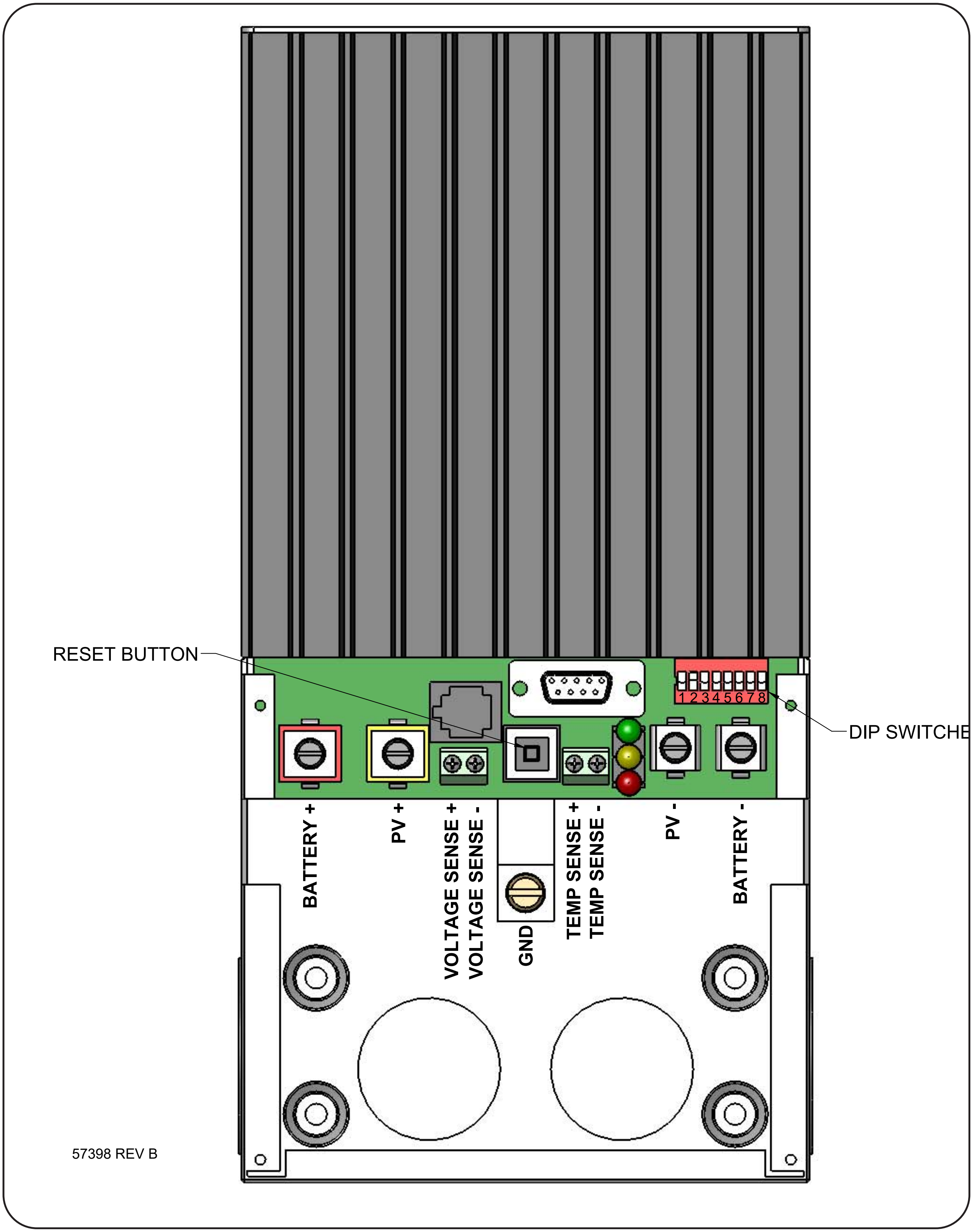


Figure 4-5 Solar Controller Components

4.6 Temperature Sensors

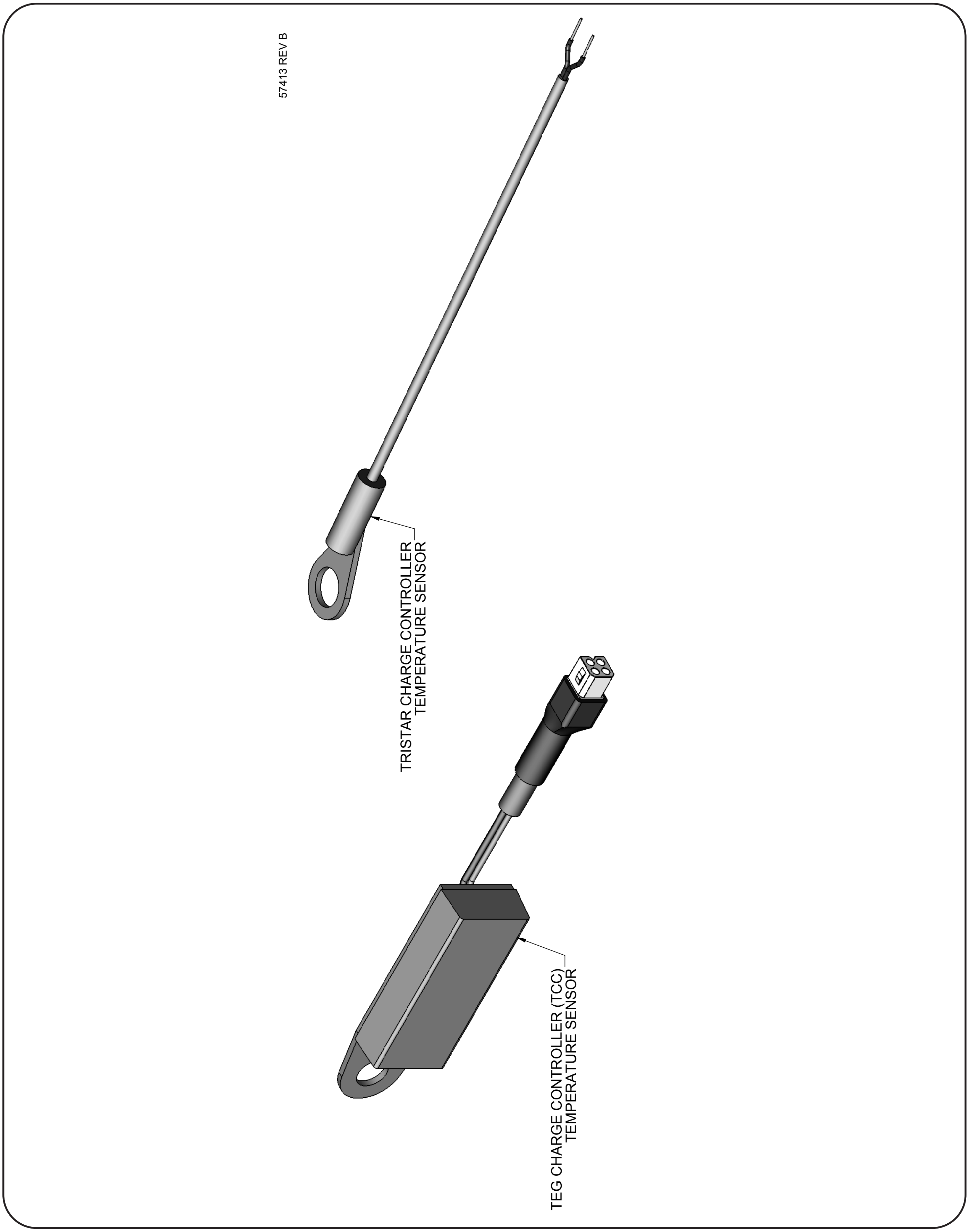


Figure 4-6 Temperature Sensors

4.7 Breaker (Junction Box) Components

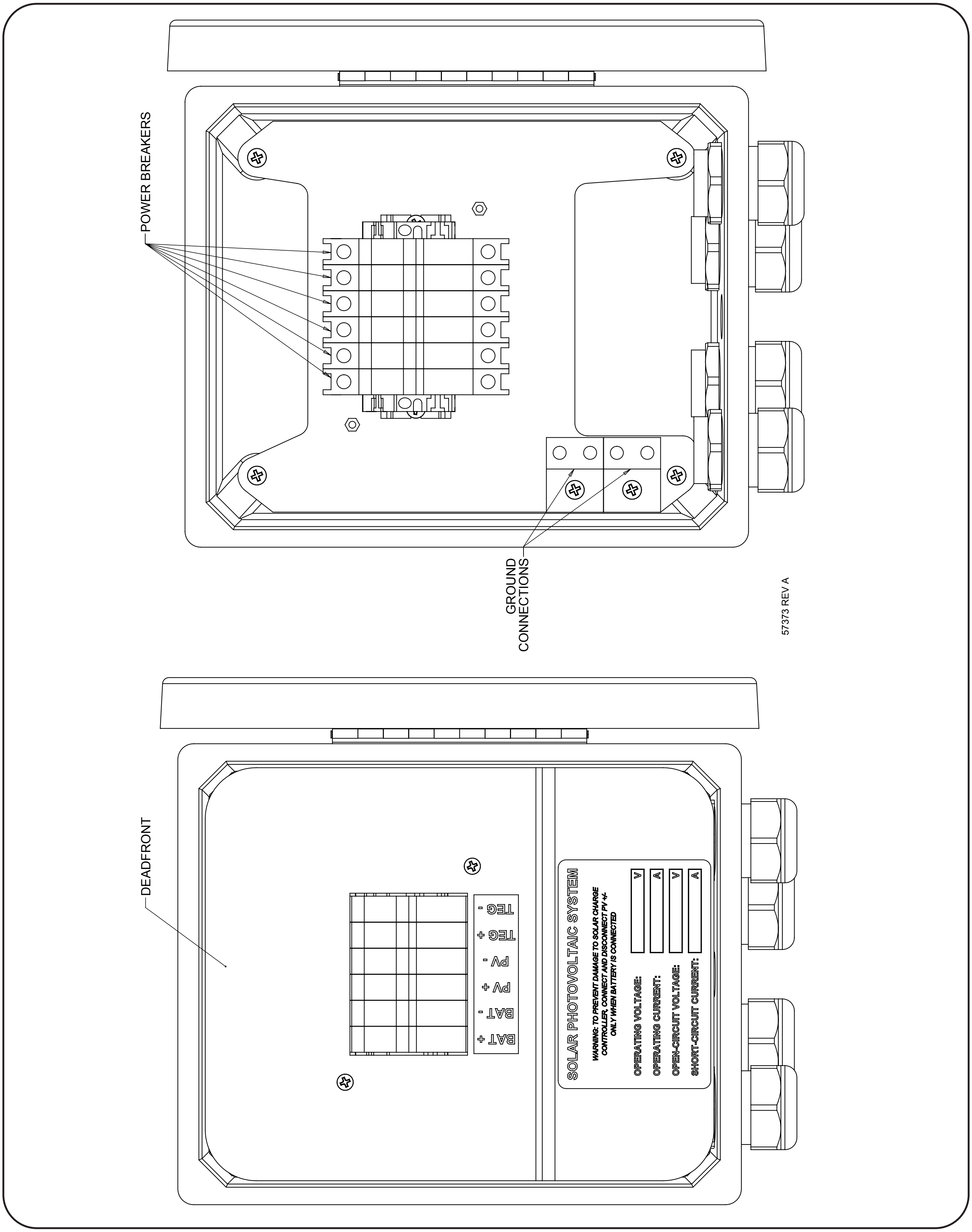


Figure 4-7 Breaker (Junction Box) Components

4.8 Combiner Box Components

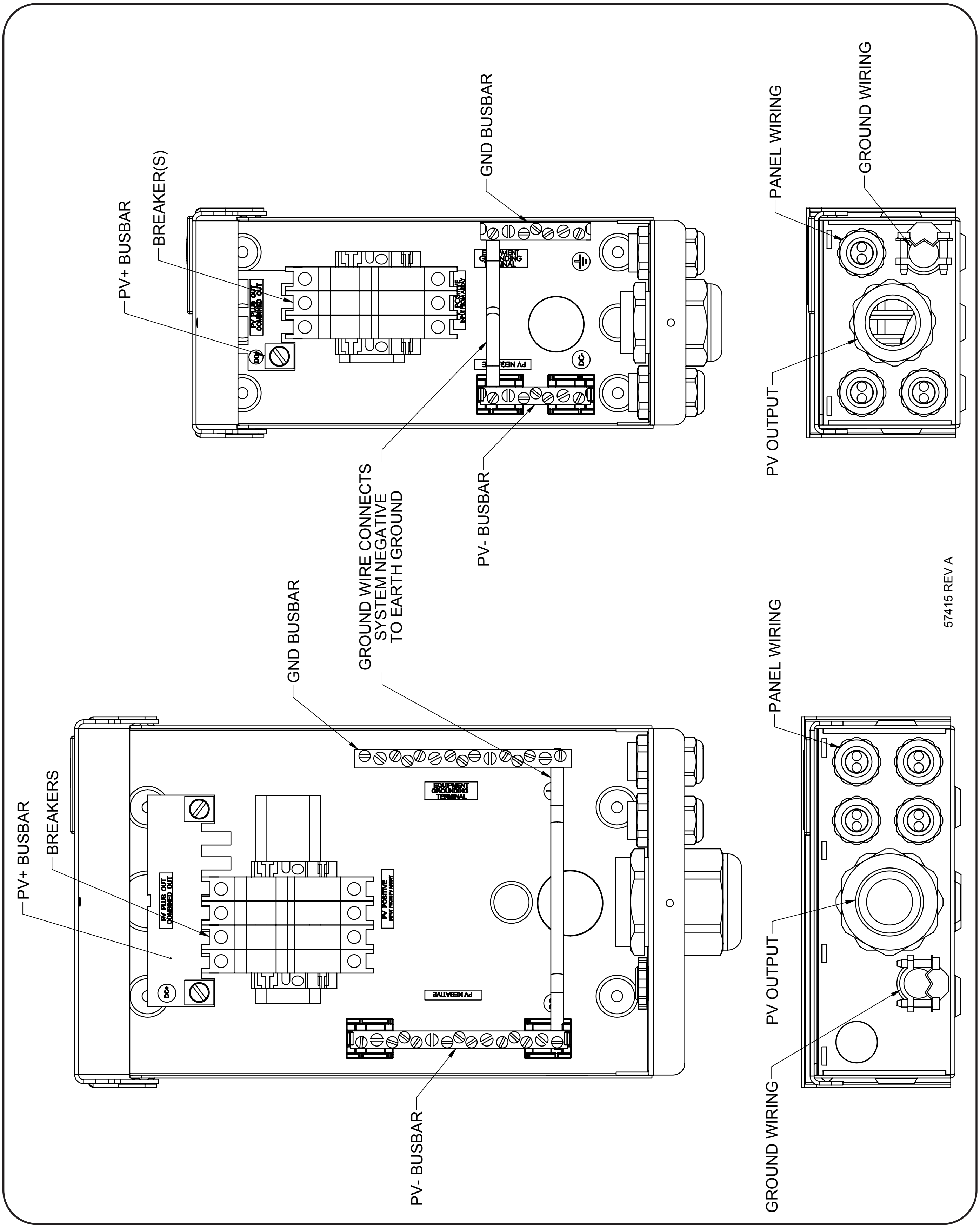


Figure 4-8 Combiner Box Components

4.9 TEG Components

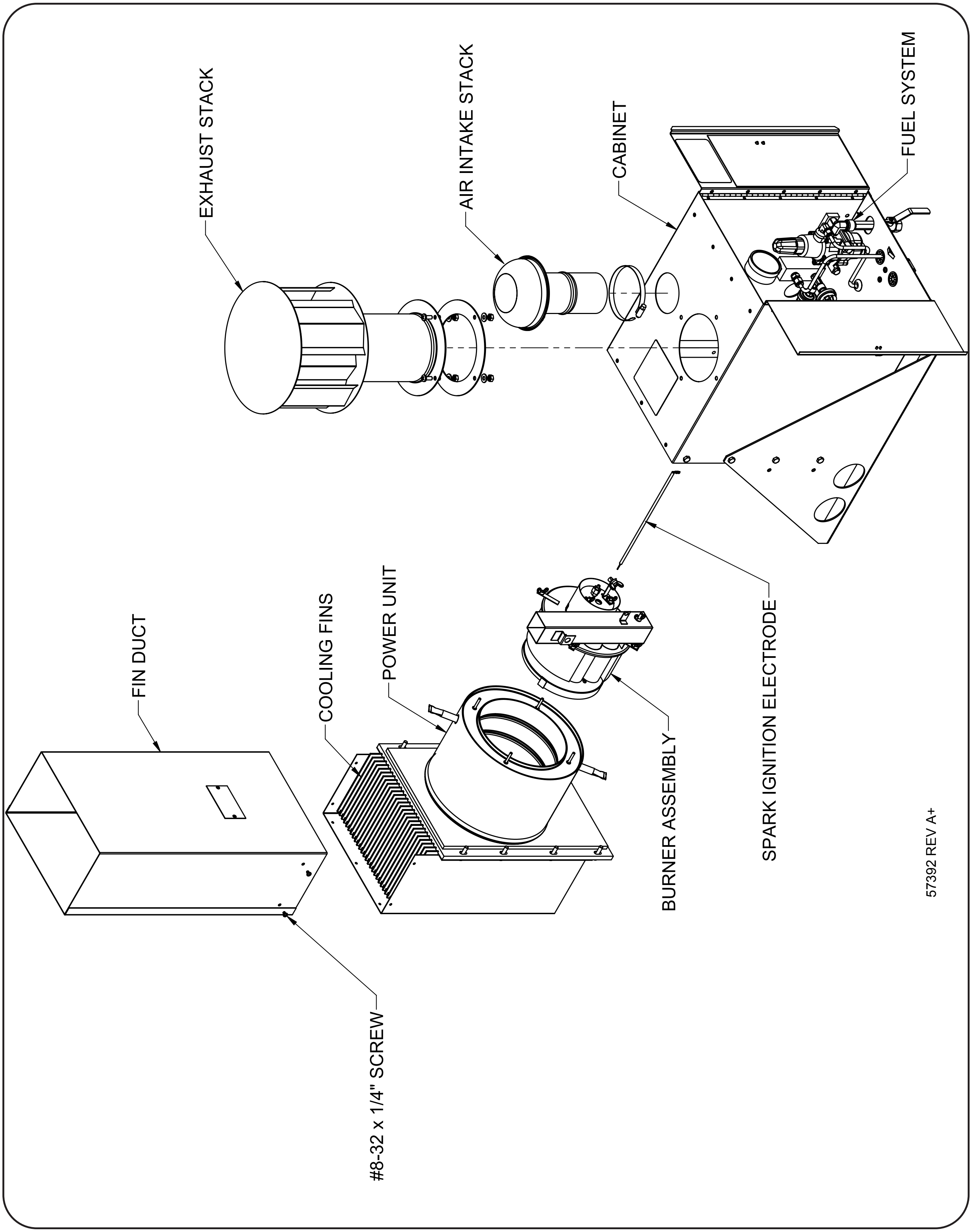


Figure 4-9 TEG Components - Model 5060

4.9 TEG Components

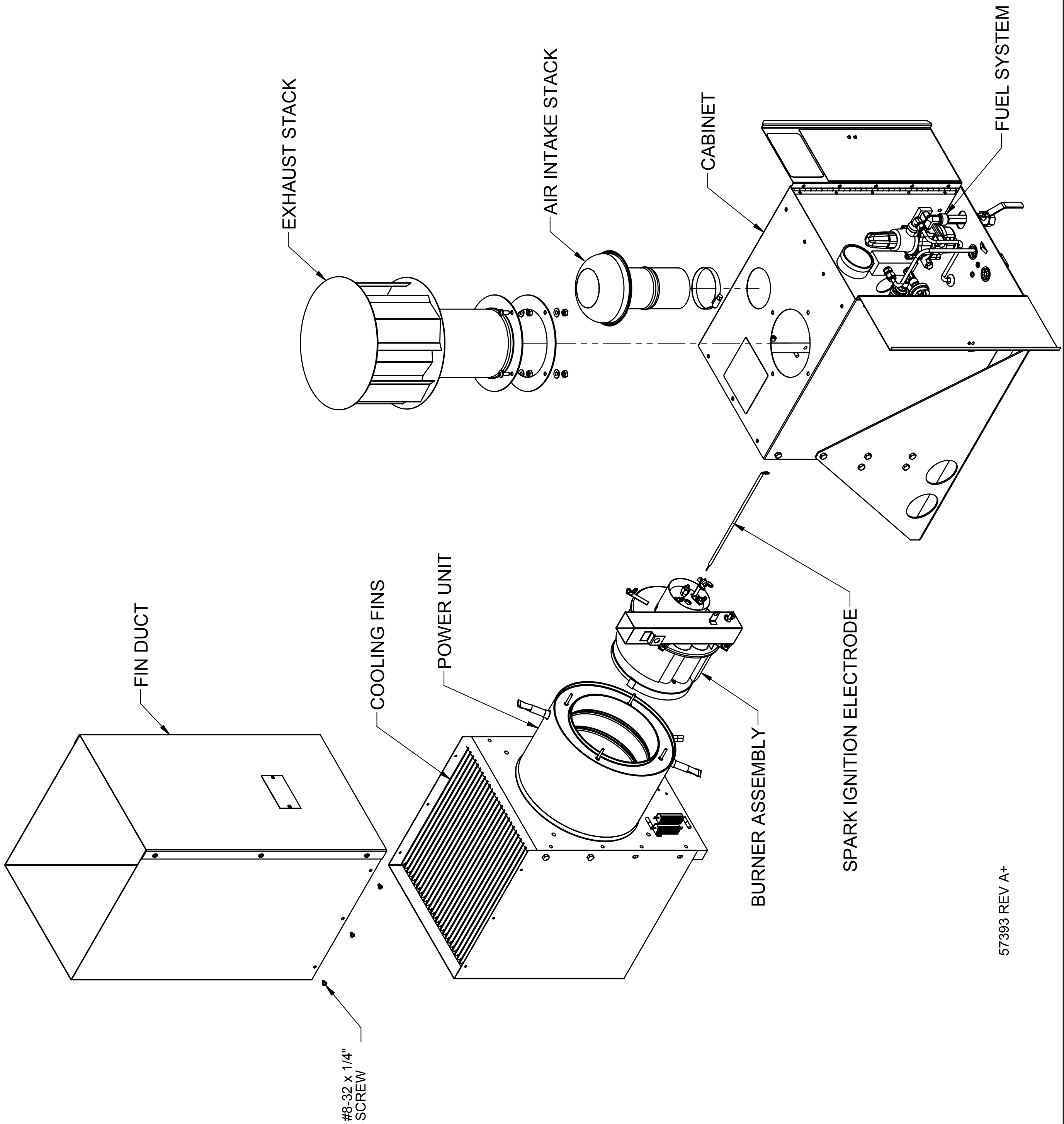


Figure 4-10 TEG Components - Model 5120

4.9 TEG Components

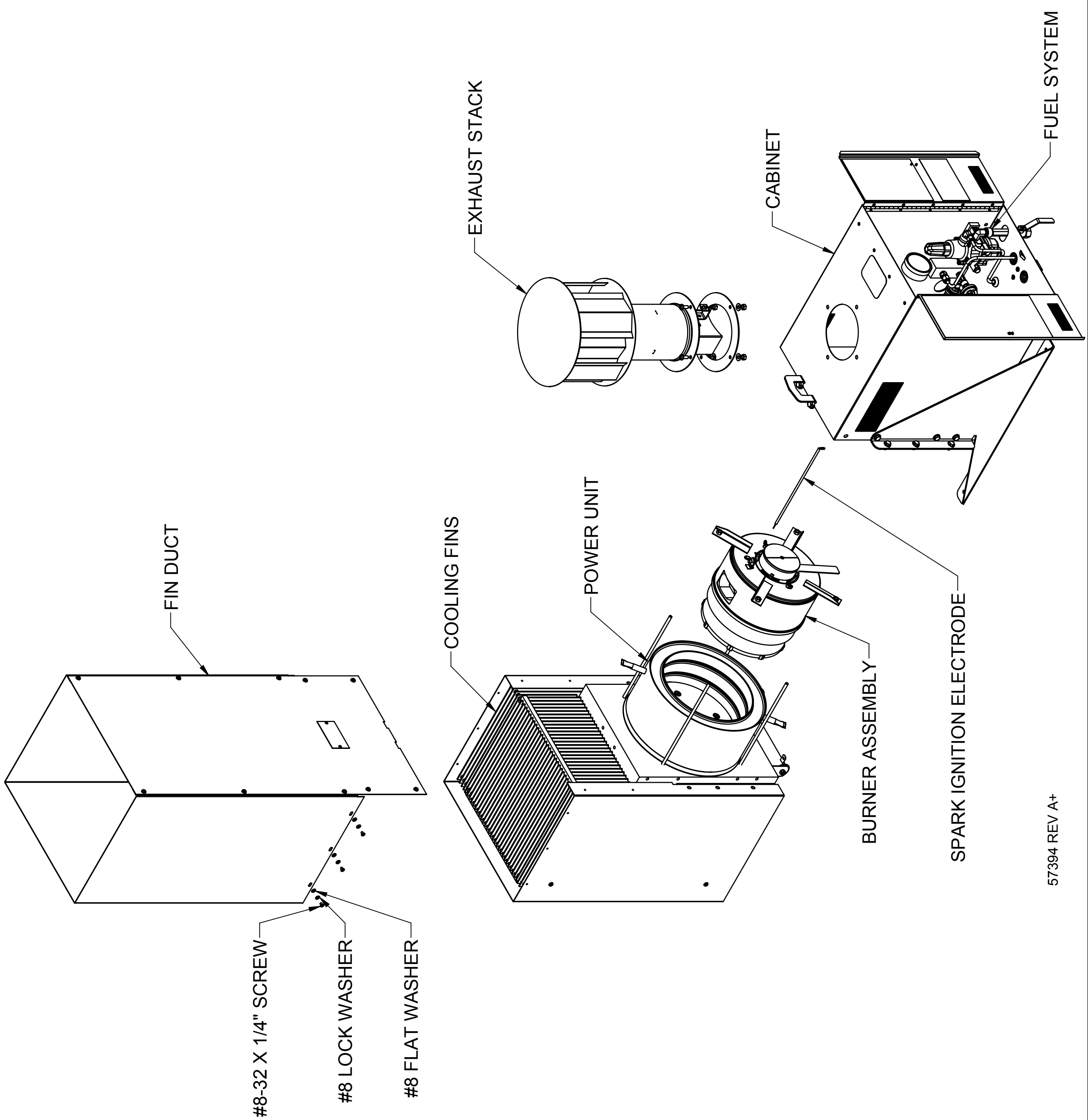


Figure 4-11 TEG Components - Model 5220

4.10 TEG Data Plate

The data plate is on the inside of the cabinet door and includes vital information about the generator.

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

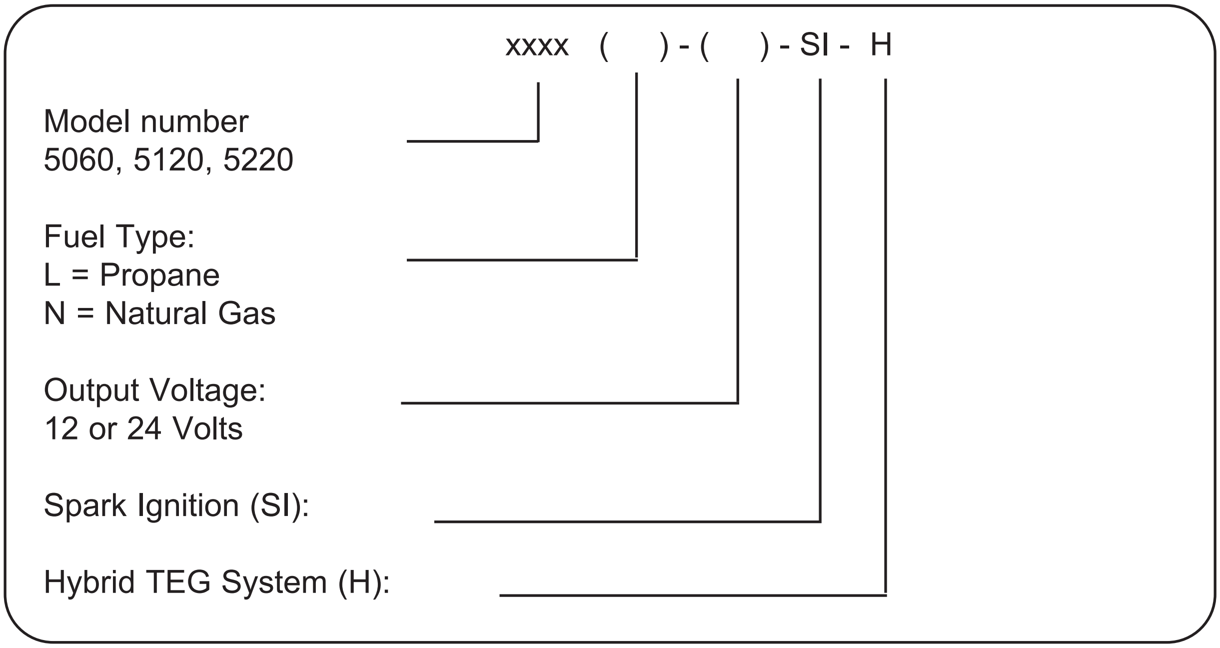


Figure 4-12 TEG Data Plate

Fuel Type: an “X” will be marked in the appropriate box to show whether the generator is set to burn natural gas (CH_4) or propane (C_3H_8). Suitable orifices are available if changing the fuel type is necessary.

Fuel Pressure, Power,Voltage: The fuel pressure, gross power output and voltage across the precision load have been included for reference only. These are the conditions set at the Global Power Technologies factory before shipping.

WARNING: The fuel pressure is recorded in kPa and the pressure gauge must be adjusted for the altitude on site as described in Section 9.

5 INSTALLATION

Mechanical Assembly:

WARNING: all breakers in the breaker box and solar combiner box should be in the OFF position during installation.

Consult local civil engineering resources for specifications on base pole installation required for site location and battery system support base for site location.

5.1 Site Layout

The following site layouts are suggested for each Global*SolarHybrid*™ system. The wiring supplied will accommodate each layout.

Model	TEG Model	# of PV Panels	Battery Box	Figure # (page #)
S-2025	5060	2	2	Figure 5-1 (page 5.2)
S-2050	5060	4	4	Figure 5-2 (page 5.3)
S-2075	5120	4	6	Figure 5-3 (page 5.4)
S-2100	5120	6	8	Figure 5-4 (page 5.5)
S-2150	5220	8	2x6-Battery Box	Figure 5-5 (page 5.6)
S-3025	5060	2	4	Figure 5-6 (page 5.7)
S-3050	5060	4	6	Figure 5-7 (page 5.8)
S-3075	5120	6	8	Figure 5-8 (page 5.9)
S-3100	5120	8	2x6-Battery Box	Figure 5-9 (page 5.10)

5.1.1 Site preparation:

Ensure the site location will have clear south horizon (north horizon, for southern hemisphere) for maximum solar performance during winter seasons. If locating on the south side of buildings, remove all trees or obstructions that will cause shadows on the solar panels at all times of the year. If the site is to be fenced in, ensure the fence is no taller than the bottom edge of the solar panels. See **Figure 4-1** System Components on page 4.2.

5.1 Site Layout

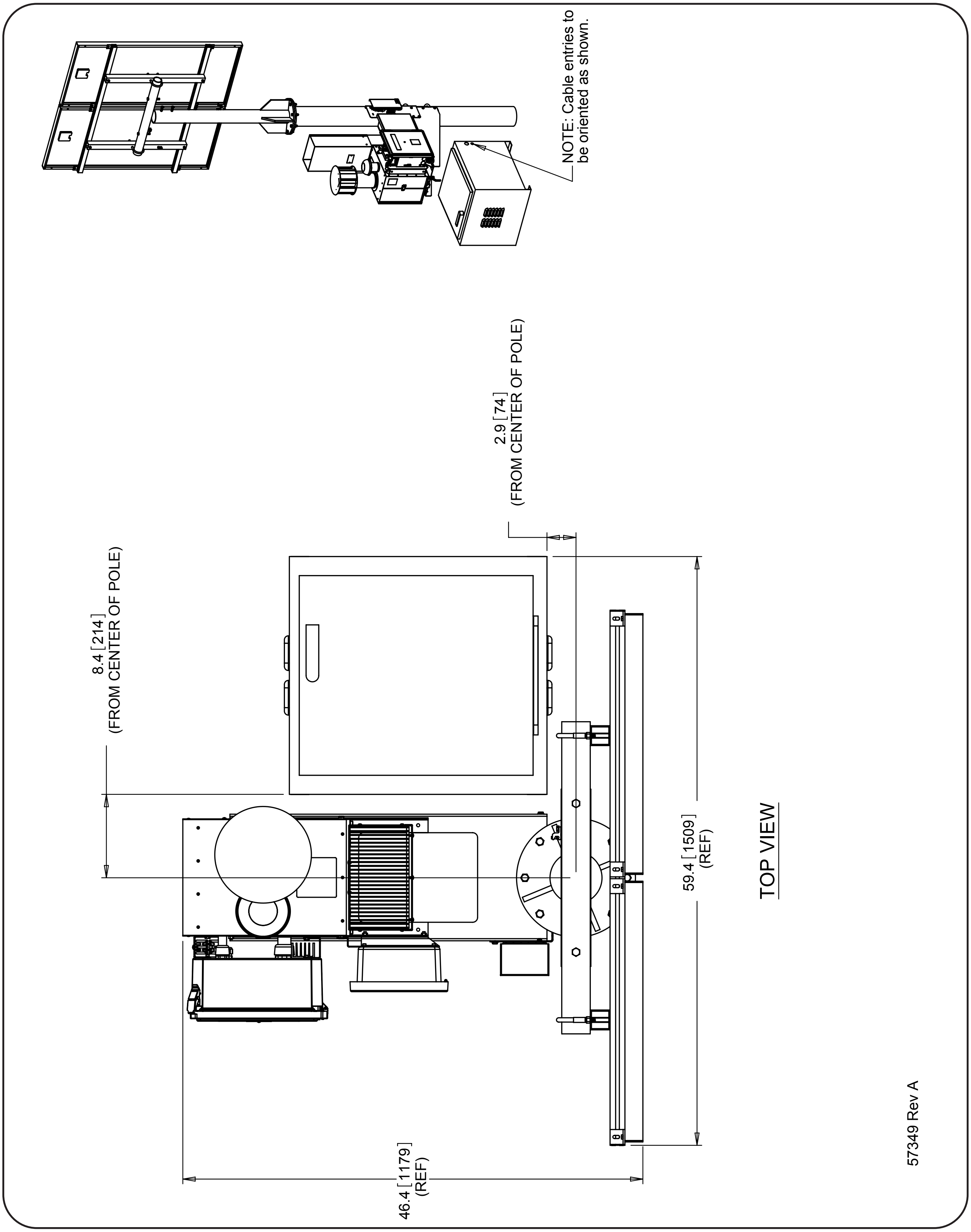


Figure 5-1 Site Layout - Hybrid Model S-2025

5.1 Site Layout

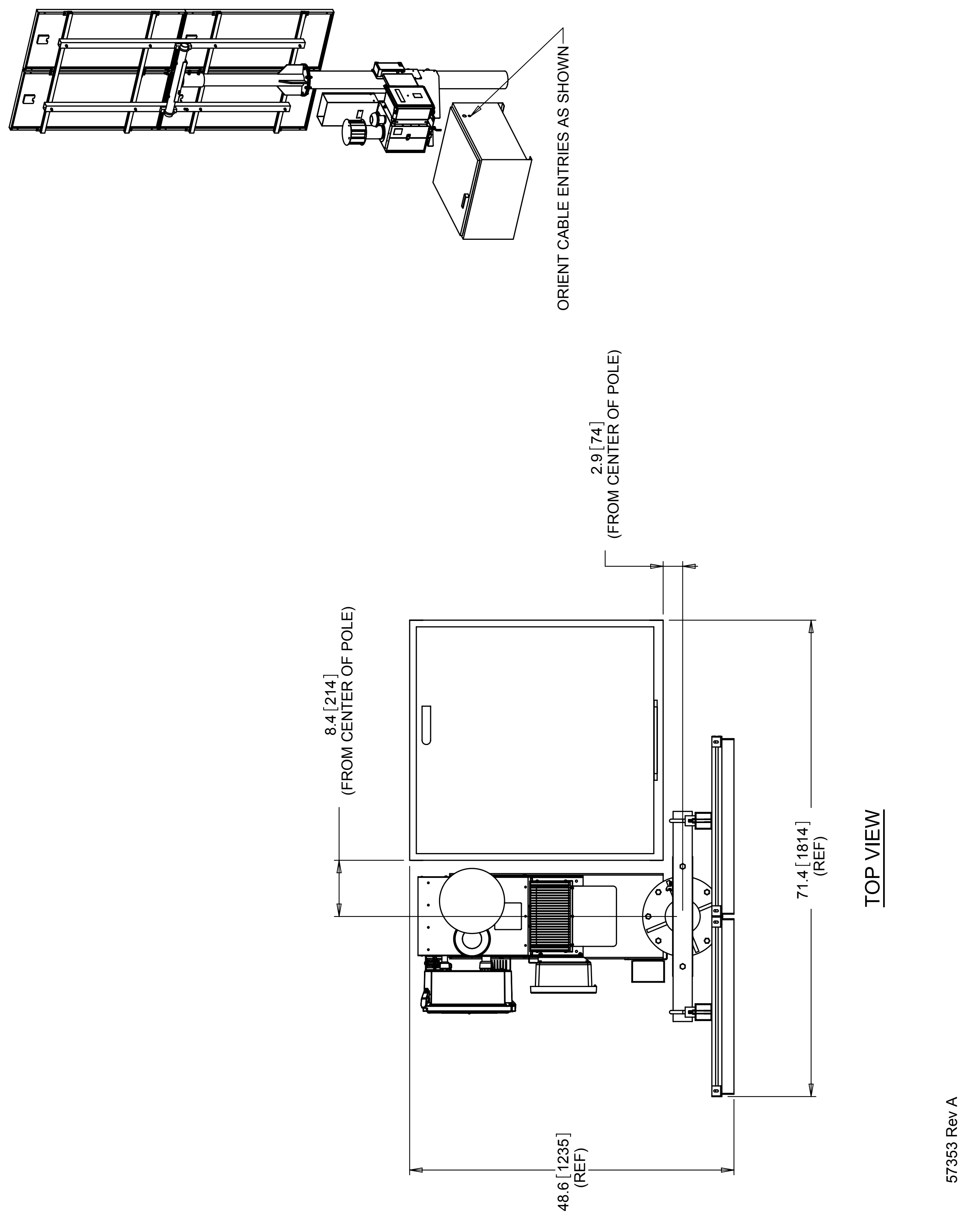


Figure 5-2 Site Layout - Hybrid Model S-2050

5.1 Site Layout

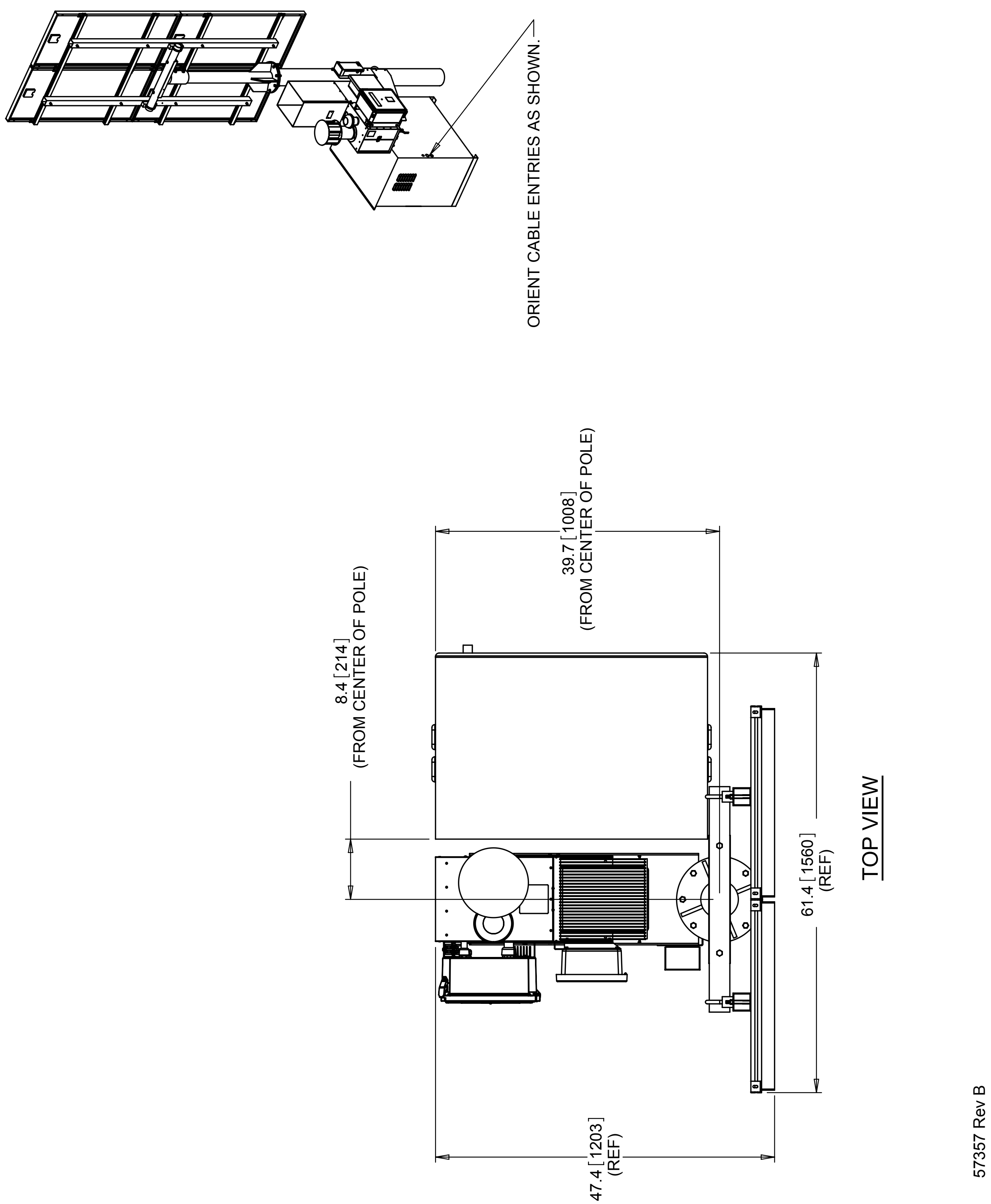


Figure 5-3 Site Layout - Hybrid Model S-2075

5.1 Site Layout

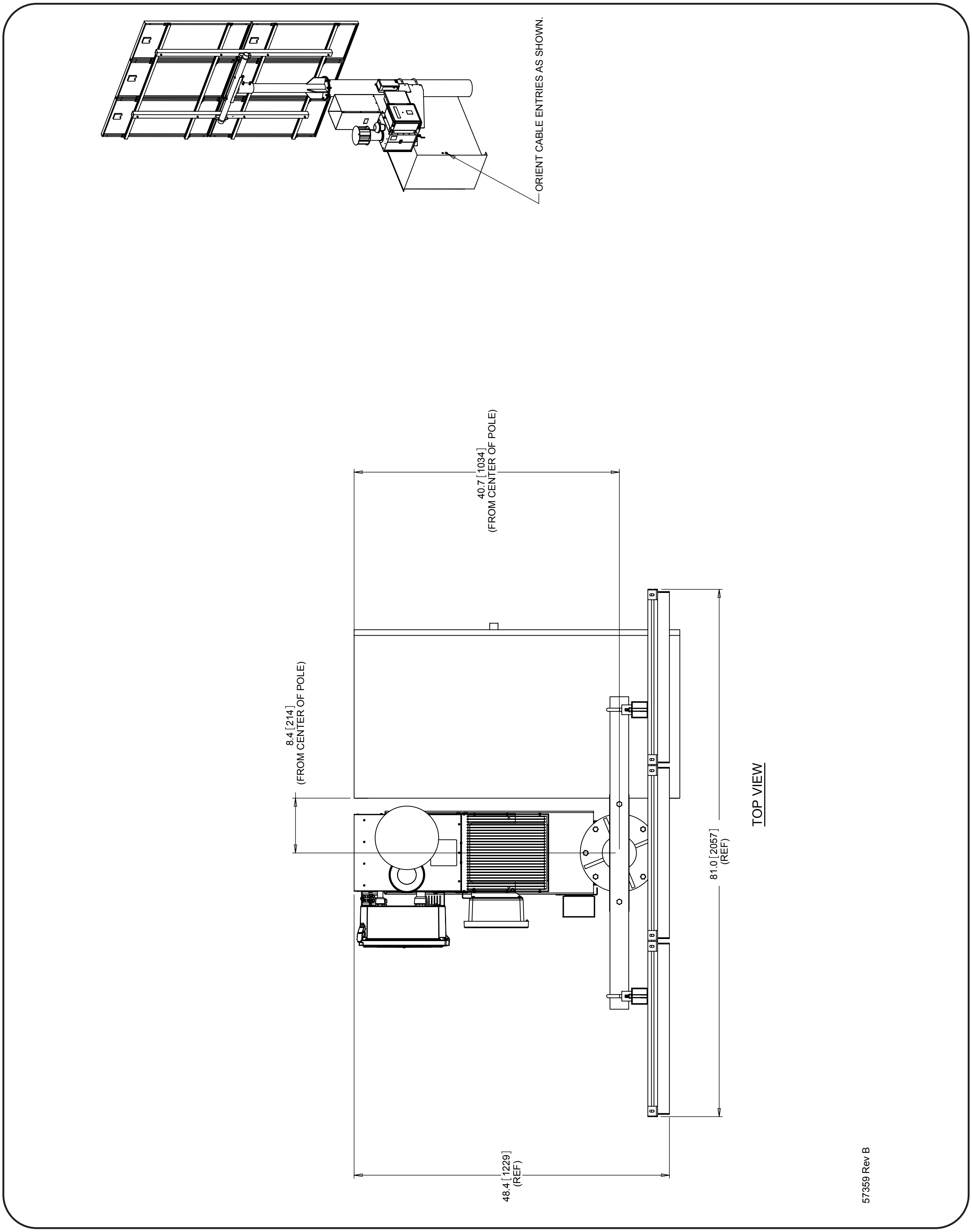


Figure 5-4 Site Layout - Hybrid Model S-2100

5.1 Site Layout

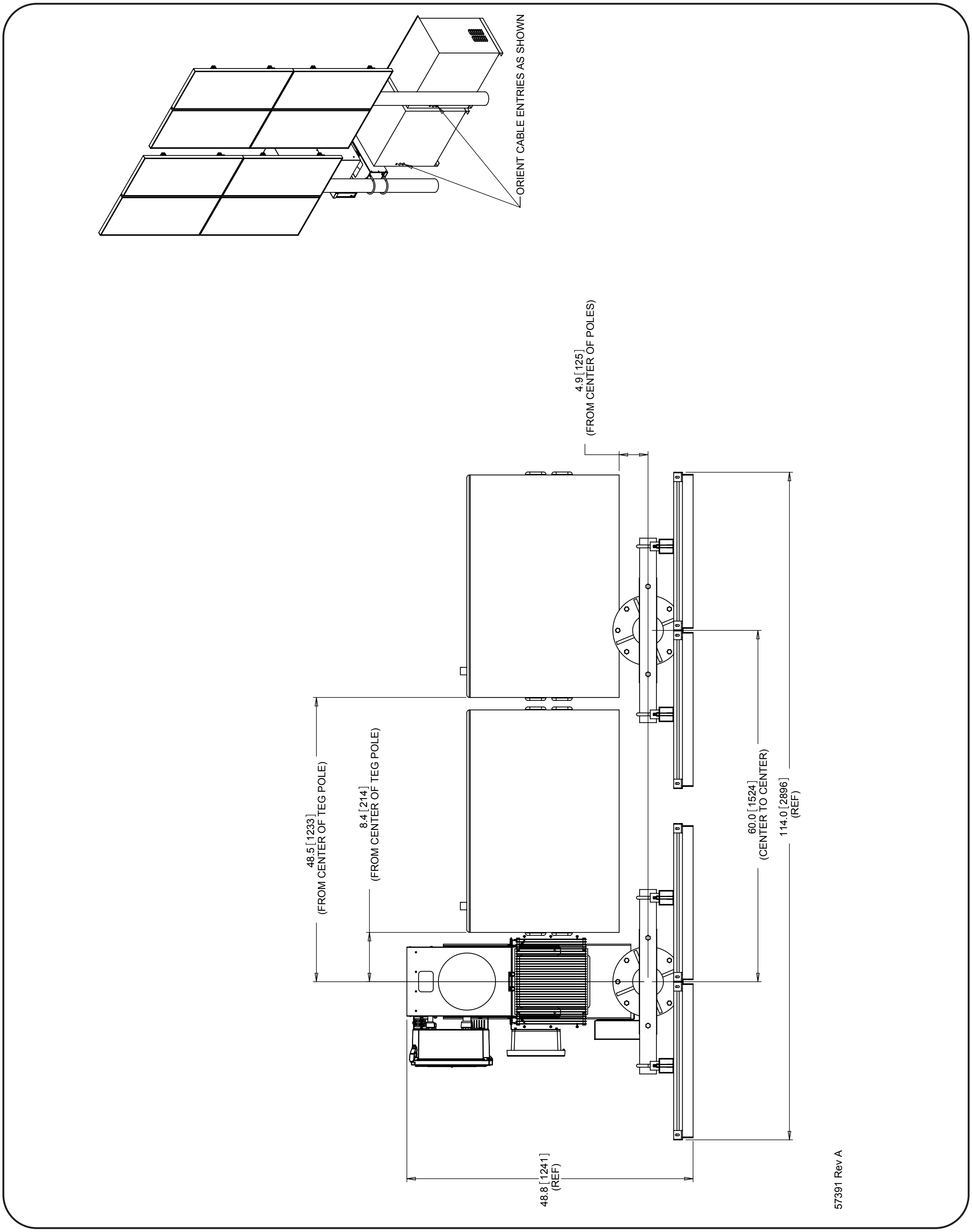


Figure 5-5 Site Layout - Hybrid Model S-2150

5.1 Site Layout

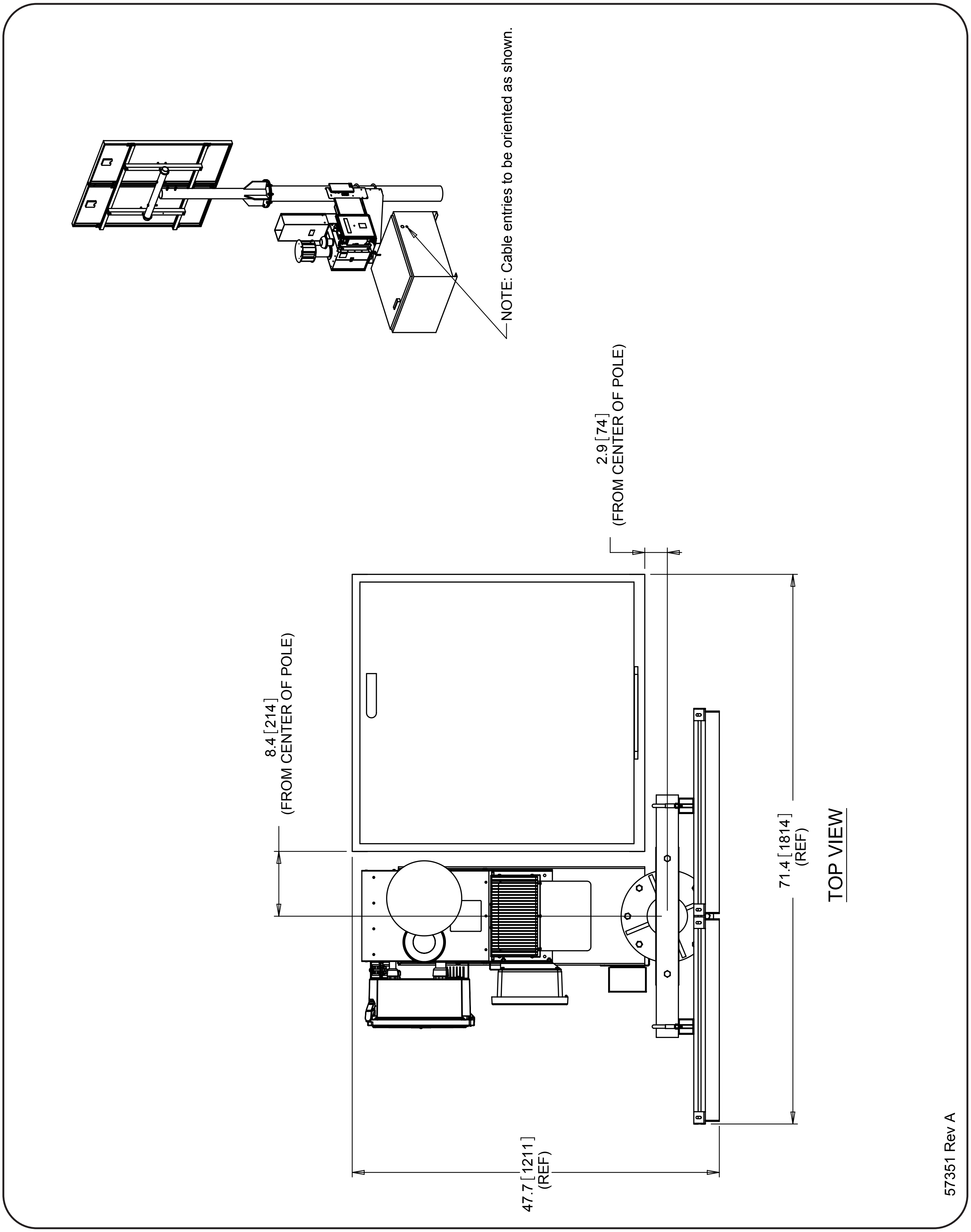


Figure 5-6 Site Layout - Hybrid Model S-3025

5.1 Site Layout

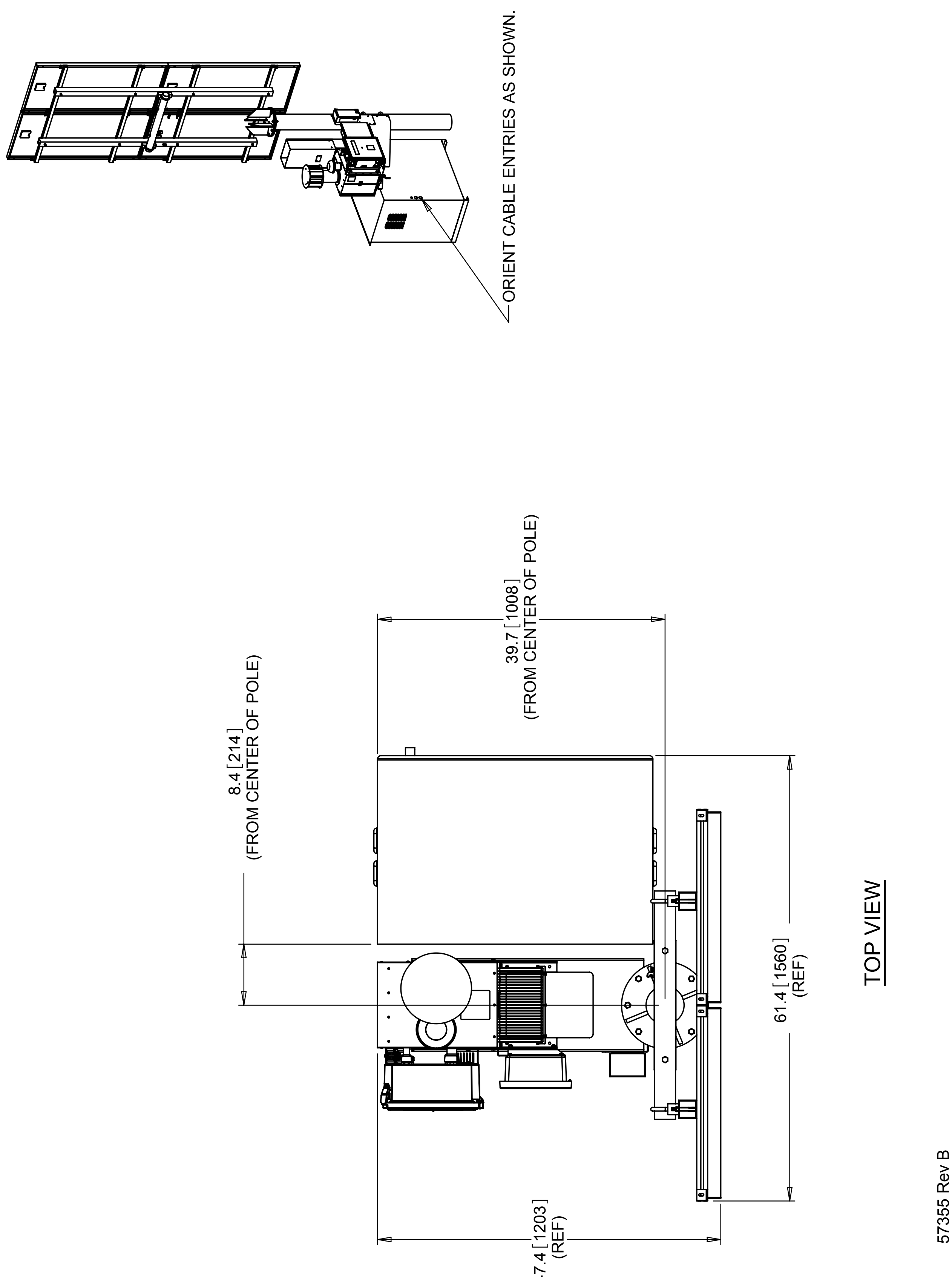


Figure 5-7 Site Layout - Hybrid Model S-3050

5.1 Site Layout

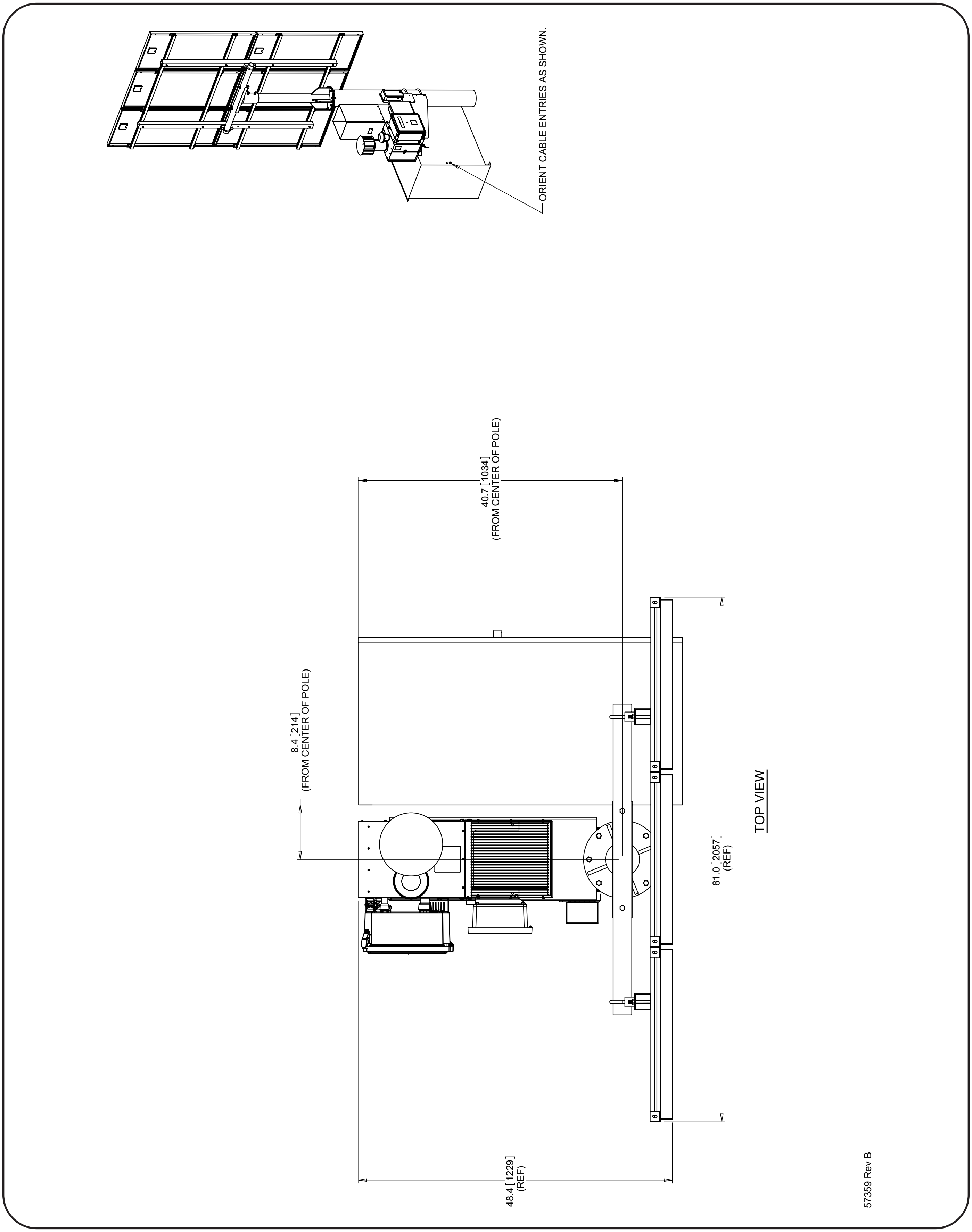


Figure 5-8 Site Layout - Hybrid Model S-3075

5.1 Site Layout

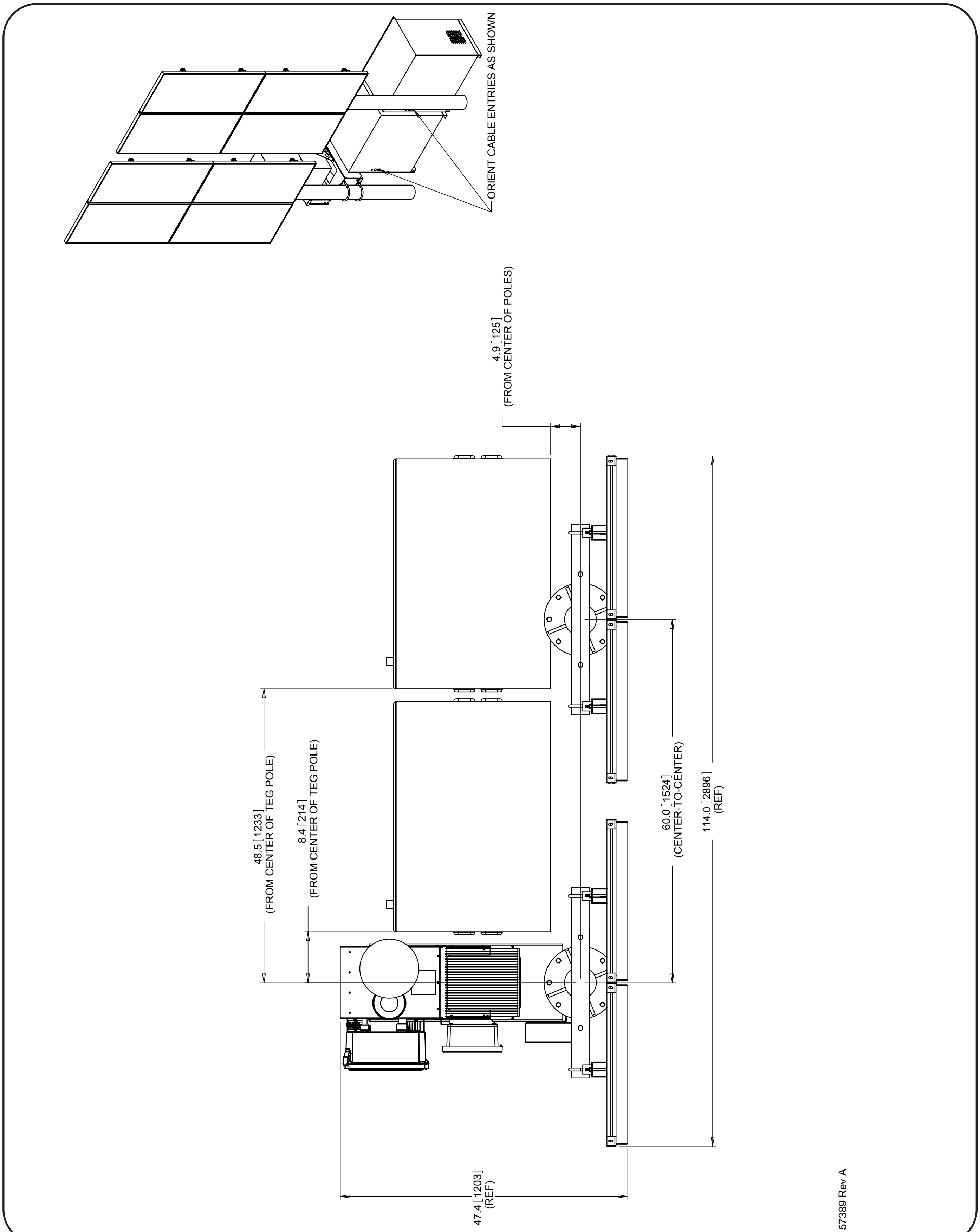


Figure 5-9 Site Layout - Hybrid Model S-3100

5.2 Installation Tool List

In addition to tradesman tool kit:

- 5/16” Allen Wrench (for Battery Box terminal blocks)
- 3/16” Allen Wrench (for Control Box terminal blocks)
- Step Drill or Hole Saw, as required to fit custom load cable to Control Box
- DC Voltmeter, accurate to 0.1V
- Clamp-on Ammeter, capable of measuring DC Current

5.3 Ground Pole Installation

Consult local civil engineering resources for specifications on ground pole installation required for site location. The following table summarizes the pole loading.

The following table is only an approximation for depth of pole given average soil conditions. Add 8 inches to the depth of pole to determine the length of ground pole required to allow for pole assembly. GPT highly recommends consulting a civil engineer for calculating pole installation.

Number of Panels	Area of Panels (sq. ft.)	Wind Load at 90mph / 29 lb/sqft (lbf)	Pole Ass’y Wt. (approx.) (lbs)
2	22 (2.0m^2)	638 (290 kgf)	620 (281kg)
3	32 (3.0m^2)	928 (420 kgf)	660 (299 kg)
4	43 (4.0m^2)	1247 (565 kgf)	710 (322 kg)
6	65 (6.0m^2)	1885 (855 kgf)	950 (431 kg)

Number of Panels	Area of Panels (sq. ft.)	Pole Depth in Ground	Ground Pole Length	Hole Diameter
2	22 (2.0m^2)	56” (1.4m)	64” (1.63m)	18” (0.46m)
3	32 (3.0m^2)	56” (1.4m)	64” (1.63m)	18”(0.46m)
4	43 (4.0m^2)	60” (1.5m)	68” (1.73m)	24” (0.61m)
6	65 (6.0m^2)	72” (1.8m)	80” (2.00m)	24” (0.61m)

For Reference Only: The installation hole should be an additional 4 to 6 inches (10 to 15 cm) deeper than required and a layer of rock or gravel placed in the bottom of the hole for drainage. Brace the pole plumb and centered in the hole and fill the hole with concrete, slope excess concrete away from the pole to divert water away from pole. Allow adequate time for concrete to set before assembling the pole, rack and panels.

A 6 inch (15 cm) diameter base pole is supplied with the 2, 3, or 4 panel systems. An 8 inch (20 cm) diameter base pole is supplied with the 6 panel systems.

The top of the ground pole is required to be at least 8" (20 cm) above ground for pole assembly, solar system and generator mounting. The flange is required to be at the top for mating to the base pole. If an assembled pole height of greater than 11 ft (330 cm) is required, consult GPT for pole limitations.

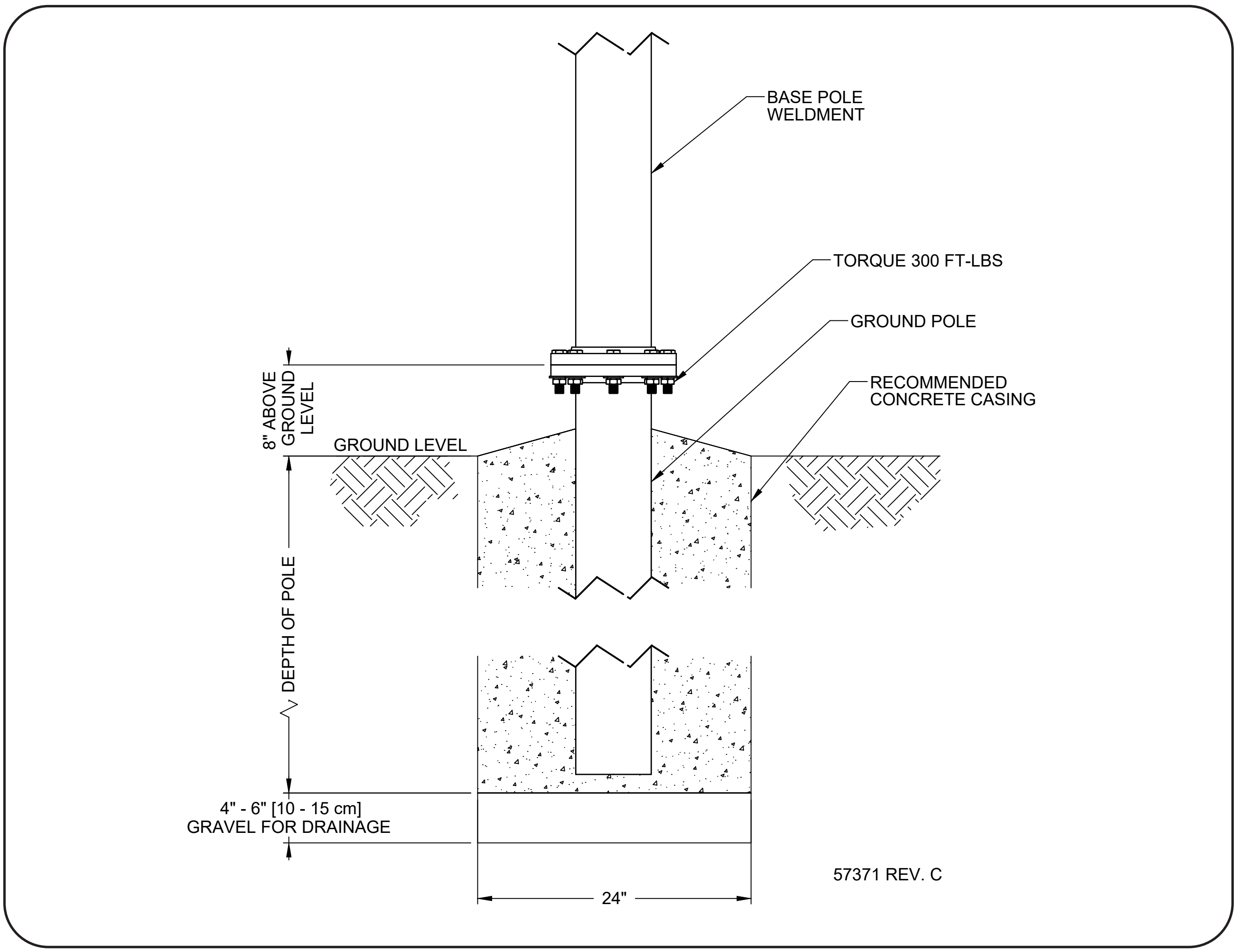


Figure 5-10 Base Pole Installation Requirements

NOTE: Consult local civil engineering resources for ground installation

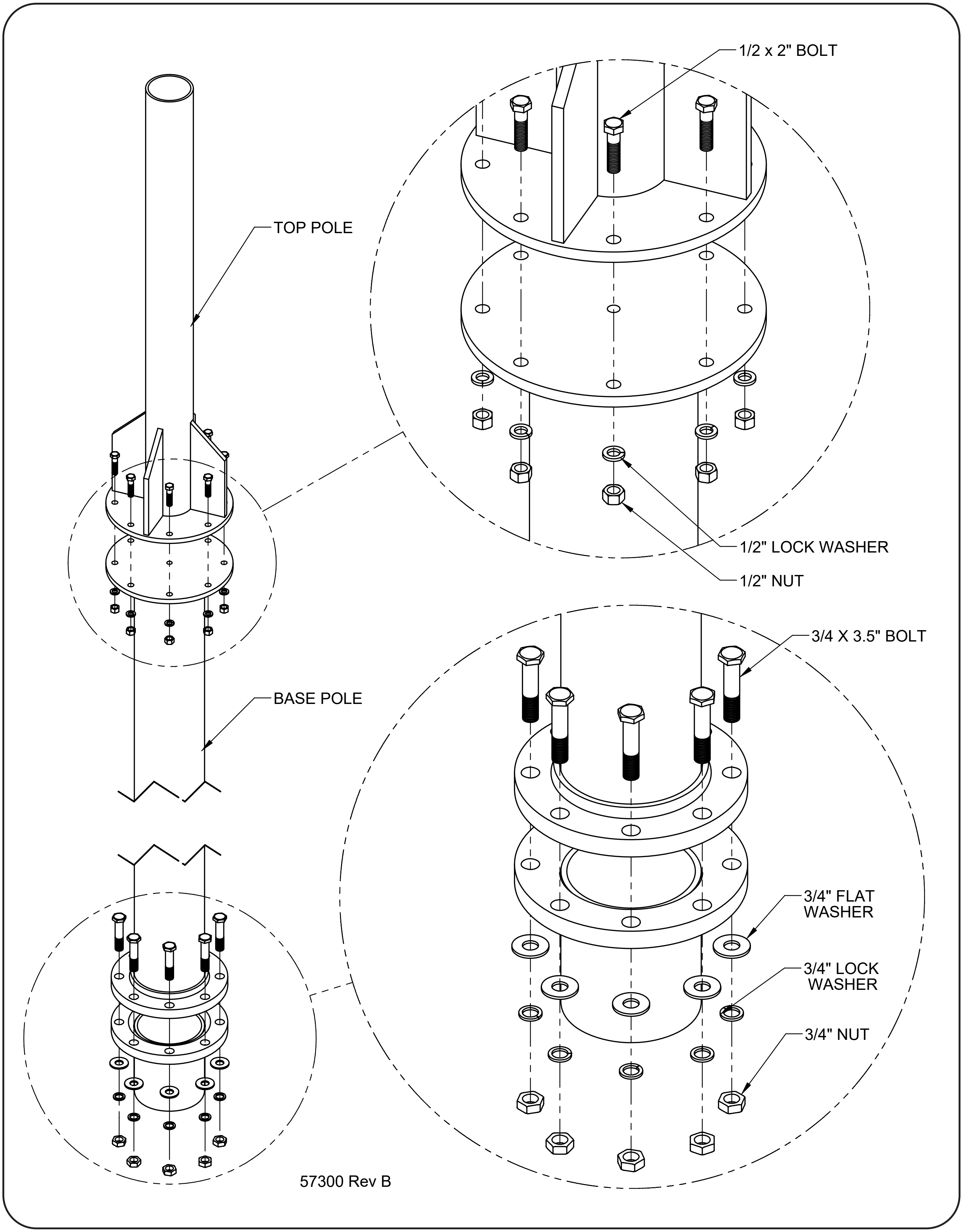


Figure 5-11 Top Pole Installation

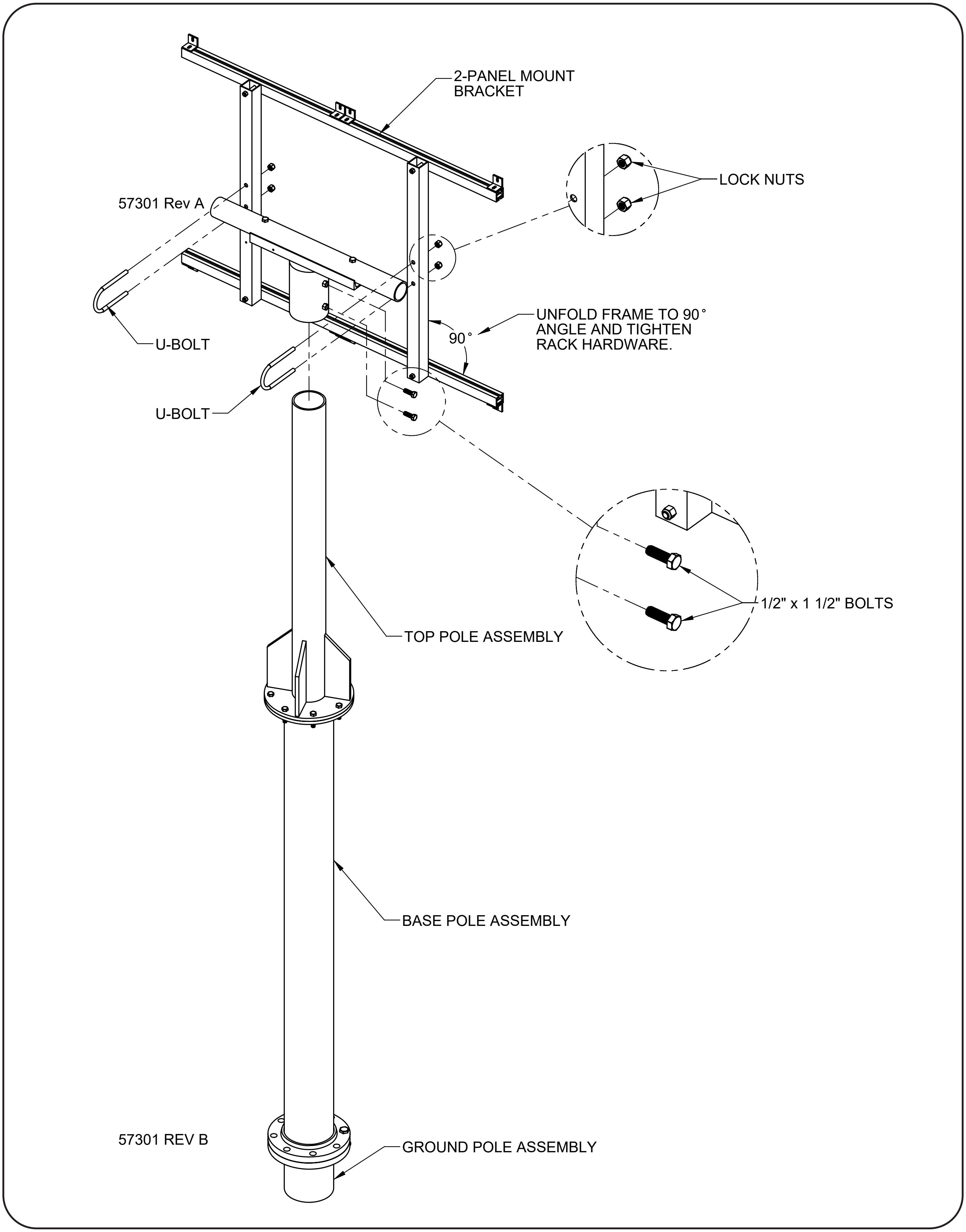


Figure 5-12 2 Panel Solar Rack and Gimbal

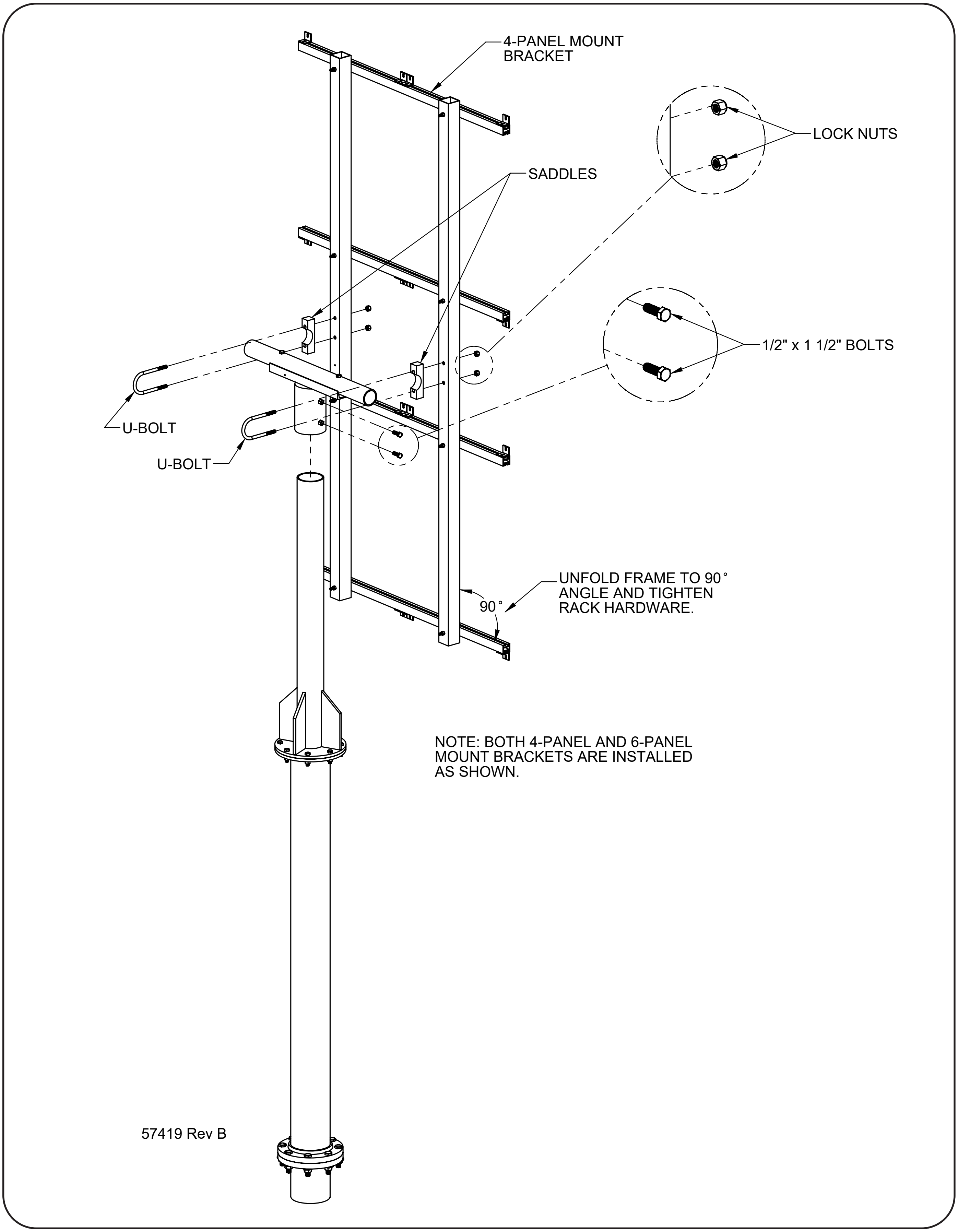


Figure 5-13 4 and 6 Panel Solar Rack and Gimbal

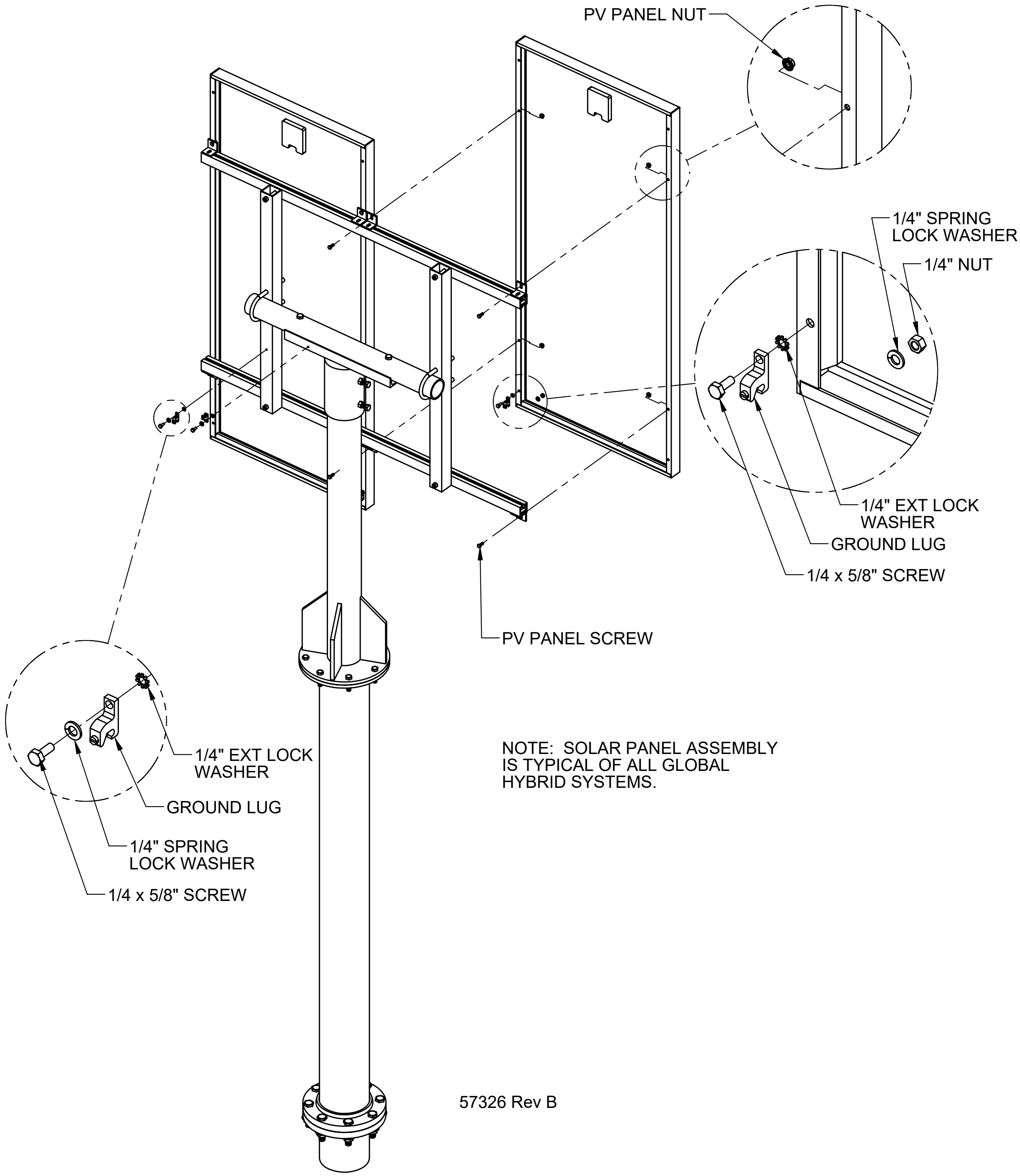


Figure 5-14 Solar Panel and Rack Assembly

5.4 Solar Panel System Installation

Set up solar panel rack assembly. Install gimbal to rack. Install rack and gimbal assembly to the top of the top pole.

- 2 panel rack - **Figure 5-12** (page 5.14)
- 4 and 6 panel rack - **Figure 5-13** (page 5.15)

WARNING: Do NOT wire the panels at this time. The PV panels are producing power whenever exposed to light. The panels should be covered during installation. The wiring must be done from the combiner box up to the solar panels. See Solar Wiring section 5.10.2 for more details.

Install solar panels and grounding lugs onto rack assembly (**Figure 5-14** - page 5.16)

<u>Optional:</u> Grounding conductor can be installed at this time. See section 5.10.1 - Wiring, System Grounding.

5.4.1 Adjusting Panel Tilt

The solar panels must be facing directly south in the northern hemisphere and directly north in the southern hemisphere. Adjust the azimuth by loosening the gimbal lock bolts and rotating the solar panel rack on the top of the top pole, (see **Figure 5-12** or **Figure 5-3**). If necessary, the azimuth can be adjusted +/-5°, without a performance penalty. Contact Global Power Technologies (GPT) if the azimuth needs to be adjusted beyond +/-5° from true south or north.

To maximize annual solar energy, the optimum panel tilt angle is calculated as:

Panel Angle = Latitude + 15°+/-2°, for latitudes between 0° and 45°, and there is no snow accumulation.

Panel Angle = 75°+/-2°, for latitudes greater that 45°, or there is annual snow accumulation

To adjust the panel tilt angle, loosen both solar panel rack mount U-bolts and rotate the panel rack until the correct angle is achieved. Retighten the U-bolts and check that the angle is correct.

5.5 TEG Mounting Bracket and Combiner Box Bracket

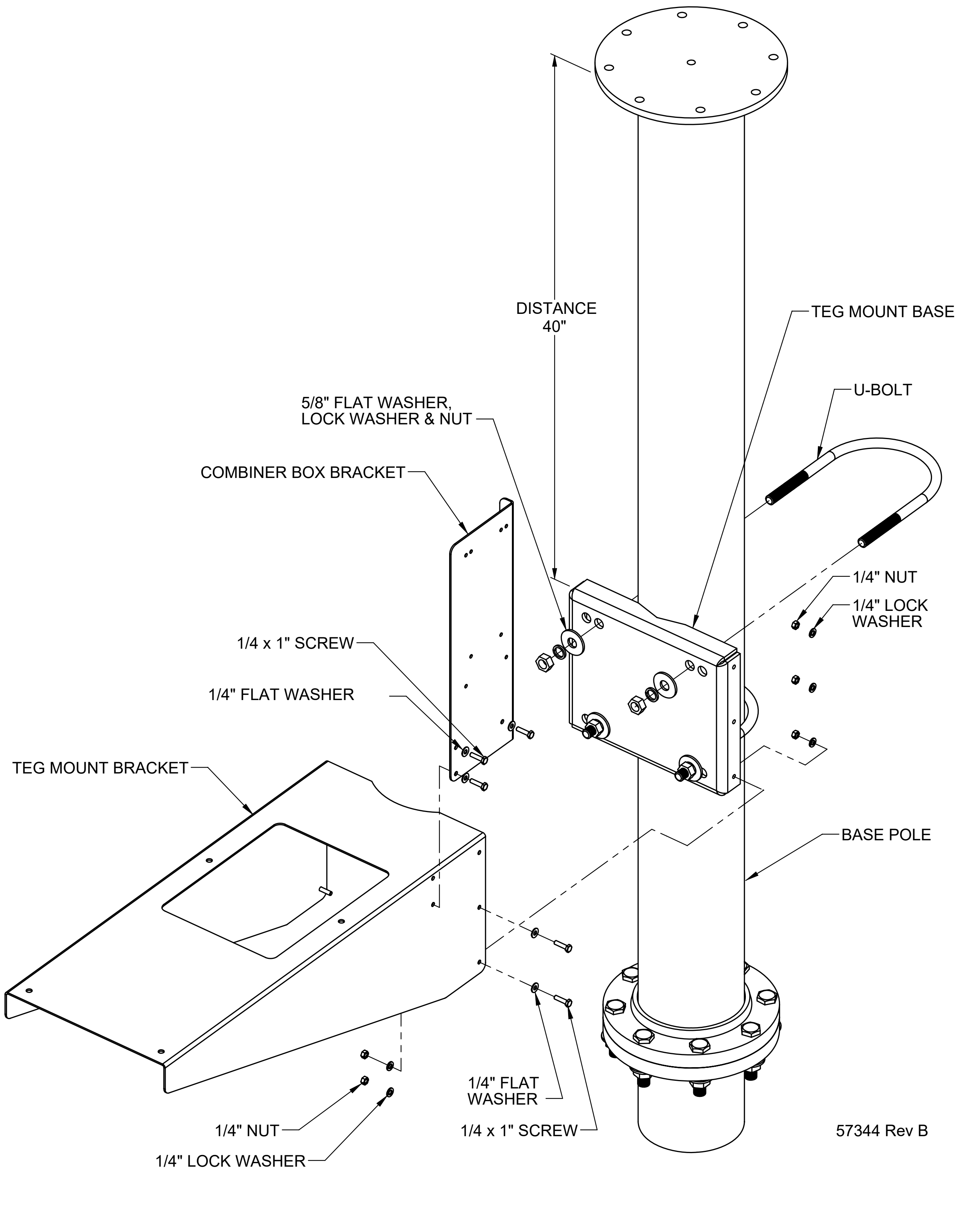


Figure 5-15 TEG Mounting Bracket and Combiner Box Bracket

5.6 Generator and Combiner Box Installation

WARNING: Do not unpack the TEG from its shipping crate and set it on the flat surface, without room for the interconnecting wiring to drape below the bottom of the TEG cabinet. The interconnecting wiring between the two electronic enclosures mounted on the side of the TEG cabinet will be damaged if weight is placed on the wires and housings.

WARNING: Inspect the TEG for damage which may have occurred during shipping. Please report any damage as soon as possible. The damage may make the generator inoperable. Check with Global Power Technologies Customer Service before starting a damaged TEG.

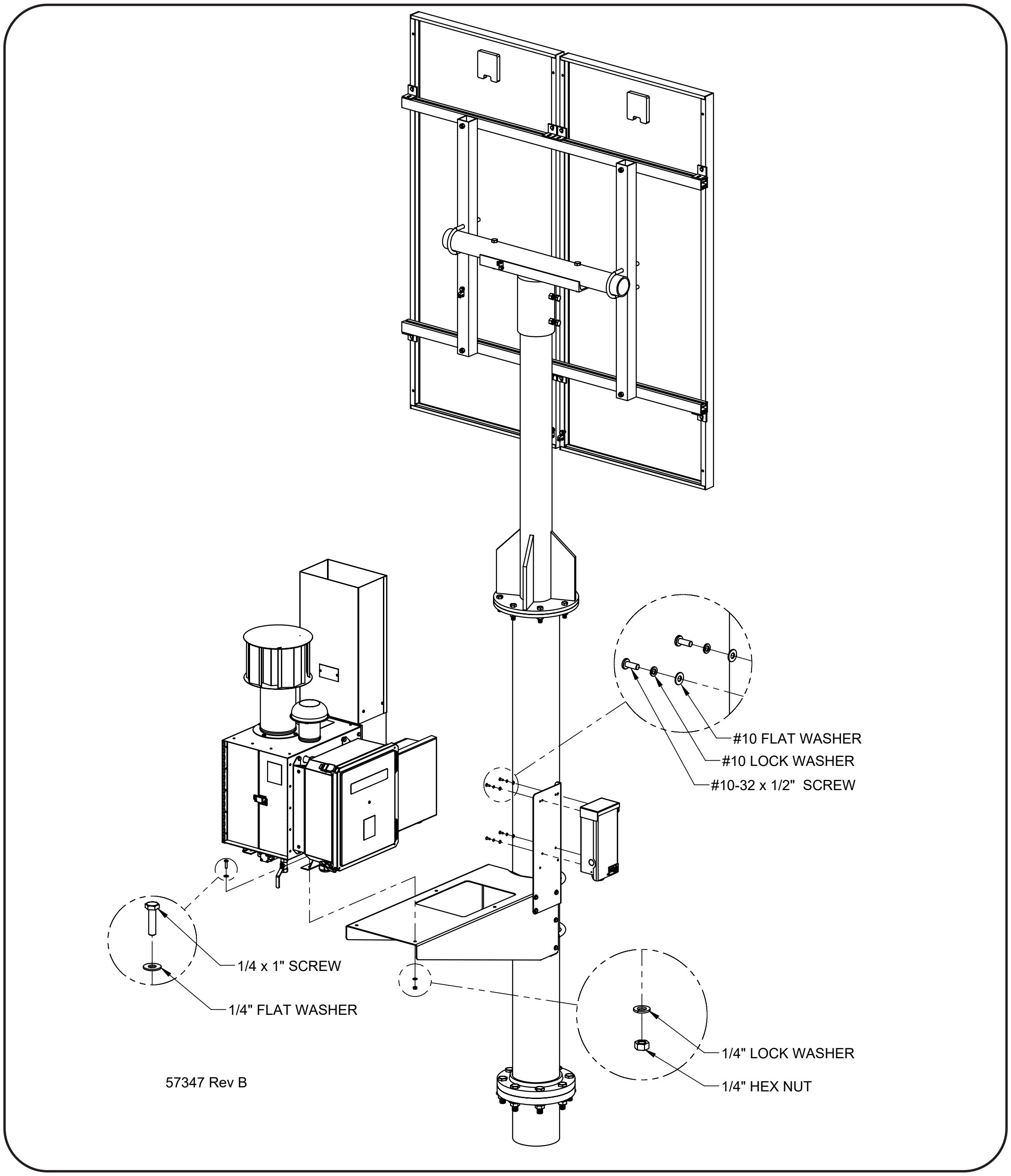


Figure 5-16 Generator and Combiner Box Installation

Install fin duct onto top of cooling fins prior to installing TEG onto TEG mounting bracket. See **Figure 4-9**, page 4.10 for 5060 TEG, **Figure 4-10**, page 4.11 for 5120 TEG and **Figure 4-11**, page 4.12 for 5220 TEG.

Install TEG onto mounting bracket and solar combiner box onto mounting bracket as shown in **Figure 5-16** (previous page).

5.7 Battery Box and Batteries

Consult local civil engineering resources for specifications for battery system support base for site location. The battery enclosure locations are shown in **Figure 5-1** to **Figure 5--9** and weights are shown in the following table. Ensure the battery enclosure support will support the weight given.

Battery Configuration	Weight* (lbs)	Length (in)	Width (in)
2 battery	450 (204kg)	28 (71cm)	24 (61cm)
4 battery	830 (376kg)	38 (97cm)	36 (91cm)
6 battery	1220 (553kg)	38 (97cm)	24 (61cm)
8 battery	1600 (726kg)	50 (127cm)	24 (61cm)

* weight includes batteries and enclosure.

The 2 battery and 4 battery systems are shipped with the batteries inside the battery enclosure. Verify that the batteries are evenly spaced between each other and the enclosure.

The 6 battery, 8 battery, and 12 battery systems have the batteries shipped separately. The 12 battery system is comprised of two 6 battery enclosures wired together. Install the batteries into the battery enclosure with the battery posts facing the doors, ensuring even spacing between batteries and the enclosure.

A grounding lug needs to be installed onto the grounding stud located inside the battery box. See **Figure 5-21** to **Figure 5-25** below in section 5.10.3 on battery wiring.

5.8 Temperature Sensor Mounting

See section 5.10.4 below for mounting the temperature sensors while wiring.

5.9 Customer Load Entry Installation

The customer load entry needs to be cut as required during installation, to connect to the load terminal block in the control box. See **Figure 4-2** on page 4.3.

5.9.1 Optional SCADA Entry Installation

The optional SCADA entry needs to be cut as required during installation, to connect to the TCC board and L/C board. See **Figure 4-3** on page 4.4 and **Figure 4-4** on page 4.5 for wiring locations.

5.10 Wiring

5.10.1 System Grounding and Bonding

Grounding conductors:

The ends of the grounding conductor, as well as each point where the conductor is accessible, must be marked with green tape or green adhesive labels, unless it is a bare conductor or the conductor is insulated or individually covered with a green or green with one or more yellow stripes.

- The solar panels must be grounded for safety.
  - A single conductor is used to connect all the solar panel frames, the rack and the poles to the ground bus bar in the solar combiner box.
  - A black cable with sunlight resistant insulation is used as the grounding conductor.
  - It must have the insulation stripped off at the locations where it goes into the grounding lay-in lugs, and green tape or green adhesive labels applied near the stripped location to identify the conductor as a grounding conductor. The lay-in lugs were previously mounted on the solar panels, rack and poles during installation.
  - The continuous grounding conductor is terminated at the ground bus bar in the solar combiner box.

See **Figure 5-17** and **Figure 5-18,** Grounding the Solar Panels, on the following pages.

- The solar combiner box is to be connected to earth using an approved method compliant with local regulations.

- When the cable is connected between the breaker box and the solar combiner box for the solar wiring, the green wire in the cable will bond the TEG electronics boxes and TEG cabinet to the solar combiner box.

- When the cable is connected between the breaker box and battery enclosure for the battery wiring, the green wire in the cable will bond the battery box to the solar combiner box.

The following is for reference and is pre-wired at the factory:

- The breaker box is bonded to the solar controller in the control box with the green wire in the wiring cable between the line side of the solar breakers and the controller.

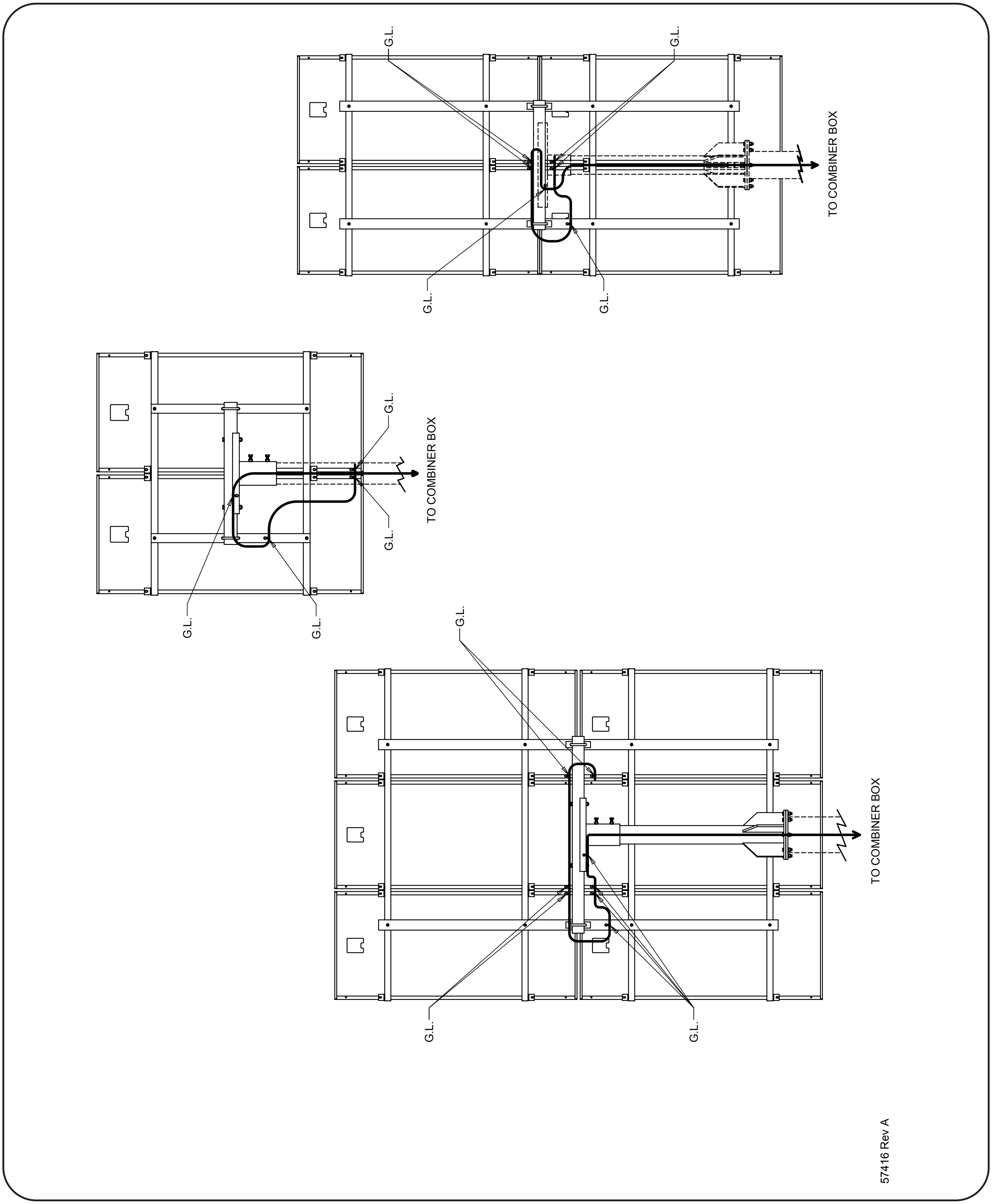


Figure 5-17 Grounding the Solar Panels

* G.L = Ground Lug

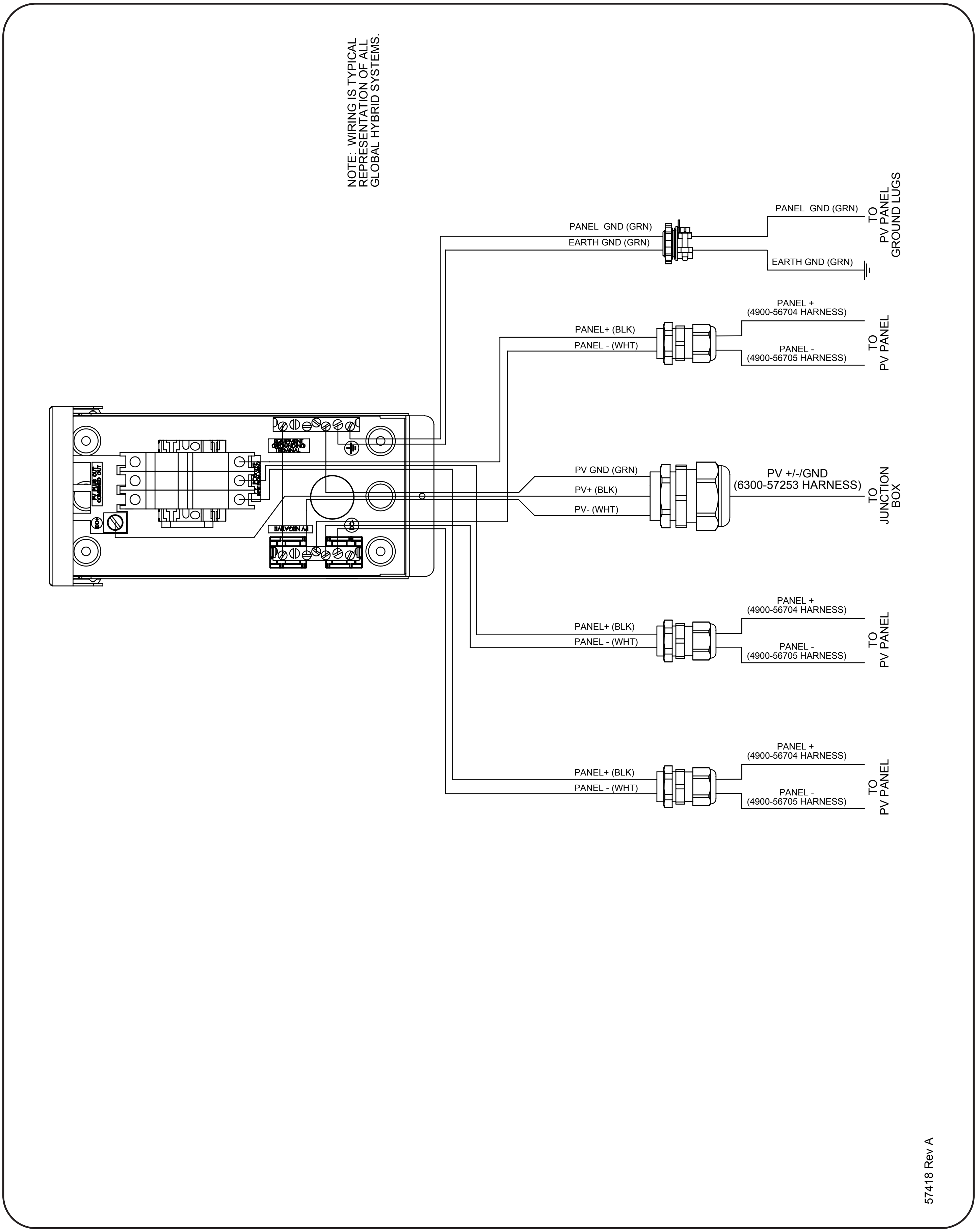


Figure 5-18 Solar Combiner Box Wiring

• The breaker box is also bonded to the backpan in the control box with the green wire in the wiring cable between the line side of the battery breakers and the control box's back-pan

• Mechanical bonding is used to bond the chassis of the solar controller to the backpan and ground bus bar to backpan in the control box.

• The TEG cabinet is wired to the ground bus bar within the control box. This conductor also provides the return path from the electrode back to the spark ignitor power source.

• Inside the control box, the TCC board has a ground connection (for the ignition system) connecting it to the ground bus bar.

5.10.2 Solar Wiring

• Wire From the Solar Combiner Box Up To the Solar Panels
The positive wire is wired from the "positive labelled" side of the breakers up to the solar panel. The negative wire is wired from the negative bus bar up to the solar panel. The solar panel plug-in connections are done last. Use weather resistant cable ties to tie wrap the cables to the pole to hold them in place.

WARNING: Do not connect the solar panel plug wiring until all wires are wired into the combiner box first. Solar panels are live devices, they are producing power whenever exposed to light and must have the bare wires wired into the combiner box before connecting the plugs into the solar panel wiring.

See **Figure 5-18** on page 5.23 for an example of the solar combiner box wiring for three strings of solar panels. Wiring is a typical representation of all systems.

In 12V systems, each panel creates its own 12V string and is wired to a separate breaker in the combiner box (see **Figure 5-19**).

In 24V systems, two panels are wired together in series to create a nominal 24V string; the positive of one panel is connected to the negative of the second panel. Each 2 panel string is wired to a separate breaker in the combiner box (see **Figure 5-20**).
• Connect the cable from the breaker box to the solar combiner box to connect the solar PV array to the solar disconnecting breakers: labelled as "PV+/- IN" in **Figure 5- 21** below. The cable will be pre-wired to the breaker box but needs to be connected to the solar combiner box as shown in **Figure 5-18**.

• The interconnecting wiring between the control box and the breaker box will be done as part of the TEG assembly.

   - The output side of the solar breakers is wired to the solar controller in the control box (see **Figure 5-21** and **Figure 5-22**).

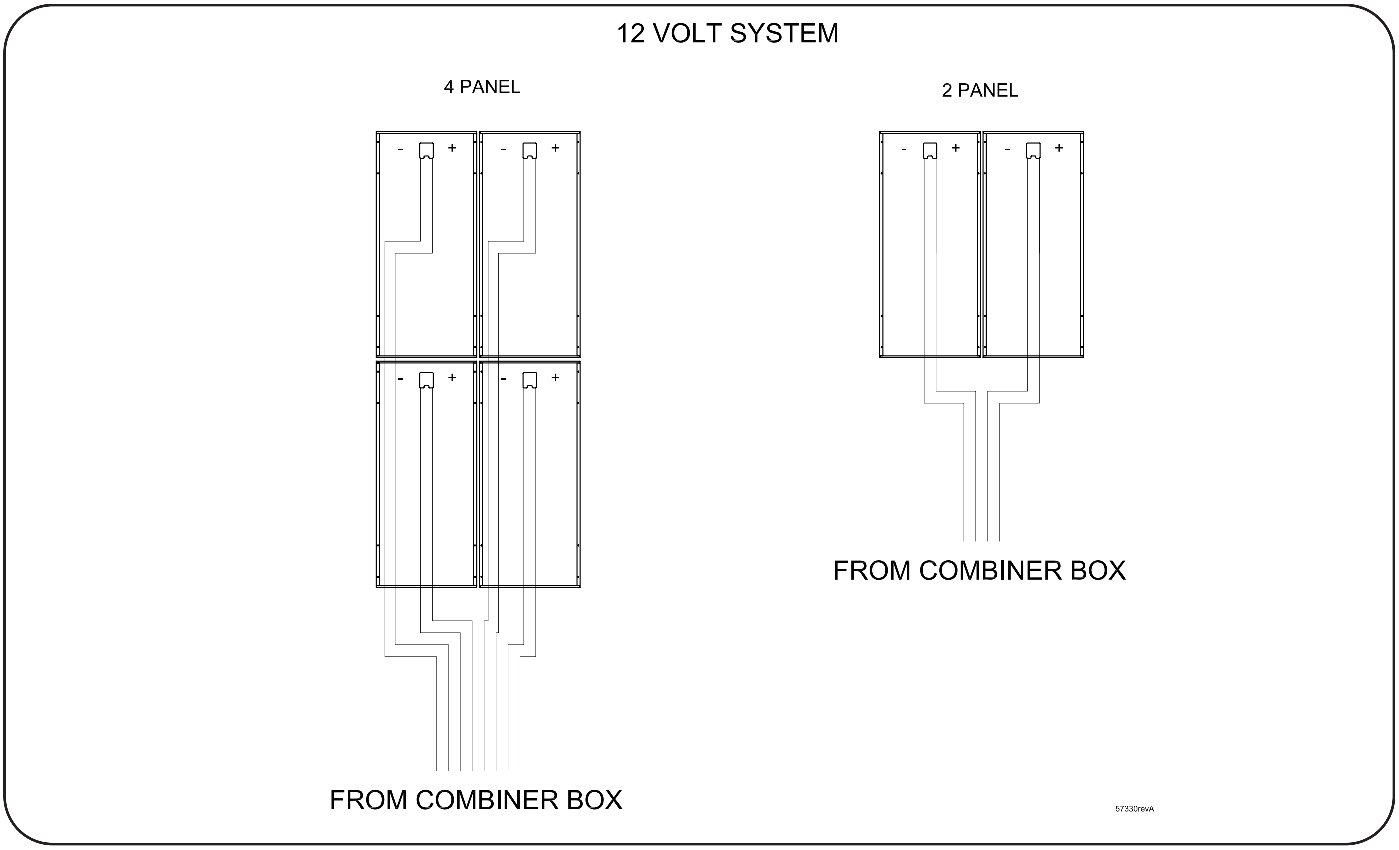


Figure 5-19 12V Solar Panel System

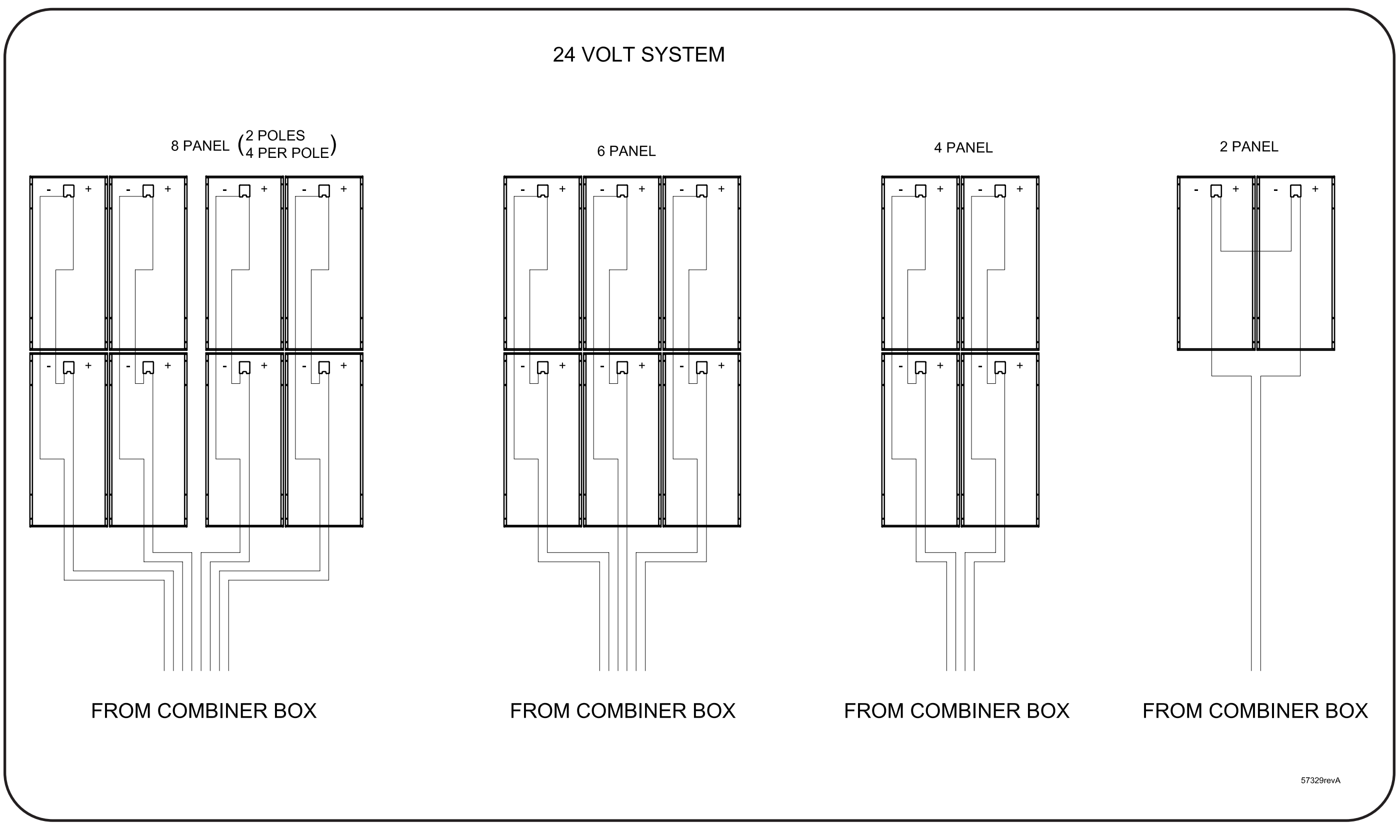


Figure 5-20 24V Solar Panel System

5.10.3 Battery Bank Wiring Interconnections

In 12V battery systems, each battery is wired in parallel. All positive terminals are connected to each other and to the positive terminal block, this is the battery system positive; all negative are connected to each other and to the negative terminal block, this is the battery system negative (see **Figure 5-23**).

In 24V battery systems, there is a combination of batteries wired in series and parallel. Two batteries are wired in series to create a nominal 24V string: positive of one battery is connected to the negative of the second battery, this is considered inter-string wiring. Each nominal 24V string is wired in parallel to the other strings: the positive terminal of each 24V string is wired together and to the positive terminal block, this is the battery system positive, and the negative terminal of each string is wired together and to the negative terminal block, this is the battery system negative. The parallel and series connections are intermixed to create even length connections to all batteries.

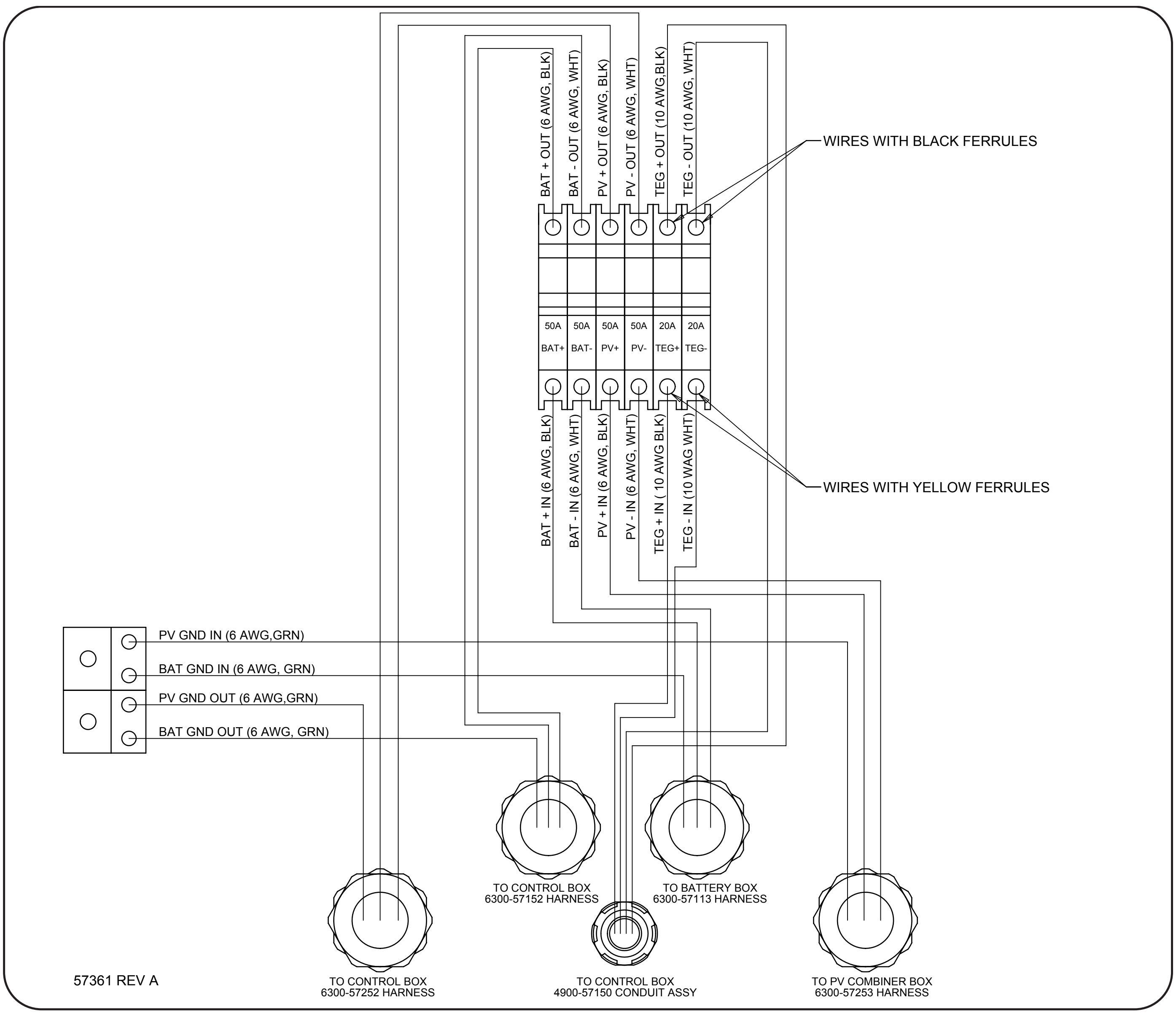


Figure 5-21 Breaker Box Wiring

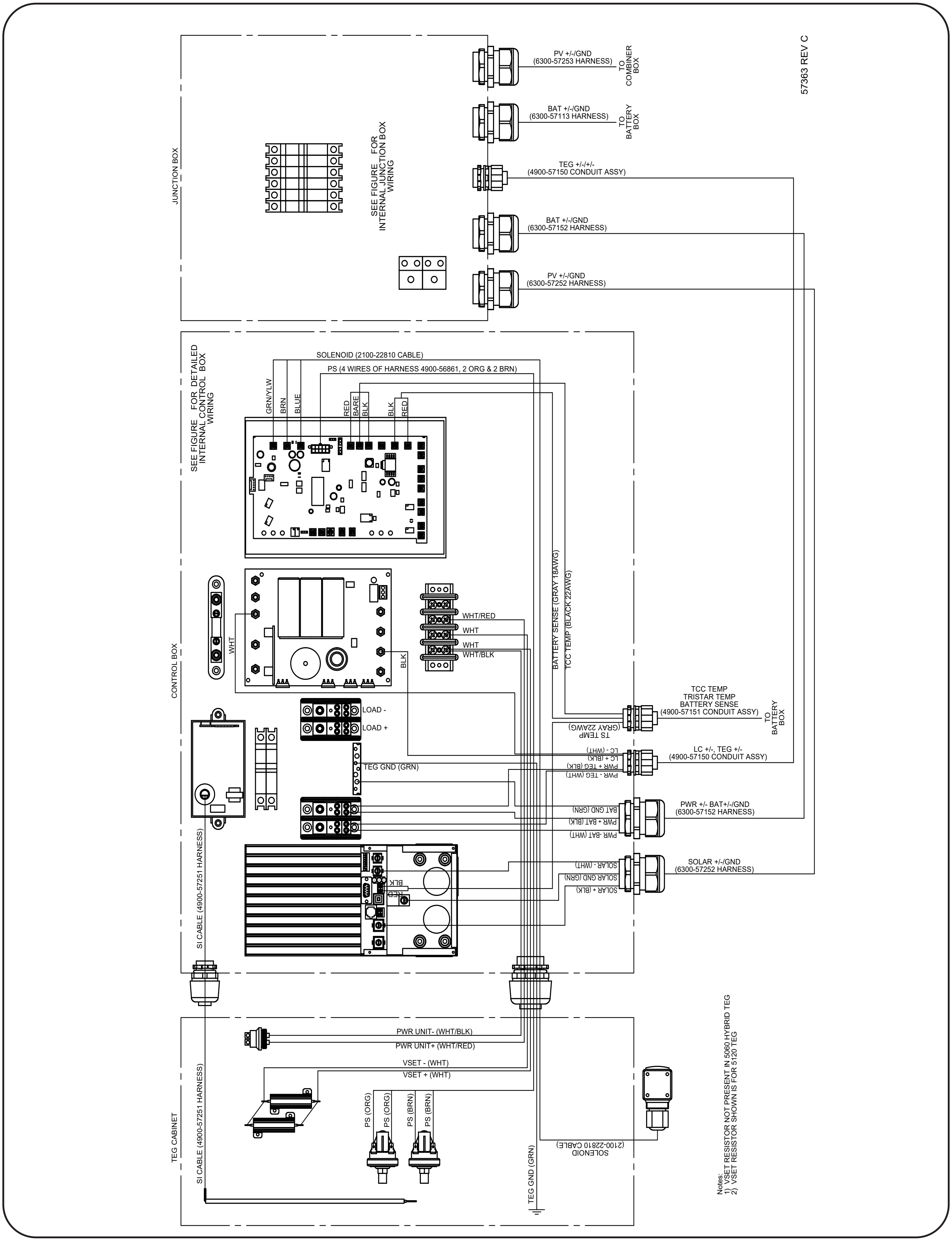


Figure 5-22 TEG Electronics Wiring

WARNING: Carefully wire each connection as per Figure 5-24. Use a multimeter to verify voltages to ensure no accidental connections are made to create other than 24V strings.

In the 12 battery system, two 6 battery system enclosures are interconnected together (see **Figure 5-25)**.

In 24V battery systems, there is a combination of batteries wired in series and parallel. Two batteries are wired in series to create a nominal 24V string: positive of one battery is connected to the negative of the second battery, this is considered inter-string wiring. Each nominal 24V string is wired in parallel to the other.

- Connect the cable from the breaker box to the battery enclosure terminal blocks to connect the battery bank to the battery disconnecting breakers: labelled as “BAT +/- IN” in **Figure 5-21**. The cable will be pre-wired to the breaker box and needs to be connected to the battery box as shown in **Figure 5-26** for routing, and in **Figure 5-27** for wire connections.

- The interconnecting wiring between the control box and the breaker box will be done as part of the TEG assembly.

    - The output side of battery breaker is wired to the system bus in the electronics control box (see **Figure 5-21** and **Figure 5-22**).

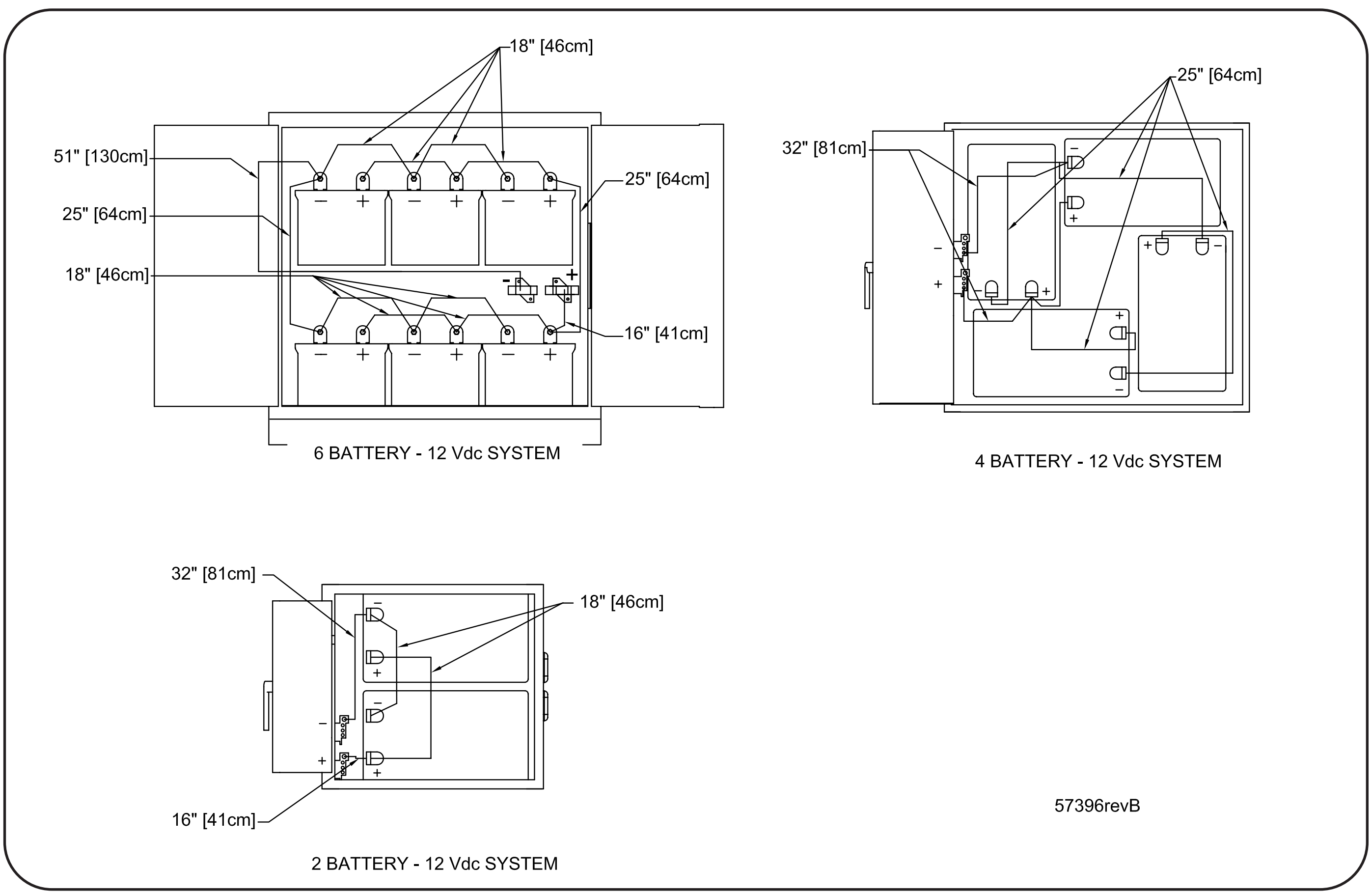


Figure 5-23 12V Battery Wiring - 2, 4 and 6 Battery Systems

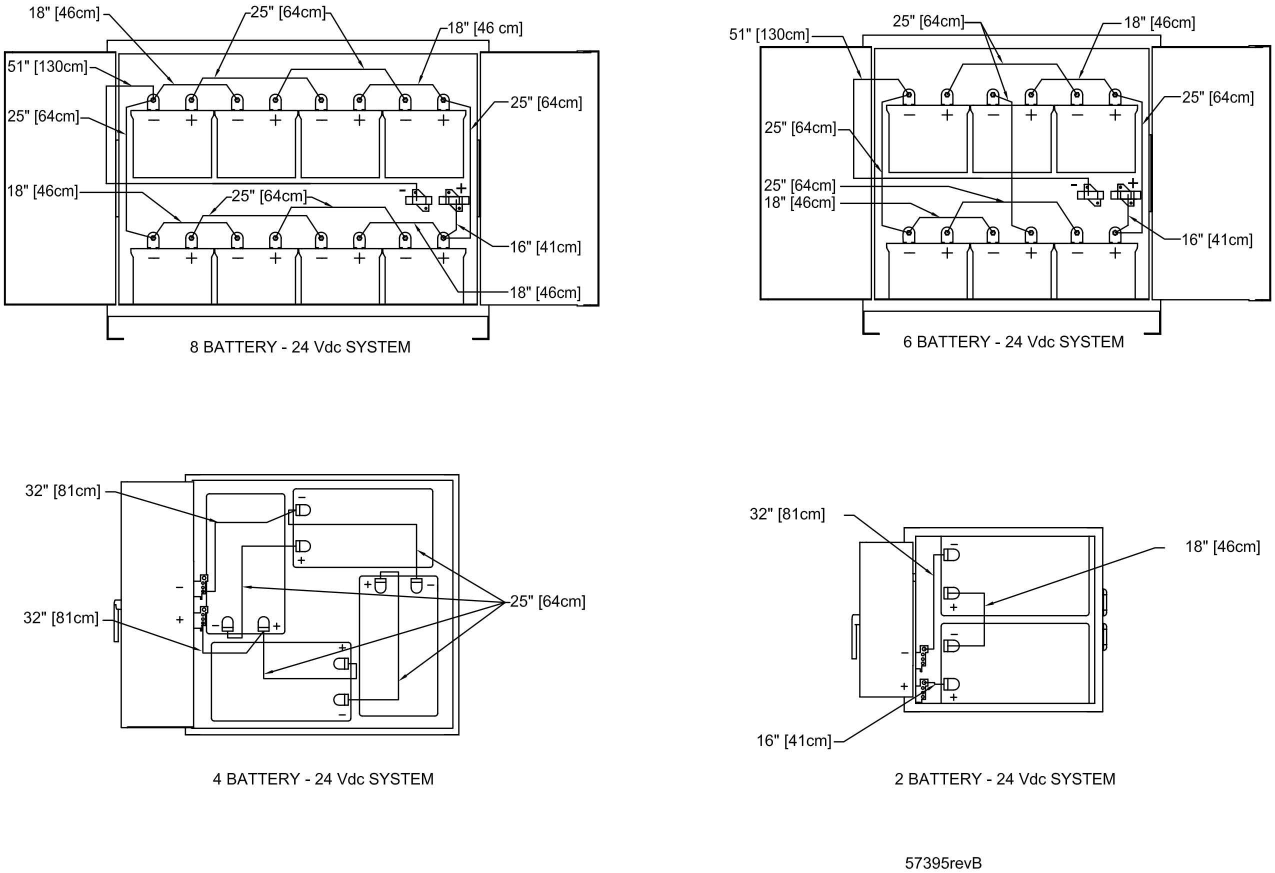


Figure 5-24 24V Battery Wiring - 2, 4 and 6 Battery Systems

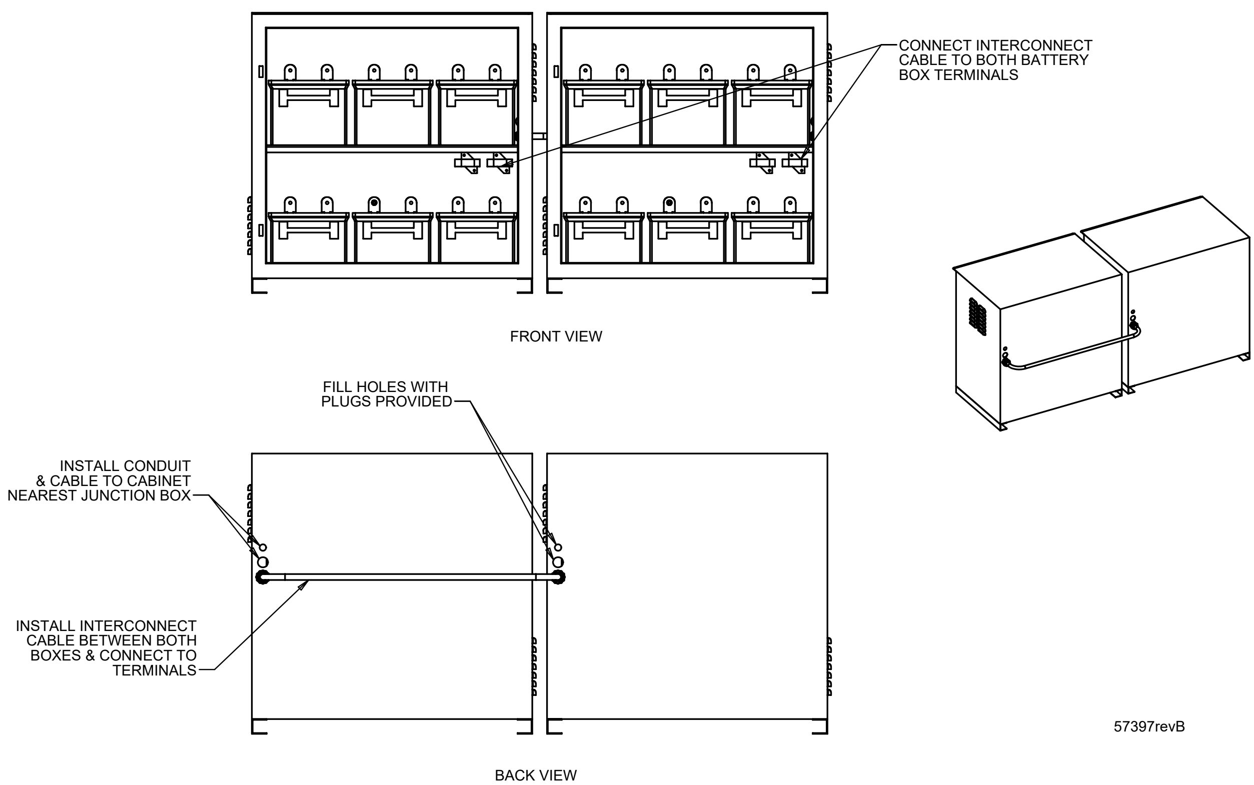


Figure 5-25 12V Battery System

5.10.4 Temperature Sensors and Battery Voltage Sensing Wires

• The TCC battery sensing wires and both temperature sensor wiring are routed in a conduit pre-wired from the control box. They need to be connected to the battery box as shown in **Figure 5-26**.

• The TCC temperature sensor should be installed on a battery system negative terminal, as shown in **Figure 5-28 or 5-29**. The definition of the battery system negative is explained in section 5.3.3 above. In 24V systems, avoid installing the sensor on a negative terminal that is part of the interconnection between two batteries in a string: a negative terminal that connects to a positive terminal. Ensure the plug on the temperature sensor is connected to the plug on the cable exiting the conduit assembly.

• The Tristar (Solar) temperature sensor is also to be installed on a battery system negative terminal, for consistency, as shown in **Figure 5-28 or 5-29**.

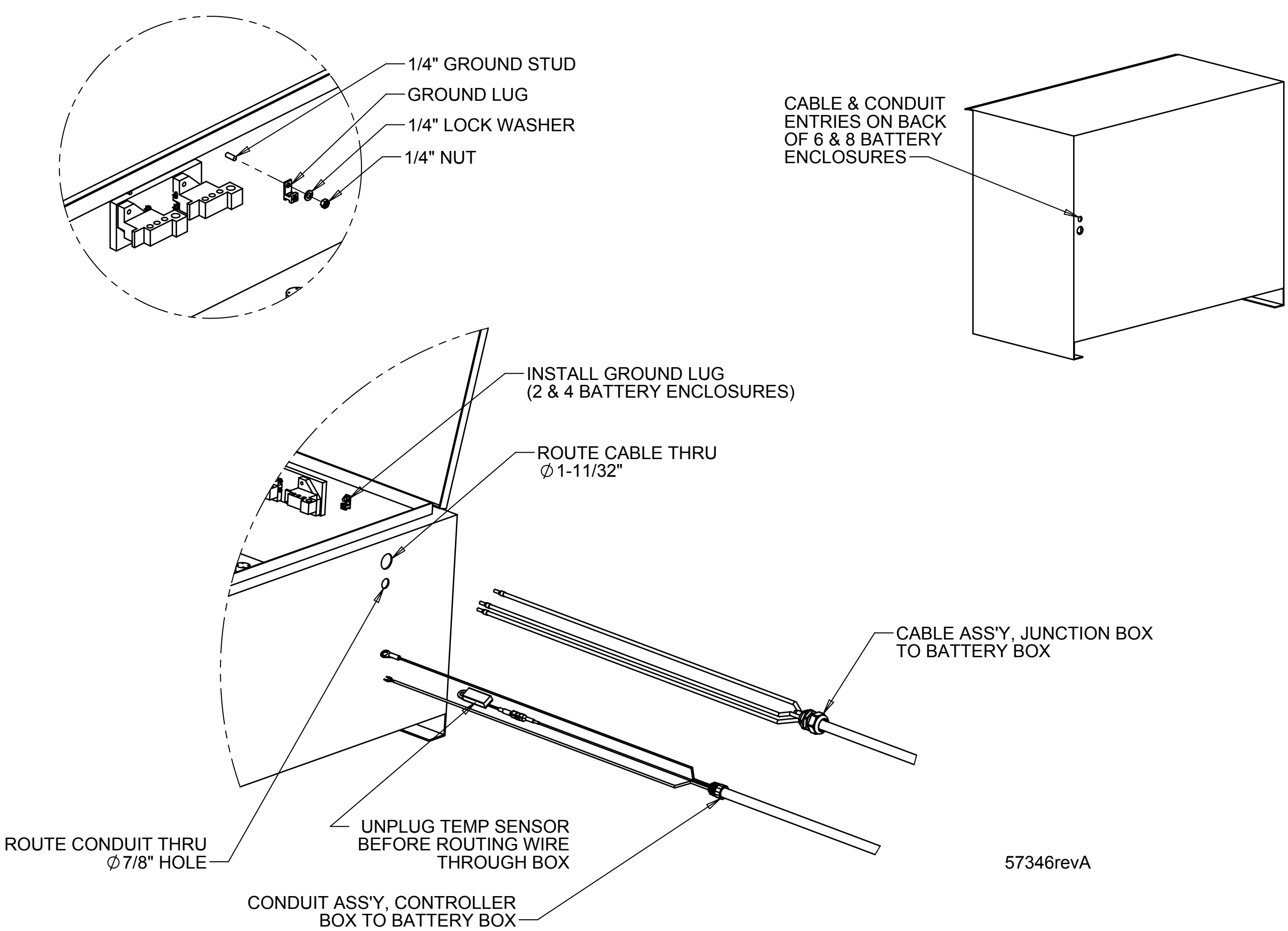


Figure 5-26 Battery Box Cable and Conduit Installation

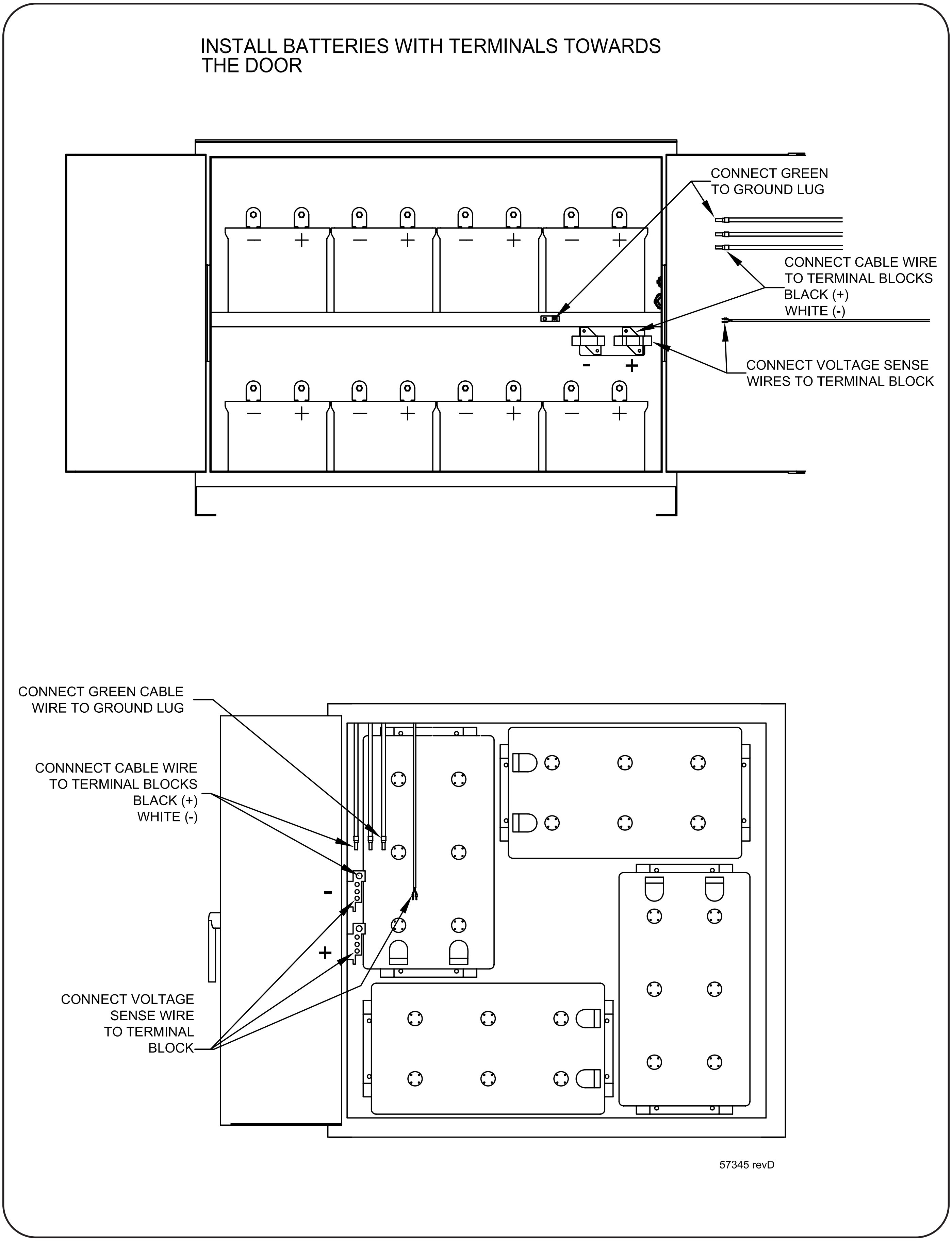


Figure 5-27 Battery Box Cable and Conduit Wiring

• Both sensors are installed on battery terminals to secure the hardware and to read the temperature of the battery.

• Wire the battery sensing wires to the two system terminals block, matching the same polarity as the battery system as shown in **Figure 5-27** and battery wiring **Figure 5-26 or Figure 5-24**.

• Ensure the Battery post hardware is tightened after installation of the two temperature sensors.

The following is for reference and is pre-wired at the factory:
• The 2-wire solar temperature sensor is wired to the solar controller in control box.
• The 3-wire TEG temp sensor is wired to the TCC board on the door in control box.
• The solar controller battery sensing connection is wired to the TCC battery connection within the control box.

5.10.5 TEG Wiring

• The TEG power interconnecting wiring between the control box and the breaker box will be done as part of the TEG assembly

- The TEG L/C board output is connected to the input side of the TEG disconnecting breakers in the breaker box.
- The output side of the TEG breakers in the breaker box is wired back to the TEG control box and is wired to the system bus.
  See **Figure 5-21** and **Figure 5-22**.

5.10.6 Customer Load Wiring

• Customer load wiring is to be connected to the load terminal blocks located inside the control box: LOAD +/-. (See **Figure 5-28).**
• Only use properly sized wire for the load current.

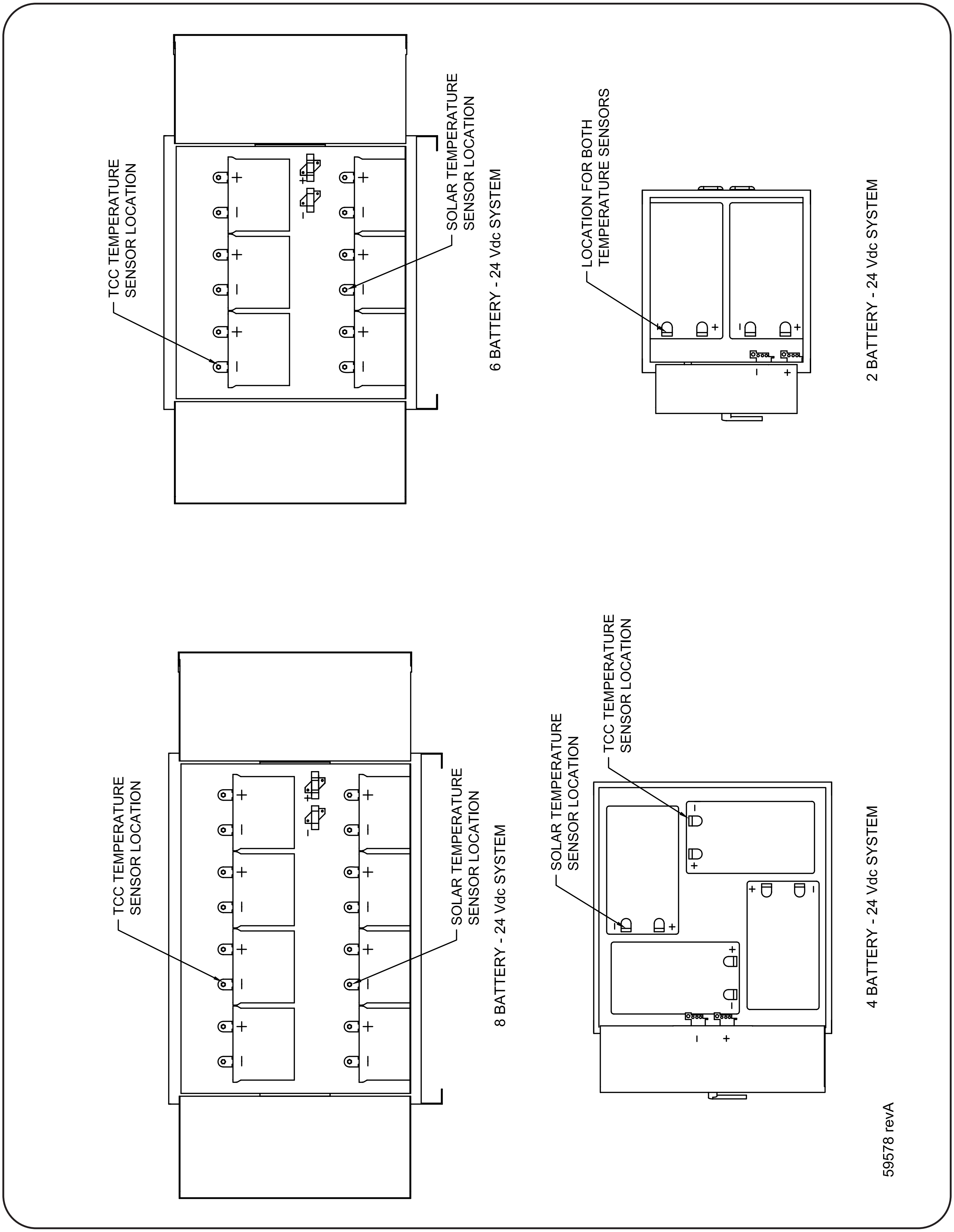


Figure 5-28 24V Battery System - Temperature Sensor Locations

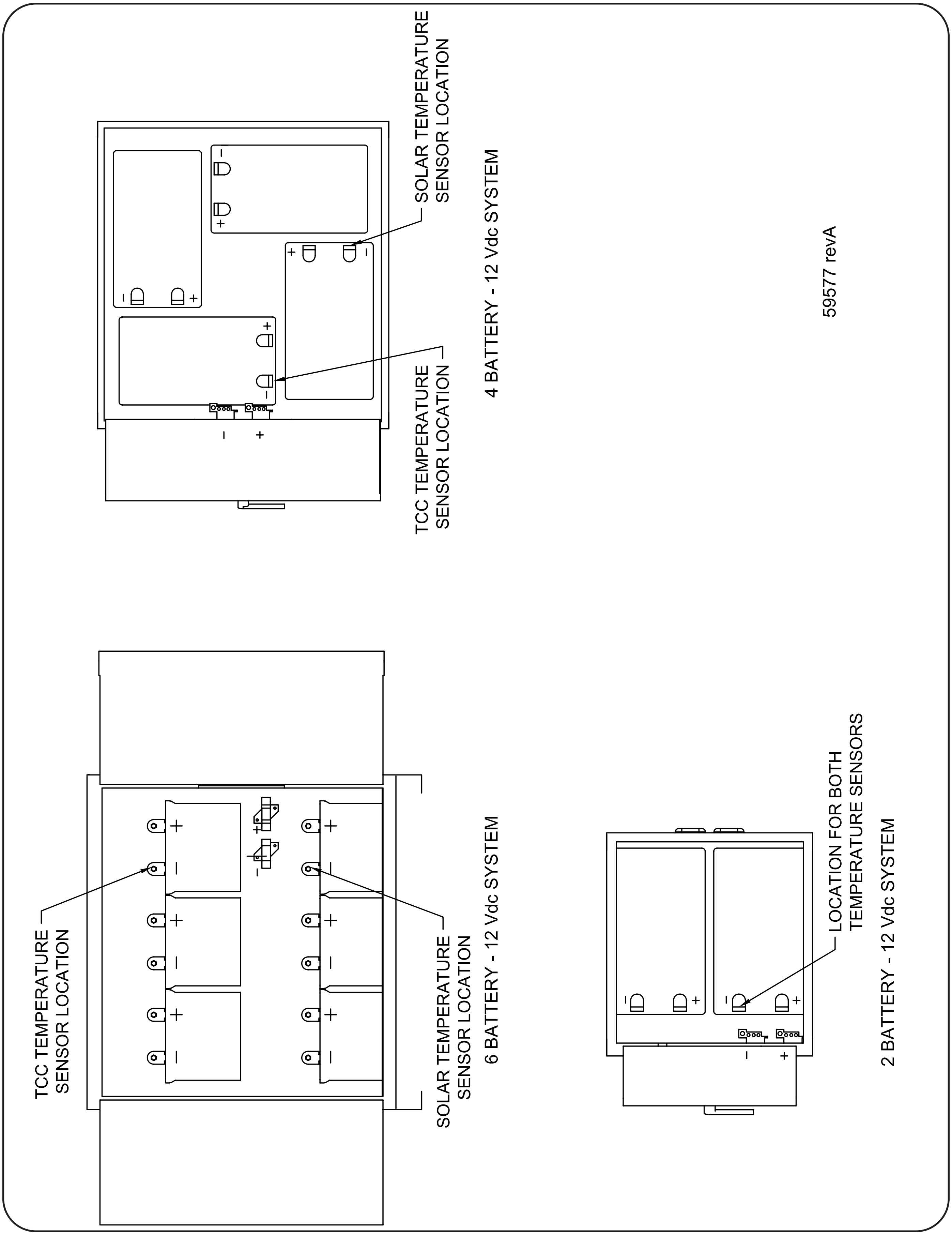


Figure 5-29 12V Battery System - Temperature Sensor Locations

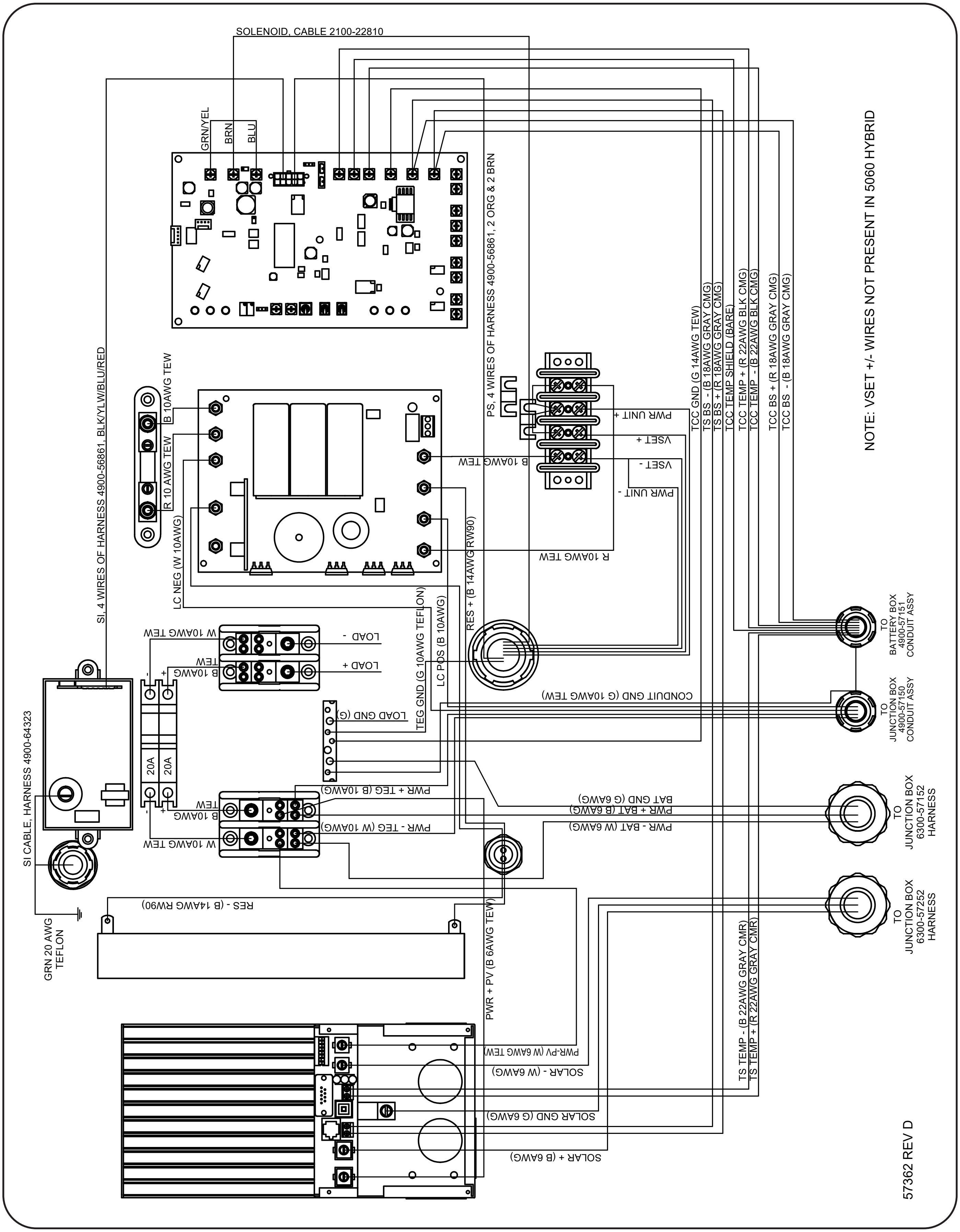


Figure 5-30 Control Box Wiring

5.10.7 Optional SCADA Wiring

SCADA wiring is customer supplied and installed in the field

- Voltage Sensing Relay Wiring
  Dry contact connection from the Limiter/Converter board to the SCADA system: Normally open, normally closed and common connection provided, allowing the SCADA system to read when the output voltage drops below a preset minimum. Maximum switching current: 2Adc resistive load (60W).

- SCADA Start Wiring
  Polarity sensitive wiring from the SCADA Start connections on the TCC board to the SCADA system; Supply a momentary nominal system voltage to the connections to activate the on-board relay, which signals a SCADA start request when the Local/Remote switch is in Remote position. Current draw is less than 20mAdc.

- SCADA Stop Wiring
  Polarity sensitive wiring from the SCADA Stop connections on the TCC board to the SCADA system; Supply a momentary nominal system voltage to the connections to activate the on-board relay, which signals a SCADA stop request when the Local/Remote switch is in Remote position. Current draw is less than 20mAdc.

- SCADA TEG On Wiring
  Dry contact connection from the SCADA TEG On Indicator Connections on the TCC board to SCADA system: Normally open, normally closed and common connection provided, allowing the SCADA system to read when the TEG has been requested to start. Maximum switching current: 2Adc resistive load (60W).

- SCADA Fuel Pressure Wiring
  Dry contact connection from the SCADA Fuel Pressure Indicator Connections on the TCC board to the SCADA system, through the Hobbs Pressure Switch: Normally open and common connection provided, allowing the SCADA system to read when the pressure switch is closed. Maximum switching current: 8Adc – 12Vdc, 4Adc – 24Vdc resistive load.

See **Figure 4-3** (page 4.4) and **Figure 4-4** (page 4.5) for wiring locations.

5.11 Fuel Supply

5.11.1 Fuel Type

Fuel must be either natural gas or propane vapour. Check the TEG data plate (**Figure 4-12**) for the fuel type, located on the inside of the TEG cabinet door. Do not use a different type of fuel than indicated.

5.11.2 Supply Pressure

Make sure that the fuel pressure is at least 69kPa (10 psig) (for 5220 TEG: 138 kPa (20 psig)) and will not exceed 345 kPa (50 psig). See the section on cold installation of propane below for more detail. If it is expected that the fuel supply pressure will vary greatly, the use of an additional primary regulator is recommended. This will hold the input pressure relatively constant.

5.11.3 Clean Fuel

The fuel used to operate the TEG must be clean and dry. See Technical Specifications (Section 14.1) for full gas specifications. If dirty fuel is anticipated then a customer supplied in-line fuel filter is recommended.

5.11.4 Propane Tank Installation

WARNING: Locate and install propane tank as required by the National Fuel Gas Code in the United States, the National Gas & Propane Installation Code in Canada, or the appropriate code for your region. If the TEG is set to run on propane, (see TEG data plate), a propane tank will be required. It is suggested that all fuel lines be no less than 3/8" diameter between the propane supply and the TEG.

5.11.5 Suggestions for low temperature propane fuel operation

Special consideration is required for propane fuel storage and transfer to ensure operation in cold weather. Where permitted by code, burying the propane tank will help maintain an adequate fuel pressure. Possible solutions include:

- Plan tank filling just prior to coldest season to have as much wetted tank surface as possible in contact with outside air.

- Provide thermal insulation from low ambient temperatures by means of an insulating blanket, and enclosure, or by using straw or other such material. Take advantage of insulating value of deep snow drifts where possible.

- Thermally insulate the fuel line from the tanks into the bottom of the TEG.

- Use a LP gas vaporizer if necessary and where practical.

Note: Engineering assistance is available on special vaporizing systems for propane fueled thermoelectric generator applications at extremely cold weather sites.

5.11.6 Connecting the fuel supply

The TEG has a 1/4 in. female NPT fuel inlet, i.e. connection to the TEG's manual shutoff valve.

Follow these steps to connect the fuel supply to the TEG:

- Remove any protective cap or plugs.

- Apply thread sealant to the fuel line threads as per **Figure 5-31**.

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

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

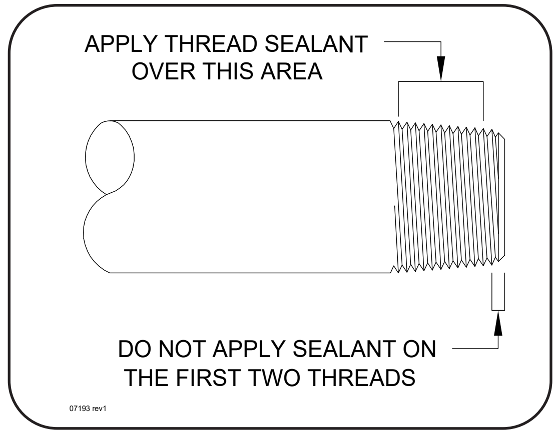


Figure 5-31 Applying Thread Sealant

Note: When any pressure testing of the gas supply piping system at test pressures in excess of 3.5 kPa (0.5 psig), the TEG and its manual shutoff valve must be disconnected from the gas supply piping system. For any pressure testing of the gas supply piping system at test pressures less than 3.5 kPa (0.5 psig), isolate the TEG from the gas supply piping system by closing its individual manual shutoff valve.

- Inspect the fuel lines and fittings to be sure they are free of foreign material.

- Purge fuel lines of all air.

Note: All fuel piping must be in accordance with local regulations.

6 INDICATORS

6.1 TCC Board Indicators

See **Figure 4-3** on page 4.4 for locations.

6.1.1 Battery Voltage Status Indicators

Three green LED's, located in the top left hand corner of the board, are used to indicate the battery voltage. Only one light is on at a time.

MIN LED: when the battery voltage is at or below the TEG On value set within the TCC, only the MIN light is on. When the system is set to Remote mode, the MIN LED is also the voltage sensing start signal, which is used to start the TEG.

MED LED: when the battery voltage is in between the TEG On and the TEG Off values, only the MED light is on. This indicates that the battery voltage is between the charging and discharging voltages.

MAX LED: when the battery voltage is at or above the TEG Off value set within the TCC, only the MAX light is on. When the system is set to Remote mode, the MAX LED is also the voltage sensing stop signal, which is used to stop the TEG.

6.1.2 SI Power Indicator (SI PWR)

One green LED, the top light in the set of lights located in the lower left hand corner of the board, is used to indicate when the spark ignitor (SI) module is being powered from the TCC board.

6.1.3 DC/DC Power Indicator (DC PWR)

One green LED, the middle light in the set of lights located in the lower left hand corner of the board, is used to indicate when the internal DC/DC converter is being powered by the TCC board.

6.1.4 SI No-Combustion Indicator (SI NC)

One red LED, the bottom light in the set of lights located in the lower left hand corner of the board, is used to display the no-combustion signal received from the SI module.

Note: The no-combustion signal is related to the functionality of the SI module; see the section on the Spark Ignitor for more information.

6.2 Solar Controller Indicators[1]

There are three LED's on the solar controller that indicate the general transitions, battery charging status, or faults/alarms. There is one green, one yellow and one red LED.
At controller start-up, the Green, Yellow and Red LED will each turn on once, in this order. Pushbutton transitions are displayed by blinking all three LED's two times.

6.2.1 Solar Controller Battery Status

While the battery is bulk charging, the approximate battery status is displayed on the LED using one or two LEDs on solid. The battery LED transitions are based on battery voltage setpoints and only provide an approximation of the battery state of charge based on the current into the battery from the solar panels.

- Green On 13.3 v to 14.0 v (based on DIP Switch Settings)
- Green/Yellow On 13.0 v to 13.3 v
- Yellow On 12.65 v to 13.0 v
- Yellow/Red On 12.0 v to 12.65 v

If the battery is discharging, either the Red LED is On, or Yellow and Red are both on.

- Red On 0.0 v to 12.0v

During Pulse Width Modulation (PWM) Absorption, the PWM control in the solar controller holds the voltage constant and the current is tapered down as the battery becomes fully charged at 95% to 100% battery state of charge. The Green LED will blink once per second.

During Float charging, the charging voltage is reduced and the Green LED blinks slowly, once every 2 seconds.

When no LED's are lit, this indicates that either a battery reverse polarity connection or a solar reverse polarity connection is present.

Faults and alarms are indicated on the solar controller's LED's, by alternating between various combinations of LED's, as described below.

- Solar short circuit Red/Green On – alternate Yellow On
- Solar Overload Red/Yellow On – alternate Green On
- Over-temperature Red On – alternate Yellow On
- High voltage disconnect Red On – alternate Green On
- DIP switch fault Red On– alternate Yellow On – alternate Green On
- Self-test faults Red On – alternate Yellow On – alternate Green On
- Temperature Probe Red/Yellow – alternate Green/Yellow On
- Battery Voltage Sense Red/Yellow – alternate Green/Yellow On

The solar controller faults and alarms are described in the troubleshooting Section 13.

7 OPERATION

ATTENTION: The system's negative bus is common and tied together through each source's disconnection breaker. The negative side of the solar panels are connected to ground in the solar combiner box, effectively negatively grounding the entire system.

7.0.1 System Operation

The solar system works in parallel with the TEG system. When the solar system can produce enough power to supply the load and partially re-charge the battery, the TEG remains off and in stand-by. When the batteries discharge to a pre-set voltage monitored by the TEG electronics, the TEG will be started and the power from the TEG will be delivered to the load, and if any additional power is available it will be delivered to the batteries.

For normal system operation:

- All breakers in the solar combiner box must be in the ON position. This connects each string of solar panels to the solar breakers in the breaker box.
- All breakers in the breaker box must be in the ON positions. This connects the battery bank, solar controller output and TEG output to the system bus.
- TEG jumper must be in the RUN position.
- TCC Voltage Reference Source Jumper must be in the RUN position.
- TCC Bench Testing Jumper must be in the RUN position.
- TCC Local/Remote switch must be in the REMOTE position.

Each power source can be isolated from the system bus by turning off the associated breakers in the breaker box.

- To isolate the TEG power, turn off both TEG breakers. This breaks the connection between the output of the TEG's Limiter/Converter electronics and the system bus.
- To isolate the solar power, turn off both Solar breakers. This breaks the connection between the output of the solar combiner box and the input to the solar controller.
- To isolate the battery, turn off the Battery breakers. This breaks the connection between the batteries and the system bus.

WARNING: If the TEG is not running and the solar array is not producing enough power to sustain the load, turning off the Battery breakers could cause power to be lost to the load.

Both the solar controller and the TCC board operate based on the battery voltage measured using their battery voltage sensing connection.

The solar controller can detect day and night conditions and the operation is automatic once installed. The solar controller's charging cycles are voltage triggered based on the battery voltage measured at the voltage sensing connection.
The TCC board is powered by the battery voltage sensing connection and senses the voltage at this point. When the TCC board is operating in Remote mode (based on the Local/Remote switch position), the measured battery voltage triggers when the generator will be started or stopped.

7.0.2 TEG Operation

WARNING: Prior to leaving the site, the TEG must be run and set up correctly at the end of the installation to ensure proper TEG operation in remote mode.

This is also the procedure to be used to start the TEG during maintenance visits. It must be set for the current ambient temperature, elevation and fuel quality at the operation site, by a qualified operator familiar with operating the TEG and having successfully completed Global Power Technologies' TEG training course.

System Performance Logs are located at the back of this manual, Sections 17 and 18. Use of these logs is recommended each time the site is visited. This information is valuable for future reference.

7.1 TEG Setup and Maintenance Start Procedure

WARNING: The Vset values and start-up fuel pressure values are only to be used as a guideline. Various parameters affect these settings. Reference the TEG Power Output Evaluation and TEG Power Output Adjustments section for detailed information.

7.1.1 Turn on gas supply to TEG (this step is required for initial installation. Gas supply should be left on during normal operation).
7.1.2 Turn off the two breakers labelled TEG in the Breaker box (this will disconnect the TEG from the system bus).

7.1.3 Move the TEG jumper clip on the terminal strip to be installed between position 2 and position 3 of the terminal strip, SETUP position (See **Figure 4-2** - Control Box Components, page 4.3).

7.1.4 Switch the Local/Remote switch on the TCC board to Local position.

WARNING: Leaving the site without setting system into Remote Mode could damage the batteries.

7.1.5 Toggle the Local Start switch.

7.1.6 The SI PWR and DC PWR lights on the TCC board should light.

7.1.7 The spark ignition system (SI) should begin clicking and the fuel will start flowing.
7.1.8 The sound of combustion should be heard within 7 seconds.
7.1.9 Adjust the fuel pressure to 10-15% less than note on the Data Nameplate.

7.1.10 After one hour measure the voltage, V_{set} , between terminal 2(+) and 4(-) of terminal strip. The initial V_{set} should be approximately 14.8V for 5060, 6.7 volts for 5120 or 14.8V for 5220. Setup should be performed by a qualified service person familiar with operation of the TEG. Reference the TEG Power Output Evaluation (Section 8) for detailed information related to TEG setup voltage appropriate for the site location. When complete:

7.1.11 Return the TEG jumper clip between position 1 and position 2 of the terminal strip.

7.1.12 Measure the TEG LC Output Voltage on studs T5 and T9 across the LC board located on the right side of the Control Box (see **Figure 4-4**).

- 12V systems - set the TEG LC output to 16V (factory setting).
- 24V systems - set the TEG LC output to 32V (factory setting).

7.1.13 If required, adjust the Output Voltage Adjustment Pot, located near the top of the board at the very back of the Control Box (see **Figure 4-4**), to set the output voltage to the value listed above per the System Voltge, using a small flat head screw driver no longer than about 4-5/8” (11.8cm).

WARNING: Do not adjust the Current Limiter pot located in front of the required pot

7.1.14 Turn on the two breakers labelled TEG in the Breaker box to connect the TEG back to the system bus.

7.1.15 Switch the Local/Remote switch on the TCC board to the Remote position. This may cause the TEG to shut off automatically if the battery voltage is above the TEG stopping voltage value.

<u>Fuel Pressure:</u>

Fuel	TEG Model	Pressure
Propane Start Up	5060	40-48 kPa (6-7psi)
	5120	41-45 kPa (6-6.5 psi)
	5220	125-140 kPa (18-20 psi)
Natural Gas Start Up	5060	35-40 kPa (5-6 psi)
	5120	24-34 kPa (3.5-4.5 psi)
	5220	130-144 kPa (18.5-21 psi)

7.2 TEG Start Up

Verify the operation of the TEG following these steps. Start the TEG to verify the operation of the TEG, without isolating the generator from the system.

7.2.1 Switch the Local/Remote switch to the Local position.
7.2.2 Toggle the Start switch.

The spark ignitor will be powered and start sparking, and the solenoid will open, starting an ignition sequence.

If combustion is not successful after three attempts, wait for the DC PWR and SI PWR lights on the TCC board to turn off, then toggle the start switch again.

WARNING: Do not leave the site with the TEG system in Local mode and the TEG running, otherwise the batteries will be over-charged and the TEG will run continuously. The output voltage of the TEG electronics is set at a higher voltage to allow battery charging up to a higher voltage during colder temperatures. When in REMOTE MODE, the TCC board calculates when to stop the TEG based on the temperature compensation and the set TEG Off value, and stops the TEG when that voltage has been reached. This functionality is not part of the LOCAL OPERATING MODE.

- Switch the Local/Remote switch back to the Remote position. The TEG will keep running until the temperature compensated TEG off value is reached.

7.3 TEG Shut Down

To turn off the TEG, follow one of the following methods:

7.3.1 Turn the TEG off using the TCC board:

7.3.1.1 Switch the Local/Remote switch to the Local position.
7.3.1.2 Toggle the Stop switch.
7.3.1.3 Power will be removed from the spark ignitor, causing the solenoid to close.
7.3.1.4 The TEG will continue to produce some power while it is still hot and cooling down.

7.3.2 Turn off the manual gas valve

7.3.2.1 The combustion will continue until the fuel pressure drops, causing the pressure switches to close.
7.3.2.2 When the pressure switch closes, the power on the TCC board will be interrupted, this removes power from the spark ignitor and causes the solenoid to close. One pressure switch is used as a switch in-line between the TCC battery voltage connection and the remainder of the board.

7.3.2.3 When the solenoid closes, a small amount of gas is trapped between the manual gas valve and the solenoid, which is enough to close the pressure switch and TCC board receives power.

7.3.2.4 The TEG will remain off unless the following situation occurs:
If the Local/Remote switch is in the Remote position, and the MIN battery voltage light is on, the TCC board will attempt to start the TEG. When an ignition sequence is started, the solenoid valve will be opened and the trapped gas will be released. The pressure switch will open and the TCC will lose power.

WARNING: Do not leave the site with the TEG system in Local Mode and the TEG not running. It will not start automatically unless it is in Remote Mode.

7.4 TEG Hybrid Operation

For operation:

- All breakers in the breaker box must be in the ON position. This connects the battery bank, solar controller output and TEG output to the system bus.
- TEG jumper must be in the RUN position.
- TCC Voltage Reference Source Jumper must be in the RUN position.
- TCC Bench Testing Jumper must be in the RUN position.

The TEG control has two modes of operation: Local and Remote.

7.4.1 Local Mode

During **LOCAL MODE**, the Local/Remote switch is in the Local position. See **Figure 4-3** for location. In this position, only the local start and local stop switches affect the operation of the TEG. The battery voltage indicator lights continue to display the battery voltage but do not affect the start and stop operation of the TEG. The TCC board does not respond to SCADA start and stop signals while in Local mode. This mode is used for operation of the TEG when on-site for installation, maintenance and troubleshooting.

Pressing the Local Start switch will start the TEG, if it is not running.

Pressing the Local Stop switch will stop the TEG, if it is running.

WARNING: Do not leave this site with the TEG system in LOCAL mode and the TEG running. The output voltage of the TEG electronics is set at a higher voltage to allow battery charging up to a higher voltage during colder temperatures. When in REMOTE mode, the TEG board controls when to stop the TEG based on the battery temperature and the set TEG off value. This voltage control is not part of the functionality of LOCAL mode. The TEG electronics output does not change with operating modes. If the site is left in LOCAL mode, and the TEG is running, damage can occur to the batteries by overcharging. If the TEG is not runnin it will not start when required to change the batteries, as backup. Always return the TEG to REMOTE mode for automatic Hybrid operation.

CAUTION: If it is desired to run the TEG continuously for long periods of time or unattended, the TEG must be set to Local Mode, started and left running, and the TEG Limiter/ Converter (L/C) output voltage **MUST** be turned down to non-temperature compensated float voltagevalues. Follow section 12.2 for adjustment steps.

- 12V systems - set the ouput of the L/C to 14.1 V
- 24V systems - set the ouput of the L/C to 27.0 V

or as recommended by battery manufacturer.

Note: The Hybrid system was intended to be operated in Remote Mode, with temperature compensation using the TCC temperature sensor, to enable cycle charging as required to backup the solar panel system. Set to factory settings as listed in secion 12.2 for Standard Hybrid operation.

7.4.2 Remote Mode

When the switch is placed in **REMOTE** mode (see **Figure 4-3** for location), the SCADA start and stop signals and the voltage sensing TEG On and TEG Off signals are used for start and stop control of the TEG. The on-board local start and local stop switches do not affect the operation. This mode is the standard operating mode, and is used for automatic control of the TEG.

When the battery voltage falls to the value of the TEG On voltage, the MIN light will turn on and the TEG On signal will start the TEG. The TEG will not stop if a remote stop signal is received while the MIN light is on.

When the battery voltage is between the TEG On and TEG Off values, the MED light is on. The remote start signal will start the TEG, and the remote stop signal will stop the TEG.

When the battery voltage rises to the value of the temperature compensated TEG Off voltage, the MAX light will turn on and the TEG Off signal will stop the TEG. The TEG will start if a remote start signal is received, but will stop as soon as the remote start signal is removed, because the battery voltage is above the TEG Off voltage.

7.5 Spark Ignitor (SI) Operation

The spark ignitor receives power from the TCC board when it signals a start of the TEG.

7.5.1 The SI starts with a 3 second delay as the module performs start-up tasks.

7.5.2 Then the unit signals a relay to power the solenoid valve and begins its first 7 second trial for ignition.

7.5.3 If a flame is sensed, the unit enters its run mode. It suppresses the spark and keeps the valve signal on, and the solenoid valve remains open.

7.5.4 If no flame is sensed, the unit performs a 10 second inter-purge, when there is no sparking, the valve signal is off and the no-combustion signal is on. This is followed by another trial for ignition.

7.5.5 If a flame is not sensed during the second trial for ignition, it performs another inter-purge and third trial for ignition.

7.5.6 If a flame is not sensed during the third and final trial for ignition, the unit will enter a hard lockout and the no-combustion signal will be on. A lockout does not allow any additional trials for ignition while the module remains powered.

7.5.7 If flame is lost during the run mode, the unit will energize the spark and perform a trial for ignition and follow the previous sequence to achieve ignition within the three attempts.

7.5.8 If a flame is sensed when the gas valve is not energized, the unit will enter the hard lockout mode and the no-combustion signal will be on. This can occur when attempting to re-start a hot TEG. The TEG will need to cool a bit before attempting a re-start.

7.5.9 A hard lockout condition in the spark ignitor module requires the module to be powered down for more than 5 seconds before restoring power to the module to re-attempt another ignition sequence. This requires the user to wait more than 5 seconds between a stop signal and a start signal.

7.5.10 The TCC board provides power to the spark ignitor when required by either the voltage sensing control signals, remote signals or user switch signals. See the TCC Operating Chart for more details about the TCC and spark ignitor control.

In the Solar Hybrid System, if the SI enters lockout and the solar system can raise the battery voltage level to the MED voltage level measured by the TCC board, the controler in the TCC will remove power to the SI and the lockout condition will be removed.

WARNING: If the solar system cannot raise the battery voltage to the MED level, when the SI has locked out due to a low voltage start, the TCC board has to be manually reset at site.

To reset the system, switch to Local mode, toggle the Stop switch to turn off the power lights in the lower left corner of the TCC board, wait 5 seconds and toggle the Start switch to attempt a re-start. When ignition has been achieved, return the switch to Remote mode.

7.6 Solar Operation[1]

For operation:

- All breakers in the solar combiner box must be in the ON position. This connects the solar panels to the solar breakers in the breaker box.
- All breakers in the breaker box must be in the ON positions. This connects the battery bank, solar controller output and TEG output to the system bus.

The operation of the solar controller is automatic, once installed and connected correctly to the solar system and battery bank. The solar controller can automatically detect day and night conditions.

The battery voltage is measured using the battery sense connection. The battery sense connections on the solar controller are wired to the TCC's battery voltage sense connections. This allows one set of wires to be routed to the battery for voltage measurement. Using the battery voltage sense connections allows more accurate battery charging and reduces battery undercharging because of the losses in the battery cables.

There are four stages of solar charging: bulk, PWM absorption, float and equalize charging. Equalization is not used in this application since Gel batteries are used in the system.

Solar Bulk Charging: The battery is charged using all the available current from the solar system and TEG, if it is on, as the battery is charged from its current voltage up to the PWM Absorption voltage. The battery charge voltage will be displayed using the LEDs. See Section 6.2 for solar controller battery status lights descriptions.

Solar PWM Absorption: The charging voltage is held constant at the PWM Absorption voltage level, and the current will gradually decrease as the battery becomes fully charged. The green LED will blink once per second indicating Absorption stage.

Solar Float Charging: The charging voltage is reduced to the float voltage level after the battery is fully recharged. The green LED will blink once every two seconds indicating the Float stage.

7.7 Customer Load Operation

The customer load is connected to the system bus through two 20A breakers. The two breakers can be used to isolate the load from the system bus by turning the breakers off.

WARNING: when isolating the load from the system always turn off both breakers.

The breakers provide over current protection by tripping one or both of the breakers.

7.8 Optional SCADA Interface

7.8.1 Voltage Sensing Relay

Voltage Sensing Relay (VSR) provides a set of contacts to indicate an alarm condition when the TEG output voltage drops below a preset minimum.

Low voltages, due to overloads, lack of fuel, a faulty generator, or when the TEG is not running, are detected by a voltage sensing circuit incorporated into the voltage limiter/converter board. When a low voltage condition is detected, the Voltage Sensing Relay (VSR) with connections NC (normally closed), NO (normally open) and COM (common) can be used to trigger an alarm or other processes. When the output of the generator is above the trip voltage, the connection between NO and COM is closed. If the output of the generator is below the trip voltage, then the connection between NO and COM is open and the connection between NC and COM is closed.

TEG Operation	Controller Operating Mode	Action	Initial Indicators	System Operation Outcome	Outcome Indicators
TEG is not running	Switch in Local Mode	Local Start Switch Pressed	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: Off SI PWR light: Off	Controller will start the TEG: SI module receives power and starts the ignition sequence	DC PWR and SI PWR lights will turn on
		Local Stop Switch Pressed	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: Off SI PWR light: Off	Controller will stop the TEG: SI module power is removed	DC PWR and SI PWR lights will be turned off
		Remote Start Signal Received	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Local Mode	No change to indicators
		Remote Stop Signal Received	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Local Mode	No change to indicators
		Battery Voltage Status MIN Light turns on	Battery Voltage Light MIN: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Local Mode	No change to indicators
		Battery Voltage Status MAX Light turns on	Battery Voltage Light MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Local Mode	No change to indicators
		Switch moved to Remote Position, Battery Voltage Status MIN light on	Battery Voltage Light MIN: On DC PWR light: Off SI PWR light: Off	Controller will start the TEG: SI module receives power and starts the ignition sequence	DC PWR and SI PWR lights will turn on
		Switch moved to Remote Position, Battery Voltage Status MED or MAX light on	Battery Voltage Light MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Battery voltage is above the TEG On value	No change to indicators
		(During Ignition Sequence)	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	The SI module attempts three ignition cycles: a sparking period, followed by a purge period.	SI NC light will light during the SI purge period
		(Failed Ignition Sequence)	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	If successful ignition has not been achieved during one of the three sparking periods, the controller will remove power to the SI module following a brief time (15 - 60 seconds). A local start can be re-attempted	DC PWR and SI PWR lights will be turned off
TEG is not running	Switch in Remote Mode	Local Start Switch Pressed	Battery Voltage Lights MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Remote mode	No change to indicators
		Local Stop Switch Pressed	Battery Voltage Lights MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Switch in Remote mode	No change to indicators
		Remote Start Signal Received	Battery Voltage Lights MED: On DC PWR light: Off SI PWR light: Off	Controller will start the TEG: SI module receives power and starts the ignition sequence	DC PWR and SI PWR lights will turn on
		Remote Start Signal Received	Battery Voltage Lights MAX: On DC PWR light: Off SI PWR light: Off	Controller will start the TEG while the start signal is applied. Once the start signal is removed the MAX battery voltage turns off the TEG	DC PWR and SI PWR lights will turn on while the start signal is applied
		Remote Stop Signal Received	Battery Voltage Lights MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG is not running	No change to indicators
		Battery Voltage Status MIN Light turns on	Battery Voltage Light MIN: On DC PWR light: Off SI PWR light: Off	Controller will start the TEG: SI module receives power and starts the ignition sequence	DC PWR and SI PWR lights will turn on
		Battery Voltage Status MAX Light turns on	Battery Voltage Light MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG is not running	No change to indicators
		Switch moved to Local Position	Battery Voltage Lights MED or MAX: On DC PWR light: Off SI PWR light: Off	No action is taken. TEG remains off. Mode has been changed; waiting for local switch to be pressed	No change to indicators
		(During Ignition Sequence)	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	The SI module attempts three ignition cycles: a sparking period, followed by a purge period.	SI NC light will light during the SI purge periods

Figure 7-1 TCC and TEG Operation Chart Page 1

TEG Operation	Controller Operating Mode	Action	Initial Indicators	System Operation Outcome	Outcome Indicators
		(Failed Ignition Sequence)	Battery Voltage Lights MIN: On DC PWR light: On SI PWR light: On	If successful ignition has not been achieved during one of the three sparking periods, the controller will locked in a failed ignition mode. A site visit is required to remove power from the controller to reset the locked condition	Battery Voltage Lights MIN: On DC PWR light: On SI PWR light: On SI NC light: On
		(Failed Ignition Sequence)	Battery Voltage Lights MED or MAX: On DC PWR light: On SI PWR light: On	If successful ignition has not been achieved during one of the three sparking periods, the controller will remove power to the SI module following a brief time (15 - 60 seconds). A remote start can be re-attempted	DC PWR and SI PWR lights will be turned off
TEG is running	Switch in Local Mode	Local Start Switch Pressed	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running	No change to indicators
		Local Stop Switch Pressed	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	Controller will stop the TEG: SI module power is removed	DC PWR and SI PWR lights will be turned off
		Remote Start Signal Received	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Local Mode	No change to indicators
		Remote Stop Signal Received	Battery Voltage Lights MIN, MED or MAX: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Local Mode	No change to indicators
		Battery Voltage Status MIN Light turns on	Battery Voltage Lights MIN: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Local Mode	No change to indicators
		Battery Voltage Status MAX Light turns on	Battery Voltage Lights MAX: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Local Mode	No change to indicators
		Switch moved to Remote Position, Battery Voltage Status MIN or MED light on	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Battery voltage is below the TEG Off value	No change to indicators
		Switch moved to Remote Position, Battery Voltage Status MAX light on	Battery Voltage Lights MAX: On DC PWR light: On SI PWR light: On	Controller will stop the TEG: SI module power is removed	DC PWR and SI PWR lights will be turned off
TEG is running	Switch in Remote Mode	Local Start Switch Pressed	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Remote mode	No change to indicators
		Local Stop Switch Pressed	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Switch in Remote mode	No change to indicators
		Remote Start Signal Received	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running	No change to indicators
		Remote Stop Signal Received	Battery Voltage Lights MIN: On DC PWR light: On SI PWR light: On	No action is taken while the battery voltage MIN light is active. TEG remain running	No change to indicators
		Remote Stop Signal Received	Battery Voltage Lights MED: On DC PWR light: On SI PWR light: On	Controller will stop the TEG: SI module power is removed	DC PWR and SI PWR lights will be turned off
		Battery Voltage Status MAX Light turns on	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	Controller will stop the TEG: SI module power is removed	DC PWR and SI PWR lights will be turned off
		Switch move to Local Position	Battery Voltage Lights MIN or MED: On DC PWR light: On SI PWR light: On	No action is taken. TEG remains running. Mode has been changed; waiting for local switch to be pressed	No change to indicators

Figure 7-2 TCC and TEG Operation Chart Page 2

The VSR is factory set at 11.5volts for 12V systems and at 23.0 volts for 24V systems. The trip voltage is adjusted by the pot labelled VSR adjust on the limiter/converter board as shown in Figure 4 on page 4.4. Adjustment instructions are provided in section 7.3.

7.8.2 SCADA Start

The SCADA start signal is sent remotely by the customer's SCADA. A momentary system voltage dependent signal is required to toggle the SCADA start relay on the TCC board (nominal 12V signal in 12V systems, nominal 24V signal in 24V systems). This start signal is used as a remote start command when the TCC board is in the Remote mode and the battery voltage is between the MIN and MAX battery voltages as indicated by the TCC indicators.

When the MIN battery voltage indicator is lit, the voltage sensing start command is active, and a remote start signal is not required.

When the MAX battery voltage indicator is lit, the voltage sensing stop command is active and overrides a remote start signal when the remote start signal is removed.

WARNING: Do not keep the remote start signal on longer than a moment. The TCC board will start the TEG and keep it running for as long as the remote start signal is applied, regardless of the voltage sensing stop command, which will over-charge the batteries and run the TEG continuously.

7.8.3 SCADA Stop

The SCADA stop signal is sent remotely by the customer's SCADA. A momentary system voltage dependent signal is required to toggle the SCADA stop relay on the TCC board (nominal 12V signal in 12V systems, nominal 24V signal in 24V systems). This stop signal is used as a remote stop command when the TCC board is in the Remote mode and the battery voltage is between the MIN and MAX voltages as indicated by the TCC indicators.

When the MIN battery voltage indicator is lit, the voltage sensing start command is active and overrides a remote stop signal.

When the MAX battery voltage indicator is lit, the voltage sensing stop command is active, and a remote stop signal is not required.

7.8.4 SCADA TEG On Indicator

The SCADA TEG On indicator provides a set of contacts to indicate when the TCC board is attempting to start the TEG and when the TEG is running.

When a start command is received by the TCC board, the TCC board will attempt to start the TEG. When the TCC board powers the SI board, the TEG On relay is also energized. When the relay is energized, the connection between the NO (normally open) and COM (common) is closed, and the connection between the NC (normally closed) and COM is open. The TEG On relay stays energized while the TEG is running and it also stays on if an SI lockout failed ignition situation occurs following a voltage sensing TEG On start.

The TEG On relay is de-energized when the TCC receives a stop command. The TEG On relay will remain energized if an SI Lockout failed ignition condition occurred following a voltage sensing TEG On start since a remote stop will not reset this condition.

7.8.5 SCADA Fuel Pressure Indicator

The SCADA Fuel Pressure indicator provides contacts to indicate when the pressure switch is closed. The connections are labelled as NO (normally open) and COM (common).

8 TEG POWER OUTPUT EVALUATION

Output power is the primary indication of correct setup, adjustment and operation of the TEG. This section describes how to determine if the TEG is providing rated power. Power output should be evaluated:

- during initial setup at site
- when adjusting a TEG
- before and after servicing a TEG, and
- whenever altering the fuel's heat of combustion

Note: Good record keeping is necessary for long term follow-up. Use the TEG Performance Log, located at the end of this manual, in Section 17, for recording details each time adjustments are made or servicing is carried out.

Ambient Temperature Effects on V_{set} and Rated Power

Power from the TEG is produced by the difference in temperature between the burner and the cooling fins. This means the power output of the TEG is affected by the ambient temperature surrounding the generator at site. Power output increases when temperature falls and decreases when temperature climbs. This effect needs to be considered when setting-up the TEG.

8.1 Model 5060 TEG

8.1.1 Set-Up Power and V_{set}

The power in the 5060 TEG is produced by the difference in temperature between the burner and the cooling fins. This means that the power output of the 5060 TEG will be affected by the ambient temperature at the generator site.

The rated power is the power that the 5060 TEG should produce at a specific ambient temperature, up to a maximum temperature of 65ºC (150ºF). The 5060 TEG is rated at 60 Watts gross power (power from the power unit) when operating at an ambient temperature of 24ºC (75ºF). As the ambient temperature rises the gross power will decrease and as the ambient temperature decreases the gross power will increase. For every rise in temperature of 1ºC the 5060 TEG will drop 0.18 Watts in gross power output.

To determine the set-up voltage V_{set} and set-up power use the graph in **Figure 8-1**. For example if the ambient temperature is 10ºC then V_{set} will be 13.7 Volts and set-up power will be 62.5 Watts.

To calculate the set-up power use the formula:

$$P = 60 + [(24^\circ - T) \times 0.18]$$

where: T = Ambient temperature ºC
P = Set-Up Power (Watts)

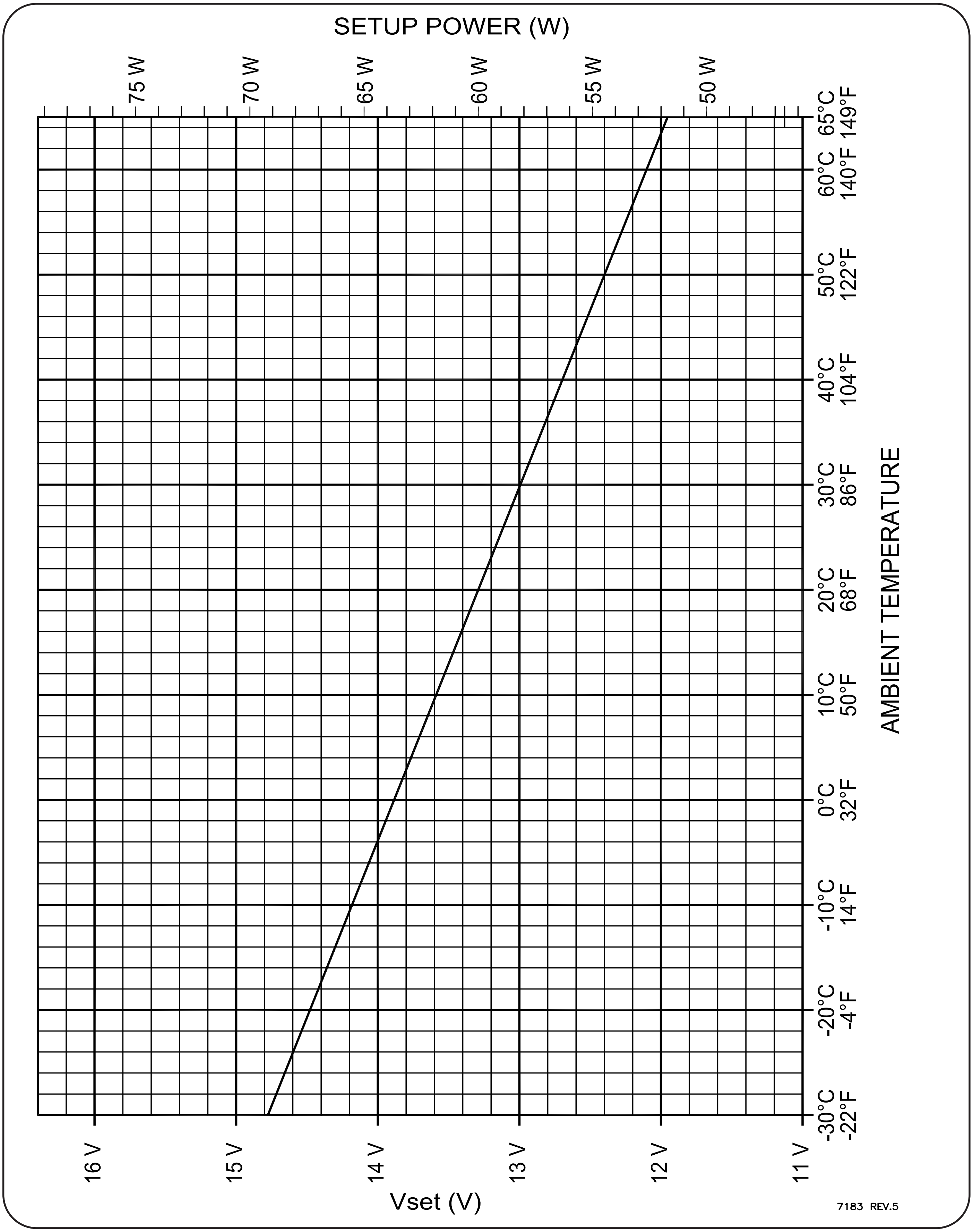


Figure 8-1 V_{set} & Rated Power vs. Ambient Temperature for 5060

EXAMPLE: The ambient temperature is 10ºC

P = 60 + [(24º - 10º) x 0.18]

= 62.52 Watts

8.1.2 V_{set} (Power) Check

After ignition has occurred the voltage between terminals 2(+) and terminals 4(-), that is, V_{set} will begin to climb as shown on the graph in **Figure 8-2**.

WARNING: DO NOT allow Vset to exceed the maximum as shown in Figure 8-2 or overheating may cause irreparable damage to the power unit.

The V_{set} will rise quickly at first then begin to level out. It will take at least one hour for the V_{set} to stabilize. When V_{set} no longer changes (±0.2 V in ten minutes) compare this value with rated V_{set} as determined in section 8.1.1, these should be within 0.2 Volts of each other.

If the measured V_{set} is greater than rated V_{set} then the fuel pressure needs to be reduced. If the measured V_{set} is less than rated V_{set} then proceed to Section 9, TEG Power Output Adjustments.

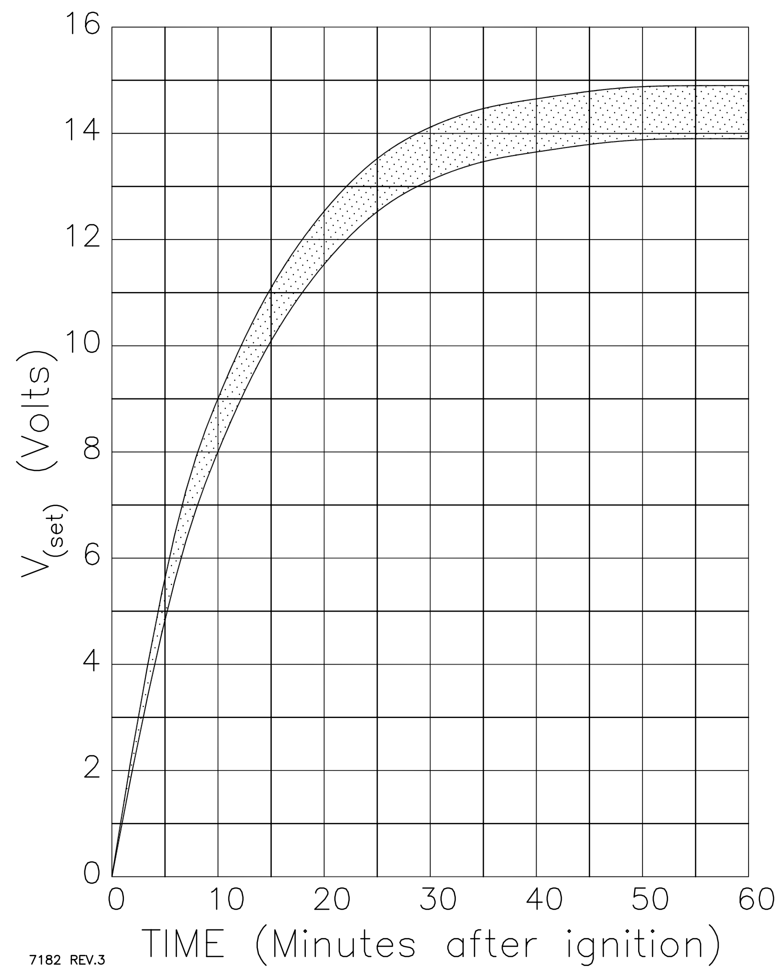


Figure 8-2 V_{set} vs. Time After Ignition for 5060

8.2 Model 5120 TEG

8.2.1 Set-Up Power and V_{set}

The power in the 5120 TEG is produced by the difference in temperature between the burner and the cooling fins. This means that the power output of the 5120 TEG will be affected by the ambient temperature at the generator site.

The rated power is the power that the 5120 TEG should produce at a specific ambient temperature, up to a maximum temperature of 65ºC (150ºF). The 5120 TEG is rated at 120 Watts gross power (power from the power unit) when operating at an ambient temperature of 24ºC (75ºF). As the ambient temperature rises the gross power will decrease and as the ambient temperature decreases the gross power will increase. For every rise in temperature of 1ºC the 5120 TEG will drop 0.36 Watts in gross power output.

To determine the required Set-up Power see graph in **Figure 8-3** and consider the following example:

1) The present site temperature is 40ºC.
2) Find 40ºC on the horizontal axis.
3) Read vertically until intersecting the rated power curve.
4) Read horizontally to the verical axis to find the set-up power.
5) Which is 114 Watts.

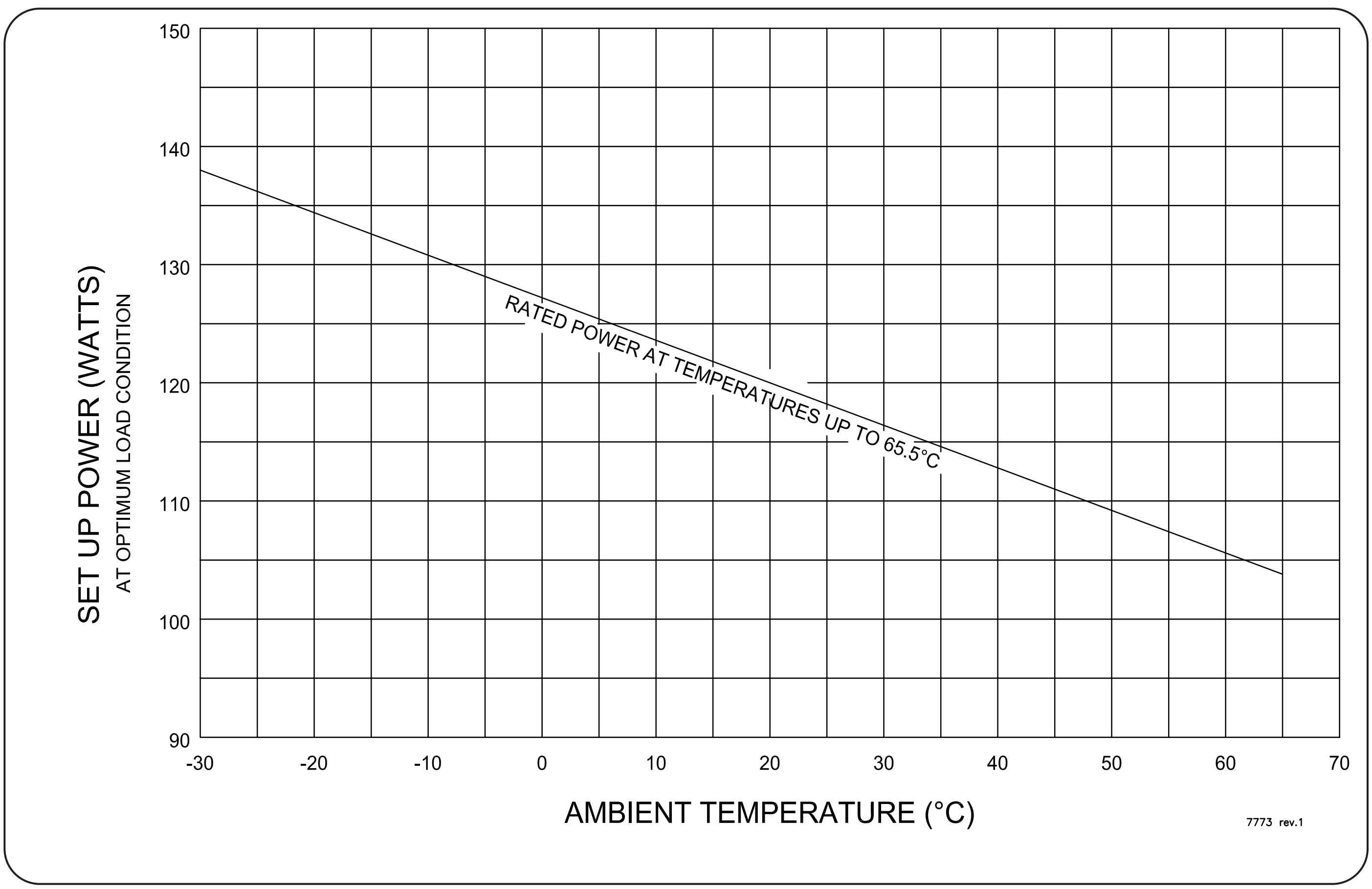


Figure 8-3 V_{set} & Rated Power vs. Ambient Temperature for 5120

V_{set}, the voltage across the precision load, is a measure of power. The value of the precision load (0.375 ohm) is selected to provide the optimum load condition for the TEG. The relationship between V_{set} (V) and power (P) is:

$$P = \frac{(V_{set})^2}{0.375}$$

This relationship is shown in **Figure 8-4**. To determine the rated V_{set} see the graph in **Figure 8-4**.

For example, if:

1) The required power is 116 Watts.
2) Locate 116 Watts on the horizontal axis.
3) Read vertically until intersecting the curve.
4) Read horizontally to the vertical axis to determine rated V_{set} .
5) Which is 6.6 volts.

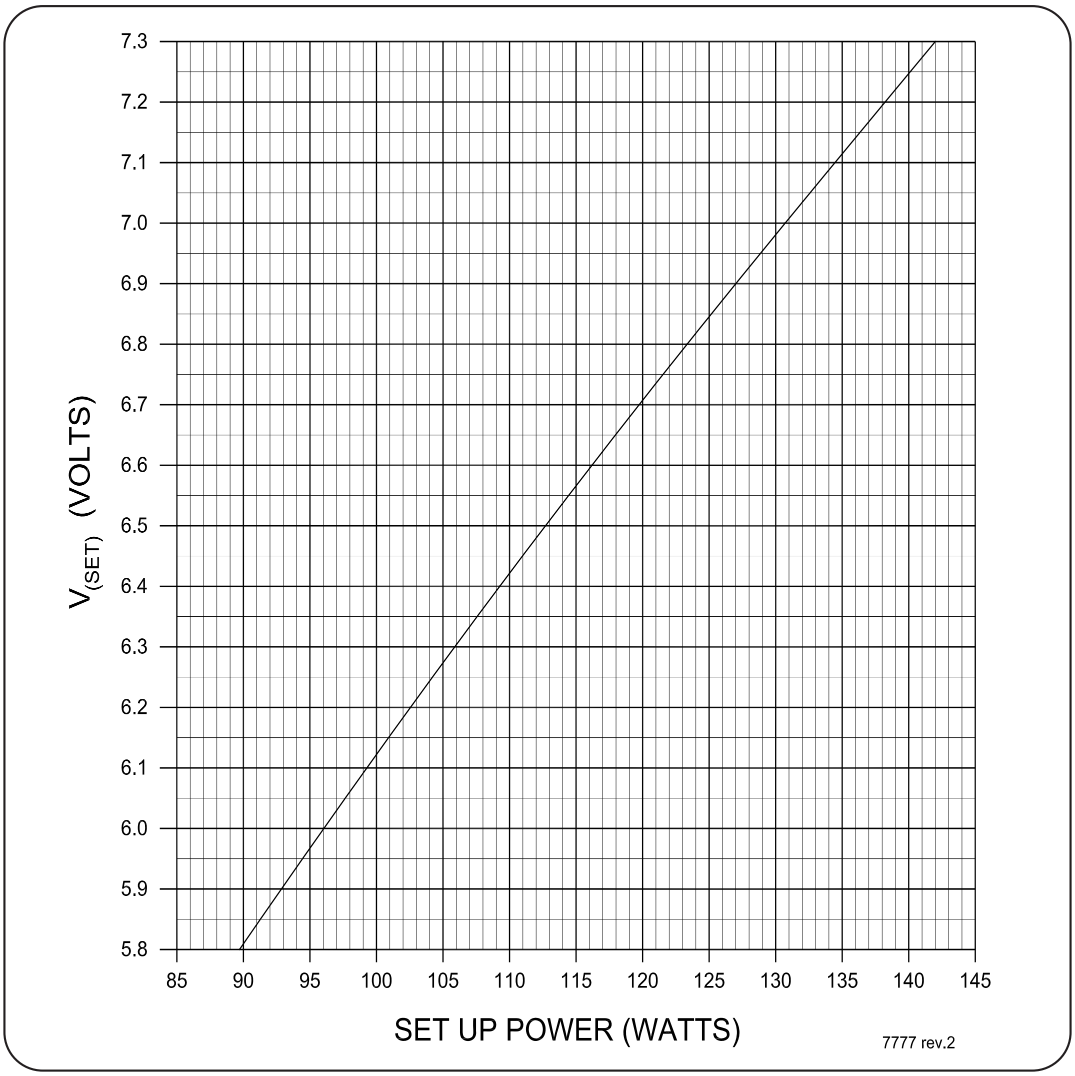


Figure 8-4 V_{set} vs. Set Up Power 5120

8.2.2 V_{set} (Power) Check

After ignition has occurred the voltage between terminals 2(+) and terminals 4(-), that is, V_{set} will begin to climb as shown on the graph in **Figure 8-5**.

The V_{set} will rise quickly at first then begin to level out. It will take at least one hour for the V_{set} to stabilize. When V_{set} no longer changes (±0.2 V in ten minutes) compare this value with rated V_{set} as determined in section 8.1.2, these should be within 0.2 Volts of each other.

If the measured V_{set} is greater than rated V_{set} then the fuel pressure needs to be reduced. If the measured V_{set} is less than rated V_{set} then proceed to Section 12, TEG Power Output Adjustments.

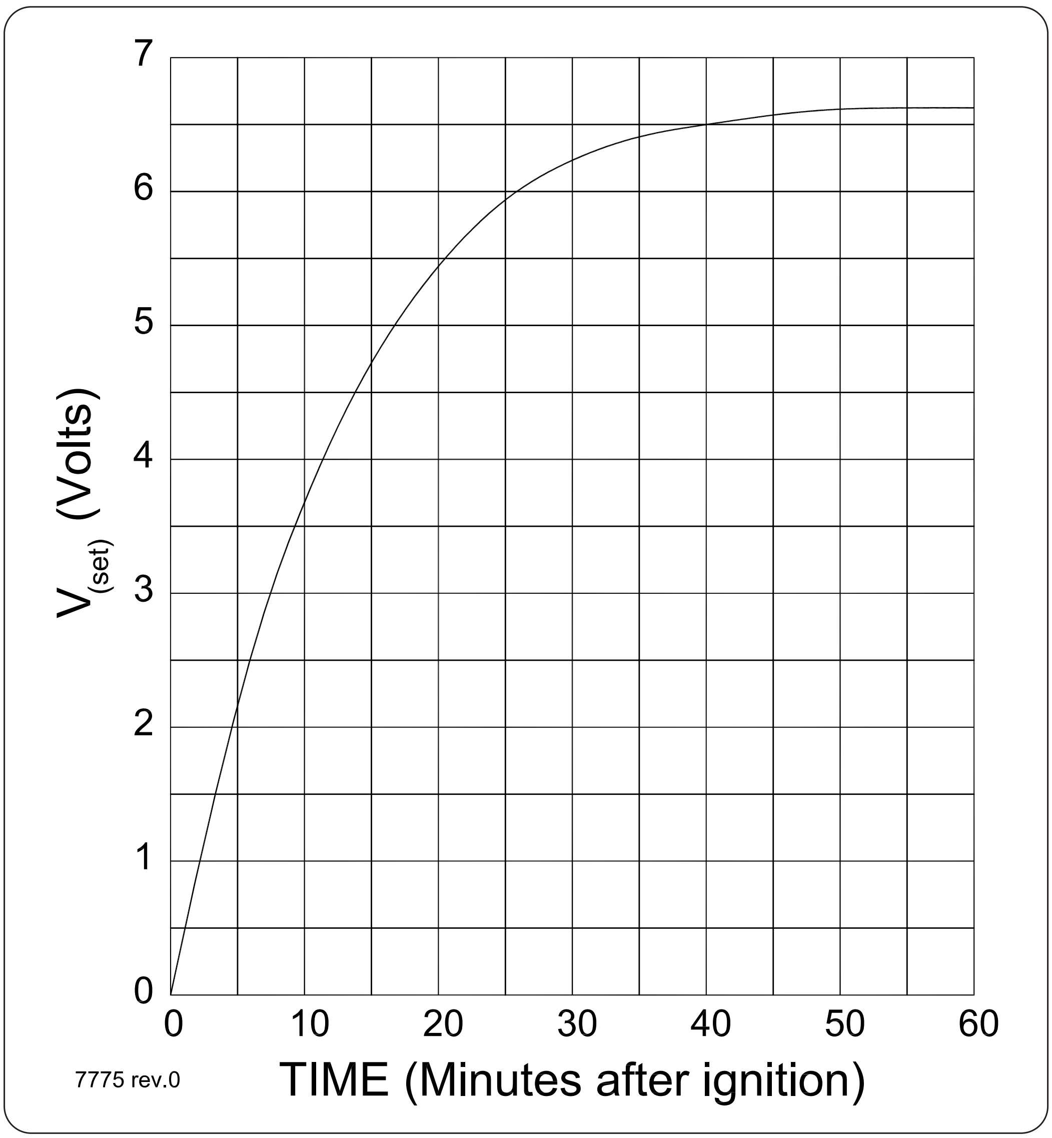


Figure 8-5 V_{set} vs. Time After Ignition for 5120

8.3 Model 5220 TEG

8.3.1 Set-Up Power and V_{set}

V_{set}, proportional to rated power, must be adjusted for actual ambient temperature at site as described below. **Figure 8-6** is used to determine the appropriate V_{set} and expected rated power at various ambient temperatures, through calculations.

Factory test data for rated power and voltage are marked on the data plate that is located inside the TEG cabinet door. These values are for a specific ambient temperature that is also indicated on the data plate. They require correction for ambient temperatures different to that indicated. The following formulas apply:

$V_{set} = V_{set\ ref.} + [(T_{ref.} - T) \times 0.026]$

Where:
- T = Ambient temperature, at site (ºC)
- $T_{ref.}$ = Reference ambient temperature, marked on Data Plate (ºC)
- $V_{setref.}$ = Reference set-up voltage, marked on Data Plate (V)
- V_{set} = Set-up voltage, at site (V)

$P_{set} = P_{setref.} + [(T_{ref} - T) \times 0.8]$

Where:
- T = Ambient temperature, at site (ºC)
- $T_{ref.}$ = Reference ambient temperature, marked on Data Plate (ºC)
- P_{setref} = Reference power marked on TEG Data Plate (W)
- P_{set} = Rated power at new ambient (W)

Note: Avoid setting-up the TEG to run at higher V_{set} or rated power values, as its life may be affected. This method is suitable for ambient temperatures of up to 65.5ºC (150ºF). If in doubt contact Global Power Technologies' Customer Service Department for guidance.

Example : Ambient temperature at site is 35ºC. Set-up power of 220 W and V_{set} of 14.9 V, 22ºC is marked on the TEG Data Plate.

$V_{set} = V_{setref.} + [(T_{ref.} - T) \times 0.026]$
$= 14.9 + [(22 - \{35\}) \times 0.026]$
$= 14.9 + [(22 - 35) \times 0.026]$
$= 14.9 + [-13 \times 0.026]$
$= 14.9 + [-0.3338]$
$= 14.9 - 0.338$
$\underline{= 14.56\ V}$

similarly,

$$
\begin{aligned}
P_{set} &= P_{setref.} + [(T_{ref.} - T) \times 0.8] \\
&= 220 + [(22 - \{35\}) \times 0.8] \\
&= 220 + [(22 - 35) \times 0.8] \\
&= 220 + [-13 \times 0.8] \\
&= 220 + [-10.4] \\
&= 220 - 10.4 \\
&= \underline{209.6\ W}
\end{aligned}
$$

A good approximation to V_{set} and rated power can be obtained from the chart shown in **Figure 8-6**. Knowing the ambient temperature, move up vertical to the line. Read the V_{set} from the right side of the graph and rated power from the left side.

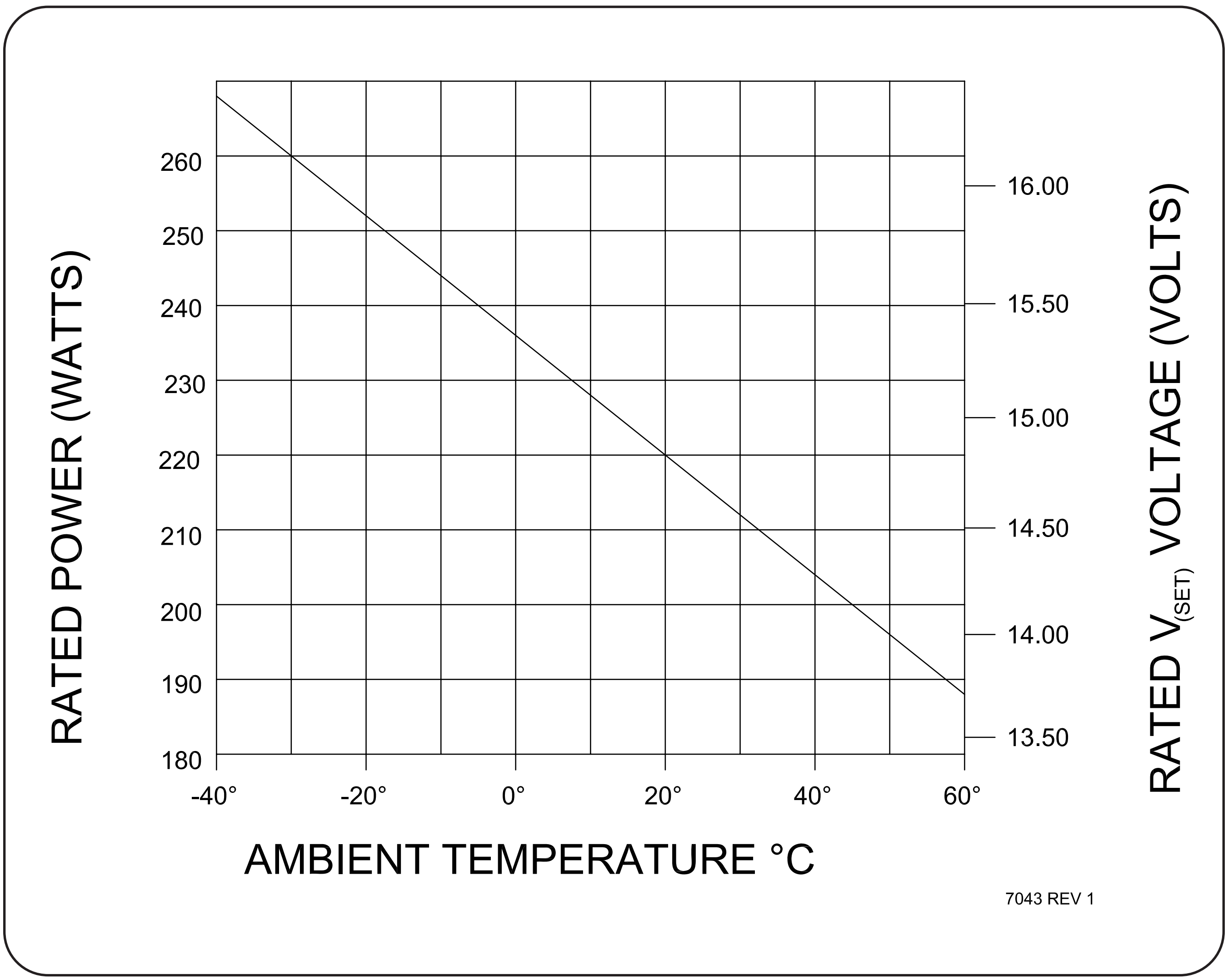


Figure 8-6 V_{set} & Rated Power vs. Ambient Temperature for 5220

8.3.2 V_{set} (Power) Check

To determine the electrical power that the generator is producing a precision resistor is provided within the generator. This resistor is called the V_{set} resistor. By connecting the generator to this resistor and measuring the voltage across it, the power produced by the generator can be calculated as follows:

Where: P = Power (watts)
V = Voltage (Volts)
R = Resistance (Ohms)

$$\mathbf{P = \frac{V^2}{R}}$$

As R = 1.0 Ohms the power calculation may be simplified to:

$$P = (V_{set})^2/1$$

V_{set} voltage, is measured across terminals 2 and 4, with the jumper clip in the setup position across terminals 2 and 3, as shown in **Figure 4-2**.

V_{set} Shortly after Ignition

Immediately after ignition the power unit warms and the resulting temperature rise produces power.

Follow these steps to check V_{set} after ignition:

8.3.2.1 Consult the data plate inside TEG door for the reference V_{set} voltage and determine the required V_{set} for the present ambient temperature.

8.3.2.2 Move the jumper clip on the terminal block TB-1 to the SETUP position, i.e. between terminals 2 and 3.

8.3.2.3 Connect a voltmeter between terminals 2 (+) and 4 (-). This is the measured V_{set}, and should tend towards the required V_{set} (determined in “a”). It will climb as shown in **Figure 8-7**.

WARNING: Do not allow the measured Vset to exceed the required Vset. Overheating will result and may cause irreparable damage to the power unit.

8.3.2.4 The measured V_{set} will rise quickly at first then begin to level out. It will take at least one hour for this voltage to level out. When the measured V_{set} no longer changes (±0.2 V in ten minutes) compare this value with required V_{set}. The measured V_{set} should be within 0.2 V of the required V_{set}

Note: Typically, if the measured V_{set} is greater than required V_{set} then the fuel pressure needs to be reduced.

V_{set} After TEG has Stabilized

Once the TEG has been running for some time, typically more than an hour, the power unit will be up to operating temperature.

Follow these steps to check V_{set}.

8.3.2.5 Consult the data plate inside TEG door for the reference V_{set} voltage and determine the required V_{set} for the present ambient temperature.

8.3.2.6 Move the jumper clip on the terminal strip to the SETUP position, i.e. between terminals 2 and 3. This connects the TEG to an internal load required for V_{set}.

8.3.2.7 Connect a voltmeter between terminals 2 (+) and 4 (-). The measured V_{set}, and should match the required V_{set} for the present temperature.

8.3.2.8 Pause approximately 10-45 minutes and when the measured voltage is stable compare it to required V_{set}. Measured V_{set} should be within 0.2 V of the required V_{set}.

Note: Pausing is necessary to allow the TEG voltage to stabilize to the new load conditions. (Changing from customer load to the on-board 1 ohm resistor).

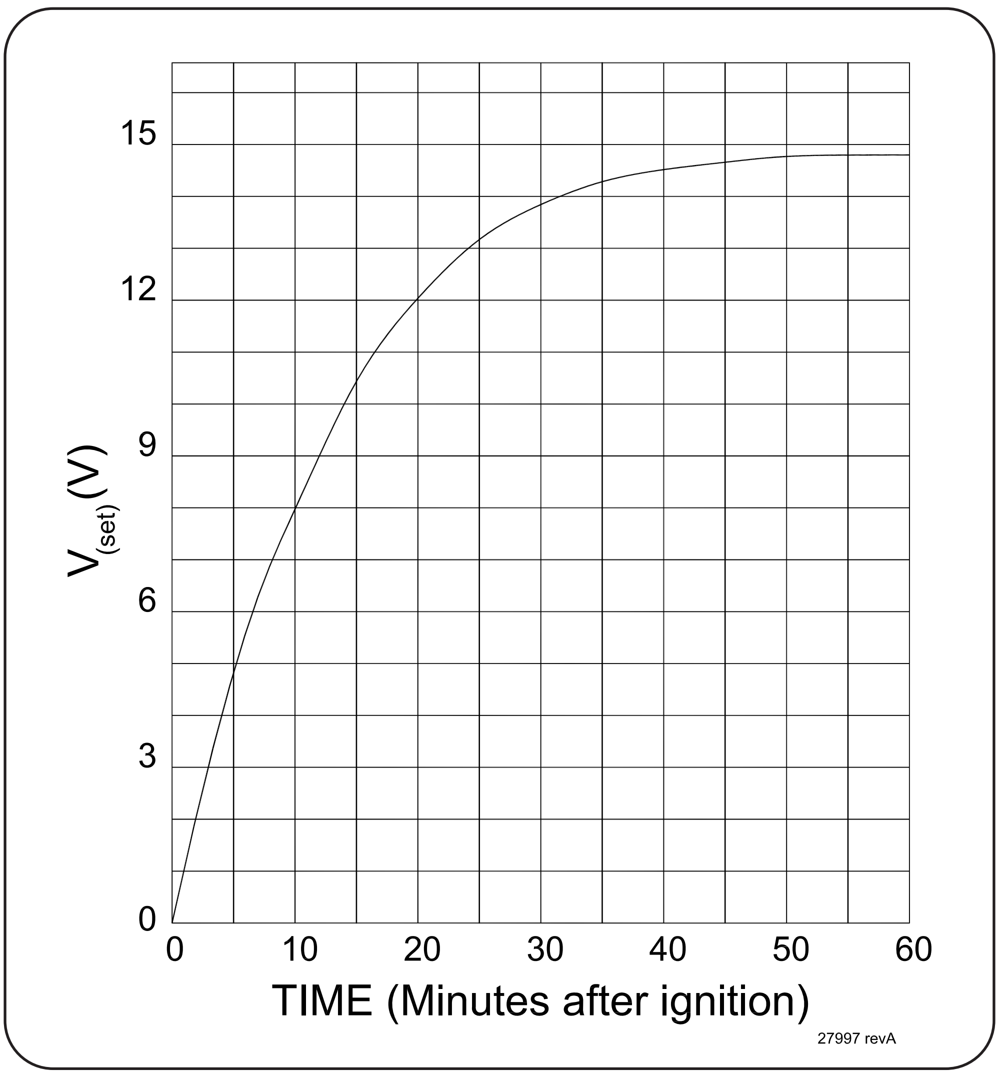


Figure 8-7 V_{set} versus Time After Ignition for 5220

9 TEG POWER OUTPUT ADJUSTMENT

TEG output power is controlled by the flow of air and fuel into the TEG. Use the following procedures to adjust the TEG's power output in sequence given.

- Adjustment for Elevation
- Air Shutter Adjustment
- Fuel Pressure Adjustment

9.1 Model 5060 TEG

9.1.1 Adjustment for Elevation

Check the fuel gauge pressure. It should be near the pressure indicated on the data plate. If the TEG is located at a different altitude than the factory, (750 m or 2460 ft.) the pressure will also be different. See **Figure 9-1**.

Example: If the site elevation is 2000m (6682 ft.) then 14 kPa (2 psi) must be added to the pressure on the data plate.

If it is necessary to adjust the pressure, remove the cover on the regulator and loosen the lock nut. Turn the adjusting screw (clockwise to increase pressure) until the required pressure is obtained. Tighten the lock nut when finished adjusting.

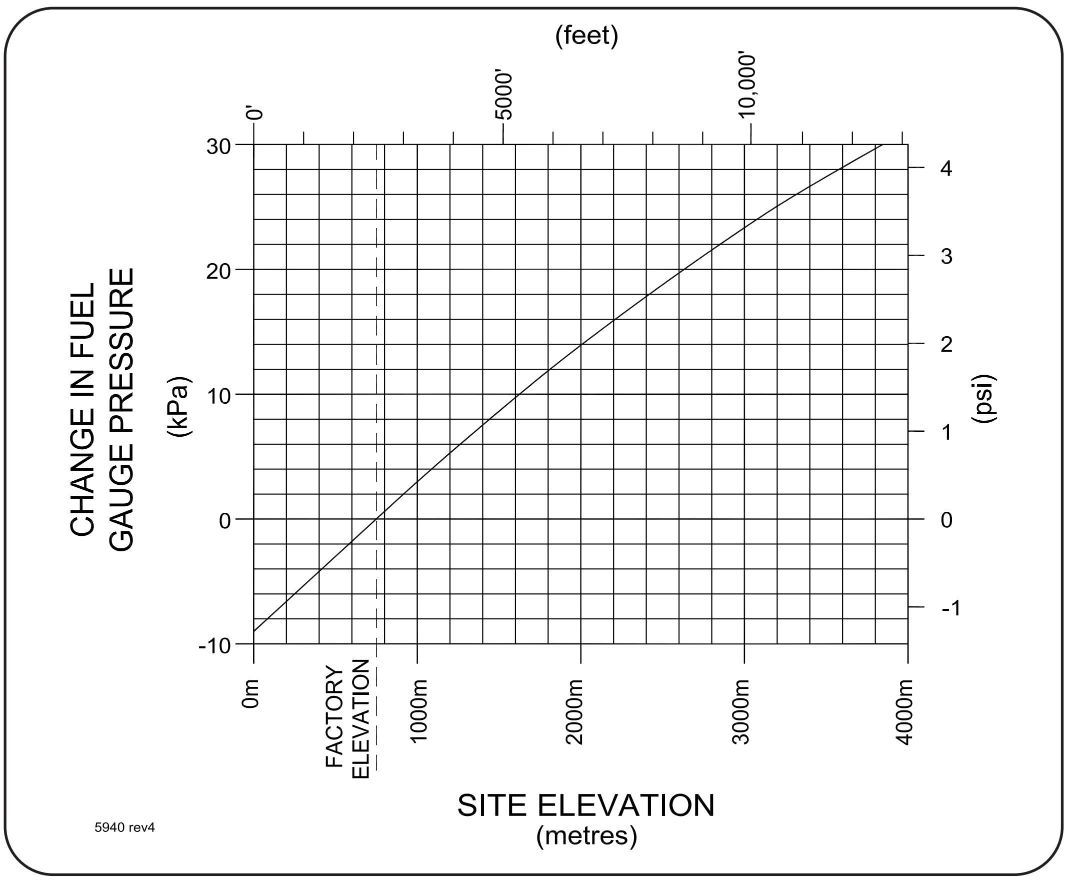


Figure 9-1 Fuel Gauge Pressure vs. Elevation for 5060

9.1.2 Air Shutter Adjustment

9.1.2.1 Record the V_{set}.
9.1.2.2 Open the doors and loosen the adjustment screw lock-nut.
9.1.2.3 Turn the adjusting screw one turn counterclockwise.
9.1.2.4 Close the doors, wait ten minutes then measure V_{set}.

If V_{set} is greater than the original value or did not change (air rich) turn the adjusting screw another turn counter-clockwise and wait ten minutes. Continue until you observe a decrease in V_{set} then proceed to next paragraph.

If V_{set} is less than original value (fuel rich) refer to **Figure 9-2**. Notice that the peak of the graph is within one quarter of a turn (either direction) of the adjusting screw. Set the adjusting screw so that it is one half turn air rich.

Tighten the lock-nut.

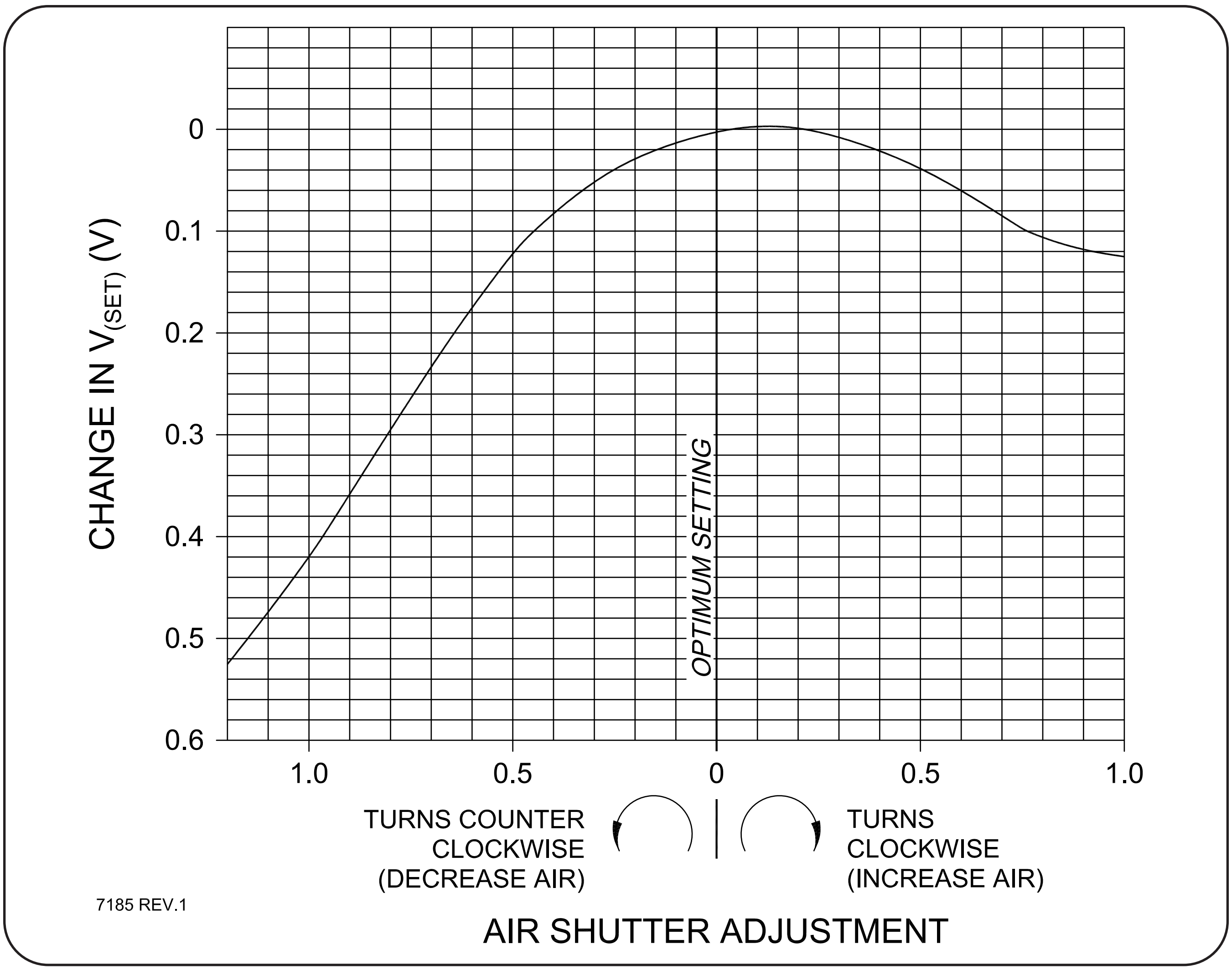


Figure 9-2 Change in V_{set} vs. Air Shutter Setting for 5060

9.1.3 Fuel Pressure Adjustment

If the fuel system and burner appear to be operating correctly, the fuel pressure may be slightly adjusted to match the TEG's voltage with the rated V_{set} value. **Figure 9-3** can be used to determine how much to adjust the fuel pressure.

EXAMPLE: Rated V_{set} = 13.2V
Measured V_{set} = 12.8V
Difference = +0.4V

As seen on the graph, the fuel pressure must be increased 2.5 kPa (0.37 psi).

9.1.3.1 To adjust the fuel pressure, remove the cover on the regulator and loosen the lock nut.

9.1.3.2 Turn the adjusting screw (clockwise to increase pressure) until the required change in pressure is obtained.

WARNING: Do not exceed the following values:
Natural Gas: 52 kPa (7.5 psi)
Propane: 62 kPa (9.0 psi)

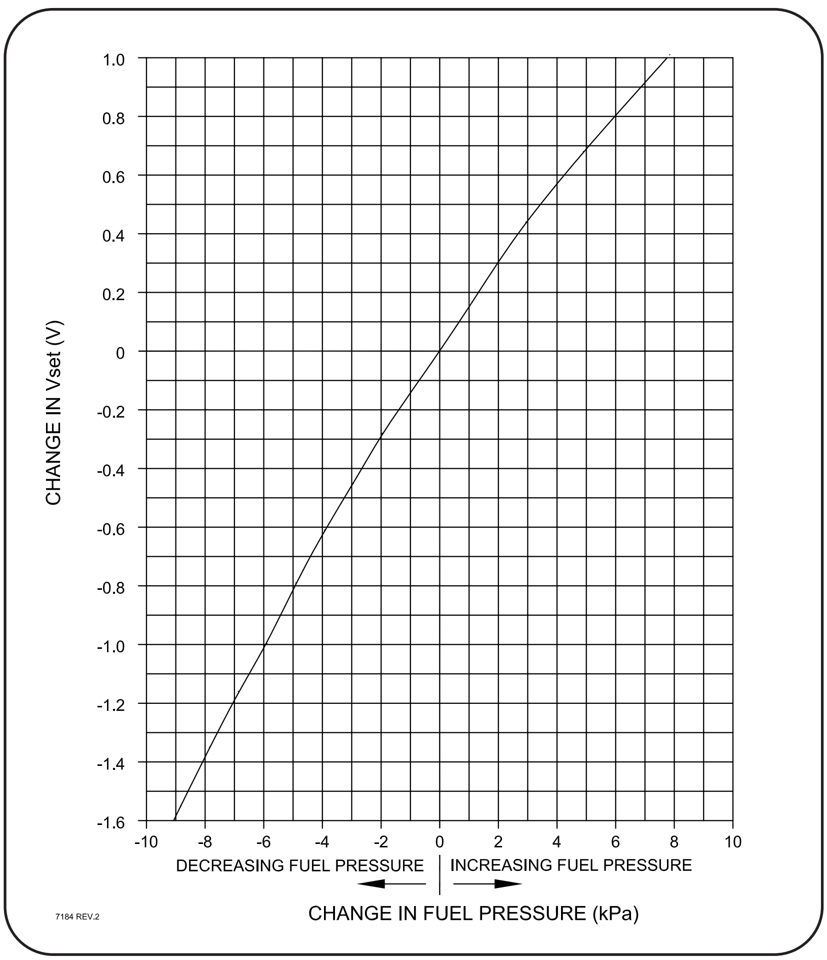


Figure 9-3 Change in V_{set} vs. Fuel Pressure Adjustment for 5060

9.1.3.3 Wait at least 10 minutes before measuring V_{set}. If the TEG still does not reach V_{set} value then a problem exists with one of the TEG's systems. See section 13, trouble shooting, for evaluation

.

9.1.3.4 Replace the cover on the fuel regulator.

9.2 Model 5120 TEG

9.2.1 Adjustment for Elevation

Check the fuel gauge pressure. It should be near the pressure indicated on the data plate. If the TEG is located at a different altitude than the factory, (750 m or 2460 ft.) the pressure will also be different (See **Figure 9-4**).

Example: If the site elevation is 2000m (6682 ft.) then 14 kPa (2 psi) must be added to the pressure on the data plate.

If it is necessary to adjust the pressure, remove the cover on the regulator and loosen the lock nut. Turn the adjusting screw (clockwise to increase pressure) until the required pressure is obtained. Tighten the lock nut when finished adjusting.

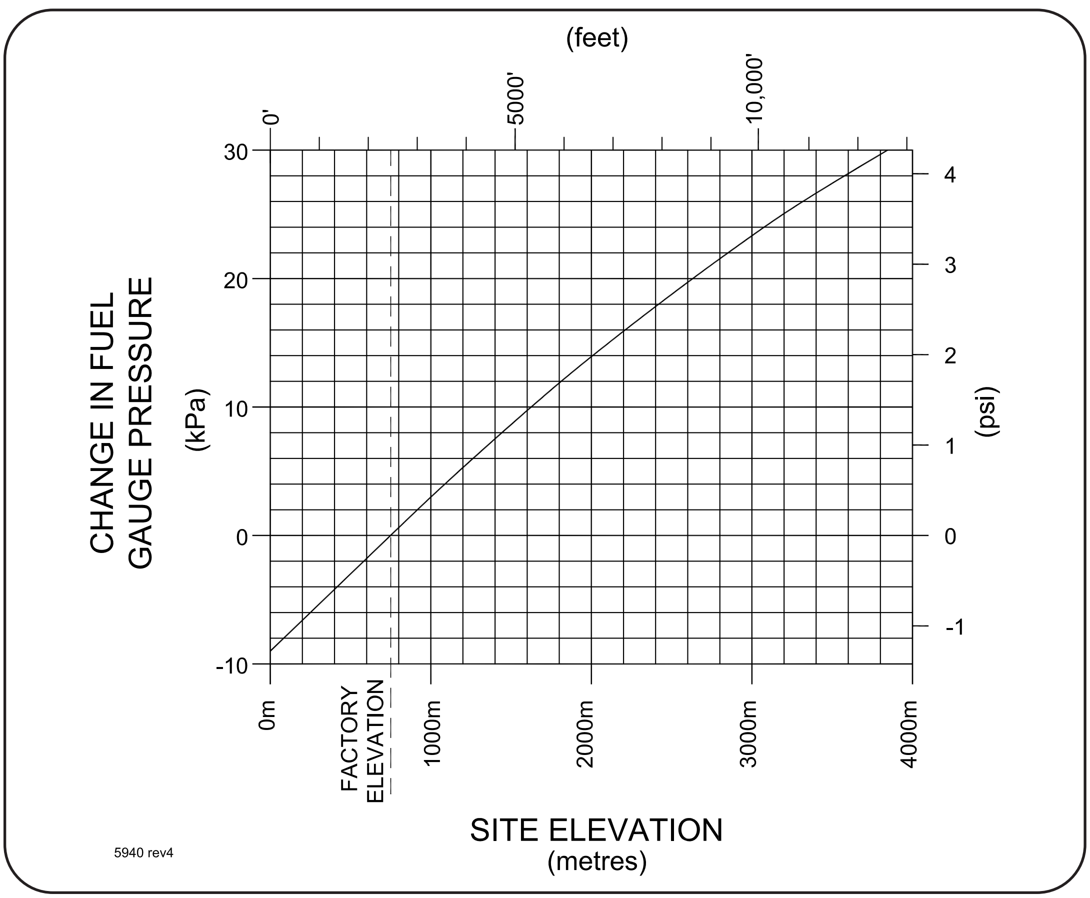


Figure 9-4 Fuel Gauge Pressure vs. Elevation for 5120

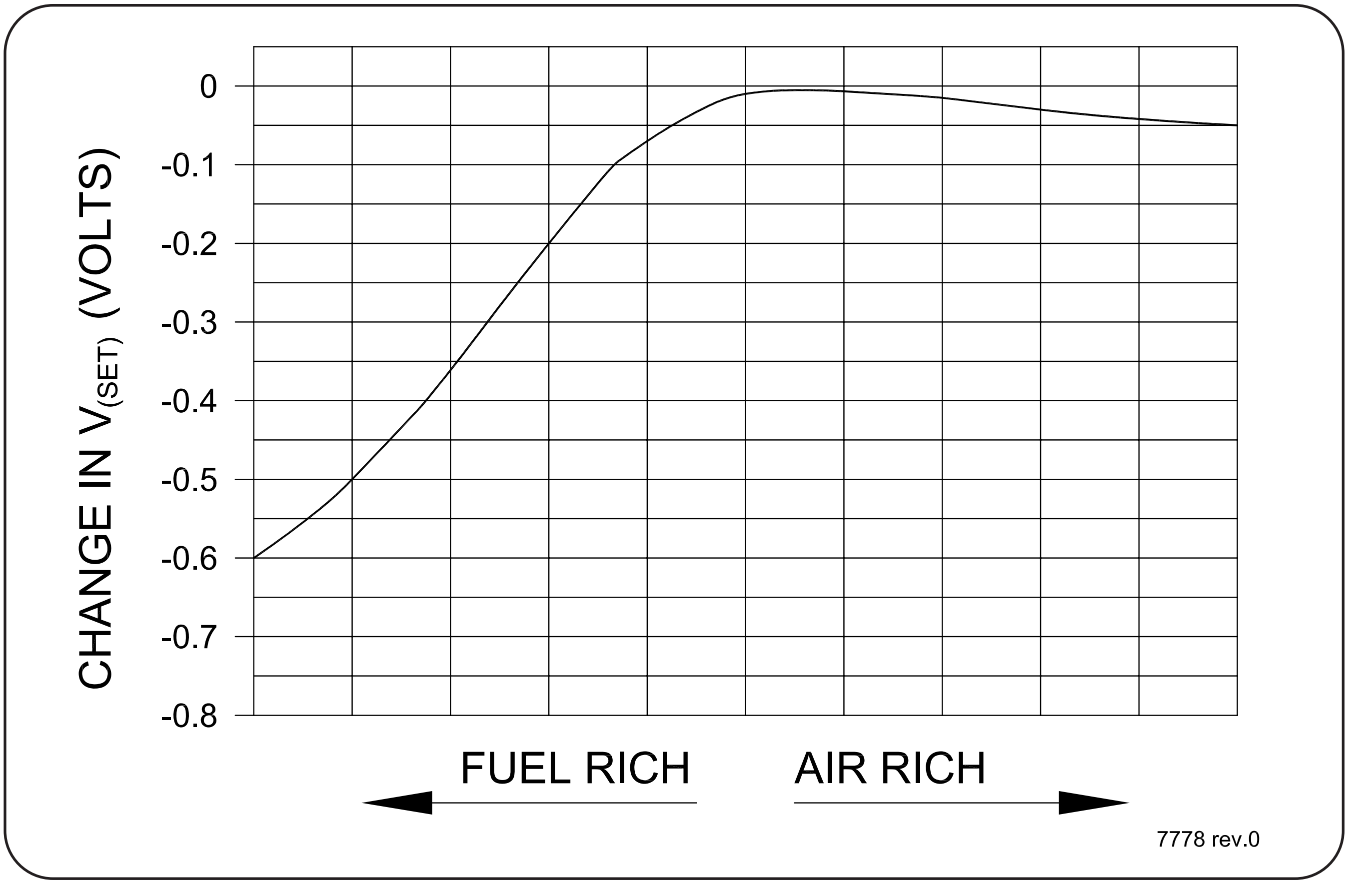


Figure 9-5 Change in V_{set} vs. Air Shutter Setting for 5120

9.2.2 Air Shutter Adjustment

9.2.2.1 Record the V_{set}.
9.2.2.2 Open the doors and loosen the adjustment screw lock-nut.
9.2.2.3 Turn the adjusting screw one turn counterclockwise.
9.2.2.4 Close the doors, wait ten minutes then measure V_{set}.

If V_{set} is greater than the original value or did not change (air rich) turn the adjusting screw another turn counter-clockwise and wait ten minutes. Continue until you observe a decrease in V_{set} then proceed to next paragraph.

If V_{set} is less than original value (fuel rich) refer to **Figure 9-5**. Notice that the peak of the graph is within one quarter of a turn (either direction) of the adjusting screw. Set the adjusting screw so that it is one half turn air rich.

Tighten the lock-nut.

9.2.3 Fuel Pressure Adjustment

If the fuel system and burner appear to be operating correctly, the fuel pressure may be slightly adjusted to match the TEG's voltage with the rated V_{set} value. **Figure 9-6** can be used to determine how much to adjust the fuel pressure.

EXAMPLE: Rated V_{set} = 6.5V
Measured V_{set} = 6.8V
Difference = -0.3V

As seen on the graph, the fuel pressure must be increased 8.5 kPa (1.2 psi).

9.2.3.1 To adjust the fuel pressure, remove the cover on the regulator and loosen the lock nut.

9.2.3.2 Turn the adjusting screw (clockwise to increase pressure) until the required change in pressure is obtained.

WARNING: Do not exceed the following values:
Natural Gas: 31 kPa (4.5 psi)
Propane: 45 kPa (6.5 psi)

9.2.3.3 Wait at least 10 minutes before measuring V_{set}. If the TEG still does not reach V_{set} value then a problem exists with one of the TEG's systems. See section 13, trouble shooting, for evaluation.

9.2.3.4 Replace the cover on the fuel regulator.

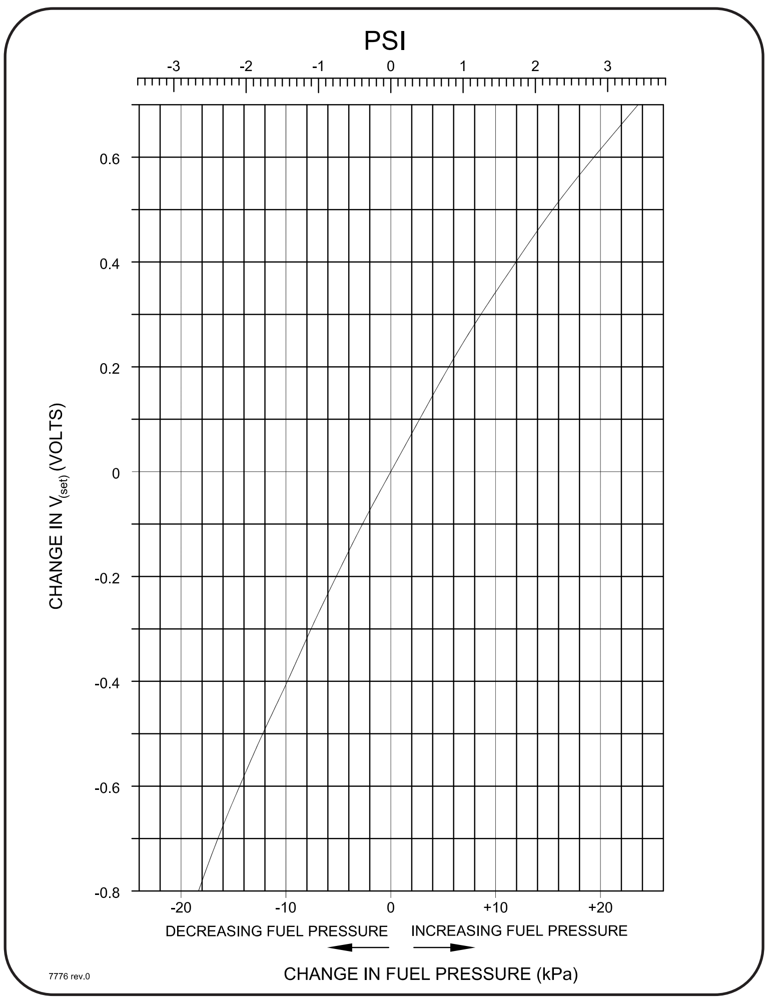


Figure 9-6 Change in V_{set} vs. Fuel Pressure Adjustment for 5120

9.3 Model 5220 TEG

9.3.1 Adjustment for Elevation

Confirm the fuel gauge pressure is near the pressure indicated on the data plate located on the inside of the cabinet doors. If the TEG is located at a different altitude than the factory, 792 m (2600 ft.), the fuel pressure will need to be different to obtain the same results also be different. Use **Figure 9-7** to determine how much to adjust the fuel pressure.

Example: If the site elevation is 1000m (3281ft.) then 2.5 kPa (0.36 psig) must be added to the pressure on the data plate.

Note: Typical settings are 130-144 kPA (18.5 - 21. psig) for natural gas and 125-140 kPa (18.0 - 20.0 psig) for propane.

Follow these steps to adjust fuel pressure:

- 9.3.1.1 Remove the cover on the regulator and loosen the lock nut.
- 9.3.1.2 Turn the adjusting screw (clockwise to increase pressure) until the required change in pressure is obtained.
- 9.3.1.3 Tighten the lock nut and replace the cover on the fuel regulator.

Note: Consult Data Plate Label Located on inner door for Reference Factory Fuel Pressure.

9.3.2 Air Shutter Adjustment

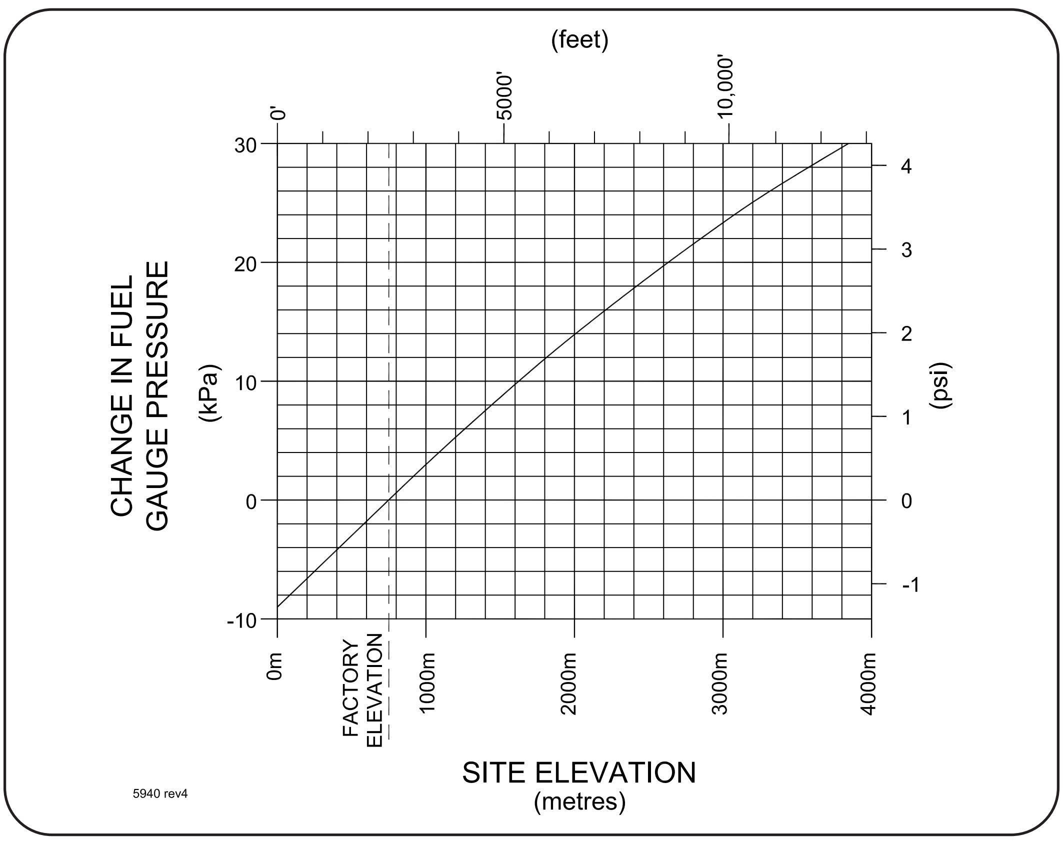


Figure 9-7 Fuel Gauge Pressure vs. Elevation for 5220

At this point, adjusting the air shutter for optimum combustion may be necessary (see **Figure 9-8**). The generator should be stable, with the V_{set} voltage constant.

WARNING: Air shutter components are hot and will burn skin. Make all air shutter adjustments using tools only, not bare skin.

9.3.2.1 Mark the original position of the air shutter with a felt pen against the burner cover.

9.3.2.2 Loosen the four screws mounting the air screen against the air shutter, leaving the air shutter still in place.

9.3.2.3 Open the air shutter slightly by rotating the shutter to enlarge the opening. Adjust the shutter only a small amount at a time. There will be a slight resistance to air shutter movement as the air shutter is still being held against the venturi by four inner wave washers.

9.3.2.4 Close the doors and let the unit stabilize for 10 minutes and measure V_{set}.

If V_{set} is greater than the original value repeat step c). Continue to enlarge the shutter opening until V_{set} decreases then rotate the shutter to the position that gave the highest V_{set}, and tighten screws A and B and measure CO.

If V_{set} is less than the original value return air shutter to the original position and then close slightly. Let the unit stabilize for 10 minutes and then measure V_{set}. Repeat until V_{set} decreases, then return to the position that gave the highest V_{set}, and tighten screws A and B.

Note: It may take several minutes to see a change in voltage if only 2 decimal places are displayed on the voltmeter.

9.3.2.5 Tighten screws A and B, replace air screen and verify V_{set} did not change.8.2.2 - V_{set}.

9.3.3 Fuel Pressure Adjustment

Once the air is adjusted, and if the fuel system and burner appear to be operating correctly, the fuel pressure may be slightly adjusted to match the measured V_{set} voltage with the required V_{set} value. Use **Figure 9-9** to determine how much to adjust the fuel pressure.

Example:	Required V_{set}	=	14.1 V
	Measured V_{set}	=	13.5 V
	Difference	=	+0.6 V

Based on Figure 24 the fuel pressure must then be increased 3.6 kPa (0.52 psig).

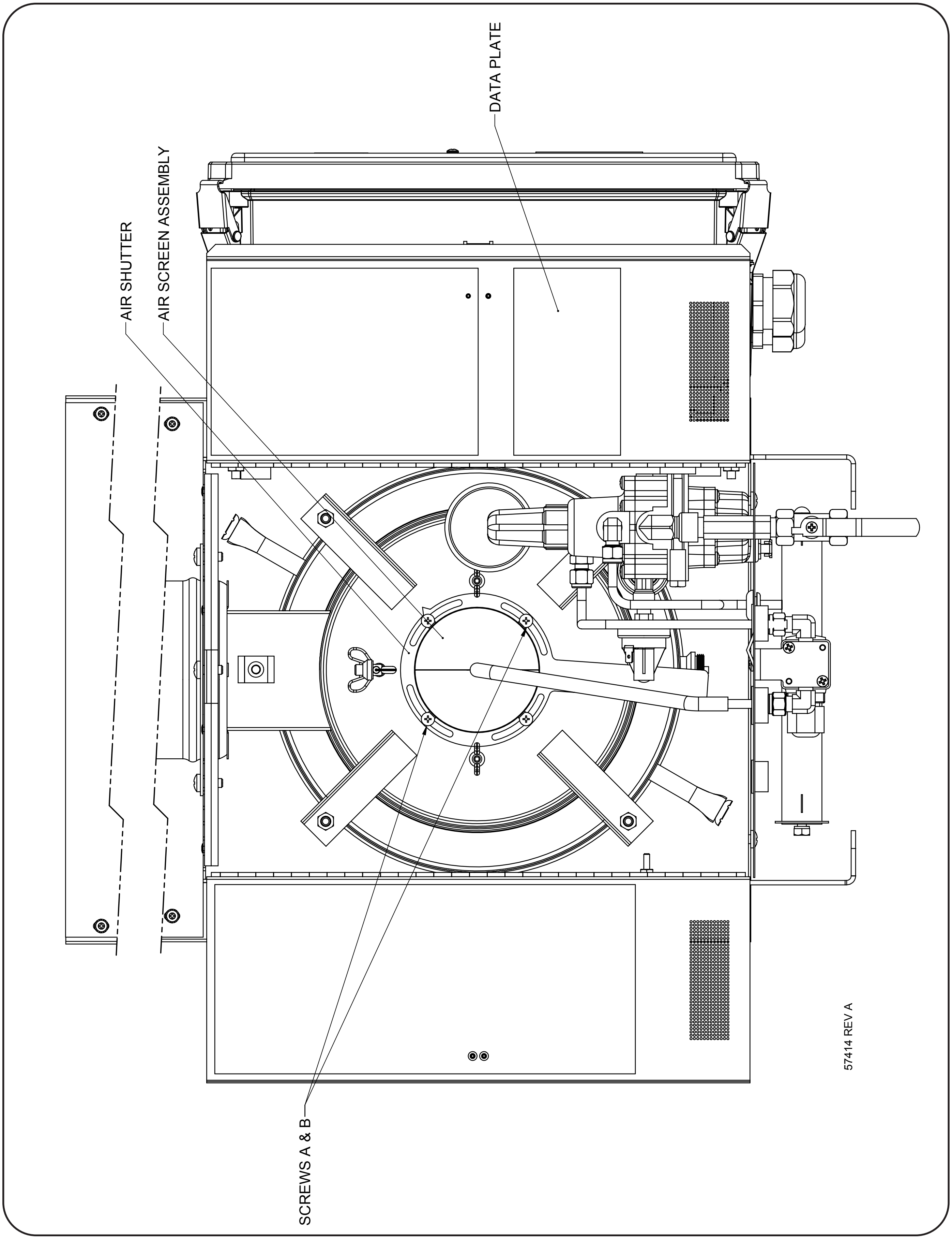


Figure 9-8 Air Shutter for 5220

Follow these steps to adjust fuel pressure:

9.3.3.1 Remove the cover on the regulator and loosen the lock nut.

9.3.3.2 Turn the adjusting screw (clockwise to increase pressure) until the required change in pressure is obtained.

Note: *Consult data plate label located on inner door for reference factory fuel pressure.*

9.3.3.3 Wait ten minutes then measure V_{set} and record. If the TEG cannot be adjusted to match required V_{set} value then a problem exists with one of the TEG's systems. If necessary see Troubleshooting, (Section 13) for guidance.

9.3.3.4 Tighten the lock nut and replace the cover on the fuel regulator.

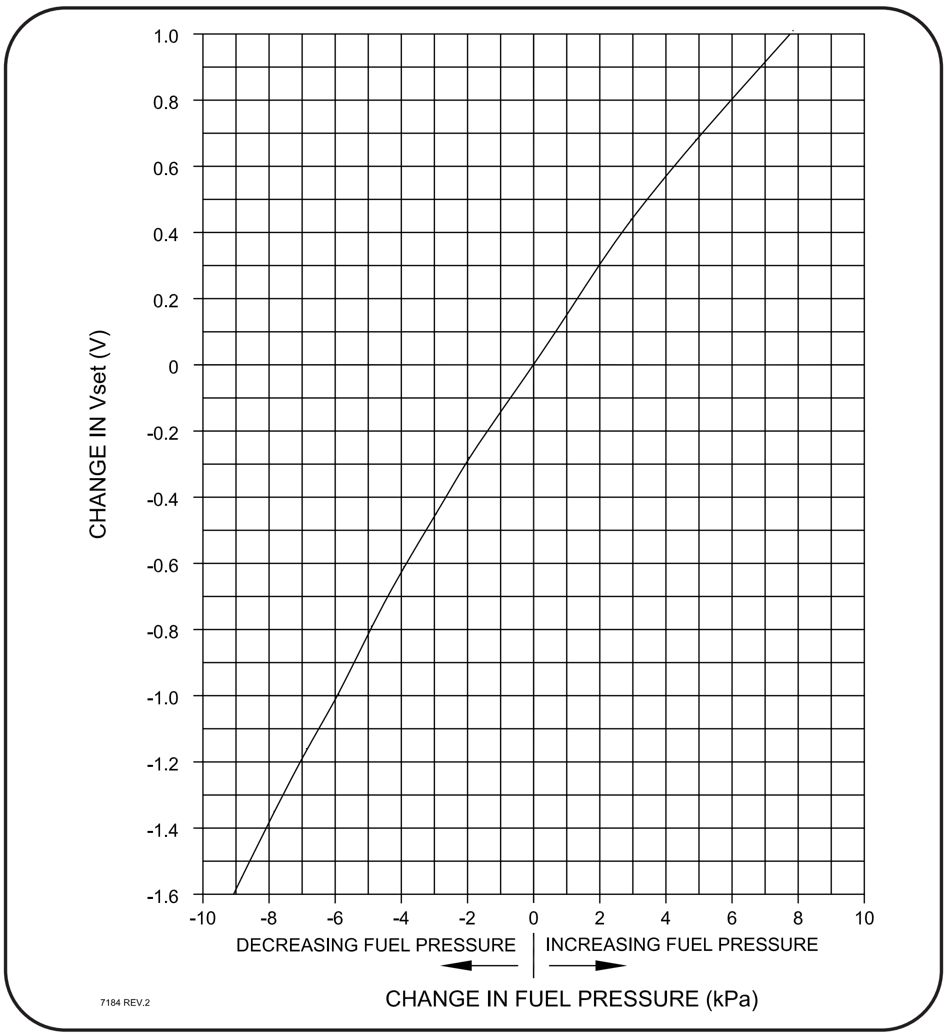


Figure 9-9 Change in V_{set} vs. Fuel Pressure Adjustment for 5220

10 HYBRID SITE ACCEPTANCE TEST

10.1 Breaker Position

Start with all system beakers in the Off position:

- Load breakers in the Control box. See **Figure 4-2**
- All breakers in the Junction box. See **Figure 4-7**
- All breakers in the PV Combiner box. See **Figure 4-8**

10.2 Verify Solar Panel System Voltage and Wiring

10.2.1 Verify that the main cable connecting the PV combiner to the Junction box has the black wire connected to the "PV PLUS OUT" busbar and the white wire is connected to the PV NEGATIVE busbar.

10.2.2 Measure the open circuit voltage of each string of PV panels connected to their associated breaker in the Combiner Box. Turn on the single breaker for the string under test and measure the voltage across the PV+ and PV- busbars. The measured voltage should be in the range of the system's open circuit voltage rating listed on the "Solar photovoltaic System" label located on the deadfront of the junction box.

10.3.3 When all strings have been connected to the combiner box and each string is verified individually as above, turn on all breakers in the combiner box and verify that the combined system voltage is in the same range as above.

10.3 Verify Battery System Voltage and Wiring without applying a load or charging

10.3.1 For 12V systems:

- All batteries must be connected in parallel. As each battery is connected together, continually measure the bus voltage to ensure it remains at the system level to avoid cross connecting any different polarity terminals.

- Typical 12V open circuit system battery voltage level is between 12.35 and 12.77 (50% - 90% state of charge) at 25°C. Adjust for ambient temperature at a rate of - 0.033V/°C. Open circuit voltage is taken after any loading (charge or discharge) has been removed from the batteries for a minimum of 4 hours, preferably 24 hours.

10.3.2 For 24V systems

- Extreme care must be taken with systems of more than two batteries, since the batteries must be connected in both two battery series strings and two or more parallel combinations.

- To ensure equal length wiring between all paralleled 24V strings in either the 6 or 8 battery systems, each 24V string is made up of non-adjacent batteries. Carefully trace the wiring connections to ensure the wiring is correct.

- Typical 24V open circuit system battery voltage level is between 24.7 and 25.54 (50% - 90% state of charge) at 25°C. Adjust for ambient temperature at a rate of - 0.066V/°C. Open circuit voltage is taken after any loading (charge or discharge) has been removed from the batteries for a minimum of 4 hours, preferably 24 hours.

10.3.3 When all interconnecting battery wiring has been connected and the battery system is connected to the terminal blocks in the battery enclosure, measure the battery system across the terminal block to ensure it is at the system level.

10.3.4 Verify that the main cable connecting the battery system to the Junction box has the black (BAT POS) wire connected to terminal block where the positive battery system was connected and that the white (BAT NEG) wire is connected to the terminal block where the negative battery system was connected, per the terminal block polarities shown in figures 36 and 37 for the appropriate system battery wiring. This can be verified with a voltage reading; a negative reading indicates either the wires are wired in reverse.

10.4 Verify Battery Temperature Sensors Connections and Voltage Sensing Wiring

10.4.1 Verify that each of the two temperature sensors are secured to a separate negative battery post associated with the battery system negative and that each is secured to a post with as few battery interconnecting cables, to ensure a tight electrical connection between the batteries for changing and discharging. See **Figure 5-28** or **5-29** for the mounting locations for the appropriate battery system voltage.

10.4.2 Verify that the TCC temperature sensor's connection plug is connected to the cable plug on the wiring harness (plugs are mated).

10.4.3 Measure the voltage at the terminal blocks in battery enclosure to identify the positive and negative terminal blocks. Ensure the voltage sensing wires are wired into the appropriate terminal block: red wire is positive, black wire is negative.

10.4.4 Verify the voltage sensing connection to the Control Box by measuring the battery voltage across at the battery voltage connections on the TEG Charge Controller board on the inside door of the Control Box. One of the Battery Voltage Status lights in the top left corner of the board will be on.

10.5 TEG Site Setup

10.5.1 TEG Startup

10.5.1.1 Turn off the two TEG breakers in the Junction box to isolate the TEG from the system

10.5.1.2 Verify or set the TCC Voltage Ref Jumper in the RUN position.

10.5.1.3 Verify or set the TCC Bench Testing Jumper in the RUN position.

10.5.1.4 Set the TCC Local/Remote switch is set to Local mode.

10.5.1.5 Verify or move the TEG jumper clip in the SETUP position (across positions 2 & 3).

10.5.1.6 Toggle the Local Start switch – The spark ignition system should begin sparking and the fuel will start flowing.

10.5.1.7 Check the fuel connection for leaks and repair if necessary.

10.5.1.8 If combustion is not successful after three ignition attempts, wait for the DC PWR and SI PWR lights on the TCC board (located on the Control Box door) to turn off, then toggle the Start switch again.

10.5.2 Perform the TEG Power Output Evaluation (Vset)

Identify the TEG model using the table at the beginning of section 4 to determine the required sub-section to follow in section 8 for TEG set-up power and Vset. If required proceed to the required sub-section of section 9 to perform any required TEG adjustments.

10.5.3 Perform TEG LC Output Voltage Setting Verification (TEG Run)

Set points required for a TEG that will be normally operating in Remote Mode with the TEG temperature sensor installed are:

- 12V system – Set the TEG L/C output to 16V (factory set)
- 24V system – Set the TEG L/C output to 32V (factory set)

10.5.3.1 Ensure the two TEG breakers in the junction box are still OFF.

10.5.3.2 Move the TEG jumper clip to the RUN position (across positions 1 & 2).

10.5.3.3 Measure the TEG LC Output Voltage on studs T5 and T9 across the LC board located on the right side of the Control box per Figure 5. Or if the deadfront of the Junction box is not installed, measure the LC output voltage at the bottom side of the two TEG breakers.

10.5.3.4 If required, adjust the Output Voltage Adjustment Pot, located near the top of the board at the very back of the Control box (see **Figure 4-4**), to set the output voltage to the value listed above per the system voltage, using a small flat head screwdriver no longer than about 4.625 inches (11.8cm).

WARNING: Do NOT adjust the Current Limiting Adjustment pot located in front of the required pot.

10.6 Load Tests using a clamp on Ammeter set to DC current reading.

All measurements are inside the control box. The load current measurements are taken on the wiring connected out of the Load Terminal Block. The Solar, Battery and TEG current measurements are taken on the specific wiring connected to the System Bus Terminal Block. See **Figure 4-2** for location of both terminal blocks.

Measure all currents consistently around either the positive leads (black wiring) or negative leads (white wiring), do not mix the polarities when taking measurements. Take note if the reading is negative or positive. When measuring on all positive leads and measuring when the load draws current, it will be a negative current reading; When the battery is being charged it will display a negative current reading or if it is supplying current it will display a positive current reading, if all measurements are taken around the same polarity of leads.

10.6.1 Load connected to Battery only

10.6.1.1. Turn the Load breakers and Battery breakers ON. Turn the PV and TEG breakers OFF.

10.6.1.2. Measure the current draw of the load.

10.6.1.3. Measure the current draw from the battery (wiring is labelled “PWR BAT” and directly exits the control box from the system bus).

10.6.1.4. These two measurements should be nearly equivalent when only the battery is connected to the system.

10.6.2. Load connected to Solar and Battery only:

10.6.2.1 Turn the Load, Battery and PV breakers ON, including all breakers in the Combiner Box. Turn the TEG breakers OFF.

10.6.2.2 Measure the current draw of the load.

10.6.2.3 Measure the current supplied by the solar controller into the System Bus Terminal block in the Control box (wiring is labelled “PWR PV” and directly connects to the Solar Controller on the left hand side).

10.6.2.4 Measure the current to or from the battery (wiring is labelled “PWR BAT” and directly exits the control box from the system bus).

10.6.2.5 Depending on the time of year, time of day and sunlight, the solar panels may be producing a wide range of power to the system. This may result in the load drawing the difference in current from the battery to supplement the solar power being produced or there is enough solar power being produced to supply the load and add to the battery as charging current (negative reading).

10.6.3 Load connected to TEG and Battery only

10.6.3.1 TEG must be running and up to power, then turn the Load, Battery and TEG breakers ON. Turn the PV breakers OFF.

10.6.3.2 Measure the current draw of the load.

10.6.3.3 Measure the current supplied by the TEG into the System Bus Terminal block in the Control box (wiring is labelled “PWR TEG” and directly exits the control box from the system bus, it is the smallest wires connected to the system bus).

10.6.3.4 Measure the current to or from the battery (wiring is labelled “PWR BAT” and directly exits the control box from the system bus).

10.6.3.5 The combination of TEG current and battery current should be nearly equivalent to the load current. If there is more current out of the TEG than the load requires, the battery current will show it is being charged (negative reading).

10.7 Final Configuration before Leaving the Site in automatic Remote Operation

WARNING: Leaving the site without setting the system into automatic Remote operation could damage the batteries.

10.7.1 TCC Voltage Ref Jumper is in the RUN position.

10.7.2 TCC Bench Testing Jumper is in the RUN position.

10.7.3 TCC Local/Remote switch is set to Remote mode.

10.7.4 TEG jumper clip is in the RUN position (across positions 1 & 2).

10.7.5 All breakers in ON position:

- LOAD breakers on in the Control Box
- BAT, PV, TEG breakers on in the Junction Box
- All breakers on in the Combiner Box

11 MAINTENANCE

TEG Generator Maintenance

This section describes how to maintain the TEG. Before attempting to maintain the TEG the qualified service person should be thoroughly familiar with its:
• technical specifications
• component descriptions
• installation
• startup and shutdown
• TEG power output evaluation, and
• TEG power output adjustment.

Note: Good record keeping is necessary for long term follow-up. Use the TEG Performance Log, located at the end of this manual in Section 18, for recording details each time adjustments are made or servicing is carried out.

11.1 Recommended Periodic Maintenance

The TEG is a solid-state high-reliability device that requires very little maintenance. However, it does require periodic service checks in order to provide the years of trouble free service of which it is capable. The maintenance interval depends on the site conditions (fuel purity, environment, etc.) and must be established based on site records. Field experience indicates that a properly installed TEG usually requires maintenance only once a year.

At least once a year evaluate Vset as per the procedure below. This should be the first procedure during any service visit and will determine what further service may be needed.

11.2 Tools and Parts Recommended for Routine Servicing

The following tools and parts should be available for routine servicing:

1	Multi-meter, including DC voltmeter accurate to ± 0.1 V (and Ohmmeter)
1	Flat-head screwdriver
1	Phillips screwdriver
1	Wrench, 9/16 in.
1	Wrench, 1/2 in.
1	Adjustable wrench, that will open to 16 mm (5/8 in.)
1	Fuel filter kit
1	Fuel orifice:
1	Magnifying glass

Refer to **Section 17** for part numbers.

11.3 Evaluate V_{set}

This procedure describes how to evaluate V_{set} and determine what further servicing could be needed. Follow these steps to evaluate V_{set}:

WARNING: Turn off the two TEG breakers in the breaker box to isolate the TEG power from the remaining system, solar and battery power.

WARNING: Be careful when working inside the control box, since all circuits are live and present a serious electrical hazard.

11.3.1 Determine the rated V_{set} for the current ambient temperature (see TEG Power Output Evaluation Section 8)

11.3.2 Move the TEG jumper clip on the terminal block to the setup position, between terminals 2 and 3 (see **Figure 4-2**).

11.3.3 Connect a voltmeter between terminals 2(+) and 4(-).

11.3.4 Allow the TEG to stabilized (approximately 10 minutes),

11.3.5 Record the measured V_{set} voltage on the performance log

11.3.6 Compare measured voltage with required Vset for present ambient temperature and act as follows:

11.3.6.1 **If measured voltage is more than 0.2 V above required V_{set}:**
The fuel pressure must be reduced. Proceed with Routine Service, Section 11.4. Remember to adjust the fuel pressure during restart or before leaving the site. See TEG Power Output Adjustment Section 9.

Caution: Do not continue operating the TEG with measured V_{set} exceeding that required for present ambient temperature, otherwise overheating may cause irreparable damage to the power unit.

11.3.6.2 **If measured voltage is within 0.2 V of required V_{set}:**
The TEG is functioning well and requires only a routine service. Proceed with Routine Service, Section 11.4

11.3.6.3 **If measured voltage is more than 0.2 V below required V_{set}:**
The cause must be determined. Refer to the last entry in the TEG Performance Log. From the log, check if the TEG was left operating at the correct V_{set} during the last service visit. Remember that V_{set} changes with ambient conditions. If the TEG was not left operating at the correct V_{set} during the last visit, determine the reason for this. If the TEG was left operating at the correct V_{set} during the last visit and is now not, consider the following possible causes:

1) *Change in Fuel Pressure*

Refer back to the last entry in the log and determine if the fuel pressure has changed. If the fuel pressure has changed, re-adjust the fuel pressure to the last entry. If this returns the measured voltage to within 0.2 V of required V_{set} proceed with Routine Service, Section 11.4

Note: *A dirty fuel filter may cause a drop in fuel pressure. A plugged fuel orifice will change fuel flow without a change in fuel pressure.*

2) Change in Air Flow
Check for obstructions at the cooling fins and the air filter stabilizer. Adjust the air shutter, see TEG Output Power Adjustment section 9. If this returns the measured voltage to within 0.2 V of required V_{set} proceed with Routine Service, Section 11.4.

3) Change in Fuel Quality
In order to maintain a constant output power it is essential that the TEG be supplied with a constant heating value fuel. Proceed with Routine Service, Section 11.4. See the Fuel Specification sheet in Section 14.1 for more information.

If the above causes have been ruled out the TEG may require more than just routine servicing. Keep the TEG operating for now and see the Troubleshooting, Section 13, for guidance.

11.4 Routine Service

Basic annual servicing is all that is required unless other maintenance is indicated by the V_{set} evaluation.

Follow these steps to perform a routine annual service:

11.4.1 Stop the TEG and pause to let cool. See Startup and Shutdown Section 7.2, 7.3.

11.4.2 Drain the pressure regulator sediment bowl. See Draining the Sediment Bowl Section 11.6.1.

.

11.4.3 Replace the fuel filter in the pressure regulator. See Fuel Filter Replacement Section 11.6.2.

11.4.4 Check the fuel orifice for clogging and replace if necessary. See Fuel Orifice Replacement Section 11.6.3.

11.4.5 Remove any debris, sand or dust from the cooling fins, air filter stabilizer and cabinet interior. See Air Filter Cleaning Section 11.8.1.

11.4.6 Check all bolts and wire connections for tightness and/or corrosion.

11.4.7 Re-start the TEG. See Startup and Shutdown, Section 7.2 and 7.3.

11.4.8 Check V_{set}, record and adjust if necessary. See Power Output Evaluation Section 9. and Power Output Adjustment Section 10, as applicable. Record the final setup in the TEG Performance Log before leaving site.

WARNING: Ensure TEG jumper clip is moved back to Run position, between terminal 1 and 2, TCC switch is in the Remote position and all breakers in the control box, breaker box and solar combiner box are on before leaving the site.

11.5 Fuel System

Components making up the fuel system control the input of fuel to the burner. The primary control is a pressure regulator that modulates fuel manifold pressure to a metering orifice. The pressure regulator includes a sediment bowl with a manual drain cock and fuel filter to remove fuel impurities. The fuel filter has a resin impregnated cellulose element which prevents solid particles from damaging the regulator and downstream parts.

The outlet of the pressure regulator leads to a manifold on which is mounted a pressure gauge to monitor the fuel pressure, and two pressure switches for the TCC board. The fuel flows through the manifold to the fuel line which connects to a orifice mounted on the front of the burner. The orifice contains a jewel with a precisely sized hole to meter the fuel flow into the burner. A solenoid valve (SV) is located beneath the cabinet and plumbed between the manifold and fuel line.

The solenoid valve is controlled by the Spark Ignition System. The Spark Ignitor opens the solenoid valve when the TCC board requires the TEG to start (only when fuel pressure is present), and closes the solenoid valve when the TCC board requires the TEG to stop, when there is no fuel pressure or the Spark Ignitor does not detect combustion. The main parts of fuel system are shown in **Figures 11-1, 11-2 and 11-3**.

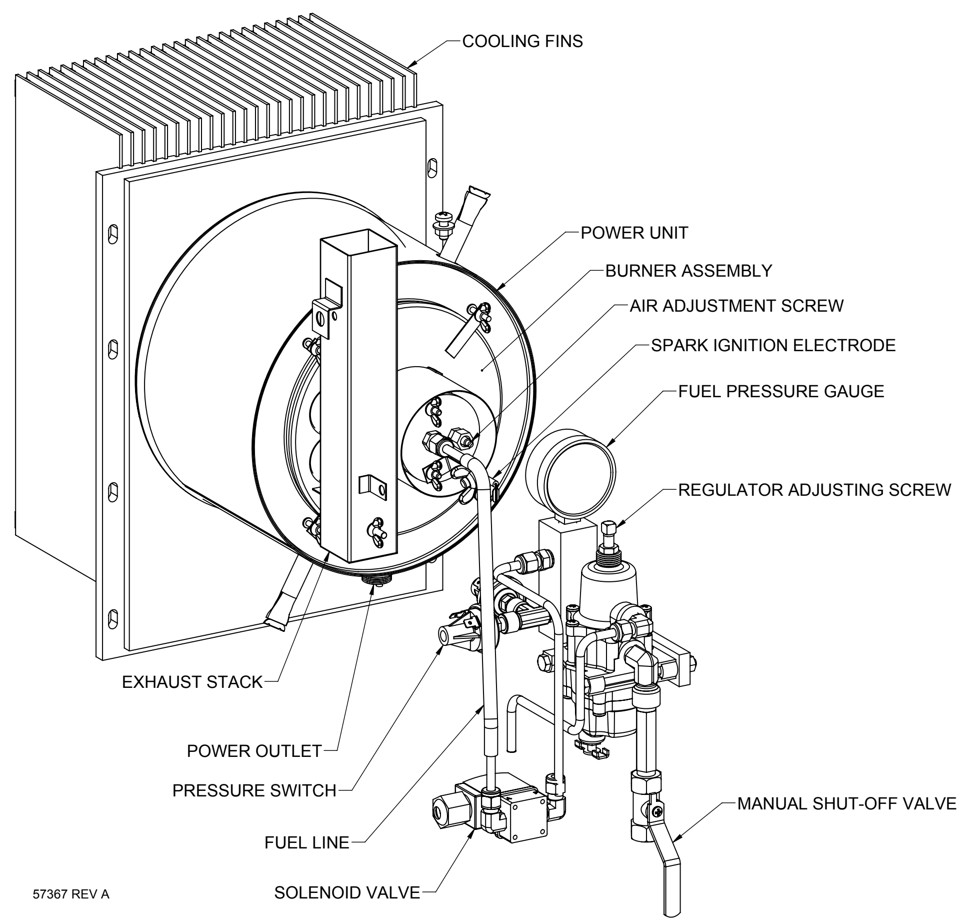


Figure 11-1 Fuel System - Model 5060 TEG

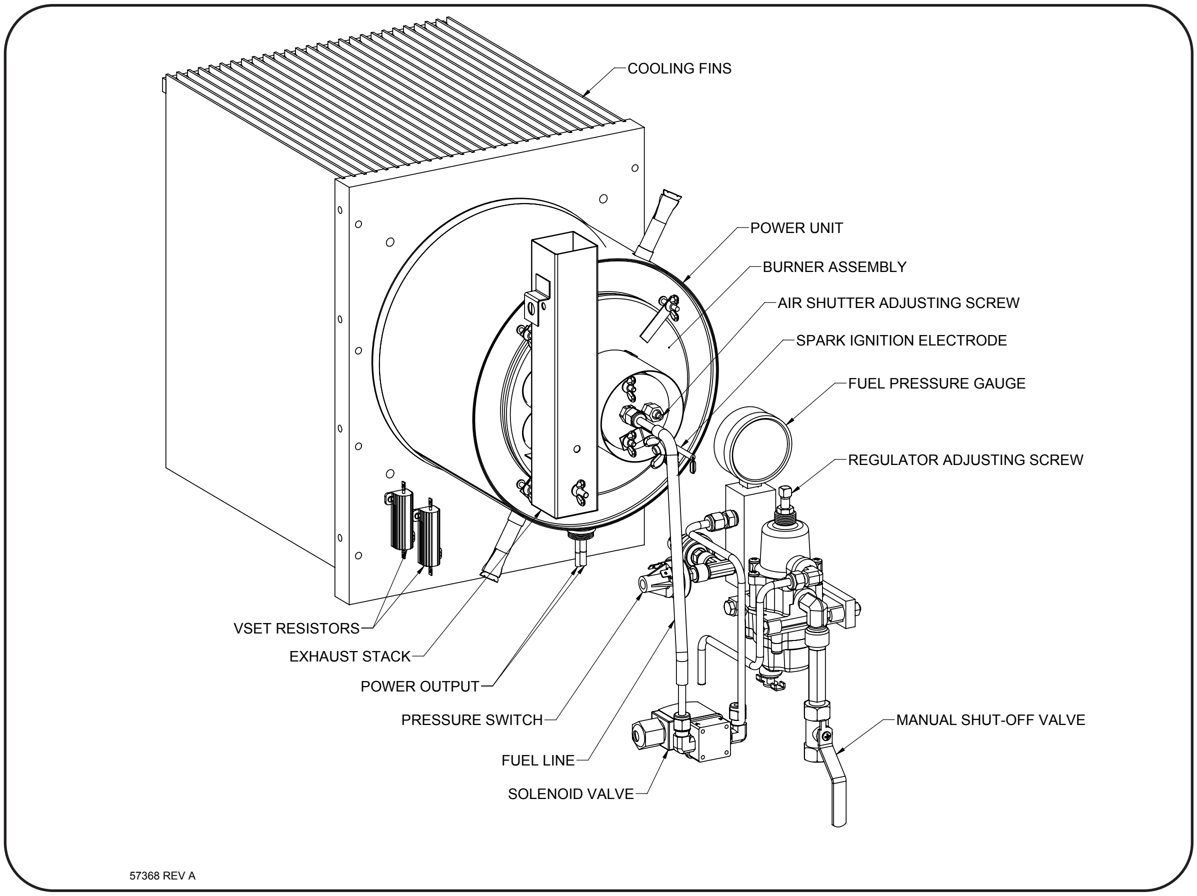


Figure 11-2 Fuel System - Model 5120 TEG

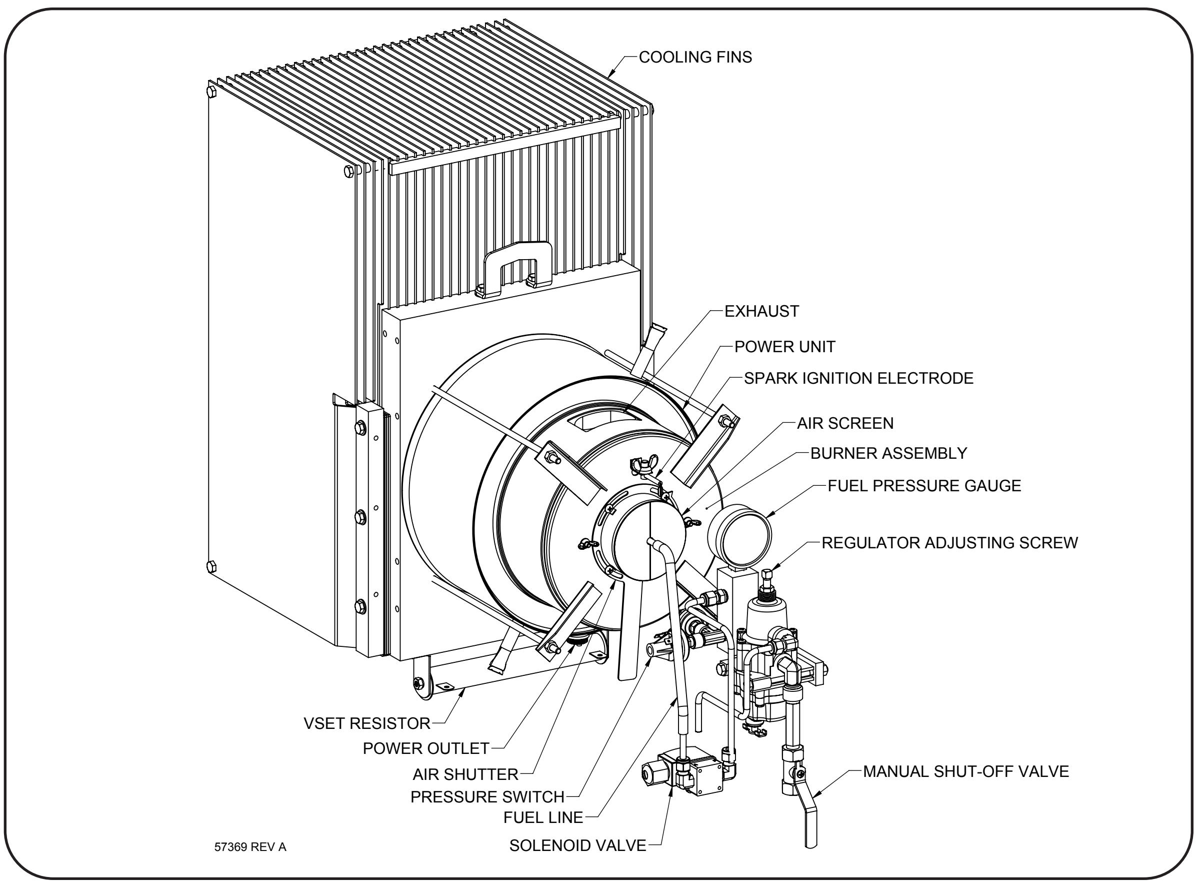


Figure 11-3 Fuel System - Model 5220 TEG

11.6 Fuel System Maintenance

This section gives procedures for servicing the fuel system.

11.6.1 Draining the Sediment Bowl

Follow these steps to drain the regulator sediment bowl:

11.6.1.1 Shut off the fuel supply to the TEG and allow to cool.
11.6.1.2 Open the drain cock located on the under side of the TEG cabinet, any impurities will drain through the cock.
11.6.1.3 Close drain cock.
11.6.1.4 Leak check the drain cock.

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

11.6.2 Fuel Filter Replacement

Follow these steps to remove the fuel filter:

11.6.2.1 Shut off the fuel supply to the TEG and allow to cool.
11.6.2..2 Remove the wires from the pressure switches.
11.6.2.3 Drain the sediment bowl by opening the drain cock.
11.6.2.4 Disconnect the flexible fuel line from the SV valve.
11.6.2.5 Disconnect the vent hose from the cabinet base.
11.6.2.6 Remove the two bolts which hold the regulator to the cabinet.
11.6.2.7 Mark the regulator body and sediment bowl, for proper orientation during re-assembly.
11.6.2.8 Turn the regulator upside down and remove the four screws from the bottom.
11.6.2.8 Remove the filter, and Viton gasket. See **Figure 11-4**.

Follow these steps to install the fuel filter:

11.6.2.9 Install the filter, and Viton gasket onto the sediment bowl. See **Figure 11-4**.
11.6.2.10 Carefully replace the bottom of the regulator making sure the filter and gasket are in their proper position.
11.6.2.11 Align the sediment bowl with the regulator body and replace the four screws and tighten.

Note: While the regulator is removed it is a convenient time to check the orifice and clean the air-filter. See Fuel Orifice Inspection, Section 11.6.3, and Air Filter Cleaning, Section 11.8.1.

11.6.2.12 Installation of the pressure regulator into the TEG is the reverse of removal. With the fuel pressure on, leak check all regulator joints and fuel connections.

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

11.6.3 Fuel Orifice Inspection

Follow these steps to inspect the fuel orifice:

11.6.3.1 Shut off the fuel supply to the TEG and allow to cool.
11.6.3.2 5220: Remove the air screen by undoing the 4 mounting screws.
11.6.3.3 Disconnect the flexible fuel line from the solenoid.
11.6.3.4 Disconnect the other end of the flexible fuel line and attached orifice from the (5060, 5120) front of the burner, (5220) center of the air shutter.
11.6.3.5 Remove the orifice fitting from the flexible fuel line.
11.3.3.6 Visually check the orifice hole. It should be free from any obstructions. Replace it if necessary. It is recommended a magnifying glass is used to aid with visual inspection.
11.6.3.7 Connect the orifice fitting to the flexible fuel line then thread the orifice back through the (5060, 5120) front of the burner, (5220) center of the air shutter. This only needs to be finger tight.

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

11.6.3.8 Connect the free end of the flexible fuel line to the solenoid.

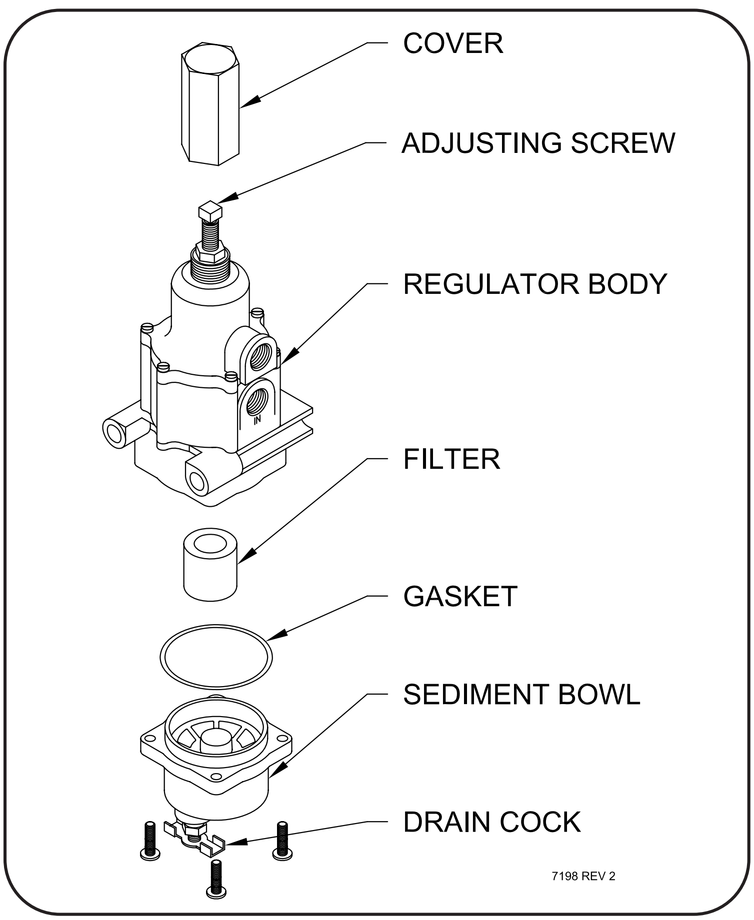


Figure 11-4 Fuel Filter Assembly

11.6.3.9 Leak check all connections using a commercial leak detector.

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

5060		5120		5220	
Natural Gas	Propane	Natural Gas	Propane	Natural Gas	Propane
Orifice # 6	Orifice # 4	Orifice # 9	Orifice # 7	Orifice # 8	Orifice # 10
PN: 4200-00688	PN: 4200-00686	PN: 4200-00690	PN: 4200-00689	PN: 4200-00690	PN: 4200-06251

11.7 Burner

The burner receives gas from the fuel system, mixes it with air and transports the mixture to the combustion zone. Air passes through an air filter stabilizer in 5060/5120 TEG and an air-shutter assembly in a 5220 TEG, allowing for adjustment of the air/fuel mixture. A downstream venturi provides the necessary suction to draw in the air. This mixture leaves the venturi and passes through a burner screen that anchors the flame. The design of the combustion chamber produces uniform heating of the power unit hot-end.

The main parts of the burner are shown in **Figures 11-5** (5060 TEG)**, 11-6** (5120 TEG) and **11-7** (5220 TEG).

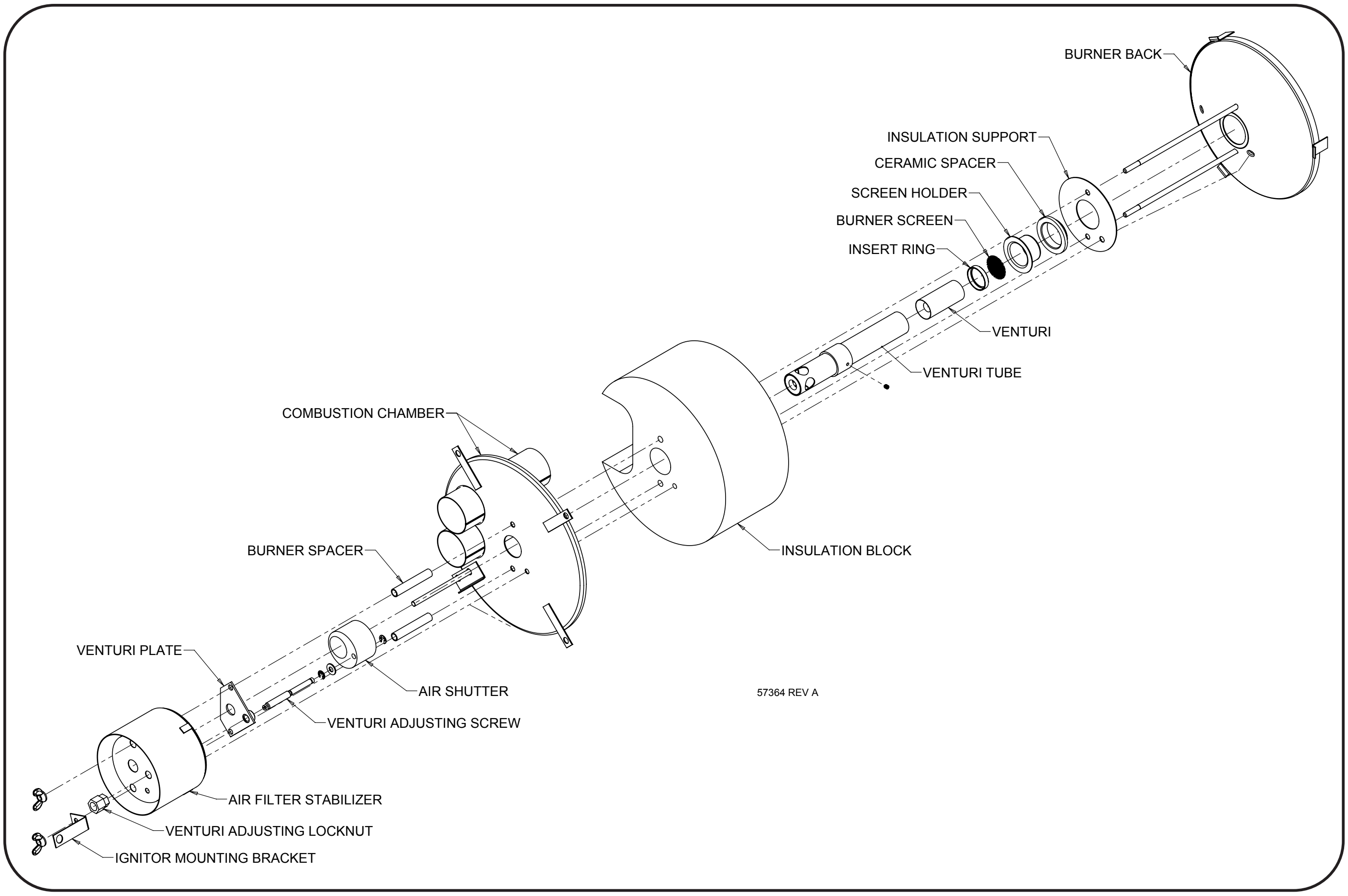


Figure 11-5 Burner Assembly - Model 5060 TEG

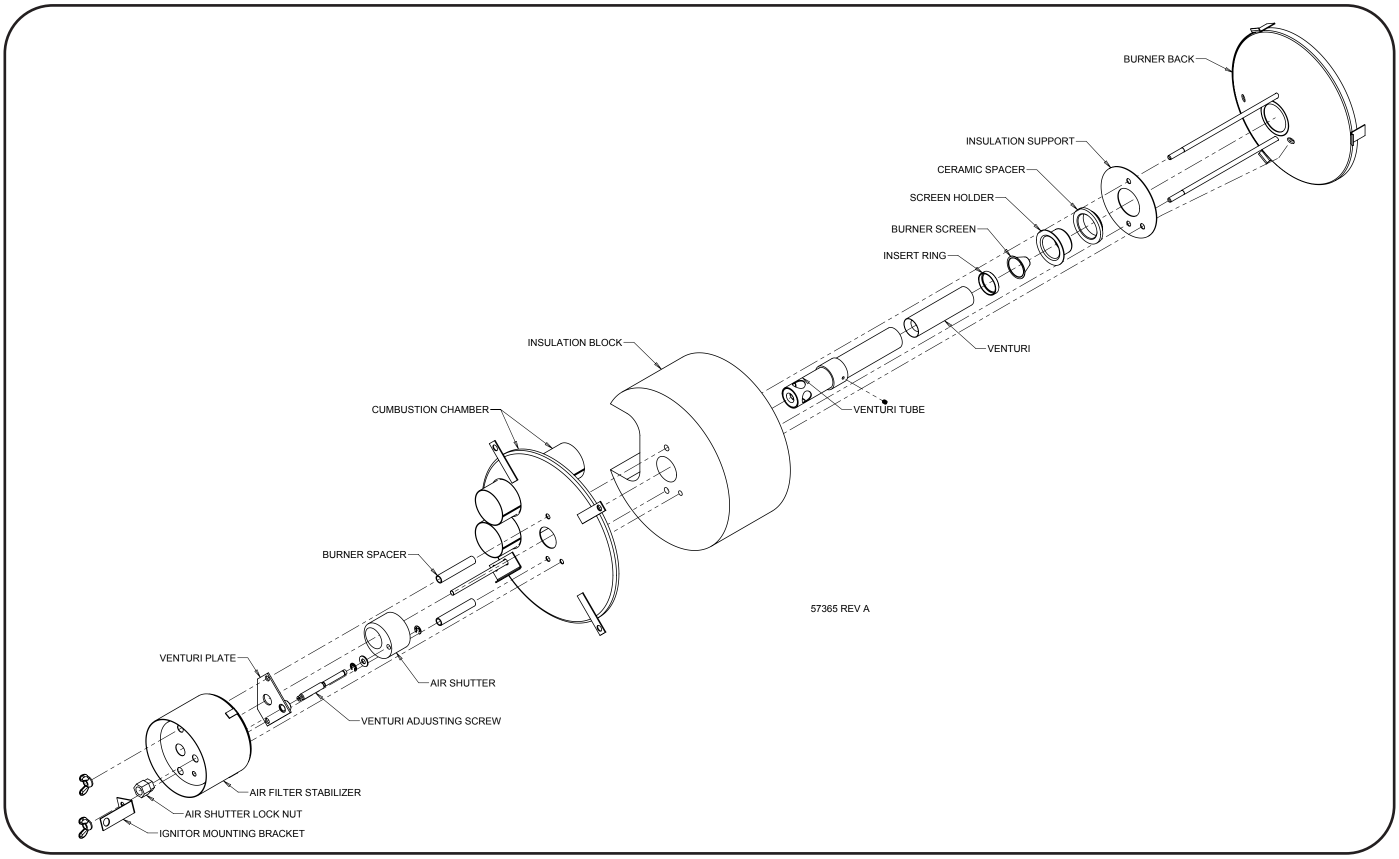


Figure 11-6 Burner Assembly - Model 5120 TEG

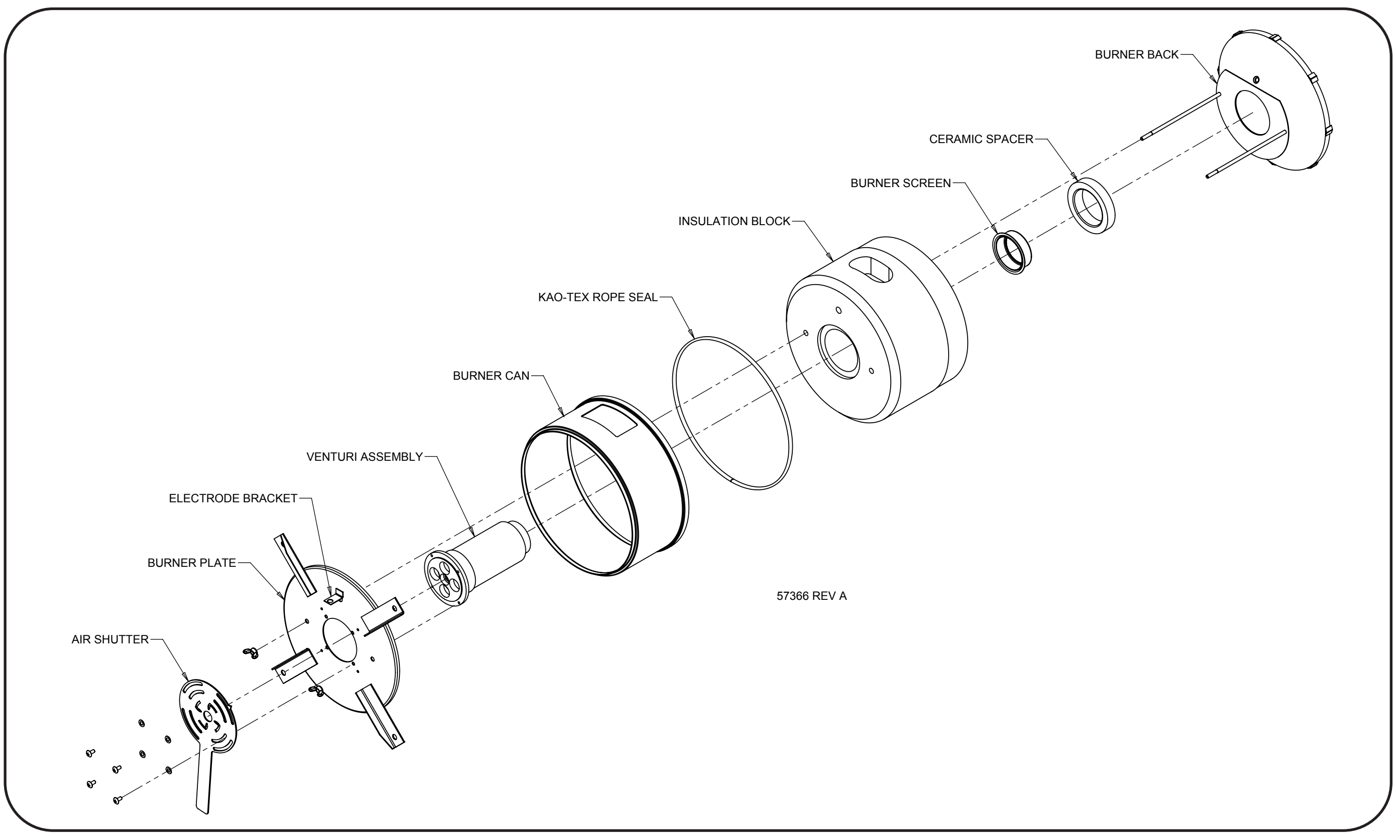


Figure 11-7 Burner Assembly - Model 5220 TEG

11.8 Burner Maintenance

This test gives procedures for servicing the burner.

11.8.1 Air Supply

For TEG Models 5060 and 5120:

The screen at the front of the burner may become clogged with dust and insects thereby preventing the proper flow of air to the burner. To clean it, proceed as follows:

11.8.1.1 Shut-off the fuel supply to the TEG.
11.8.1.2 Disconnect the flexible fuel line from the front of the burner.
11.8.1.3 Remove the orifice fitting, the adjusting screw lock nut and the two wing-nuts.
11.8.1.4 Remove the screen.
11.8.1.5 Clean the screen by forcing air through it or washing in water.
11.8.1.6 Replace screen and fittings.
11.8.1.7 Turn the venturi adjusting screw counter-clockwise as far as it will go then turn it clockwise four turns. This will set the adjustment in the correct range to begin balancing the air-fuel mixture when re-starting.
11.8.1.8 Before re-starting the TEG, leak check all fuel connections.

For TEG Model 5220:

The air-filter stabilizer screen at the front of the burner may become clogged with dust and insects thereby preventing the proper flow of air into the burner. Follow these steps to clean the air filter:

11.8.1.8 Shut-off the fuel supply to the TEG and allow to cool.
11.8.1.9 Remove the air screen by undoing the 4 mounting screws
11.8.1.10 Clean the air-filter screen by forcing air through it or washing in water.
11.8.1.11 Replace screen and mounting screws.

Note: If the air shutter setting was disturbed. Set the air shutter to the correct range to begin balancing the air-fuel mixture when re-starting, as per Air Shutter Adjustment, Section 9.3

11.8.2 Inspection of Burner Components

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

For TEG Models 5060 and 5120:

Follow these steps to remove the burner:

11.8.2.1 Shut-off the fuel supply to the TEG and allow to cool.

WARNING: If the TEG has not cooled sufficiently it can be very hot.

11.8.2.2 Disconnect the high voltage wire from the spark electrode.
11.8.2.3 Loosen the wing-nut and slide the spark electrode out.
11.8.2.4 Remove the wing-nut near the bottom of the exhaust stack then slide the exhaust stack out.
11.8.2.5 Disconnect the flexible fuel line from the front of the air screen.
11.8.2.6 Remove the orifice fitting.
11.8.2.7 If necessary, disconnect and remove the fuel system (See Section 11.5).
11.8.2.8 Remove the four wing-nuts holding the burner in place and slide the burner out.

Follow these steps to inspect the burner:

11.8.2.9 Check the venturi assembly. If it looks severely corroded it should be replaced. Make sure the venturi is properly located in the venturi tube (5060: 2.75” from end, **Figure 11-8**) (5120: 1.50” from end, **Figure 11-9**), and that the venturi is facing the proper direction.
11.8.2.10 Check the air filter screen for any tears or holes. If any are found it should be replaced.
11.8.2.11 Check the burner screen.
11.8.2.12 Check the ceramic spacer.

For TEG Model 5220:

Follow these steps to remove the burner:

11.8.2.13 Shut-off the fuel supply to the TEG and allow to cool.

WARNING: If the TEG has not cooled sufficiently it can be very hot.

11.8.2.14 Disconnect the ignition wire from the spark electrode.
11.8.2.15 Slide the spark electrode out. See **Figure 4-11** on page 4.12. and **Figure 11-3** on page 11.5.
11.8.2.16 Remove the air screen.
11.8.2.17 Disconnect the flexible fuel line from the safety SV valve.
11.8.2.18 Disconnect the other end of the flexible fuel line and attached orifice from the center of the air shutter.

Note: It may be convenient to disconnect and remove the fuel system.

11.8.2.19 Remove the four hex-nuts holding the burner in place and slide the burner out. See **Figure 11-7** on page 11.9

Follow these steps to inspect the burner:

11.8.2.20 Check the air filter screen for any tears or holes. If any are found it should be replaced.
11.8.2.21 Check the burner screen.
11.8.2.22. Check the ceramic spacer.

Follow these steps to install the burner:

11.8.2.23 Reassembly is the reverse of disassembly.

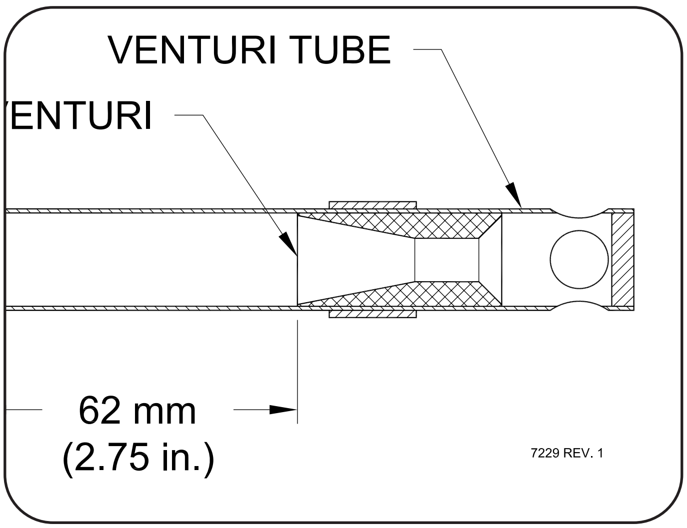


Figure 11-8 Venturi Tube - Model 5060

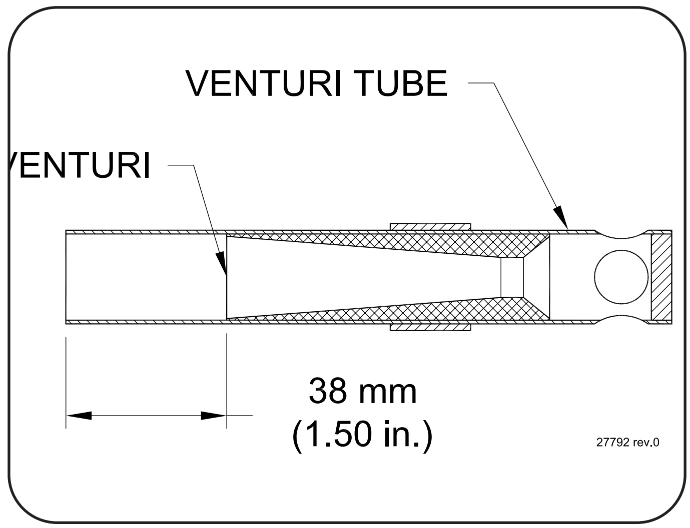


Figure 11-9 Venturi Tube - Model 5120

Note: The orifice fitting only needs to be finger tight when threaded back through the front of the air screen.

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

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

11.9 Pressure Switches

When the manual ball valve is opened, fuel pressure causes the pressure switches (located in fuel system) to close. This allows the battery voltage connection on the TCC board to power the remainder of the board through one pressure switch, allowing the TCC board to operate. The second pressure switch is a straight through connection on the TCC board allowing a SCADA connection.
Follow these steps to check the pressure switch:

11.9.1 Remove the two wires from the pressure switch and connect a multi-meter across the pressure switch terminals, set to measure resistance (ohms). See **Figure 11-1, 11-2, 11-3** for location and **Figure 5-22**, on page 5.27, for wiring.

11.9.2 Remove fuel pressure from the pressure switch by closing the manual gas valve, placing the TCC Local/Remote switch in the Local position and toggling the Local start switch to purge most of the gas trapped between the manual gas valve and the solenoid. The local start switch may need to be toggled a second time to remove all the trapped fuel. The TCC board will not be powered when all fuel has been removed from between the manual gas valve and the solenoid (all three TCC battery voltage lights will be off)

11.9.3 With no fuel pressure in the fuel manifold, check the resistance measured across the switch is near infinity, which indicates the switch is open. Replace the pressure switch if necessary.

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

11.9.4 Provide fuel pressure to the switch by opening the manual shutoff valve.

11.9.5 Check the resistance measured across the switch is near zero, which indicates the switch being closed. Replace the pressure switch if necessary.

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

11.10 Spark Ignition (SI) System

The spark ignition system consists of the following parts:

- Spark electrode
- Spark ignitor module
- Solenoid valve
- Pressure switches

When the TCC requires the TEG to start because of voltage sensing or a start signal, it powers the spark ignitor module. When the spark ignitor module is powered, it begins ignition sequences which generate sparks from the electrode to the combustion chamber, as well as opening the solenoid valve allowing gas to flow into the burner chamber, causing ignition to occur. Once combustion is detected, the SI will stop sparking and the SI will continue to monitor the presence of flame at the electrode. If the SI did not detect combustion for a period of 7 seconds, it will stop sparking and turn off the valve signal causing the solenoid to close, and wait for a 10 second purge period and then make another attempt at ignition. The SI will attempt 3 ignition trials and if flame detection cannot be maintained, the spark ignitor will lockout. The TCC board provides power to the spark ignitor. See the TCC Operating Chart for more details about the TCC and spark ignitor control.

The solenoid is system voltage dependent and draws power from the battery voltage connection on the TCC board.

11.10.1 Spark Ignition System Maintenance

The SI system may require occasional maintenance. If the Igniting Control system fails to ignite it must be checked and serviced as necessary. Use the procedures below to maintain the SI system.

WARNING: Remove the fuse in the TCC board, to remove power from the TCC and indirectly from the spark ignition system to prevent any signals or switches from accidentally starting the system and cause a possible high voltage shock.

11.10.2 Check the Spark Electrode

Follow these steps to check the spark electrode:

11.10.2.1 Remove the Spark Electrode by loosening the wing-nut and sliding the electrode out.
11.10.2.2 Inspect the electrode for any cracks in the ceramic rod. If any cracks are found the electrode must be replaced.
11.10.2.3 Slide the electrode back into position through the burner back until it stops, then pull it back 3 mm (1/8 in.). The ceramic rod should extend about 25 mm (1.5 in.) from the holding screw.
11.10.2.4 Tighten the wing-nut only until it is snug. DO NOT over tighten or the ceramic rod will crack.
11.10.2.5 Switch the TCC Local/Remote switch to the Local position.
11.10.2.6 Re-install the fuse into the TCC board.
11.10.2.7 Toggle the Local start switch. Arcing should occur in the combustion chamber (making a clicking noise) at the rate of ten per second. Fuel combustion should occur, if the fuel is connected and available.
11.10.2.8 If arcing occurs the SI system is functioning well.

11.10.3 Check power supply to the Spark Ignitor

Follow these steps to check the power supply voltage to the spark ignitor

11.10.3.9 Locate the wiring connector plugged into the spark ignitor module (see **Figure 4-2** on page 4.3) and disconnect the connector.
11.10.3.10 Use a voltmeter to probe and measure the voltage between the red and black wires of the spark ignitor connector.
11.10.3.11 Switch the TCC Local/Remote switch to the Local position.
11.10.3.12 Toggle the Local start switch.
11.10.3.13 The voltage should be greater that 13V and the TCC SI PWR light should be on.

11.10.4 Check Operation of the Spark Ignitor

Follow these steps to verify operation of the ignition controller correct.

11.10.4.14 Verify electrode gap (1/8”), (See section above “Check the Spark Electrode”).
11.10.4.15 Start the TEG
11.10.4.16 If arcing occurs, the ignition control module is functioning.
11.10.4.17 If no arcing occurs, see section above “Check Power Supply Voltage to Spark Ignitor”). If it is as specified, replace ignition module.

11.11 Solenoid Valve

The solenoid is system voltage dependent and draws power from the battery voltage connection on the TCC board.

12V solenoid is used in a 12V system
24V solenoid is used in a 24V system

Follow these steps to check the Solenoid Valve Operation:

11.11.1 If, at the beginning of sparking, the solenoid is not heard to click open, unplug the solenoid valve connector from the solenoid and make a note of which stake is connected to ground. Measure resistance between the two stakes connecting the blue wire and brown wire. The12V solenoid should measure approximately 65 Ω. The 24V solenoid should measure appoximately 260 Ω. If the resistance is greater than +/- 20%, replace the solenoid valve.

Note: *If measuring across the ground stake and one of the coil stakes, the resistance should measure an open connection.*

11.11.2 Start the TEG. While SI is sparking, measure voltage of the solenoid connection on the TCC board. If the voltage is not approximately the same as the system battery voltage, check power supply to ignition controller as per topic above.

11.11.3 Check for broken wires in the solenoid cable. If it is ok, replace the ignition module.

11.12 Power Unit

The power unit contains the thermoelectric materials which produce the electrical power. Because these materials corrode in atmospheric conditions at high temperatures they are contained in a sealed unit.

The power unit normally requires no maintenance. If after maintaining and adjusting all other systems and TEG will not produce required power consider examining the power unit. Use the procedures below for the TEG's to help determine if the power unit could be damaged. The 5060 TEG runs in open circuit when the jumper clip is in the SETUP position. There is no momentary open circuit value to calculate the internal resistance.

Note: The power unit cannot be repaired after leaving the factory.

For further information or assistance, please contact the customer service department at Global Power Technologies.

<u>Check Internal Resistance (5120 & 5220 only)</u>

Note: *replace jumper clip when this check is concluded.*

Follow these steps to check the power unit's internal resistance:

11.12.1 Start the TEG following the start up procedure for maintenance check

11.12.2 Move the jumper clip to the SETUP position, between terminals 2 and 3 of the terminal block (see **Figure 4-2** and **Figure 4-4**).

11.12.3 Connect a voltmeter between terminals 2 (+) and 4 (-).

11.12.4 Wait for the TEG to reach operating temperature and a stable voltage measurement between terminal 2 and 4, 15 minutes may be sufficient if the TEG was already warm. Allow 1 hour if the TEG was just started from cold.

11.12.5 Measure V_{set} with the voltmeter connected between terminals 2 and 4 and record.

11.12.6 While observing the voltmeter display remove the jumper clip, creating an open circuit condition, and note the momentary voltage. On a digital multi-meter this will be the first number displayed after removing the clip, within a 2 second timeframe of removing the clip.

Record the number as the momentary open circuit voltage (Voc). If this was not recorded quickly enough replace the jumper clip and repeat steps 11.12.4 to 11.12.6 above.

Note: *When the jumper clip is suddenly removed the measured voltage leaps up to a value, known as the momentary open circuit voltage (Voc). Measured voltage continues to climb.*

WARNING: Do not allow Voc to exceed two seconds otherwise the TEG can be damaged.

11.12.7 Calculate the internal resistance using the equations below.

$$I_L = V_{set} / R_L$$
$$Ri = (Voc - V_{set}) / I_L$$

Where: Ri = internal resistance (A)
Voc = momentary open circuit voltage (V)
Vset = setup voltage (V)
I_L = load current (A)
R_L = precision load resistance (Ω) 0.375Ω for 5120 (5220 - 1.0 Ω)

11.12.8 Check the internal resistance, Ri, is less than 0.38 Ω for 5120 (1.1 Ω for 5220). If not the power unit may be damaged.

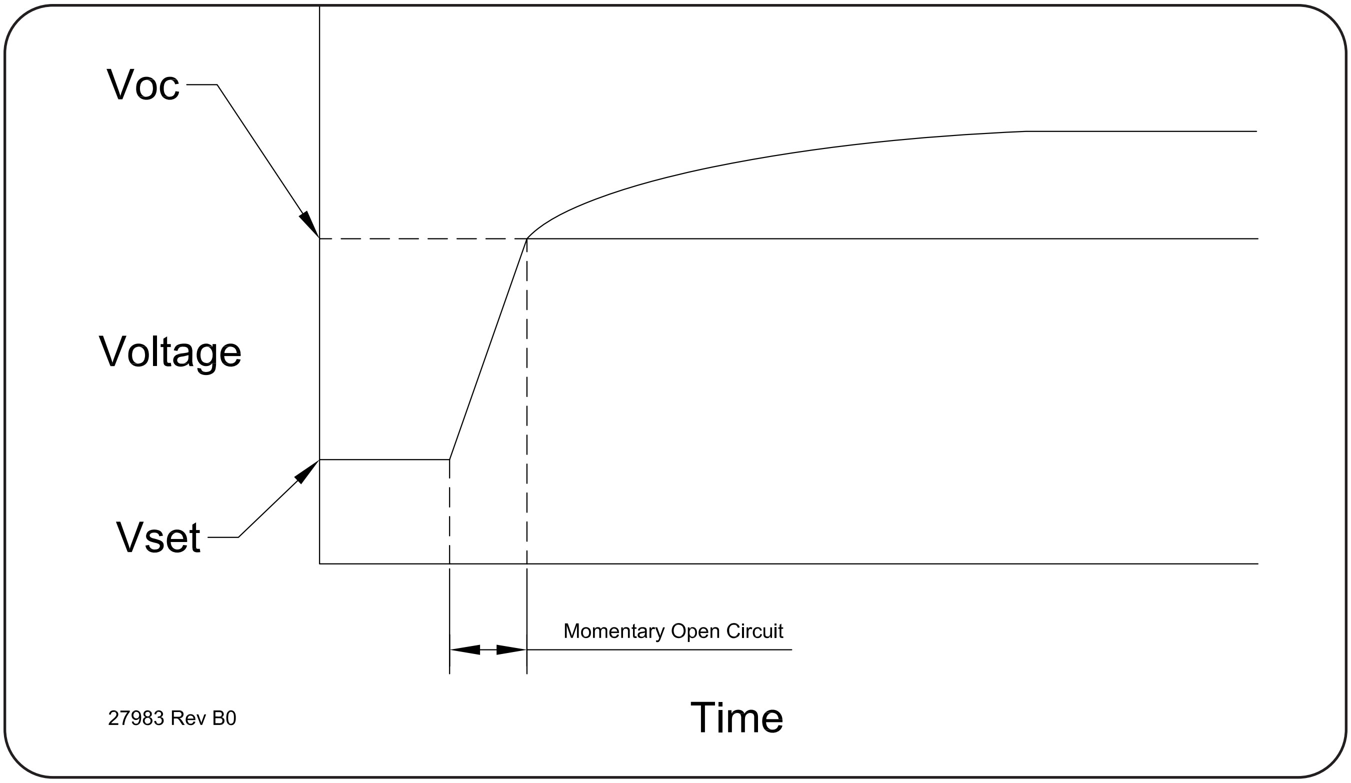


Figure 11-10 Momentary Open Circuit Diagram

5220 Example: If the Vset voltage and momentary open circuit voltages were measured as 5.88 V and 28 V respectively and the precision load resistance was 1.0 A then:

IL = Vset / RL
= 14.9 / 1.0
= 14.9 A

RINT = (Voc - V_{set}) / IL
= (28 - 14.9) / 14.9
= 13.1 / 14.9
= 0.88 Ω

Internal resistance is acceptable, < 1.1 Ω .

For further information or assistance, please contact Global Power Technologies' Customer Service Department.

11.13 Control Box Components

11.13.1 L/C Examination

The L/C normally requires no maintenance. If the TEG is producing required V_{set} but it is not supplying expected power to the load and battery then the operation of the L/C should be checked and serviced as necessary. Use the procedures below to help determine if the L/C could be damaged.

11.13.2 Check L/C Selector Switch Settings

Check the selector switches are set correctly for the required output voltage, as per section 7.4. See **Figure 4-4** (page 4.5) to locate switches.

Note: *Switch 1 should be ON for 12 V or OFF for 24 V nominal output. Switch 2 should be ON for 5060 or 5120 and OFF for 5220*

11.13.3 Check Input Voltage to the L/C

Follow these steps to check the input voltage to the L/C:

11.13.1.1 Disconnect the TEG from the system by turning off the two TEG breakers in the breaker box

11.13.1.2 Place the jumper clip between terminals 1 and 2 of TB-1, i.e. in the RUN position.

11.13.1.3 Connect a voltmeter between terminals 2(+) and 4(-) on the terminal block and measure the input voltage.

11.13.1.4 Wait for the TEG to reach operating temperature and a stable voltage measurement between terminal 2 and 4, 15 minutes maybe sufficient if the TEG was already warm. Allow 1 hour if the TEG was just started from cold.

11.13.1.5 Unloaded input voltage, between terminals 2 and 4 of terminal block, should be about 10 V - 11 V (5060, 5120) or 16V (5220). If it is not around the stated voltage, suspect an electrical short, damaged limiter or power unit.

11.13.4 Check Output Voltage from the L/C

Follow these steps to check the output voltage from the L/C:

11.13.4.1 Disconnect the TEG from the system by turning off the two TEG breakers in the breaker box

11.13.4.2 Place the jumper clip between terminals 1 and 2 of TB-1, i.e. in the RUN position.

11.13.4.3 Attach a voltmeter between the two output studs (T5 & T9)located on the L/C board (See **Figure 4-4** on page 4.5).

11.13.4.4 Alter the output voltage by turning the output voltage adjustment pot. If the unloaded output voltage, measured across the two output studs, does not change when the adjustment pot is altered the L/C needs replacing.

Note: *If the TEG produces required V_{set}, the L/C is operating properly and it still will not provide expected lower to the load then the power unit should be checked.*

11.13.5 TCC Board Examination

The TCC board does not require routine maintenance. When operating correctly and all board jumpers are in the correct positions, one of the battery voltage indicator lights will be on when fuel is available and the board is connected to the battery bank.

11.13.6 Verify Basic Operation of the TCC Control Board

Follow these steps to check the operation of the TCC when fuel is available and the TEG is not running.

11.13.6.1 Switch the Local/Remote switch to the Local position

11.13.6.2 Toggle the Local Start switch

11.13.6.3 The SI PWR, DC PWR and SI NC lights should turn on

11.13.6.4 After three seconds, the SI NC light should turn off and the spark ignitor should start sparking, as well as the solenoid should open, to start an ignition sequence.

11.13.6.5 If the spark ignitor does not sense flame, the SI NC light will be turned on while the spark ignitor is performing an inter-purge.

11.13.6.6 If there is no ignition or no lights as described in step C, verify that there is input voltage on the battery connections. Verify the fuse is not damaged and needs replacing. See “Checking the pressure switches” section above to verify the pressure switches are closed when fuel is present.

11.13.6.7 If there is power to the board, one of the battery voltage LED’s are on, but the DC PWR or SI PWR lights do not turn on, the TCC board may need to be replaced

11.13.7 Solar Controller

The solar controller does not require routing maintenance.

During the site maintenance visit, check the controller for standard operation. Verify no errors or faults require attention.

Confirm the battery charging is correct for the GEL battery being used; voltage should be adjusted for temperature compensation when the temperature sensor is connected.

Observe the battery voltage during PWM absorption charging (green LED blinking ½ second on, ½ second off), or the battery state of charge displays solid LED(s) during bulk charging.

11.14 Photovoltaic (PV) Panel Maintenance[3]

Under most weather conditions, rainfall will keep the module glass surface clean. If dirt and other particulate become excessive, the glass can be cleaned with a soft cloth and mild detergent and water. Use Caution when cleaning the back surface, to avoid penetrating the back sheet.

During each maintenance visit, check the general condition of the wiring and verify mounting hardware is tight. Loose connections may result in a damaged module or array.

11.15 Battery Maintenance[5]

The battery connections should be checked for tightness (do not over tighten the battery connections, it can cause damage to the battery posts) and cleaned during period maintenance.

Note: In a multi-battery installation, it is often best to replace the entire set of batteries when one battery is weak or has failed, especially if the system is over 2 years old.

11.15.1 Checking Each Battery in the Battery Bank

11.15.1.1 To test the batteries, isolate (disconnect) the battery bank from the system, so it is neither receiving a charge, nor connected to the load, by turning off the two Battery breakers in the breaker box.

11.15.1.2 Let the batteries rest for a half hour (overnight is preferred if the temperature is near 20-25ºC).

11.15.1.3 Using a multi-meter, measure the voltage across each battery individually and make a note of the voltage readings. Each single battery is a nominal 12V battery. No single 12V battery’s voltage should be more than 0.5V different than the average. If it is, perform a quick discharge test to see if the battery has failed.

Old batteries, in service for more than two years, cannot be mixed with new batteries. If a failed battery is found on a bank in service more than two years, replace all of the batteries in the bank.

12 ADJUSTMENT

12.1 TEG Run/Setup Jumper Position

The TEG Run/Setup jumper is used to switch between commissioning/maintenance mode and normal operation. When the Run/Setup jumper is in the Setup position, between position 2 and 3 (see **Figure 4-2** and **Figure 4-4**) on the terminal strip, the generator power unit is connected to the precision load resistor allowing the TEG to be checked, serviced and/or adjusted. When the Run/Setup jumper is in the Run position, between position 1 and 2 on the terminal strip, the generator power unit is connected to the TEG Limiter/Converter for normal operation.

WARNING: The TEG jumper clip must be installed in one of the two operating positions in the terminal strip otherwise damage to the generator cannot be prevented.

See **Figures 4-2** and **Figure 4-4** - Control Box Components.

12.2 TEG Limiter/Converter Output Voltage Adjustment

The output voltage of the TEG L/C needs to be set at a higher output voltage than the standard values to allow a higher charging voltage in colder temperature. The TCC will stop the TEG based on the charging voltage of the battery and will compensate for temperature when running in Remote mode.

In colder temperatures, the charging voltage needs to be higher to charge to the same battery capacity. By increasing the output voltage, the TEG L/C will not be limiting the charging voltage because of the output setting, and the TCC can properly control stopping the TEG at the right charge voltage.

In warmer temperatures, the charging voltage needs to be lower, to charge to the same battery capacity. The TCC will properly control the stopping of the TEG at a lower charge voltage as required based on the battery temperature.

The output voltage adjustment pot is used to set the output voltage when no load is connected to the output of the L/C

12.2.1 To adjust the TEG L/C output voltage, the TEG must be running and up to full power.

12.2.2 Turn off both TEG breakers located in the breaker box. This removes the battery connection from the output of the L/C, allowing the no load voltage to be adjusted.

12.2.3 Attach a voltmeter between the two output studs (T5 and T9) located on the L/C board. (See **Figure 4-4** - L/C Components, page 4.5).

12.2.4 Use a small flat screwdriver to adjust the output voltage adjustment pot located on the TEG L/C horizontal board, located near the back of enclosure.

NOTE: *<u>DO NOT TOUCH</u> the current limiting adjustment pot located on the same board near the front of the enclosure (factory use only).*

- For 12V systems: Set the output of the L/C to 16V (factory setting)
- For 24V systems: Set the output of the L/C to 32V (factory setting)

12.2.5 Turn on both TEG breakers located in the breaker box to reconnect the battery

12.3 TEG L/C Voltage Sensing Relay Adjustment

The output voltage adjustment pot is used to adjust the no load output voltage used by the VSR circuit to activate the trip point. The VSR adjustment pot adjusts the trip point.

12.3.1 To adjust the VSR trip point, the TEG must be running and up to full power.

12.3.2 Turn off both TEG breakers located in the breaker box. This removes the battery connection from the output of the L/C, allowing the no load voltages to be adjusted.

12.3.3 Attach a voltmeter between the two measurement studs T8 and T9) located on the L/C board (See **Figure 4-4** - L/C Components, page 4.5.).

12.3.4 Use a small flat screwdriver to adjust the output voltage adjustment pot located on the TEG L/C horizontal board, located near the back of enclosure, to the desired VSR trip point voltage.

NOTE: *<u>DO NOT TOUCH</u> the current limiting adjustment pot located on the same board near the front of the enclosure (factory use only)*

12.3.5 Place an ohmmeter between the common and normally open contact of the VSR terminal block.

12.3.6 Turn the VSR adjustment pot until the contacts open (the normally open contacts are closed when the output voltage is above the VSR set point).

12.3.7 Using the output voltage adjustment pot raise the output voltage to a value where the VSR relay will energize and close the normally open contracts.

12.3.8 To re-check the trip point, lower the output voltage and monitor the opening of the VSR contacts. Fine tune as required to achieve the desired no load trip point.

12.3.9 Reset the output voltage

- For 12V systems: Set the output of the L/C to 16V (factory setting)
- For 24V systems: Set the output of the L/C to 32V (factory setting)

12.3.10 Turn on both TEG breakers located in the breaker box to reconnect the battery.

12.4 TEG L/C Selector Switches

Switch 1 is used to change the output voltage range of the converter output adjustment pot. When switch 1 is on, the output voltage range is adjustable for a 12V system. When switch 1 is off, the output voltage range is adjustable for a 24V system.

Switch 2 is factory set. The position is dependent on the TEG model connected to the limiter/converter. Switch 2 on is for 5060 and 5120 models. Switch 2 off is for 5220 models. In order to use the control box on a generator other than what it was factory set for, it must be readjusted at the factory.

See **Figure 4-4** - L/C Components, page 4.5.

12.5 TEG L/C Protective Limiter Adjustment

The protective limiter adjustment pot is used by the factory to set the required voltage protection limit. The protective limiter voltage is set at the factory to 10 Volts for 5060 and 5120, and 16 Volts for 5220 TEGs. If using the control box on another generator than what it was factory set for, it must be readjusted at the factory.

12.6 TEG L/C Current Limiting Adjustment

The current limiting adjustment pot is used by the factory to set the current limiting for overload protection when the load draws excess current. The result is a proportional drop in output voltage. In order to use the control box on a generator other than what it was factory set for, it must be readjusted at the factory.

12.7 TCC Voltage Reference Source Jumper

The jumper is located on the left hand side, near the middle of the TCC board. See **Figure 4-3** - TCC Components, page 4.4.

There are two positions: RUN and VADJ

- RUN position uses the battery voltage, connected at the lower right hand corner of the board, to display the battery voltage status on the light and to start and stop the TEG when running in Remote mode. This is the position the jumper needs to be in for operation.

- VADJ position uses the reference voltage connected at the VREF connectors, located below the jumper, to display its voltage on the status lights. The purpose of this jumper position is to use an alternate adjustable power source to make changes to the TEG ON and TEG OFF voltages. The Local/Remote switch should be in the Local position when using this position, since the connected voltage affects the voltage sensing on and off signals that control the starting and stopping of the TEG.

When the jumper is removed, the battery voltage status lights will turn off. When the jumper is re-installed, wait 10 seconds to allow the internal programming to finish initializing, before using the battery voltage status lights as indicators

12.8 TCC Bench Testing Jumper

The jumper is located on the right hand side, near the middle of the board by the fuse and 10-position connector. **Figure 4-3** - TCC Components, page 4.4.

There are two positions: RUN and TEST

- RUN position uses the system fuel pressure switch to connect the power from the battery to the remainder of the board. This is the position the jumper needs to be in for operation
- TEST position is for bench testing purposes. When the jumper is in the TEST position, it bypasses the pressure switch and makes the connection on the board allowing the board to be configured on the bench.

12.9 TCC Enable/Disable Temperature Compensation

Temperature compensation is enabled when the temperature sensor is connected to the TCC board. The temperature sensor comes with a short length of wires and a plug. The plug attaches to a temperature sensor extension cable which takes the signal from the temperature sensor to the TCC board.

To disable temperature compensation on the TCC board, the plug between the temperature sensor and the extension cable must be disconnected or the temperature sensor extension cable where it connects to the TCC board must be disconnected. Unbolting the temperature sensor from the battery WILL NOT disable temperature compensation since the sensor will pick up the air temperature and compensate for it.

WARNING: The temperature sensor should always be installed and connected to the TCC board. Disconnecting the temperature sensor will cause the system to not operate as intended and can cause harm to the batteries.

12.10 TCC TEG On/Off Value In-Field Adjustment using the TEG

WARNING: The following procedure uses live circuits. Take extreme care when making or breaking the jumper connections, as touching other connections may damage multiple components.

Equipment required:

- Voltmeter
- small flat blade screwdriver
- Two wires to connect the L/C board output to the VREF connections on the TCC board.

To make adjustments to the TEG OFF voltages, the temperature compensation must be disabled, by disconnecting the temperature sensor from the TCC board. Either disconnect the wiring at the TCC board or disconnect the in-line connector between the sensor and the wiring harness located in the battery enclosure.

12.10.1 Within the Junction Box, turn off the two TEG breakers (one for positive, one for negative). This disconnects the TEG output from the system.
12.10.2 Switch the Local/Remote switch on the TCC board to Local position.
12.10.3 If the TEG is running, skip to step 6.
12.10.4 If the TEG is not running, press and release the Local Start switch. The TEG will begin its ignition sequence.

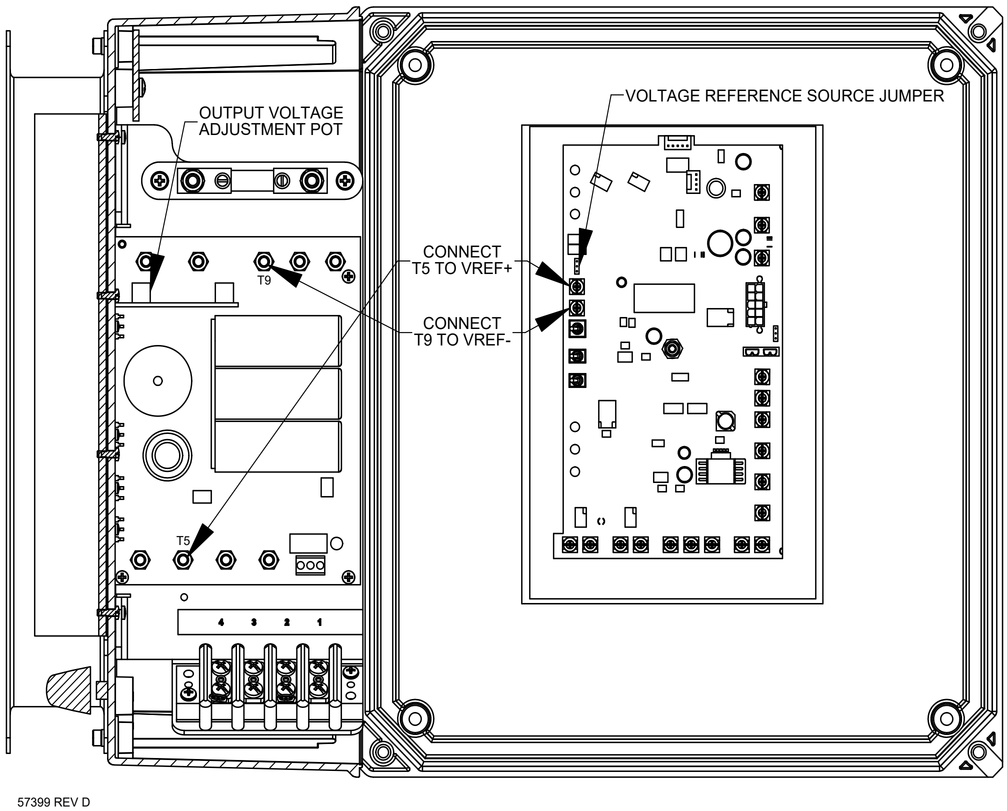


Figure 12-1 Connections for TEG On / Off Adjustment In-Field

12.10.5 If the TEG was just started, allow the TEG to run for a minimum of 15 minutes with the breakers turned off to allow the TEG to start generating enough power for the converter to output a no-load stable voltage.

12.10.6 Carefully connect jumper wires from L/C output voltage connection to the TCC VREF connections (see **Figure 11-11**)

WARNING: All components in the Control Box are live circuits. Be very careful connecting wire from one board to the other. Observe the correct polarity and do not touch any other connections.

12.10.7 Move the Voltage Reference Source Jumper from the RUN position to the VADJ position. Wait 10 seconds to allow internal programming to finish initializing.

12.10.8 Use the Output Voltage Adjustment Pot on the L/C board to vary the voltage source to the desired value for setting either the TEG On value or TEG Off value, monitor with a voltmeter.

12.10.9 See required procedure below (Section 12.12 or Section 12.13) for detailed instructions on setting the TEG On or Off value.

12.10.10 When the adjustments are complete, reset the TEG L/C Output Voltage:

- For 12V systems: Set the output of the L/C to 16V
- For 24V systems: Set the output of the L/C to 32V

12.10.11 Follow the steps listed under “Restore the TCC board to Operating Mode” (Section 12.14).

12.11 TCC TEG On/Off Value Bench Adjustment

Equipment required:

- Voltmeter
- 30Vdc 1Adc power supply
- small flat blade screwdriver

To make adjustments to the TEG OFF voltages, the temperature compensation must be disabled, by disconnecting the temperature sensor from the TCC board.

12.11.1 Switch the Local/Remote switch to the Local position.
12.11.2 Connect the power supply to the VREF.
12.11.3 Move the Voltage Reference Source Jumper from the RUN position to the VADJ position.
12.11.4 Use the power supply voltage to vary the voltage source to the desired value for setting either the TEG On value or TEG Off value.
12.11.5 See required procedure below for detailed instructions on setting the TEG On or Off value.

12.12 TCC TEG ON Adjustment

The TEG ON adjustment is setting the voltage at which the TEG will start. It is typically a voltage setting where the customer wants the battery charging to begin.

The TEG ON adjustment pot is located on the left hand side, near the top of the TCC board. It is the upper of the two pots and is labeled “TEG ON”.

12.12.1 Set the voltage source to the desired voltage for turning the TEG ON. The boards come set from the factory at 12.2 V for a 12 V system and 24.4 V for a 24 V system.

Start the adjustments with the MIN LED (shown on previous page) in the OFF state. If it is lit, turn the adjustment screw on the TEG ON potentiometer counter clockwise unit it goes off.

12.12.2 Turn the adjusting screw on the TEG ON potentiometer clockwise until the MIN LED lights. You can repeat this several times to get comfortable with how fast (slow) to turn the pot to get the LED to light.

Once set, the adjustment can now be verified by adjusting the voltage source. Start by adjusting the voltage source so the MIN LED is off. Reduce the voltage on the voltage source until the MIN LED lights up and determine if your setting is correct.

12.12.3 Follow the steps listed under “Restore the TCC board to Operating Mode”(Section 12.14).

12.13 TCC TEG OFF Adjustment

The TEG OFF adjustment is setting the voltage at which the TEG will stop. It is typically a voltage setting where the customer wants the battery charging to end. To adjust this value, the temperature compensation must be disabled, by disconnecting the temperature sensor. This voltage is set using the charging voltage based on 25ºC, without temperature compensation.

The TEG OFF adjustment pot is located on the left hand side, near the top of the TCC board. It is the lower of the two pots and is labeled “TEG OFF”.

12.13.1 Set the voltage source to the desired voltage for turning the TEG OFF. The boards come set from the factory at 13.6 V for a 12 V system and 27.2 V for a 24 V system.
Start the adjustments with the MAX LED (shown on previous page) in the OFF state. If it is lit, turn the adjustment screw on the TEG OFF potentiometer clockwise until it goes off.

12.13.2 Turn the adjusting screw on the TEG ON potentiometer counter clockwise until the MAX LED lights. You can repeat this several times to get comfortable with how fast (slow) to turn the pot to get the LED to light.

Once set, the adjustment can now be verified by adjusting the voltage source. Start by adjusting the voltage source so the MAX LED is off. Increase the voltage on the voltage source until the MAX LED lights up and determine if your setting is correct.

12.13.3 Follow the steps listed under “Restore the TCC board to Operating Mode” (Section 12.14).

12.14 Restore the TCC Board to Operating Mode

Following the adjustments, return the unit to operating mode.

12.14.1 Replace the jumpers from ADJ to RUN.
12.14.2 Remove the voltage source from the VREF terminals.

WARNING: If the adjustments were made in the field, the wires connected to the L/C board are live when the TEG is hot.

12.14.3 Reconnect the temperature sensor.
12.14.4 Switch the Local/Remote switch to the Remote position. This may turn off the TEG if the battery voltage is at or above the compensated TEG Off value.
12.14.5 If the adjustments were made in the field using the TEG, reconnect the TEG output to the system by turning on the two TEG breakers in the breaker box.

12.15 Solar Controller DIP Switches[1]

WARNING: The solar controller must be turned off to adjust the DIP switches. Disconnect the solar array by turning off both solar breakers in the breaker box. Disconnect the battery by turning off both battery breakers. This will disconnect the battery from the system bus and load.

There are eight DIP switches used to configure the solar controller. See table below

Switch	Position	Details
1	OFF	Configure the unit for solar charging
2, 3	(see table below)	System voltage selection
4	OFF	Sealed gel battery. Charging to 14.0V. No equalization is required for gel batteries
5	OFF	Sealed gel battery. Charging to 14.0V. No equalization is required for gel batteries
6	OFF	Sealed gel battery. Charging to 14.0V. No equalization is required for gel batteries
7	OFF	Configure to manual battery equalization. Gel batteries should not be equalized.
8	OFF	Configure for PWM charging

Solar DIP Switch 8: Noise Reduction

The solar controller uses a PWM battery charging algorithm , which can cause noise on connected loads. If the noise can not be suppressed by other means through grounding or filtering, the charging process can be changed to an On-Off charge regulation although it is less effective. Move switch 8 to the ON position to configure for On-Off charging.

Solar Controller System Voltage Selection

Voltage	**Switch 2**	**Switch 3**
12 V	OFF	On
24 V	On	OFF

See **Figure 4-5**, page 4.6

12.16 Solar Controller Push Button

The pushbutton can be used to reset the controller from an error or fault.

The pushbutton can be pressed and held for 5 seconds to enter and exit from battery equalization manually (Green LED flashes quickly, two to three times per second).

WARNING: Battery equalization should not be used in this application with Gel batteries.

See **Figure 4-5**, page 4.7.

13 TROUBLESHOOTING

Below are two tests for troubleshooting the solar panels.

13.1 Selective Shading Test

The following can be done without disconnecting any wiring in the array. Use an object large enough to shade at least 4 cells. Monitor the current while the array is connected and working, and shade a portion of the module. A noticeable drop in the current will be observed if that module is functioning. No change in the current means that module is out of the circuit and the module's wiring should be checked or a module in series with it needs to be checked.

13.2 Fading in the Heat

Heat fade shows up most severely in battery systems. If the difference between the array voltage and the battery voltage approaches zero, then current flow can drop nearly to zero. The voltage of a solar module decreases with temperature increases. Nominal 12-volt solar modules are designed to sustain good current flow all the way to 17 or 18V at 25°C. This allows for voltage drop at higher temperatures. If heat fade is severe, it MAY be caused by weak solar modules or by any other weak links in the power chain, including undersized wiring, poor connections and controller losses.

Confirm heat fading by cooling the array with water while monitoring the current during operation. If the current rises to normal, determine where the drop in voltage is occurring. Connect a voltmeter to the solar array at the combiner box and disconnect the array from the controller by turning off the two solar breakers in the breaker box. This will allow an open circuit voltage reading to be taken. If the voltage is less than 18V (in a 12V system), then part or the entire array may be defective. Follow the Selective Shading Test above to locate weak modules.

Reconnect the array to the system and measure voltage drops in the wiring under good sunlight. Measure the voltage at the PV array and again at the controller input. The voltage drop in the wiring will increase as more current is supplied by the solar array: typical voltage drop should be under 0.1V in this system between the combiner box and the solar controller in the control box.

If voltage drop occurs at a single point (at a connector or within the controller) then concentrated heat will result. It can be felt or signs of heat damage may be seen. If the voltage drop is evident at the loads then check for corroded connections.

13.3 Troubleshooting Chart

Hybrid Troubleshooting			
Problem	**Probable Cause**	**Possible Solution**	**Lookup Section**
None of the TCC battery voltage indicator lights are on	TCC Voltage Reference Source jumper may be in the VADJ position	Switch the TCC Voltage Reference Source jumper to the RUN position. One of the battery voltage indicators should light.	**Section 12 -Adjustments**
	Fuse is blown	Check the TCC on-board fuse for damage and replace if needed	
	Pressure switch not closing with fuel available	Check the pressure switch for contact closure	**Section 11.9 - Pressure Switches**
	TCC battery connection wiring not receiving voltage with fuel available	Verify TCC battery connection wiring is connected to the terminal blocks inside the battery box	**Section 5.10 - Wiring**
	Out of fuel	Power to the TCC board is routed through one of the pressure switches. When there is no fuel, the TCC board is not connected to battery power	
TEG does not attempt to ignite	TCC battery voltage indicator either MED or MAX lite	Battery voltage measured is not requiring the TEG to start. This is normal operation.	
	TCC battery voltage indicator MIN is lite. Board may be in Local mode	Switch the TCC Local/Remote switch to Remote position	**Section 12 - Adjustments**
	TCC battery voltage indicator MIN is lite and SI may be locked out. TCC lower lights are on (SI PWR, DC PWR, SI NC) A site visit is required to manually start the TEG to reset the SI lockout condition	Switch the TCC Local/Remote switch to Local position and toggle the TCC Start switch to start the TEG on site. System will not respond to a Remote start while the MIN battery voltage indicator is on. When TEG is running, return switch to Remote position	**Section 7 - Operation**
	TCC two lower lights are on (SI PWR, DC PWR) and SI is not sparking	Check electrode spark gap	**Section 11.10 - Check the Spark Electrode**
		Check SI system	**Section 7.5 - Spark Ignitor Operation**
	Remote Start signal sent while TCC battery voltage indicator MAX is lite.	TEG will not start when the MAX battery voltage level is indicated	
TEG Burner does not ignite	Air in fuel line	Purge fuel lines of air	
	Supply gas pressure too low	Increase the gas supply pressure to the TEG	**Section 5.11 - Fuel Supply**
	Fuel filter dirty	Drain the regulator sediment bowl	**Section 11.6.1 - Draining the Sediment Bowl**
		Replace the fuel filter	**Section 11.6.2 - Fuel Filter Replacement**
	Fuel pressure adjustment incorrect	Adjust the TEG fuel regulator pressure	**Section 10 - Fuel Pressure Adjustment**
	Fuel orifice plugged	Replace the fuel orifice	**Section 11.6.3 - Fuel Orifice Inspection**
	Fuel orifice size incorrect	Replace the orifice with one of the correct size	
	Air filter dirty	Clean the air filter	**Section 11.8.1 - Burner Maintenance - Air Supply**
	Air-shutter adjustment incorrect	Adjust the air-shutter	**Section 10 - TEG Power Output Adjustment**
	Electrode spark gap not set correctly	Check electrode spark gap	**Section 11.10 - Check the Spark Electrode**

13.3 Troubleshooting Chart

TEG Burner will ignite but will not continue to burn	Supply gas pressure too low	Increase the gas supply pressure to the TEG	**Section 5.11 - Fuel Supply**
	Fuel filter dirty	Drain the regulator sediment bowl	**Section 11.6.1 - Draining the Sediment Bowl**
		Replace the fuel filter	**Section 11.6.2 - Fuel Filter Replacement**
	Fuel pressure adjustment incorrect	Adjust the TEG fuel regulator pressure	**Section 10 - Power Output Adjustment**
	Fuel orifice plugged	Replace the fuel orifice	**Section 11.6.3 - Fuel Orifice Inspection**
	Fuel orifice size incorrect	Replace the orifice with one of the correct size	
	Air filter dirty	Clean the air filter	**Section 11.8.1 - Burner Maintenance - Air Supply**
	Air shutter adjustment incorrect	Adjust the air-shutter	**Section 10 - Power Output Adjustment**
TEG Low output power or low voltage	Vset adjustment incorrect	Determine required Vset for present ambient temperature at site and adjust	**Section 9 - TEG Power Output Evaluation**
	Airflow past cooling fins insufficient	Clean the cooling fins of any debris	
	Fuel filter dirty	Drain the regulator sediment bowl	**Section 11.6.1 - Draining the Sediment Bowl**
		Replace the fuel filter	**Section 11.6.2 - Fuel Filter Replacement**
	Fuel orifice plugged	Replace the fuel orifice	**Section 11.6.3 - Fuel Orifice Inspection**
	Fuel orifice size incorrect	Replace the orifice with one of the correct size	
	Fuel pressure adjustment incorrect	Adjust the TEG fuel regulator pressure	**Section 10 - Power Output Adjustment**
	Air filter dirty	Clean the air filter	**Section 11.8.1 - Burner Maintenance - Air Supply**
	Air-shutter adjustment incorrect	Adjust air-shutter	**Section 10 - Power Output Adjustment**
	L/C damaged	Examine the L/C	**Section 11.13 - L/C Examination**
	L/C adjustment incorrect	Adjust the L/C	**Section 7 - Adjustment**
	Power unit damaged	Examine the power unit	**Section 11.12 - Power Unit**
TEG Output power is too high	Fuel pressure adjustment incorrect	Adjust the TEG fuel regulator pressure	**Section 10 - Power Output Adjustment**
TEG Output voltage is too high	L/C damaged	Examine the L/C	**Section 11.13 - L/C Examination**
	L/C adjustment incorrect	Adjust the L/C	**Section 7 - Adjustment**
No lights are showing on the Solar controller	Night conditions are detected by the solar controller	This is normal operating condition if it is night and no light source is available	
	Reverse polarity connected to solar input	Verify the PV wiring to the solar controller	**Section 5.10 - Wiring**
	Reverse polarity connected to battery input	Verify the Battery wiring to the solar controller	**Section 5.10 - Wiring**
	Either or both the Solar breakers or the Battery breakers are turned off in the Breaker box	Turn on the Battery Breakers before turning on the Solar breakers	**Section 4 - Identification**
	Battery bank voltage is below the turn on voltage for the solar controller: 9 VDC	Attempt to start the TEG and charge the batteries. If the batteries will not take or hold a charge, they may need to be replaced	**Section 7 - Operation**

13.3 Troubleshooting Chart

Solar controller LED's: Red/Green on alternating to Yellow on	Short Circuit Fault: A short circuit condition is detected by the solar controller. Two attempts are made to reconnect the output, then the internal switches remain open till the short is repaired. No battery charging can occur until the fault is repaired	Troubleshoot the system wiring to determine and correct the short circuit, then restore battery power to the solar controller.	**Section 5.10 - Wiring**
Solar controller LED's: Red/Yellow on alternating to Green on	Solar Overload Alarm: When the solar input current rises above the controller's rating, the controller will reduce the overload to an average current below the controller's rating, equivalent to the amount heating caused by full rated input current. If the current exceeds the maximum 130% that can be handled by the controller, the solar is disconnected for 10 seconds and the alarm will be displayed. After 10 seconds, the switches are closed and charging resumes, until these conditions are meet again. This cycle continues and occurs as required.	This is part of the protective operation of the solar controller and is self correcting.	
Solar controller LED's: Red on alternating to Yellow on	Solar Over Temperature Alarm When the heatsink temperature limit is reached at 95ºC, the controller reduces the solar input current to prevent more heating. If the heating continues to increase, the solar input is disconnected until the heatsink cools to 70ºC, when it is reconnected	This is part of the protective operation of the solar controller and is self correcting.	
Solar controller LED's: Red on alternating to Green on	Solar High Voltage Disconnect Alarm: If the battery voltage rises above 0.2V above the PWM absorption voltage, the solar controller will disconnect the solar input, as long as the FET switches can open and are not damaged because of a failure. When the voltage falls to 13.0V, the switches will reconnect the solar input.	This is part of the protective operation of the solar controller. If the switches are damaged and do not disconnect the solar power from the panels, the solar controller must be replaced	
Solar controller LED's: Red on, alternating to Yellow on, alternating to Green on	DIP Switch Fault: If a DIP switch is changed will the controller is powered, the FET switches will open. No battery charging can occur until the fault is repaired	The controller must be restarted to clear this fault: press the push button on the solar controller. If this does not clear the fault, disconnect power to the solar controller by first turning off the PV breakers, then disconnect the battery power. Turning off the Battery breakers will also disconnect battery power to the load. Restore power by applying the battery power first, then the solar power.	
	Self-Test Fault: The controller may detect other wiring issues in the system and display this as a self-test fault. No battery charging can occur until the fault is repaired	Check for other Solar fault conditions and external system wiring problems. Restore power to the controller by first connecting the battery power, followed second by the solar power	

13.3 Troubleshooting Chart

Solar controller LED's: Red\Yellow on alternating to Green\Yellow on	Remote Temperature Probe Fault: May occur if a short circuit, open circuit or loose terminal connection happens in the remote temperature sensor after it has been working. The solar input is disconnected until the fault is corrected and the controller is powered down. No battery charging can occur until the fault is repaired If the controller is restarted with the same failed temperature probe, the controller may not detect that the temperature probe is connected and will not indicate a problem	Verify the temperature probe is wired into the solar controller at the temp sense connections and with the correct polarity. Check for shorts or open connections in the wiring	**Section 5.9 - Wiring**
	Battery Voltage Sense Failure: May occur if a short circuit, open circuit or loose terminal connection happens after the battery sense has been working. If the controller is restarted with the same failed battery sense connection, the controller may not detect that the battery sensing is connected and will not indicate a problem.	Verify that the voltage sense wires are wired into the solar controller at the correct location and with the correct polarity. Use a multimeter to measure the voltage at the voltage sense connection on the solar controller matches with the voltage measured at the TCC battery connection. Verify TCC battery connection wiring is connected to the terminal blocks inside the battery box	**Section 5.10 - Wiring**
Overcharging or undercharging the batteries	Solar controller DIP switches may be set wrong	Verify the DIP switch on the solar controller are set according to the settings listed in the :Solar Controller DIP switches" section	**Section 12 -Adjustments**
	Solar controller temperature probe is not functioning	Verify the temperature probe is wired into the solar controller at the temp sense connections and with the correct polarity. Check for shorts or open connections in the wiring	**Section 5.10 - Wiring**
	TCC temperature sensor probe is not functioning	Verify the temperature probe is wired into the TCC at the temp sensor connections and with the correct wire connections as labeled. Check for shorts or open connections in the wiring. Replace the temperature sensor	**Section 5.10 - Wiring**
The battery bank is not being charged	Verify all breakers are turned on in the breaker box		**Section 4 - Identification**
	The TEG has failed to start and the SI may be locked out. A site visit is required to manually start the TEG to reset the SI lockout condition	Switch the TCC Local/Remote switch to Local position and toggle the TCC Start switch to start the TEG on site. When TEG is running, return switch to Remote position	**Section 7 - Operation**
	There may be a fault in the solar panel array	Perform Selective Shading Test and Fading in Heat test	**Section 12.1 & 12.2**
	Battery bank capacity has been reduced: may near end of life or one or more batteries are failing or have failed.	Batteries should be replaced if they can no longer provide 50% of the original capacity.	

14 TECHNICAL SPECIFICATIONS

Technical Specification by TEG model: 5060, 5120, 5220

TEG Power Specifications	5060	5120	5220
Power Ratings, 20ºC, 750m above sea level	54 W @ 12 V 54 W @ 24 V	108 W @ 12 V 108 W @ 24 V	176 W @ 12 V 176 W @ 24 V
Electrical			
Adjustment	12V 12-18 Volts 24V 24-33 Volts		
Reverse Current Protection	Yes		
Load Output	Terminal Block can accept wires from 14 AWG to 1/0 AWG easily		
Fuel	**5060 / 5120**		**5220**
Maximum Supply Pressure	345 kPa (50 psi)		345 kPa (50 psi)
Minimum Supply Pressure	69 kPa (10 psi)		138 kPa (20 psi)
Fuel Connection	1/4 in. MNPT connection		
Environmental			
Ambient Operating Temperatures, Continuously Running TEG	Max. 45ºC (130ºF) Min. -40ºC (-67ºF)		
Operating Conditions	Unsheltered Operation		
Materials of Construction			
Cabinet	304 SS		
Cooling Type	Natural Convection		
Burner	Meeker type/Inconel 600		

Ignition Control System
The following table gives the technical specifications for the Ignition Control System.

TCC SCADA connections:

Electrical SI Power Supply	Input Voltage	Minimum: 5.0V
		Maximum: 35.0V
	Power Input	4.16 Watts
	Output Voltage	13.8 Vdc
SI	Spark Rate	10/second
	Trial For Ignition	7 seconds
	Number of tries for Ignition	3 trials until lockout
	Inter-Purge Time	10 seconds
Spark Gap	Nominal	4.8 mm (0.19 in)
	Minimum	3.3 mm (0.13in)
	Maximum	6.3 mm (0.25in)

SCADA TEG On Connection: maximum switching current: 2A
SCADA Fuel Pressure Connection through Hobbs Pressure Switch:
maximum switching current: 8A – 12Vdc, 4A – 24Vdc

14.1 Standard Gaseous Fuel Specifications

Gaseous fuels provided 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/m^3 (2) (approx. 170 ppm) of H_2S.

4. Shall not contain more than 60 mg/m^3 (approx. 88 ppm) of Mercaptan Sulphur.

5. Shall not contain more than 200 mg/m^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/m^3 of water vapour.

8. Shall not contain more than 1% by volume of free oxygen.

9. Shall have a higher heating value (HHV):

Natural Gas:	37 MJ/m^3 (1000 BTU/cu.ft.)(1)(2)
Propane:	93 MJ/m^3 (2500 BTU/cu.ft.)(1)(2)
Butane:	122 MJ/m^3 (3300 BTU/cu.ft)(1)(2)

10. Shall not exceed 60ºC (140ºF) in temperature.

Notes:

(1) - For gaseous fuels outside of these specifications, please contact GPT.
(2) - At 1 atm and 15ºC.

8G8DLTP-DEKA

SPECIFICATIONS

Nominal Voltage (V)	12V
Capacity at C/100	265Ah
Capacity at C/20	225Ah
Weight	157 lbs. (71.2 kg)
Plate Alloy	Lead Calcium
Posts	Forged Terminals & Bushings
Container/Cover	Polypropylene
Operating Temperature Range	-76°F (-60°C) - 140°F (60°C)
Charge Voltage @ 68°F (20°C)	
Cycle	2.30 - 2.35VPC
Float	2.25 - 2.30VPC
Vent	Self-sealing
Electrolyte	Sulfuric acid thixotropic gel
Terminal	T (T975)

Rated non-spillable by ICAO, IATA and DOT

Made in the U.S.A. by East Penn Manufacturing Co, Inc.

Distributed by:

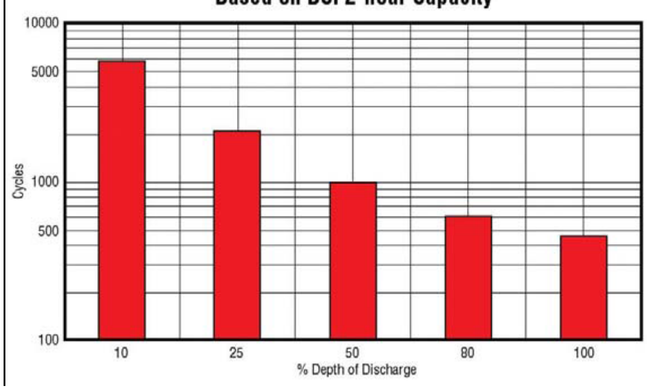
GENTHERM
GLOBAL POWER TECHNOLOGIES

Valve-Regulated, Gelled-Electrolyte Battery

DIMENSIONS

Length (mm)	**21.03 (534 mm)**
Width (mm)	**11.00 (279 mm)**
Height (mm)	**10.82 (275 mm)**

Gel Cycle Life vs Depth of Discharge at +25°C (77°F)
Based on BCI 2-hour Capacity



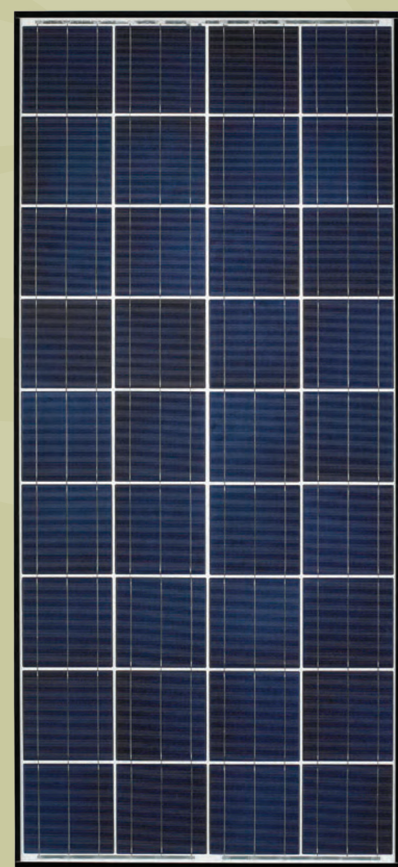
14.3 Solar Panel Specification Sheet

HIGH EFFICIENCY MULTICRYSTAL PHOTOVOLTAIC MODULE

KYOCERA

KD 135 F Series

KD135GX-LFBS KD140GX-LFBS



CUTTING EDGE TECHNOLOGY

As a pioneer with over 35 years in the solar energy industry, Kyocera demonstrates leadership in the development of solar energy products. Kyocera's *Kaizen* Philosophy, commitment to continuous improvement, is shown by repeatedly achieving world record cell efficiencies.

QUALITY BUILT IN

- UV stabilized, aesthetically pleasing black anodized frame
- Supported by major mounting structure manufacturers
- Easily accessible grounding points on all four corners for fast installation
- Proven junction box technology with 12 AWG PV wire to work with transformerless inverters
- Quality locking MC4 plug-in connectors to provide safe and quick connections

RELIABLE

- Proven superior field performance
- Tight power tolerance
- Only module manufacturer to pass rigorous long-term testing performed by TÜV Rheinland

QUALIFICATIONS AND CERTIFICATIONS

UL Listing
QIGU.E173074

Registered to ISO9001-2000

NEC 2008 Compliant, UL 1703, ISO 9001, and ISO 14001
UL1703 Certified and Registered, UL Fire Safety Class C, CEC, FSEC
Certified IEC61215 Ed 2 IEC61730 by JET

SOLAR by KYOCERA

14.3 Solar Panel Specification Sheet

KD 135 F Series

ELECTRICAL SPECIFICATIONS

Standard Test Conditions (STC)
*STC = 1000 W/M² irradiance, 25°C module temperature, AM 1.5 spectrum**

	KD135GX-LFBS	KD140GX-LFBS	
P_{mp}	135	140	W
V_{mp}	17.7	17.7	V
I_{mp}	7.63	7.91	A
V_{oc}	22.1	22.1	V
Is_c	8.37	8.68	A
$P_{tolerance}$	+5/-5	+5/-5	%

Nominal Operating Cell Temperature Conditions (NOCT)
*NOCT = 800 W/M² irradiance, 20°C ambient temperature, AM 1.5 spectrum**

	KD135GX-LFBS	KD140GX-LFBS	
T_{NOCT}	45	45	°C
P_{max}	97	101	W
V_{mp}	16.0	16.0	V
I_{mp}	6.10	6.33	A
V_{oc}	20.2	20.2	V
I_{sc}	6.78	7.03	A
PTC	120.3	124.9	W

Temperature Coefficients

	KD135GX-LFBS	KD140GX-LFBS	
P_{max}	-0.45	-0.45	%/°C
V_{mp}	-0.52	-0.52	%/°C
I_{mp}	0.0066	0.0066	%/°C
V_{oc}	-0.36	-0.36	%/°C
I_{sc}	0.060	0.060	%/°C
Operating Temp	-40 to +90	-40 to +90	°C

System Design

Series Fuse Rating	15 A
Maximum DC System Voltage (UL)	600 V
Hailstone Impact	1in (25mm) @ 51mph (23m/s)

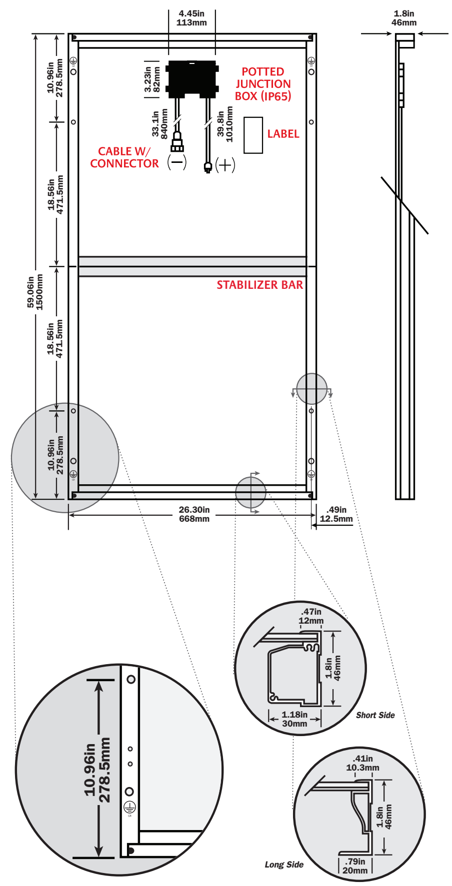
* Subject to simulator measurement uncertainty of +/- 3%.
KYOCERA reserves the right to modify these specifications without notice.

MODULE CHARACTERISTICS

Dimensions: *length/width/height*	59.06in/26.30in/1.8in (1500mm/668mm/46mm)
Weight:	28.4lbs (12.9kg)

PACKAGING SPECIFICATIONS

Modules per pallet:	20
Pallets per 53' container:	54
Pallet box dimensions: *length/width/height*	63.19in/27.56in/49.02in (1605mm/700mm/1245mm)
Pallet box weight:	650lbs (295kg)



Expanded View of Grounding Holes

Frame Cross Section Diagrams

NEC 2008 COMPLIANT
UL 1703 LISTED
CERTIFIED IEC61215 ED2 IEC61730 BY JET

Registered to ISO9001-2000

WARNING: Read the instruction manual in its entirety prior to handling, installing & operating Kyocera Solar modules.

Legend
MOUNTING HOLES .35in (9mm) · DRAINAGE HOLES · GROUND SYMBOL .35in (9mm)

041212

OUR VALUED PARTNER

KYOCERA Solar, Inc. 800-223-9580 800-523-2329 fax www.kyocerasolar.com

15 SELECT ELECTRICAL COMPONENT REPLACEMENT INSTRUCTIONS

15.1 Control Box Installation

WARNING: For all wiring and installation, ensure that all breakers in the Breaker box are turned off.

Removal or installation of the control box can only be done when the TEG is cold.

The standard mounting location for the control box is on the right hand side of the TEG cabinet. The box is mounted to the cabinet using 4 bolts, two on each of the mounting brackets, and secured with a washer and nut in the cabinet.

The TEG wiring is fed into the cabinet from various holes the back of the enclosure matching to holes in the side of the TEG cabinet. The solenoid, high energy cable, two pressure switches and chassis ground wires are feed from the control box to the cabinet and wired in the cabinet as shown in **Figure 5-22**. The power unit wires and precision load resistor wires are fed from the cabinet into the control box and are wired to the TEG terminal strip, as shown in the same figure. See **Figure 5-30** for internal wiring of the control box.

Two temperature sensors are wired from the control box to the battery box. One temperature sensor is used by the TCC board to measure the voltage of the battery and calculate the temperature compensated stop point for the TEG. The other temperature sensor is used by the solar controller to temperature compensate the charging voltage from the solar panels. Each temperature sensor should be mounted to a battery post within the battery enclosure

Battery voltage sensing wires are wired from the TCC board to the battery terminal in the battery box. The TCC board get its power from these sensing wires and it also uses the measured voltage to start and stop the TEG. Any voltage drop lost across the charging wires from the output of the TEG L/C to the battery does not have to be voltage compensated, because the actual battery voltage is being measured.

Inside the control box, the TCC battery sensing wires are also wired to the solar controller's sensing wire input. This provides the actual battery voltage measurement to the solar controller and it can charge the battery to the correct voltage when solar is present.

The output of the TEG limiter/converter is wired to the TEG breakers in the Breaker box for over current protection and a TEG output disconnect. The output of the breaker is wired back to the control box to the system bus terminal

The solar controller's "Solar" connections (inside yellow positive terminal and inside negative terminal) are wired from the output of the Solar breakers in Breaker box, for over current protection and Solar disconnect. The solar controller's "Battery" connections (outside red positive terminal and outside negative terminal) are wired to the system bus terminal.

The battery charging wires are wired into the Battery breakers in the Breaker box. From the output of the Battery breakers, it is wired to the system bus terminal where it is charged by either the Solar system or the TEG.

The Load terminal block is for connecting the customer load to the system bus terminal through two load breakers.

The Ground bus bar is used to wire most of the grounds in one common location. The Solar controller input wiring utilizes the grounding lug located in the solar controller for ease of wiring. The TCC ground connection, TEG ground wire and battery ground wiring is all wired to the ground bus bar.

15.2 TCC Board Installation

The TCC is mounted to the door of the control box using a single screw through the door from the outside through the middle of the board and secured with a nut on the inside.

Some of the wiring is factory installed, and some of the wiring is field installed. SCADA wiring is to be supplied and installed by the customer, as needed (see **Figure 5-30**).

15.2.1 Solenoid Wiring

3 conductor wire 18 AWG Silflex wire is factory installed from the TCC board to the solenoid in the TEG cabinet.

The solenoid receives power from the battery voltage sensing wires connected to the Battery connections on the TCC board, only when the SI module is powered and requiring the solenoid valve to be operational.

15.2.2 10-position Connector Wiring

Consists of a wiring harness that is factory installed from the TCC board to the SI module and the pressure switches inside the TEG cabinet.

Four wires are connected to the SI module: two are power to the module, one is the valve control signal, and one is a no-combustion signal.

Two sets of two wires are connected to the two pressure switches. One pressure switch is used as a SCADA indicator of fuel pressure. The second pressure switch is a switch connecting the battery power to the remainder of the TCC board to allow operation when fuel is present.

15.2.3 Temperature Sensor Wiring

3 conductor temperature sensor wiring harness is to be cut to length and installed in the field.

Trim back about 1 inch (2.5 cm) of the outer sheath of the wiring harness; be careful not to cut into any of the inner wire insulation. Install the fork terminals onto the ends of each wire. The bare drain wire does not have covering insulation.

The temperature sensor harness is terminated with a female quick connect plug that mates to the male quick connect plug installed on the temperature sensor, to be mounted in the battery enclosure on or near the batteries.

15.2.4 Ground Wire

Single green wire is factory installed from the TCC board to the ground bus bar on the backpan within the control box.

The ground wire is required for the spark return path. The generated spark is connected to the electrode in the TEG burner assembly, and sparks to the generator chassis. It returns to the TCC via the connected grounding wires.

WARNING: Damage to the electronics can occur if the grounding wires are not installed.

15.2.5 Battery Voltage Sense Wiring

Two wires are field installed from the TCC board to the batteries within the battery enclosure. These wires are used to power the TCC board and to sense the battery voltage at the battery.

15.2.6 Voltage Reference Connection Wiring

No wires are permanently wired to these connections during standard operation.

The voltage reference connection is used to set the TEG On and non-temperature compensated TEG Off values, either on the bench or in the field. This is a temporarily wired connection for adjustment only.

15.2.7 SCADA Wiring

SCADA wiring is customer supplied and installed in the field.

SCADA Start Wiring

Polarity sensitive wiring to SCADA system; Supply a momentary nominal system voltage to the connections to activate the on-board relay, which signals a SCADA start request in Remote Mode.

SCADA Stop Wiring

Polarity sensitive wiring to SCADA system; Supply a momentary nominal system voltage to the connections to activate the on-board relay, which signals a SCADA stop request in Remote Mode.

SCADA TEG On Wiring

Dry contact connection to SCADA system: Normally open, normally closed and common connection provided, allowing the SCADA system to read when the TEG has been requested to start. Maximum switching current: 2A.

SCADA Fuel Pressure Wiring

Dry contact connection to SCADA system: Normally open and common connection provided, allowing the SCADA system to read when the pressure switch is closed. Maximum switching current: 8A – 12Vdc, 4A – 24Vdc.

15.3 Solar Controller Installation

WARNING: Never turn off the battery power to the solar controller without first turning off the solar power to the solar controller. Battery power should always be turned off last and turned on first.

For removal, wiring and installation ensure that both solar breakers in the Breaker box are turned off first.

It is advisable to turn off the battery power to the solar controller by turning off both battery breakers in the Breaker box. Note: this will disconnect the battery bank from the system bus, including disconnecting the battery from the load.

It is also advisable to turn off the TEG if it is running and turn off both TEG breakers, to ensure there is no power on the L/C board and on the system bus. The TCC board will remain powered as it is wired directly to the battery via the voltage sensing wires.

With both the solar and battery power disconnected from the solar controller, remove all the wiring to the solar controller in its wiring compartment. Mark the wires for re-installation. See **Figure 4-5** for reconnections. Outside red positive terminal and outside negative terminal are wired to the system bus terminals and are the battery connections to the solar controller. The inside yellow positive terminal and inside negative terminal are wired to the output of the Solar breakers in the Breaker box and are the solar connections to the controller. Remove the ground wire from the ground lug.

The two wires closest to the left side, yellow terminal are the voltage sensing wires, and must be wired with the red wire closest to the yellow terminal and black wire to its right.

WARNING: These wires are live and connected directly to the battery, so use electrical tape to tape off each end to prevent shorting together or to the enclosure.

The two wires closest to the negative terminals is the temperature sensor wiring and is not polarity sensitive. For consistency, wire the red wire on the left, and the black wire to its right. The solar controller is mounted inside the control box with the back of the controller mounted on the left side wall of the enclosure. Four screws are used to mount the controller, they are located at the bottom of the controller, and access to the screws is gained in the wiring compartment.

Remove the two knock outs located in the bottom of the replacement solar controller, and route the wires though the knock outs before mounting the controller inside the control box.

Left Knock Out: black positive “battery” wire and both small 2-conductor wires.
Right Knock Out: white negative “battery” wire, 3 conductor wire routed from breaker box (grey – positive solar wire, white – negative solar wire, green – ground wire).

15.4 Spark Ignitor

Remove the plug to the spark ignitor located on the right hand side first. This removes the power wires to the ignitor. Disconnect the high voltage ignition cable.

The spark ignitor is mounted using two screws, located at either end.

15.4 Limiter/Converter Board

It is not advisable to replace the limiter/converter board. Four board mounted components are mounted and isolated to the external heatsink, mounted to the back of the enclosure and special care must be taken when dealing with this component.

16 BIBLIOGRAPHY

1. MorningStar Corporation, TriStar Solar System Controller Installation and Operation Manual, version May 03

2. Web Article: “How do Photovoltaics Work?” By Gil Knier. http://science.nasa.gov/headlines/y2002/solarcells.htm

3. Web Article: “Troubleshooting A PV Array” By Windy Dankoff http://www.solarray.com/TechGuides/Troubleshooting_T.php

4. Web Article: “How Lead Acid Batteries Work” By Constantin von Wentzel http://www.vonwentzel.net/Battery/00.Glossary/index.html

5. East Penn Manufacturing Co.,Inc. Valve-Regulated Lead-Acid (VRLA) Technical Manual, No.0130 Rev. 5/07

17 PARTS LISTS

17.1 Hybrid Model S-2025 Parts List

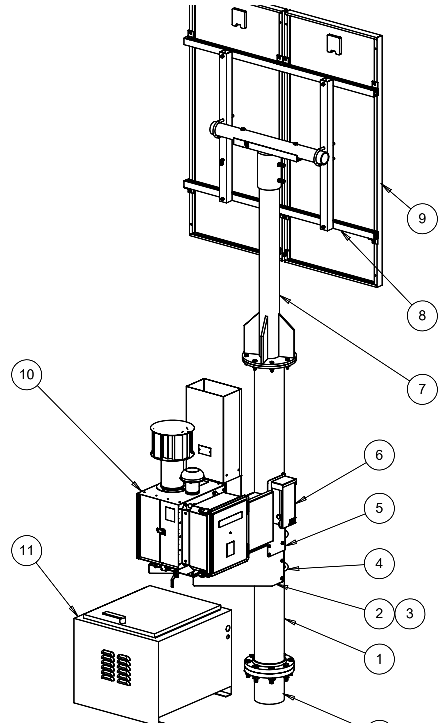


Figure 17-1 Hybrid Model S-2025

Item	Qty.	Part No.	Description
1	1	4900-56937	BASE POLE, 6”, WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE C/W NUTS/WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
7	1	4900-56933	TOP POLE, WELDMENT
8	1	4900-57091	MOUNT BRACKET, 2 SOLAR PANEL
9	2	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
12	1	4900-57439	GROUND POLE, WELDMENT, 6”
12 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 2 BREAKER
10	1	9560-08250	HYBRID TEG, 5060, 12V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 12V, PROPANE
11	1	4900-57240	BATTERY SYSTEM, 2 x 8G8DLTP-DEKA, 400Ah @ 12V
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
24 V SYSTEM			
6	1	6300-57044	COMBINER BOX ASSY, 1 BREAKER
10	1	9560-08252	HYBRID TEG, 5060, 24V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 24V, PROPANE
11	1	4900-56664	BATTERY SYSTEM, 2 x 8G8DLTP-DEKA, 200Ah @ 24V
Not Shown	1	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	1	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.2 Hybrid Model S-2050 Parts List

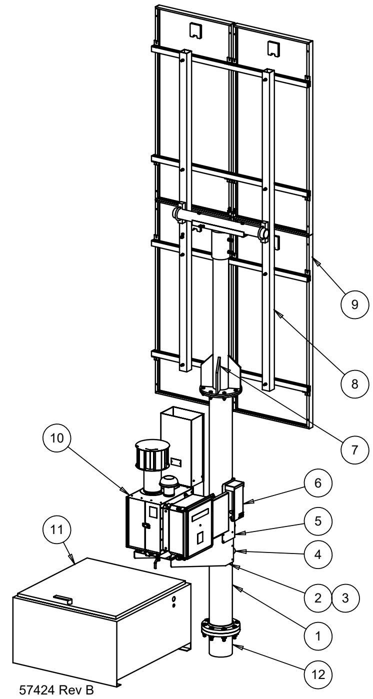


Figure 17-2 Hybrid Model S-2050

Item	Qty.	Part No.	Description
1	1	4900-56937	BASE POLE, 6”, WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE C/W NUTS/WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
7	1	4900-56933	TOP POLE, WELDMENT
8	1	4900-57089	MOUNT BRACKET, 2 x 2 SOLAR PANEL
9	4	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
12	1	4900-57439	GROUND POLE, WELDMENT, 6”
12 V SYSTEM			
6	1	6300-57047	COMBINER BOX ASSY, 4 BREAKER
10	1	9560-08250	HYBRID TEG, 5060, 12V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 12V, PROPANE
11	1	4900-57241	BATTERY SYSTEM, 4 x 8G8DLTP-DEKA, 800Ah @ 12V
Not Shown	4	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	4	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
24 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 2 BREAKER
10	1	9560-08252	HYBRID TEG, 5060, 24V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 24V, PROPANE
11	1	4900-56666	BATTERY SYSTEM, 4 x 8G8DLTP-DEKA, 400Ah @ 24V
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.3 Hybrid Model S-2075 Parts List

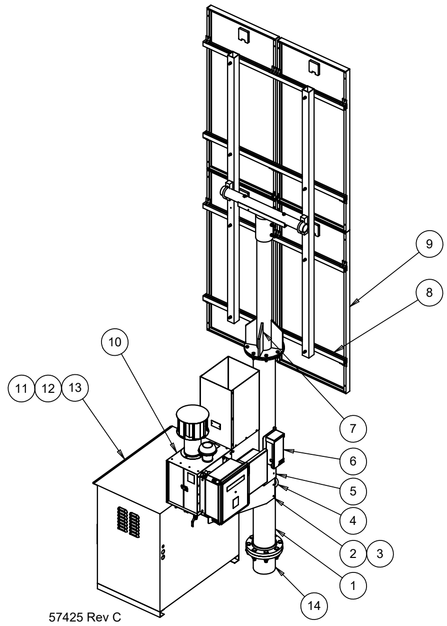


Figure 17-3 Hybrid Model S-2075

Item	Qty.	Part No.	Description
1	1	4900-56937	BASE POLE, 6”, WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE C/W NUTS/WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
7	1	4200-56642	MOUNT BRACKET, 2 SOLAR PANEL
8	1	4900-56686	MOUNT BRACKET, 2 x 2 SOLAR PANEL
9	2	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
11	6	2400-56642	BATTERY, 12V GEL,8G8 DEKA, 200Ah
12	1	4900-56696	ENCLOSURE, BATTERY, CDN, 6 x 8G8DLTP-DEKA
14	1	4900-57439	GROUND POLE, WELDMENT, 6”
12 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 2 BREAKER
10	1	9560-08250	HYBRID TEG, 5060, 12V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 12V, PROPANE
13	1	4900-56664	BATTERY INTERCONNECT KIT, 6 BAT, 12 V
Not Shown	4	4900-56704	CABLE ASSY, 153XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	4	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
24 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 1 BREAKER
10	1	9560-08252	HYBRID TEG, 5060, 24V, NATURAL GAS
10	1	9560-08253	HYBRID TEG, 5060, 24V, PROPANE
13	1	2400-56703	BATTERY SYSTEM, 2 x 8G8DLTP-DEKA, 200Ah @ 24V
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.4 Hybrid Model S-2100 Parts List

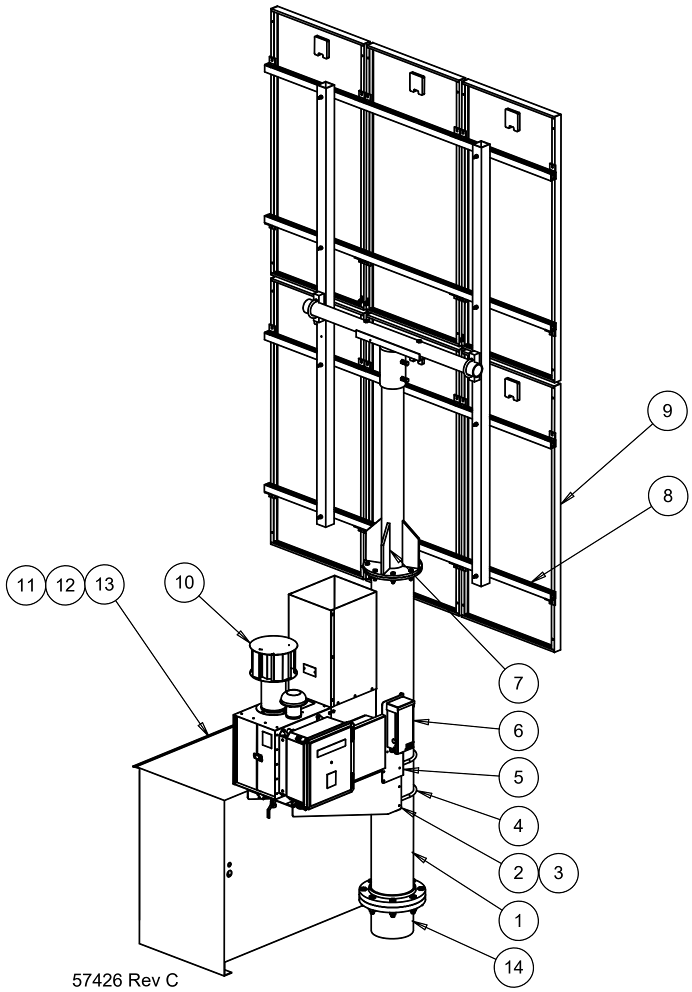


Figure 17-4 Hybrid Model S-2100

Item	Qty.	Part No.	Description
1	1	4900-56938	BASE POLE, 8” WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56978	U-BOLT, 8” PIPE, C/W NUTS / WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
6	1	6300-57046	COMBINER BOX ASSEMBLY, 3 BREAKER
7	1	4900-56933	TOP POLE, WELDMENT
8	1	4900-56818	MOUNT BRACKET, 2x3 SOLAR PANEL
9	6	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
10	1	9512-08052	HYBRID TEG, 5120, 24V, NATURAL GAS
10	1	9512-08053	HYBRID TEG, 5120, 24V, PROPANE
11	8	2400-56642	BATTERY, 12V GEL, 8G8DLTP-DEKA, 200Ah
12	1	4900-56698	ENCLOSURE, BATTERY, CDN, 8 X 8G8DLTP-DEKA
13	1	2400-56728	BATTERY INTERCONNECT KIT, 8 BAT. 24V
14	1	4900-57432	GROUND POLE, WELDMENT, 8”
Not Shown	3	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	3	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.5 Hybrid Model S-2150 Parts List

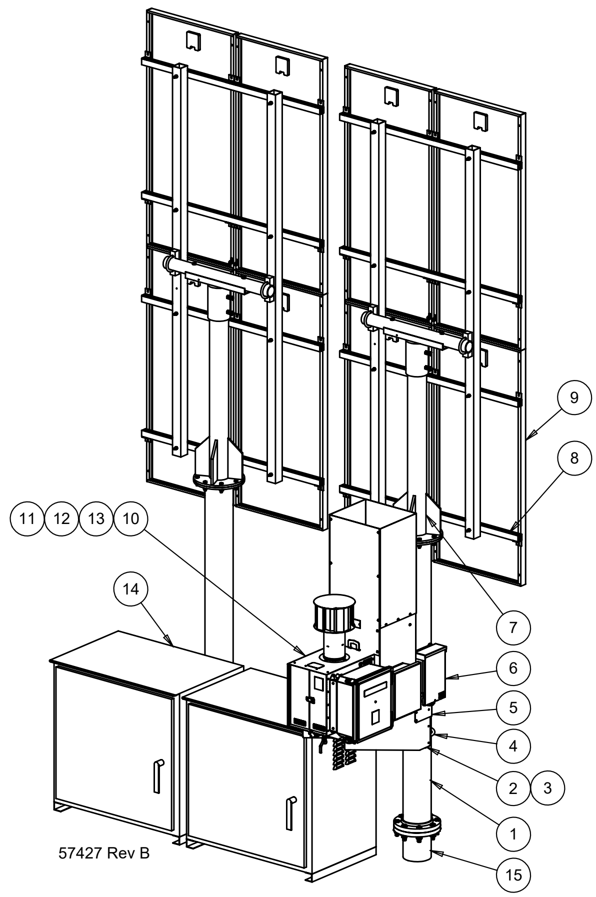


Figure 17-5 Hybrid Model S-2150

Item	Qty.	Part No.	Description
1	2	4900-56937	BASE POLE, 6” WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE, C/W NUTS / WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
6	1	6300-57047	COMBINER BOX ASSEMBLY, 4 BREAKER
7	1	4900-56933	TOP POLE, WELDMENT
8	2	4900-57089	MOUNT BRACKET, 2x2 SOLAR PANEL
9	8	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
10	1	9522-09552	HYBRID TEG, 5220, 24V, NATURAL GAS
10	1	9522-09553	HYBRID TEG, 5220, 24V, PROPANE
11	12	2400-56642	BATTERY, 12V GEL, 8G8DLTP-DEKA, 200Ah
12	2	4900-56696	ENCLOSURE, BATTERY, CDN, 6 X 8G8DLTP-DEKA
13	2	2400-56703	BATTERY INTERCONNECT KIT, 6 BAT. 24V
14	1	2400-57249	BATTERY INTERCONNECT KIT, 12 BAT. 24V
15	1	4900-57439	GROUND POLE, WELDMENT, 6”
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
Not Shown	2	4900-57244	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-57245	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 PLUG 1 END

17.6 Hybrid Model S-3025 Parts List

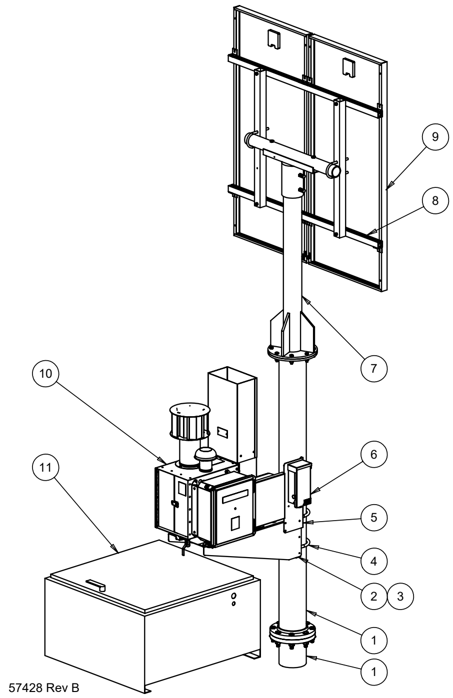


Figure 17-6 Hybrid Model S-3025

Item	Qty.	Part No.	Description
1	1	4900-56937	BASE POLE, 6”, WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE C/W NUTS/WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
7	1	4200-56933	TOP POLE, WELDMENT
8	1	4900-57091	MOUNT BRACKET, 2 SOLAR PANEL
9	2	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
12	1	4900-57439	GROUND POLE, WELDMENT, 6”
12 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 2 BREAKER
10	1	9560-08250	HYBRID TEG, 5060, 12V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 12V, PROPANE
11	1	4900-57241	BATTERY SYSTEM, 4 x 8G8DLTP-DEKA, 800Ah @ 12V
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
24 V SYSTEM			
6	1	6300-57044	COMBINER BOX ASSY, 1 BREAKER
10	1	9560-08252	HYBRID TEG, 5060, 24V, NATURAL GAS
10	1	9560-08253	HYBRID TEG, 5060, 24V, PROPANE
11	1	4900-56666	BATTERY SYSTEM, 4 x 8G8DLTP-DEKA, 400Ah @ 24V
Not Shown	1	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	1	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.7 Hybrid Model S-3050 Parts List

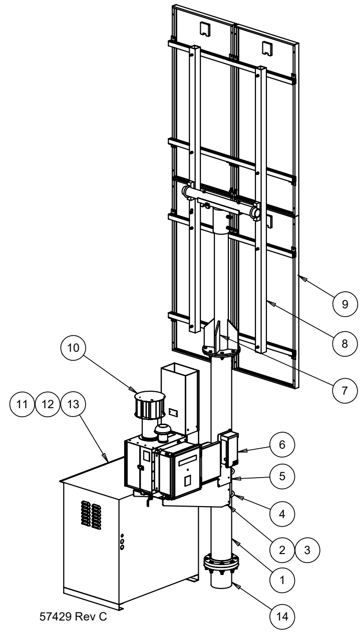


Figure 17-7 Hybrid Model S-3050

Item	Qty.	Part No.	Description
1	1	4900-56937	BASE POLE, 6”, WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE C/W NUTS/WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
7	1	4200-56933	TOP POLE, WELDMENT
8	1	4900-57089	MOUNT BRACKET, 2 x 2 SOLAR PANEL
9	2	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
11	6	2400-56642	BATTERY, 12V GEL,8G8DLTP-DEKA, 200Ah
12	1	4900-56696	ENCLOSURE, BATTERY, CDN, 6 x 8G8D
14	1	4900-57437	GROUND POLE, WELDMENT, 6”
12 V SYSTEM			
6	1	6300-57047	COMBINER BOX ASSY, 4 BREAKER
10	1	9560-08250	HYBRID TEG, 5060, 12V, NATURAL GAS
10	1	9560-08251	HYBRID TEG, 5060, 12V, PROPANE
13	1	4900-56664	BATTERY INTERCONNECT KIT, 6 BAT, 12 V
Not Shown	4	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	4	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END
24 V SYSTEM			
6	1	6300-57045	COMBINER BOX ASSY, 2 BREAKER
10	1	9560-08252	HYBRID TEG, 5060, 24V, NATURAL GAS
10	1	9560-08253	HYBRID TEG, 5060, 24V, PROPANE
Not Shown	2	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.8 Hybrid Model S-3075 Parts List

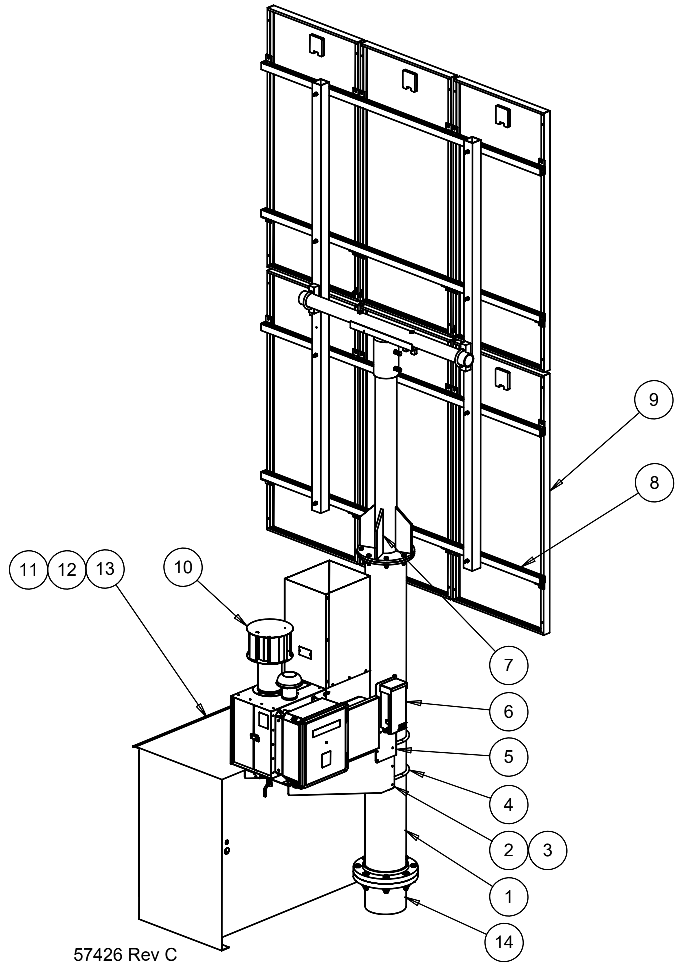


Figure 17-8 Hybrid Model S-3075

Item	Qty.	Part No.	Description
1	1	4900-56938	BASE POLE, 8” WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56978	U-BOLT, 8” PIPE, C/W NUTS / WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
6	1	6300-57046	COMBINER BOX ASSEMBLY, 3 BREAKER
7	1	4900-56933	TOP POLE, WELDMENT
8	1	4900-56818	MOUNT BRACKET, 2x3 SOLAR PANEL
9	6	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
10	1	9512-08052	HYBRID TEG, 5120, 24V, NATURAL GAS
10	1	9512-08053	HYBRID TEG, 5120, 24V, PROPANE
11	8	2400-56642	BATTERY, 12V GEL, 8G8DLTP-DEKA, 200Ah
12	1	4900-56698	ENCLOSURE, BATTERY, CDN, 8 X 8G8D
13	1	2400-56728	BATTERY INTERCONNECT KIT, 8 BAT. 24V
14	1	4900-57432	GROUND POLE, WELDMENT, 8”
Not Shown	3	4900-56704	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	3	4900-56705	CABLE ASSY, 13’XLPE, 10 GA, W/ MC4 PLUG 1 END

17.9 Hybrid Model S-3100 Parts List

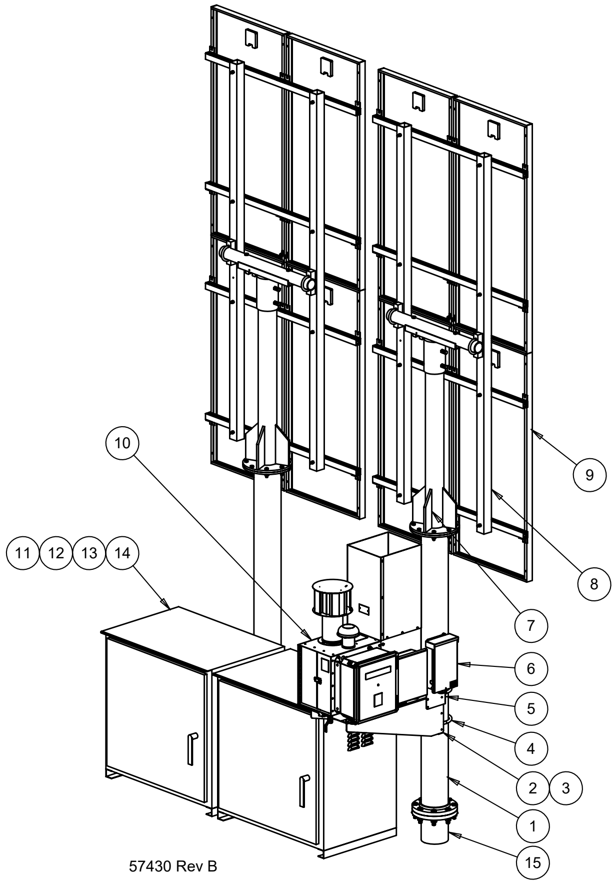


Figure 17-9 Hybrid Model S-3100

Item	Qty.	Part No.	Description
1	2	4900-56937	BASE POLE, 6” WELDMENT
2	1	4900-56977	MOUNTING BRACKET, TEG
3	1	4099-57100	MOUNT, TEG
4	2	2900-56976	U-BOLT, 6” PIPE, C/W NUTS / WASHERS
5	1	4900-57040	BRACKET, COMBINER BOX
6	1	6300-57047	COMBINER BOX ASSEMBLY, 4 BREAKER
7	1	4900-56933	TOP POLE, WELDMENT
8	2	4900-57089	MOUNT BRACKET, 2x2 SOLAR PANEL
9	8	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
10	1	9512-08052	HYBRID TEG, 5120, 24V, NATURAL GAS
10	1	9512-08053	HYBRID TEG, 5120, 24V, PROPANE
11	12	2400-56642	BATTERY, 12V GEL, 8G8DLTP-DEKA, 200Ah
12	2	4900-56696	ENCLOSURE, BATTERY, CDN, 6 X 8G8DLTP-DEKA
13	2	2400-56703	BATTERY INTERCONNECT KIT, 6 BAT. 24V
14	1	2400-57249	BATTERY INTERCONNECT KIT, 12 BAT. 24V
15	1	4900-57439	GROUND POLE, WELDMENT, 6”
Not Shown	2	4900-56704	CABLE ASSY, 15’XLPE, 10 GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-56705	CABLE ASSY, 15’XLPE, 10 GA, W/ MC4 PLUG 1 END
Not Shown	2	4900-57244	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 SOCKET 1 END
Not Shown	2	4900-57245	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 PLUG 1 END

17.10 Hybrid TEG Parts List - Model 5060

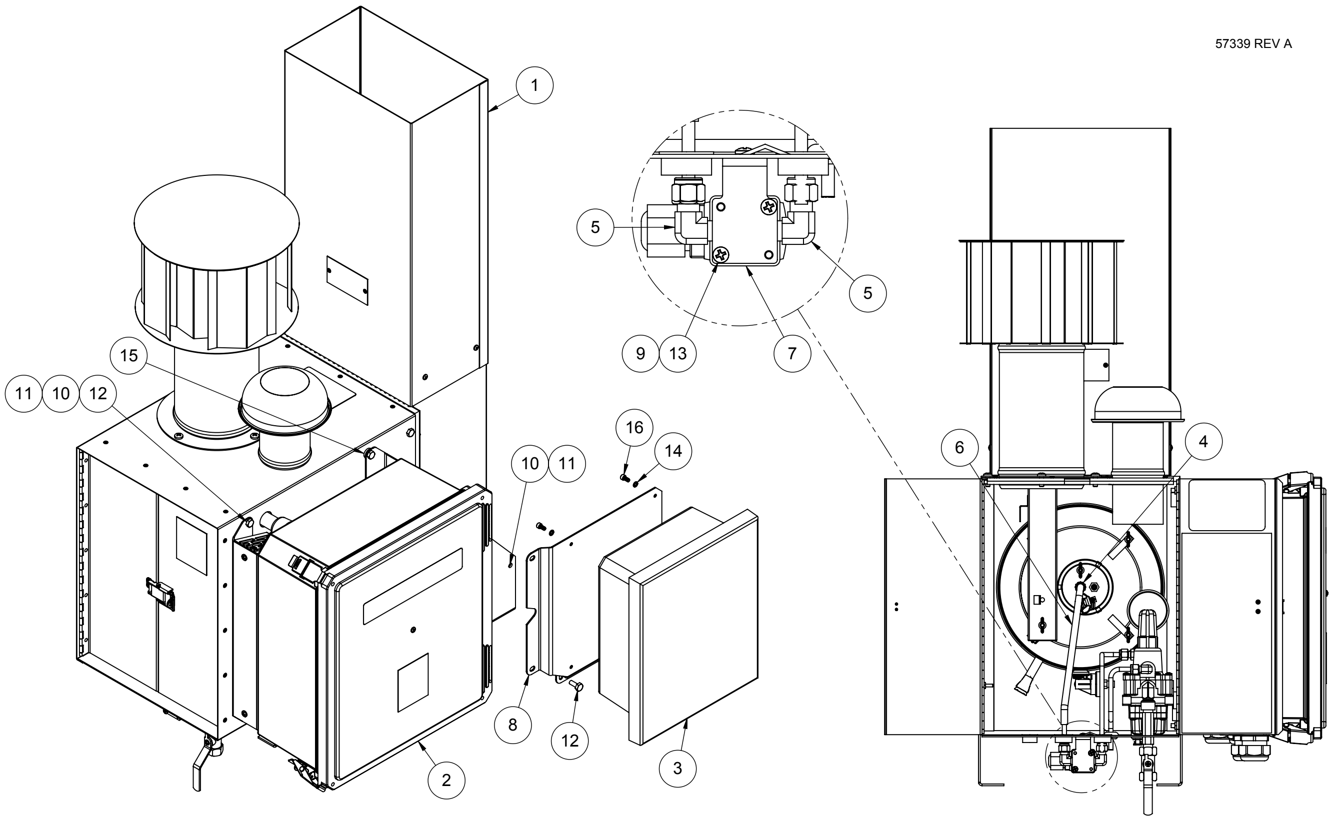


Figure 17-10 Hybrid TEG Parts List - Model 5060

Item	Qty.	Part No.	Description
1	1	6000-56643	5060 HYBRID, BASE TEG
2	1	6300-56708	CONTROL BOX ASSY, 12V, GLOBAL HYBRID
2	1	6300-56709	CONTROL BOX ASSY, 24V, GLOBAL HYBRID
3	1	6300-56866	JUNCTION BOX ASSY, GLOBAL HYBRID
4	1	4200-00688	ORIFICE, 6, 0.0185, 5060-N (NATURAL GAS)
4	1	4200-00686	ORIFICE, 4, 0.0145, 5060-L/5030-N (PROPANE)
5	2	3031-26518	ELBOW, 1/4 TB X 1/8 MNPT, SS
6	1	4200-05286	KIT, FUEL LINE, 10 IN.
7	1	3094-27927	VALVE, SOLENOID, 12VDC
7	1	3098-29354	VALVE, SOLENOID, 24VDC
8	1	4900-56993	BRACKET, JUNCTION BOX 5060/5120, GLOBAL HYBRID
9	2	2808-00538	WASHER, LOCK, SPRING, #8, SS
10	6	2814-00541	WASHER, LOCK, SPRING, 1/4, SS
11	6	2714-00611	NUT, HEX, 1/4-20, SS
12	6	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 X 5/8, SS
13	2	2508-23438	SCREW, MACH, P-H-P, M4 X 12MM, SS
14	4	2810-23540	WASHER, LOCK, SPRING, #10, SS
15	1	2814-56826	WASHER, FLAT, 1/4, 9/32 ID, 5/8 OD, 0.125 THK, 18-8 SS
16	4	2510-56827	SCREW, CAP, HEX SOCKET, 10-32, 0.375 LG, 18-8 SS

17.11 Hybrid TEG Parts List - Model 5120

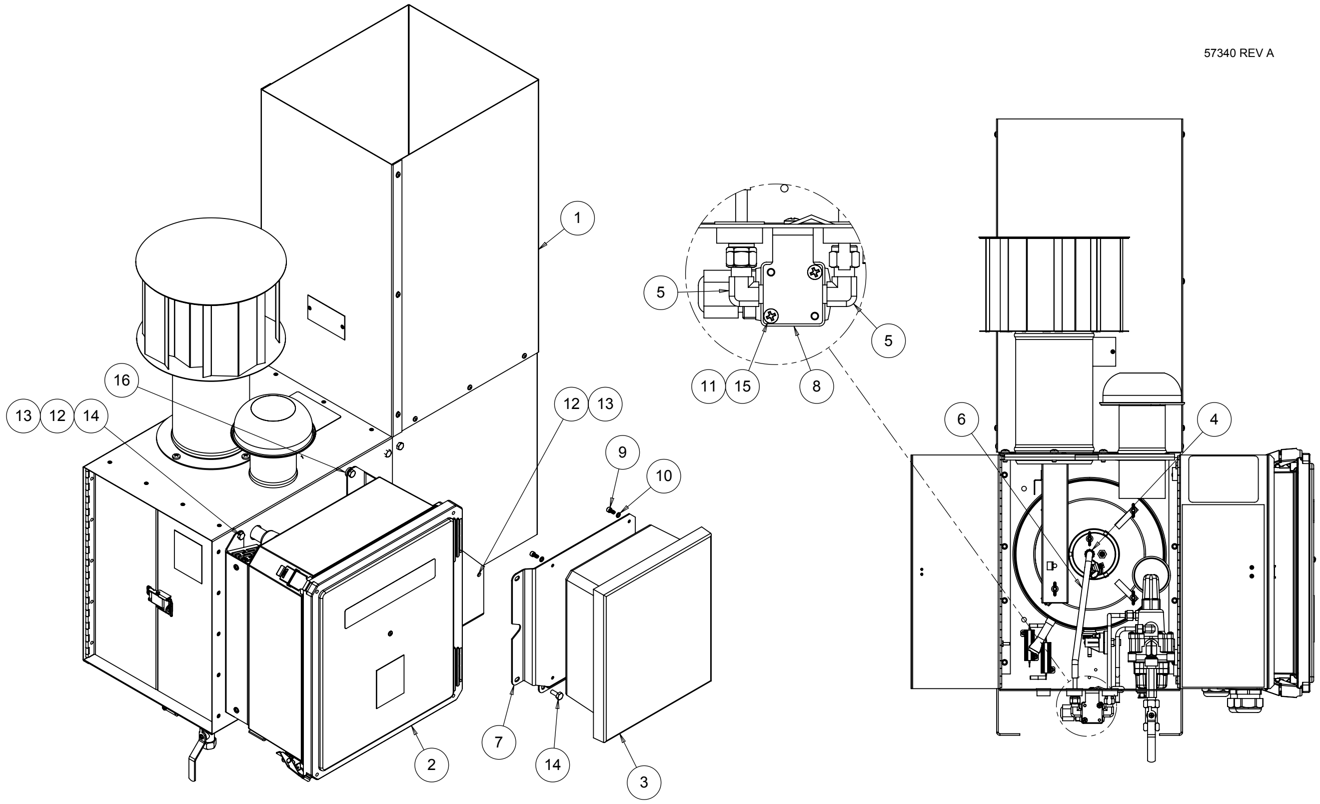


Figure 17-11 Hybrid TEG Parts List - Model 5120

Item	Qty.	Part No.	Description
1	1	6000-56735	5120 HYBRID, BASE TEG
2	1	6300-56708	CONTROL BOX ASSY, 12V GLOBAL HYBRID
2	1	6300-56709	CONTROL BOX ASSY, 24V GLOBAL HYBRID
3	1	6300-56866	JUNCTION BOX ASSY, GLOBAL HYBRID
4	1	4200-00690	ORIFICE, 0.029, 8, 5120-N & 5220-N (NATURAL GAS)
4	1	4200-00689	ORIFICE, 0.021, 7, 5120-L (PROPANE)
5	2	3031-26518	ELBOW, 1/4 TB X 1/8 MNPT, SS
6	1	4200-05286	KIT, FUEL LINE, 10 IN.
7	1	4900-56993	BRACKET, JUNCTION BOX 5060/5120, GLOBAL HYBRID
8	1	3094-27927	VALVE, SOLENOID, 12VDC
8	1	3098-29354	VALVE, SOLENOID, 24VDC
9	4	2510-56827	SCREW, CAP, HEX SOCET, 10-32, 0.375 LG, 18-8 SS
10	4	2810-23540	WASHER, LOCK, SPRING, #10, SS
11	2	2808-00538	WASHER, LOCK, SPRING, #8 SS
12	6	2814-00541	WASHER, LOCK, SPRING, 1/4, SS
13	6	2714-00611	NUT, HEX, 1/4-20, SS
14	6	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 X 5/8, SS
15	2	2508-23438	SCREW, MACH, P-H-P, M4 X 12MM, SS
16	1	2814-56826	WASHER, FLAT, 1/4, 9/32 ID, 5/8 OD, 0.125 THK, 18-8 SS

17.12 Hybrid TEG Parts List - Model 5220

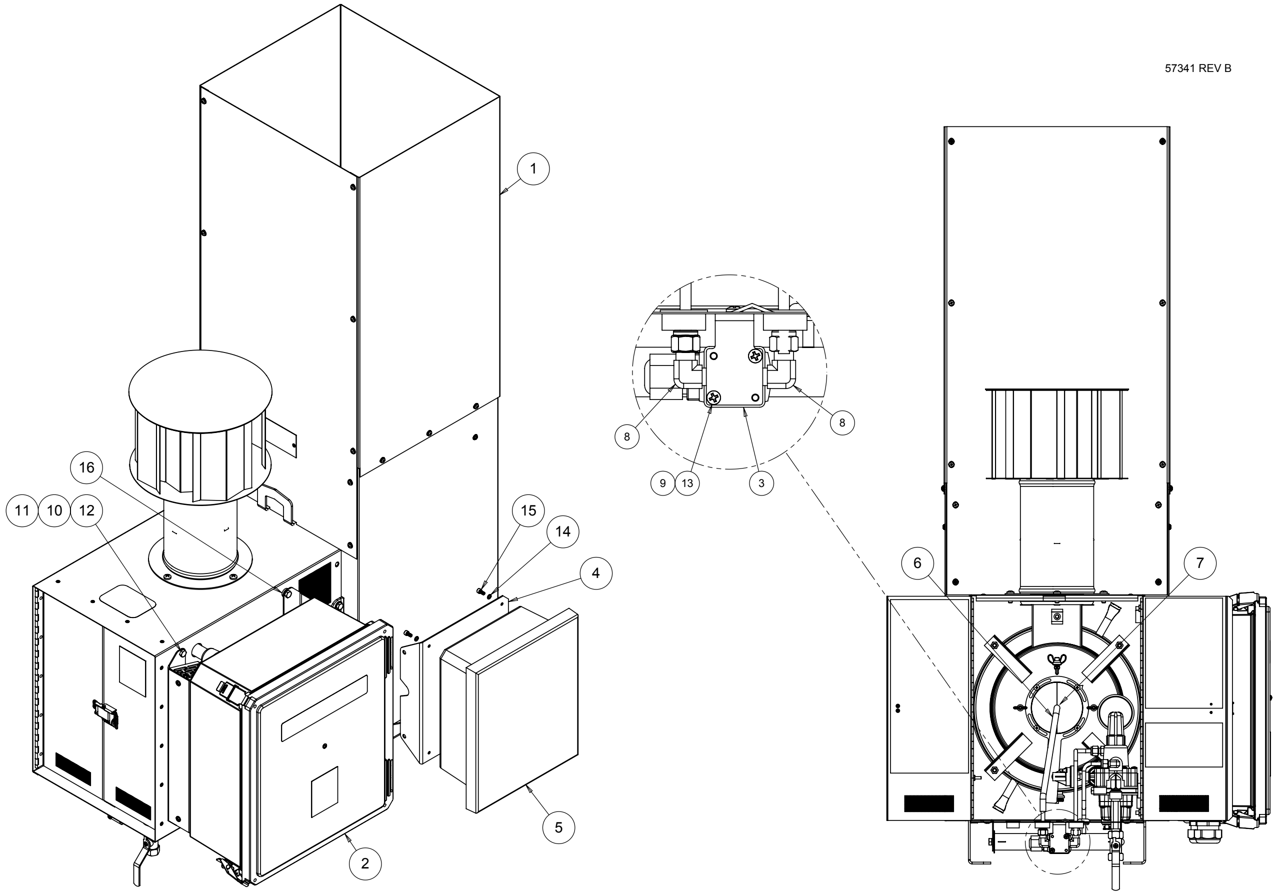


Figure 17-12 Hybrid TEG Parts Lists - Model 5220

Item	Qty.	Part No.	Description
1	1	6000-56645	5220 HYBRID, BASE TEG
2	1	6300-56706	CONTROL BOX ASSY, 24V, GLOBAL HYBRID
3	1	3098-29354	VALVE, SOLENOID, 24VDC
4	1	4900-57146	BRACKET, JUNCTION BOX, 5220, GLOBAL HYBRID
5	1	6300-56866	JUNCTION BOX ASSY, GLOBAL HYBRID
6	1	4200-05286	KIT, FUEL LINE, 10IN.
7	1	4200-00690	ORIFICE, 0.029, 8, 5120-N & 5220-N (NATURAL GAS)
7	1	4200-06251	ORIFICE, 10,0.024,5220-L (PROPANE)
8	2	3031-26518	ELBOW, 1/4 TB X 1/8 MNPT, SS
9	2	2808-00538	WASHER, LOCK, SPRING, #8, SS
10	4	2814-00541	WASHER, LOCK, SPRING, 1/4, SS
11	4	2714-00611	NUT, HEX, 1/4-20, SS
12	4	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 X 5/8, SS
13	2	2508-23438	SCREW, MACH, P-H-P, M4 X 12MM, SS
14	4	2810-23540	WASHER, LOCK, SPRING, #10, SS
15	4	2510-56827	SCREW, CAP, HEX SOCKET, 10-32, 0.375 LG, 18-8 SS
16	1	2814-56826	WASHER, FLAT, 1/4, 9/32 ID, 5/8 OD, 0.125 THK, 18-8 SS

17.13 Base TEG Parts List - Model 5060

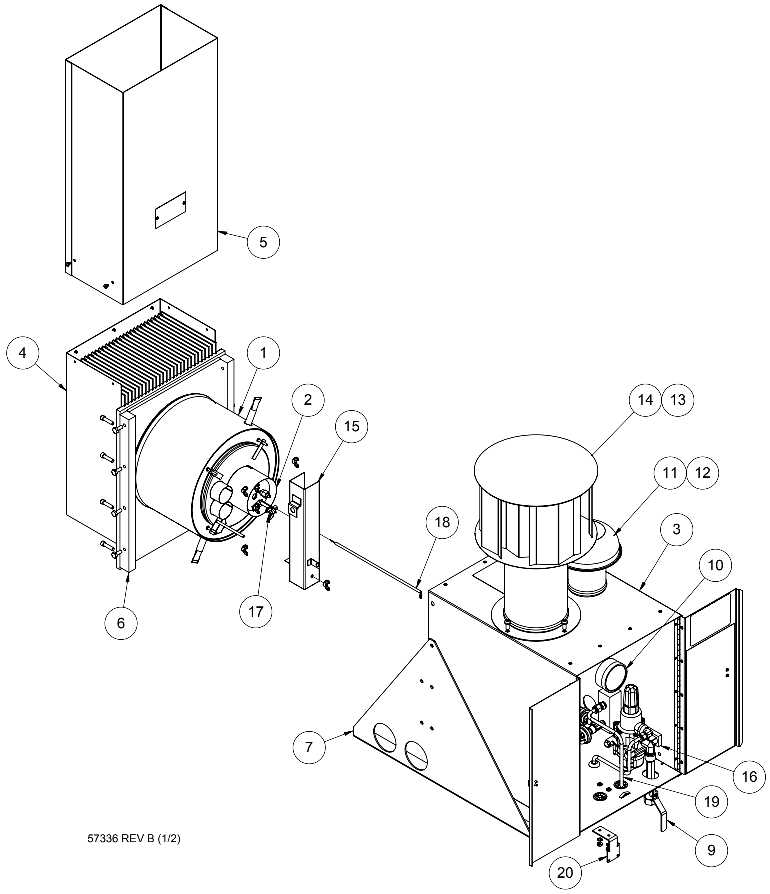


Figure 17-13 Base TEG Parts List - Model 5060

Item	Qty.	Part No.	Description
1	1	7900-08903	POWER UNIT, 5060
2	1	6100-29238	BURNER ASSY, TEG REMOTE START
3	1	6200-56749	CABINEY ASSY, 5060/5120 HYBRID
4	1	4100-00881	FIN DUCT, LOWER
5	1	4100-00882	FIN DUCT ASSY, UPPER
6	2	4900-00900	MOUNTING BAR
7	1	4100-01019	LEG, LEFT, 5120/5060
8	1	4100-56751	LEF, RIGHT, 5060/5120 HYBRID
9	1	3094-24653	VALVE, BALL, 1/4 NPT, BRASS CG/CSA/UL APP'D, 600# WOG
10	1	6400-56734	FUEL SYSTEM, 5060/5120 HYBRID
11	1	4500-01026	INTAKE STACK ASSY, 5120/5060
12	1	2900-01809	CLAMP, HOSE, TRIDON #HAS-48 SS
13	1	4500-28376	FLANGE, EXHAUST STACK, RAIN CAP
14	1	4500-51516	EXHAUST STACK ASSY, WITH RAIN CAP
15	1	4500-00979	EXHAUST STACK ASSY, INNER,5120/5060
16	1	4900-22372	SPACER, 3/8", FUEL SYSTEM W/CFR REGULATOR
17	1	4900-07004	PIN, MOUNTING, SI ELECTRODE
18	1	4900-58496	ELECTRODE ASSY, FLAME SENSING, SI
19	1	4200-27904	FUEL LINE, MANIFOLD, 5220
20	1	4200-27844	BRACKET, SOLENOID VALVE, 5120/5220

17.13 Base TEG Parts List - Model 5060

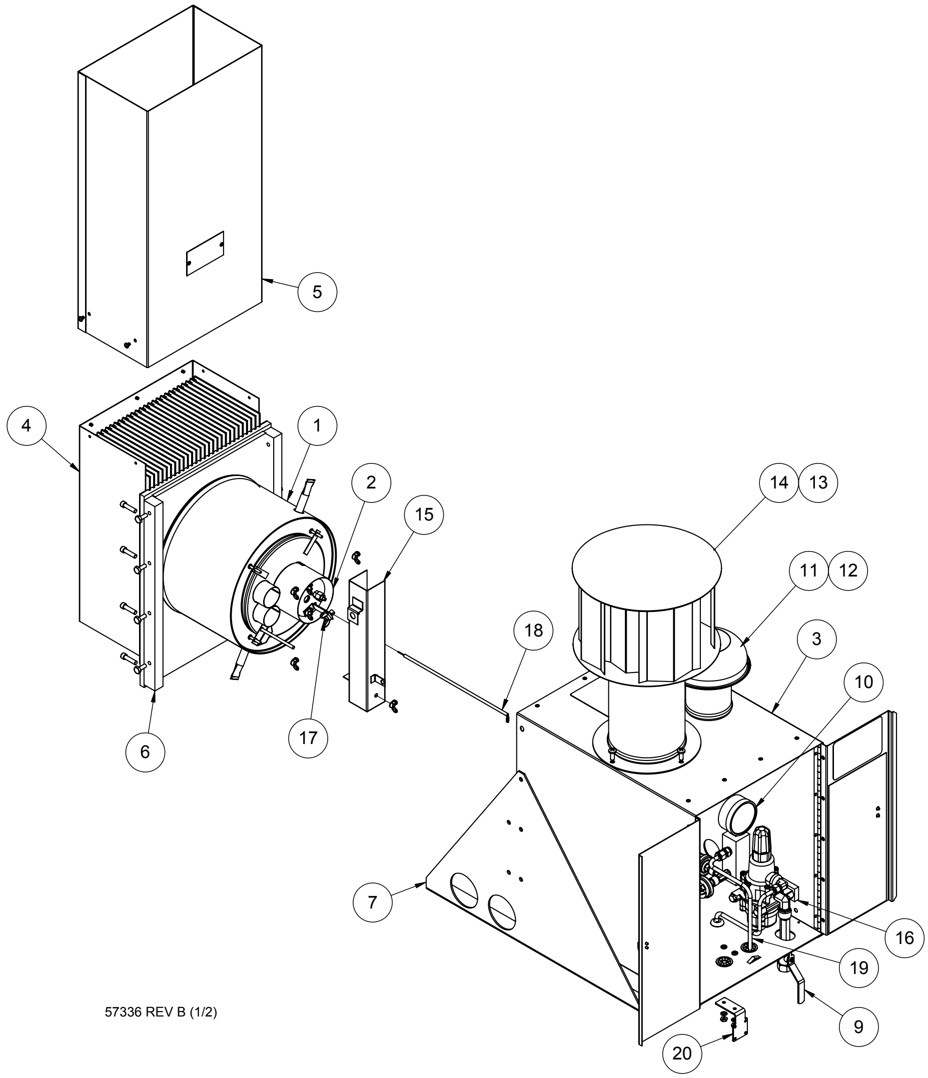


Figure 17-13 Base TEG Parts List - Model 5060

Item	Qty.	Part No.	Description
21	1	2756-07005	NUT, WING, 5/16-18, SS
22	2	2510-00255	SCREW, MACH, P-H-P, 10-32 X 3/8 SS
23	4	2514-00258	SCREW, MACH, P-H-P, 1/4-20 X 5/8, SS
24	8	2514-00267	SCREW, CAP, SOC, 1/4-20 X 1 SS
25	2	2808-00473	WASHER, LOCK, EXT. 1/4, SS
26	4	2814-00557	WASHER, FLAT, 1/4" SS
27	4	2708-00600	NUT, WING, 8-32, SS
28	1	2710-00601	NUT, WING, 10-32, SS
29	2	2710-00609	NUT, HEX, 10-32, SS
30	6	2714-00611	NUT, HEX, 1/4-20, SS
31	7	2508-07410	SCREW, MACH, P-H-P, 8-32 X 1/4, SS
32	8	2514-20535	SCREW, CAP, HEX-HD 1/4-20 x 5/8, SS
33	2	2514-22520	SCREW, HEX HD, 1/4-20 X 3.75" SS
34	2	2810-23437	WASHER, LOCK, EXT. #10, SS

17.14 Base TEG Parts List - Model 5120

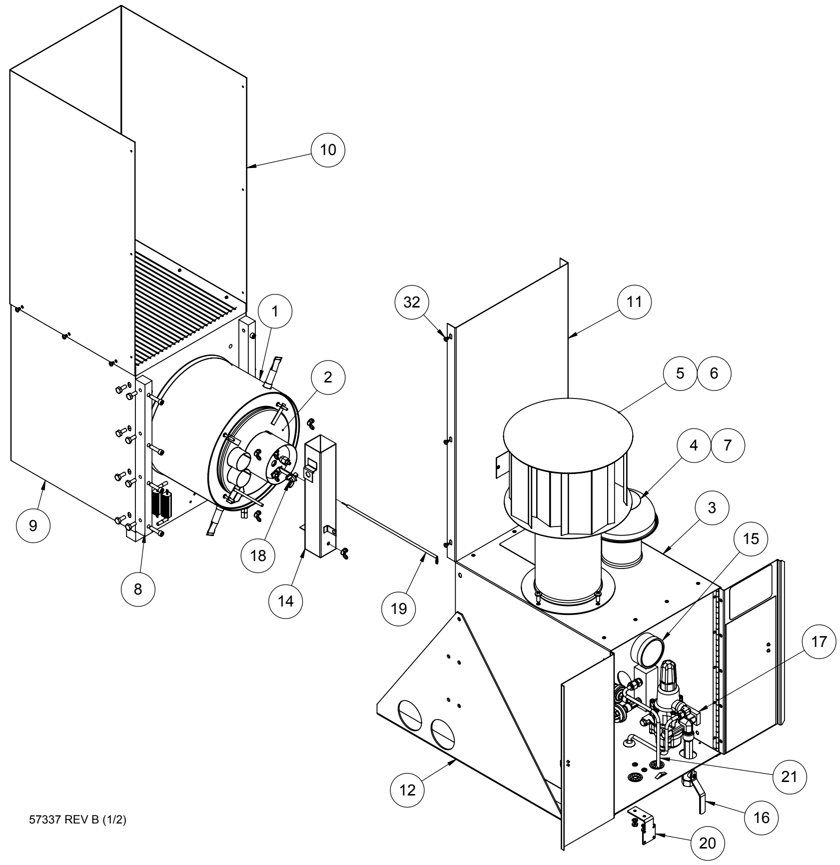


Figure 17-14 Base TEG Parts List - Model 5120

Item	Qty.	Part No.	Description
1	1	7900-08900	POWER UNIT, 5120
2	1	6100-27834	BURNER ASSY, 5120 REMOTE START
3	1	6200-56749	CABINET ASSY, 5060/5120 HYBRID
4	1	4500-01026	INTAKE STACK ASSY, 5120/5060
5	1	4500-51516	EXHAUST STACK ASSY, WITH RAIN CAP
6	1	4500-28376	FLANGE, EXHAUST STACK, RAIN CAP
7	1	2900-01809	CLAMP, HOSE, TRIDON #HAS-48 SS
8	2	4900-01028	MOUNTING BAR, 5120
9	1	4100-01035	FIN DUCT, LOWER, 15.2”, 5120
10	1	4100-01033	FIN DUCT, UPPER, 21.56”, 5120, 5220
11	1	4100-01029	COVER ASSY, UPPER, FIN DUCT, 5120
12	1	4100-01019	LEG, LEFT, 5120/5060
13	1	4100-56751	LEG, RIGHT, 5060/5120 HYBRID
14	1	4500-00979	EXHAUST STACK ASSY, INNER,5120/5060
15	1	6400-56734	FUEL SYSTEM, 5060/5120 HYBRID
16	1	3094-24653	VALVE, BALL, 1/4 NPT, BRASS CG/CSA/UL APP’D, 600# WOG
17	1	4900-22372	SPACER, 3/8”, FUEL SYSTEM W/CFR REGULATOR
18	1	4900-07004	PIN, MOUNTING, SI ELECTRODE
19	1	4900-58496	ELECTRODE ASSY, FLAME SENSING, SI
20	1	4200-27844	BRACKET, SOLENOID VALVE, 5120/5220
21	1	4200-27904	FUEL LINE, MANIFOLD, 5220

17.14 Base TEG Parts List - Model 5120

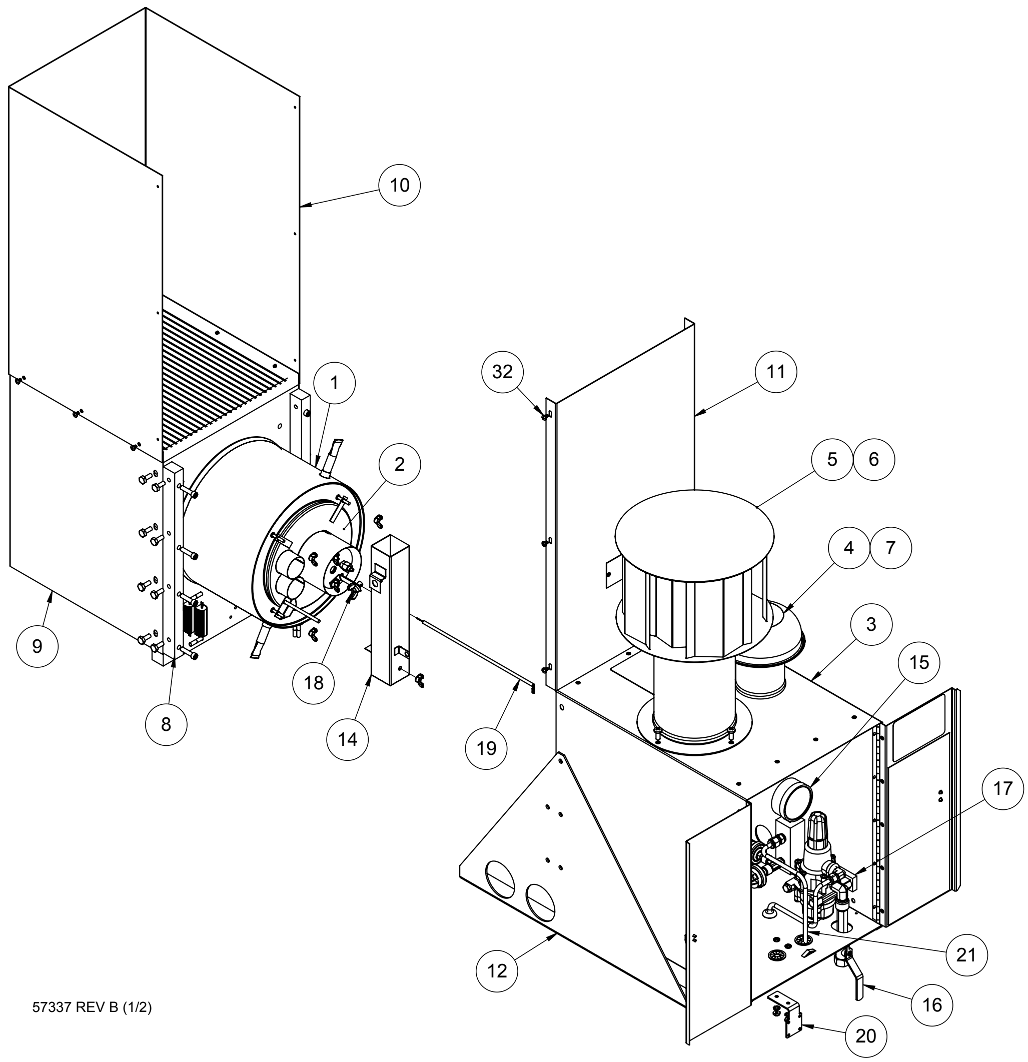


Figure 17-14 Base TEG Parts List - Model 5120

Item	Qty.	Part No.	Description
22	2	2510-00255	SCREW, MACH, P-H-P, 10-32 X 3/8 SS
23	4	2514-00258	SCREW, MACH, P-H-P, 1/4-20 X 5/8, SS
24	1	2756-07005	NUT, WING, 5/16-18, SS
25	2	2808-00473	WASHER, LOCK, EXT. 1/4, SS
26	4	2814-00557	WASHER, FLAT, 1/4" SS
27	4	2708-00600	NUT, WING, 8-32, SST
28	1	2710-00601	NUT, WING, 10-32, SST
29	2	2710-00609	NUT, HEX, 10-32, SS
30	6	2714-00611	NUT, HEX, 1/4-20, SS
31	8	2514-00677	SCREW, CAP, SOC, 1/4-20 X 1 1/2, SS
32	12	2508-07410	SCREW, MACH, P-H-P, 8-32 X 1/4, SS
33	16	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 x 5/8, SS
34	2	2810-23437	WASHER, LOCK, EXT. #10, SS
35	2	2514-22520	SCREW, HEX HD, 1/4-20 X 3.75" SS

17.15 Base TEG Parts List - Model 5220

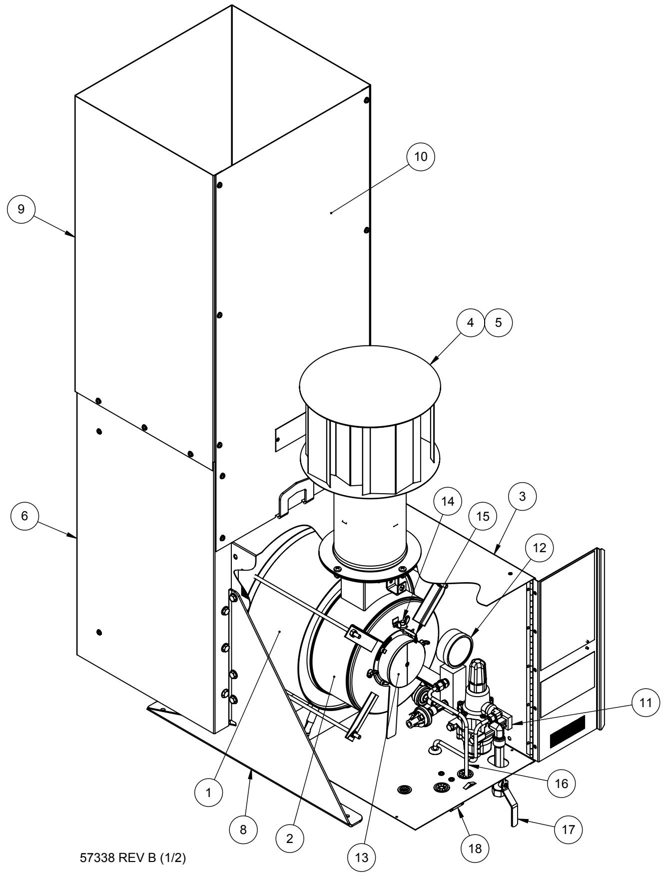


Figure 17-15 Base TEG Parts List - Model 5220

Item	Qty.	Part No.	Description
1	1	7900-08908	POWER UNIT, 5220, WIDE BODY
2	1	6100-27902	BURNER ASSY, PROFILED SHUTTER, 5220
3	1	6200-56831	CABINET ASSY, 5220 HYBRID
4	1	4500-51734	EXHAUST STACK ASSY, WITH RAIN CAP, 5220
5	1	4500-28376	FLANGE, EXHAUST STACK, RAIN CAP
6	1	4100-22947	FIN DUCT, LOWER, SS, 5220 WB
7	1	4100-56835	LEG, RIGHT, 5220 HYBRID
8	1	4100-22945	LEG, LEFT, 5220 WB
9	1	4100-22875	FIN DUCT, UPPER, SS, 5220 WB
10	1	4100-22906	COVER ASSY, UPPER FIN DUCT, 5220 WIDE BODY
11	1	4900-22372	SPACER, 3/8”, FUEL SYSTEM W/CFR REGULATOR
12	1	6400-56830	FUEL SYSTEM, 5220 HYBRID
13	1	4000-05586	AIR SCREEN ASSY, 5220, TCELL
14	1	4900-07004	PIN, MOUNTING, SI ELECTRODE
15	1	4900-58496	ELECTRODE ASSY, FLAME SENSING, SI
16	1	4200-27904	FUEL LINE, MANIFOLD, 5220
17	1	3094-24653	VALVE, BALL, 1/4 NPT, BRASS CG/CSA/UL APP’D, 600# WOG
18	1	4200-27844	BRACKET, SOLENOID VALVE, 5120/5220
19	1	4900-29082	LIFTING LUG, 5220

17.15 Base TEG Parts List - Model 5220

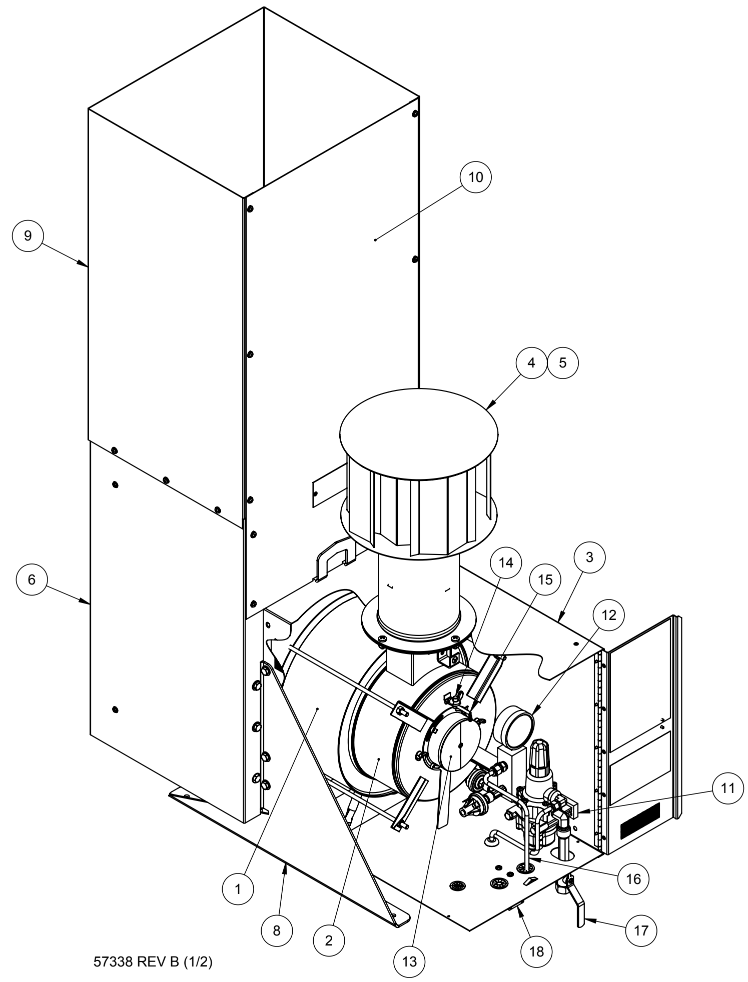


Figure 17-15 Base TEG Parts List - Model 5220

Item	Qty.	Part No.	Description
20	1	2756-07005	NUT, WING, 5/16-18, SS
21	2	2510-00255	SCREW, MACH, P-H-P, 10-32 X 3/8 SS
22	4	2514-00258	SCREW, MACH, P-H-P, 1/4-20 X 5/8, SS
23	21	2808-00472	WASHER, LOCK, EXT. #8, SS
24	2	2808-00473	WASHER, LOCK, EXT. 1/4, SS
25	16	2808-00553	WASHER, FLAT, #8, SST
26	16	2814-00557	WASHER, FLAT, 1/4” SS
27	2	2710-00609	NUT, HEX, 10-32, SS
28	10	2714-00611	NUT, HEX, 1/4-20, SS
29	4	2508-05047	SCREW, TRUSS-H-P, 8-32 X 3/8, SS
30	2	2856-05578	WASHER, Flat, 5/16, SS
31	4	2508-07324	SCREW, MACH, P-H-P, 8-32 X 1/2, SS
32	16	2508-07410	SCREW, MACH, P-H-P, 8-32 X 1/4, SS
33	12	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 x 5/8, SS
34	2	2514-22520	SCREW, HEX HD, 1/4-20 X 3.75” SS
35	2	2810-23437	WASHER, LOCK, EXT. #10, SS
36	2	2556-24485	SCREW, Cap, Hex HD, 5/16-18 UNC x 0.75, 316 SS

17.16 Burner Parts List - Model 5060

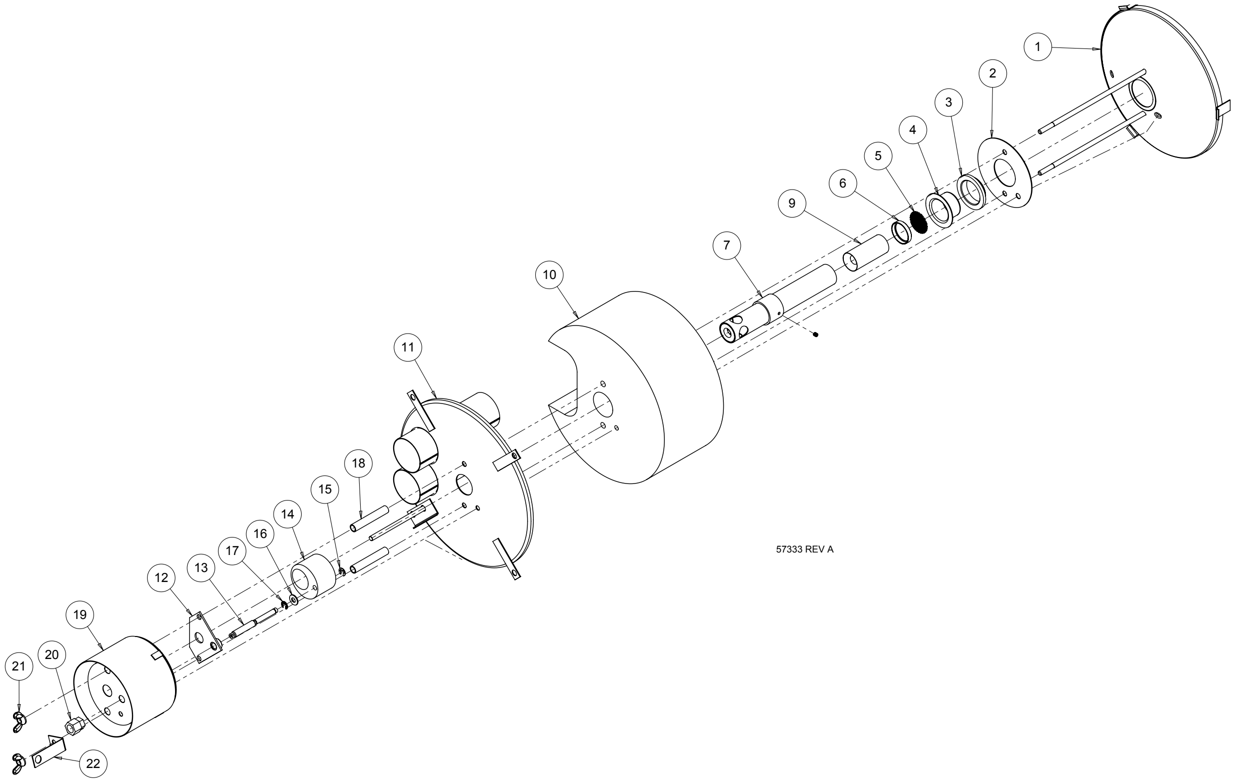


Figure 17-16 Burner Parts List - Model 5060

Item	Qty.	Part No.	Description
1	1	4000-24584	BURNER BACK ASSY, 5060, 5120
2	1	4000-24586	INSULATION SUPPORT, 5060
3	1	4000-00701	SPACER, INSULATION
4	1	4000-00693	SCREEN HOLDER, 5015/5030/5060/5120/1120
5	1	4000-01008	BURNER SCREEN ASSY, 5060/TCELL
6	1	4000-00694	INSERT RING, BURNER, 5120/5060/5030/1120
7	1	4000-00999	VENTURI TUBE HOLDER, 5120/5060
8	1	2506-00479	SCREW, SET, SOC-HD. 6-32 X 1/8, SS, CONE POINT
9	1	4000-00698	VENTURI, 5060, TCELL
10	1	4000-27856	INSULATION BLOCK, 5120
11	1	4000-27855	BURNER COVER ASSY, 5120
12	1	4000-00747	VENTURI PLATE ASSY, 5120/5060
13	1	4000-00700	VENTURI ADJUST SCREW 5120/5060/5030
14	1	4000-00990	AIR SHUTTER, 5120/5060/5030
15	1	2900-00549	RING, RETAINING, OPEN, SST, VEN PART# 39-5133-18-H
16	1	2810-00569	WASHER, FLAT, #10, SST
17	1	2900-07267	E-RING, BOWED, SS, SPAENAUR 251-802
18	2	4000-01005	SPACER, BURNER, 5120/5060
19	1	4000-27867	AIR STABILIZER ASSY, 5120
20	1	4000-00758	NUT, LOCK, VENTURI ADJ. SCREW
21	2	2710-00601	NUT, WING, 10-32, SST
22	1	4000-27835	BRACKET, IGNITOR MOUNT, 5120

17.17 Burner Parts List - Model 5120

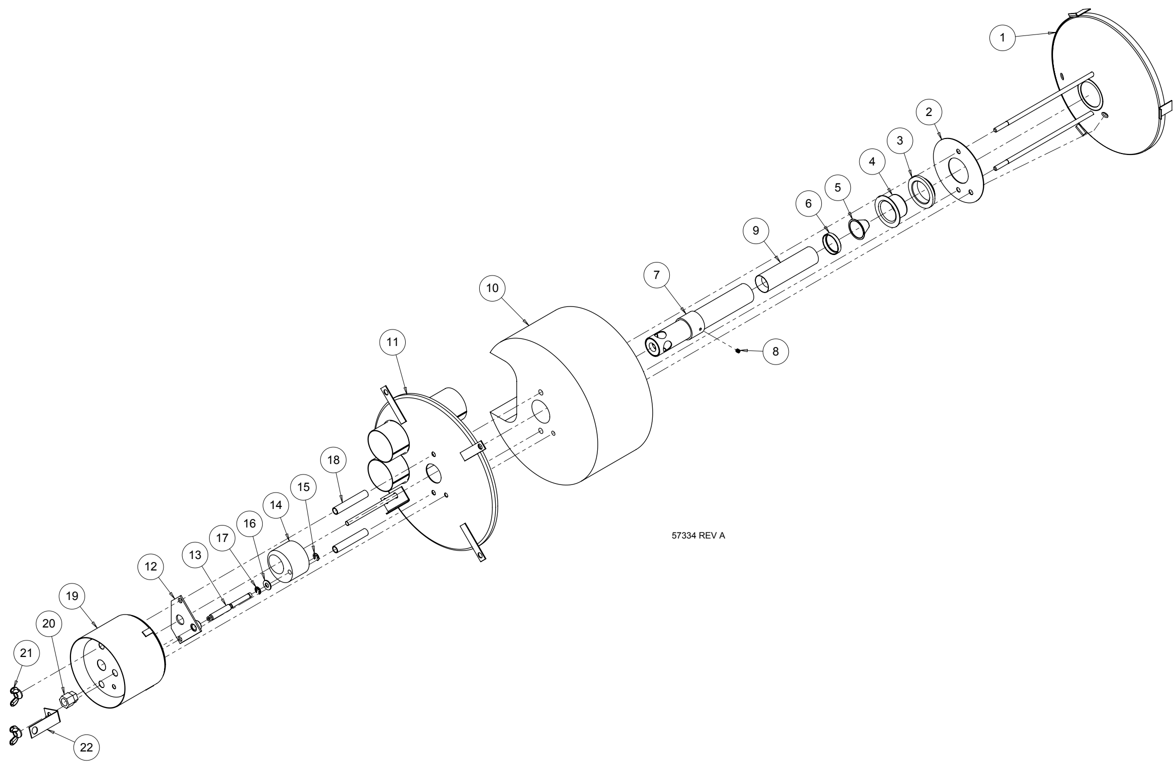


Figure 17-17 Burner Parts List - Model 5120

Item	Qty.	Part No.	Description
1	1	4000-24584	BURNER BACK ASSY, 5060, 5120
2	1	4000-24586	INSULATION SUPPORT, 5060
3	1	4000-00701	SPACER, INSULATION
4	1	4000-00693	SCREEN HOLDER, 5015/5030/5060/5120/1120
5	1	4000-00873	SCREEN, BURNER, 5120/1120
6	1	4000-00694	INSERT RING, BURNER, 5120/5060/5030/1120
7	1	4000-00999	VENTURI TUBE HOLDER, 5120/5060
8	1	2506-00479	SCREW, SET, SOC-HD. 6-32 X 1/8, SS, CONE POINT
9	1	4000-00971	VENTURI, 5120, 1120, TCELL
10	1	4000-27856	INSULATION BLOCK, 5120
11	1	4000-27855	BURNER COVER ASSY, 5120
12	1	4000-00747	VENTURI PLATE ASSY, 5120/5060
13	1	4000-00700	VENTURI ADJUST SCREW 5120/5060/5030
14	1	4000-00990	AIR SHUTTER, 5120/5060/5030
15	1	2900-00549	RING, RETAINING, OPEN, SST, VEN PART# 39-5133 18-H
16	1	2810-00569	WASHER, FLAT, #10, SST
17	1	2900-07267	E-RING, BOWED, SS, SPAENAUR 251-802
18	2	4000-01005	SPACER, BURNER, 5120/5060
19	1	4000-27867	AIR STABILIZER ASSY, 5120
20	1	4000-00758	NUT, LOCK, VENTURI ADJ. SCREW
21	2	2710-00601	NUT, WING, 10-32, SST
22	1	4000-27835	BRACKET, IGNITOR MOUNT, 5120

17.18 Burner Parts List - Model 5220

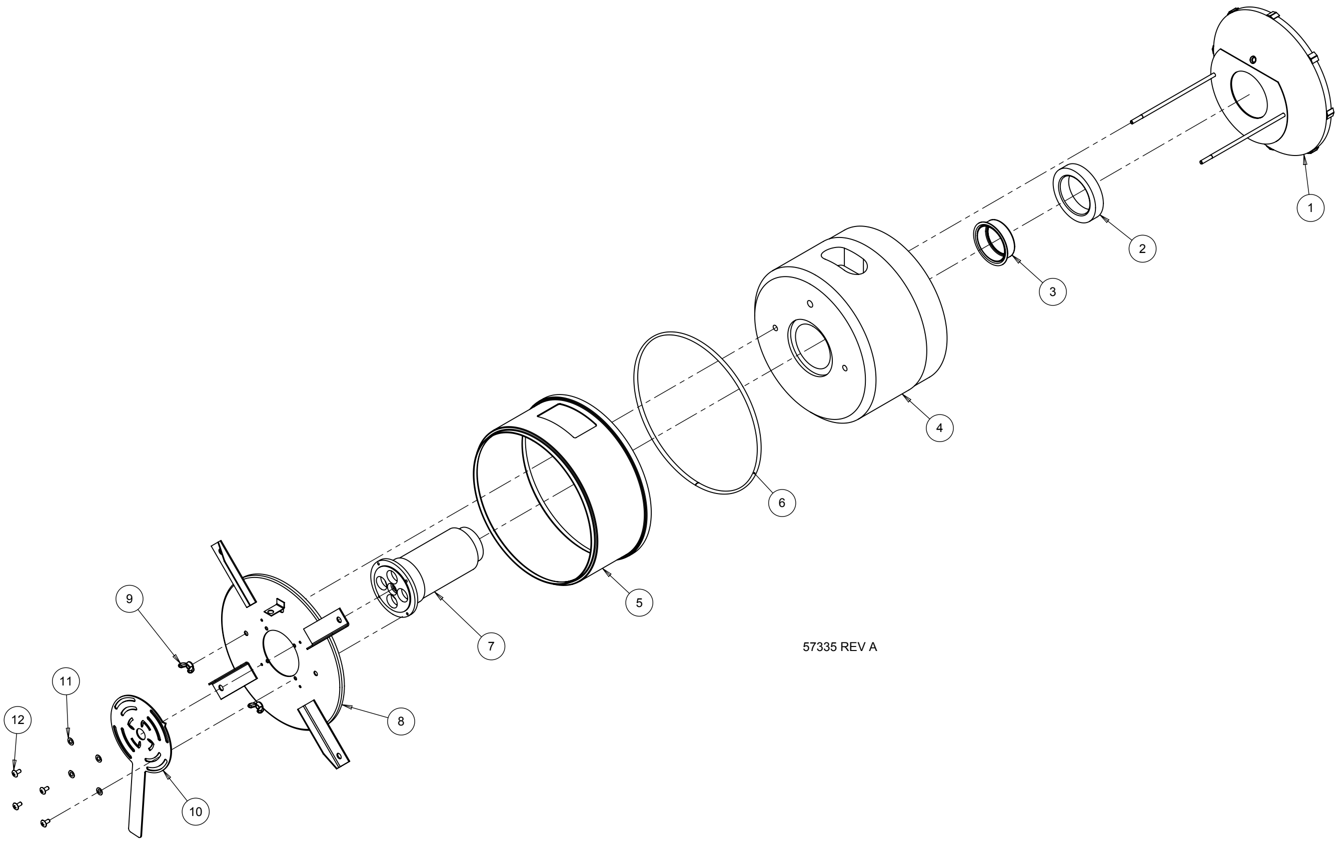


Figure 17-18 Burner Parts List - Model 5220

Item	Qty.	Part No.	Description
1	1	4000-05606	BURNER BACK ASSY 5220
2	1	4000-05605	HOLDER, SCREEN INSULATOR, 5220
3	1	4000-05390	BURNER SCREEN ASSY, 5220
4	1	4000-06086	INSULATION BLOCK, 5220
5	1	4000-06186	BURNER CAN, SHORT, MACHINED, 5220
6	1	4000-06631	ROPE, 1/4”, KAO-TEX 2000
7	1	4000-05375	VENTURI ASSY, 5220
8	1	4000-05378	BURNER TOP ASSY, 5220
9	2	2710-00601	NUT, WING, 10-32, SST
10	1	4000-27900	AIR SHUTTER, PROFILED, 5220
11	4	2810-27901	WASHER, BOWED, 5 MM, A2 SS, SPAENAUR 681-821
12	4	2508-05047	SCREW, TRUSS-H-P, 8-32 X 3/8, SS

17.19 Fuel System Parts List - Model 5060 / 5120

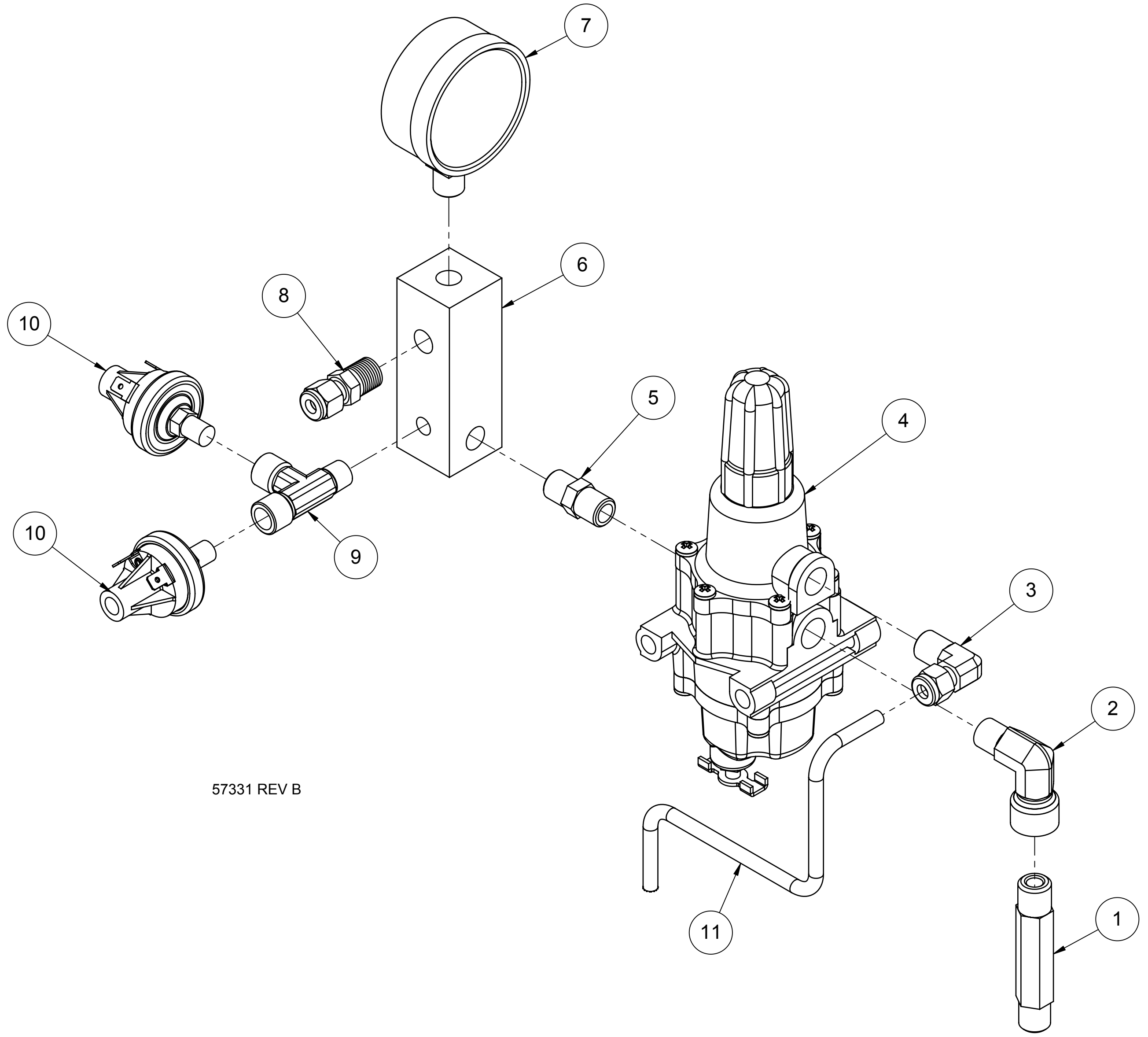


Figure 17-19 Fuel System Parts List - Model 5060 / 5120

Item	Qty.	Part No.	Description
1	1	3044-02154	NIPPLE, HEX, 1/4” X 3”, BRASS
2	1	3034-21569	ELBOW, STREET 1/4 NPT, B-4-SE
3	1	3031-20071	ELBOW, 1/4 TB X 1/4 MNPT, SS, SS-400-2-4
4	1	3100-63312	REGULATOR, FISHER 67CFR, 0-20 PSI, UL 144/ UL 252
5	1	3044-00501	NIPPLE, HEX, 1/4 NPT X 1 1/8, BRASS (FAIRVIEW)
6	1	4200-02100	MANIFOLD BLOCK, FUEL SYSTEM
7	1	3200-00691	GAUGE, PRESSURE, 0-15 PSI
8	1	3021-00380	CONNECTOR, 1/4 TB X 1/4 MNPT, 316 SS, SS-400-1-4
9	1	3074-23643	TEE, STREET, 1/8 NPT, BRASS, B-2-ST, or 107-A
10	2	3400-06471	SWITCH, PRESSURE 1.6 PSI, 76056-DB 1.6-0.5
11	1	4200-07981	VENT TUBE ASSY, REGULATOR, SS, 5060/5120/5220

17.20 Fuel System Parts List - Model 5220

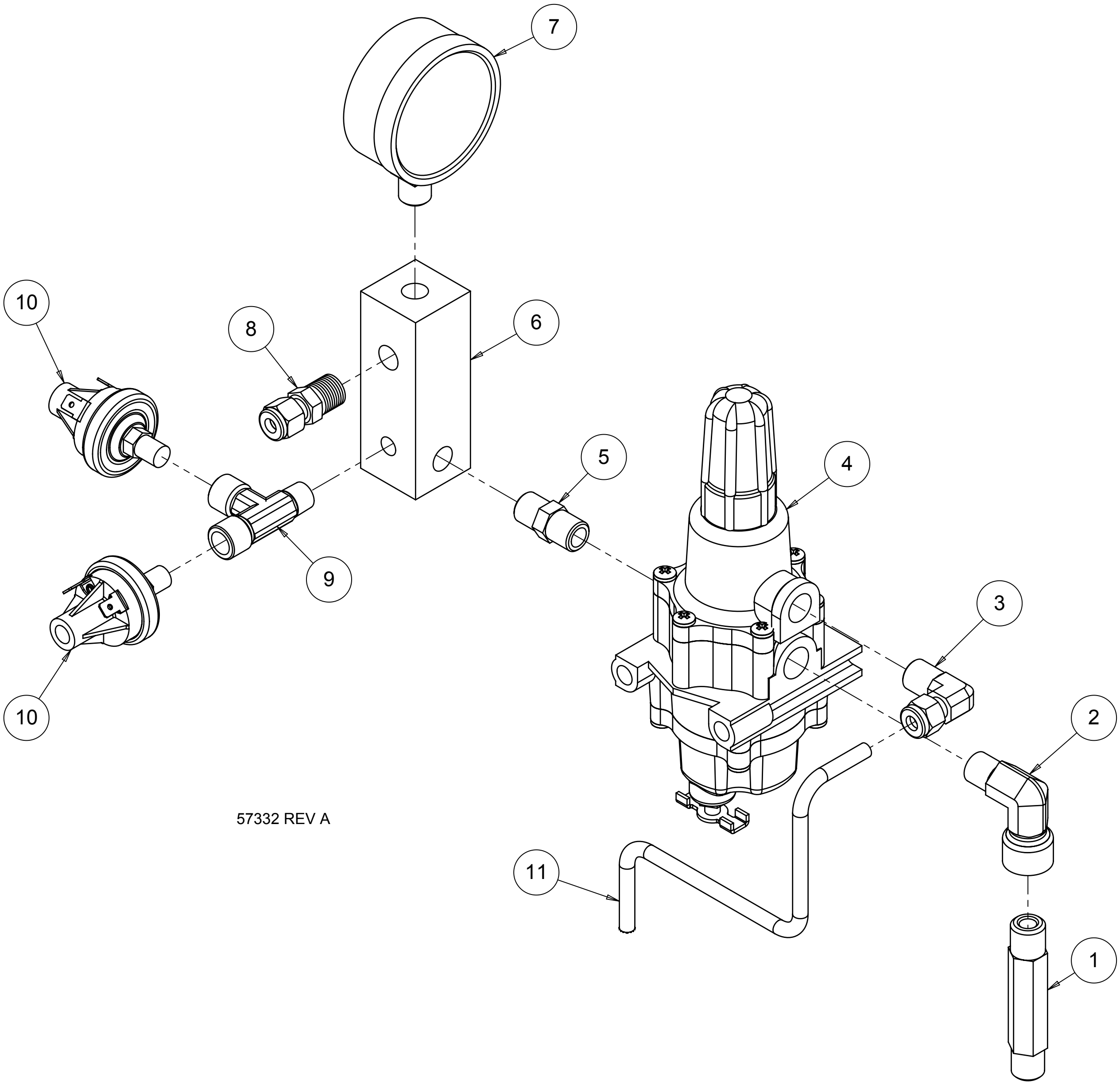


Figure 17-20 Fuel System Parts List - Model 5220

Item	Qty.	Part No.	Description
1	1	3044-02154	NIPPLE, HEX, 1/4” X 3”, BRASS
2	1	3034-21569	ELBOW, STREET 1/4 NPT, B-4-SE
3	1	3031-20071	ELBOW, 1/4 TB X 1/4 MNPT, SS, SS-400-2-4
4	1	3100-64104	REGULATOR, FISHER 67CFR, 0-35 PSI, UL144, UL252
5	1	3044-00501	NIPPLE, HEX, 1/4 NPT X 1 1/8, BRASS (FAIRVIEW)
6	1	4200-02100	MANIFOLD BLOCK, FUEL SYSTEM
7	1	3200-00406	GAUGE, PRESSURE, 0-30 PSI
8	1	3021-00380	CONNECTOR, 1/4 TB X 1/4 MNPT, 316 SS, SS-400-1-4
9	1	3074-23643	TEE, STREET, 1/8 NPT, BRASS, B-2-ST, or 107-A
10	2	3400-06471	SWITCH, PRESSURE 1.6 PSI, 76056-DB 1.6-0.5
11	1	4200-07981	VENT TUBE ASSY, REGULATOR, SS, 5060/5120/5220

17.21 Control Box Parts List

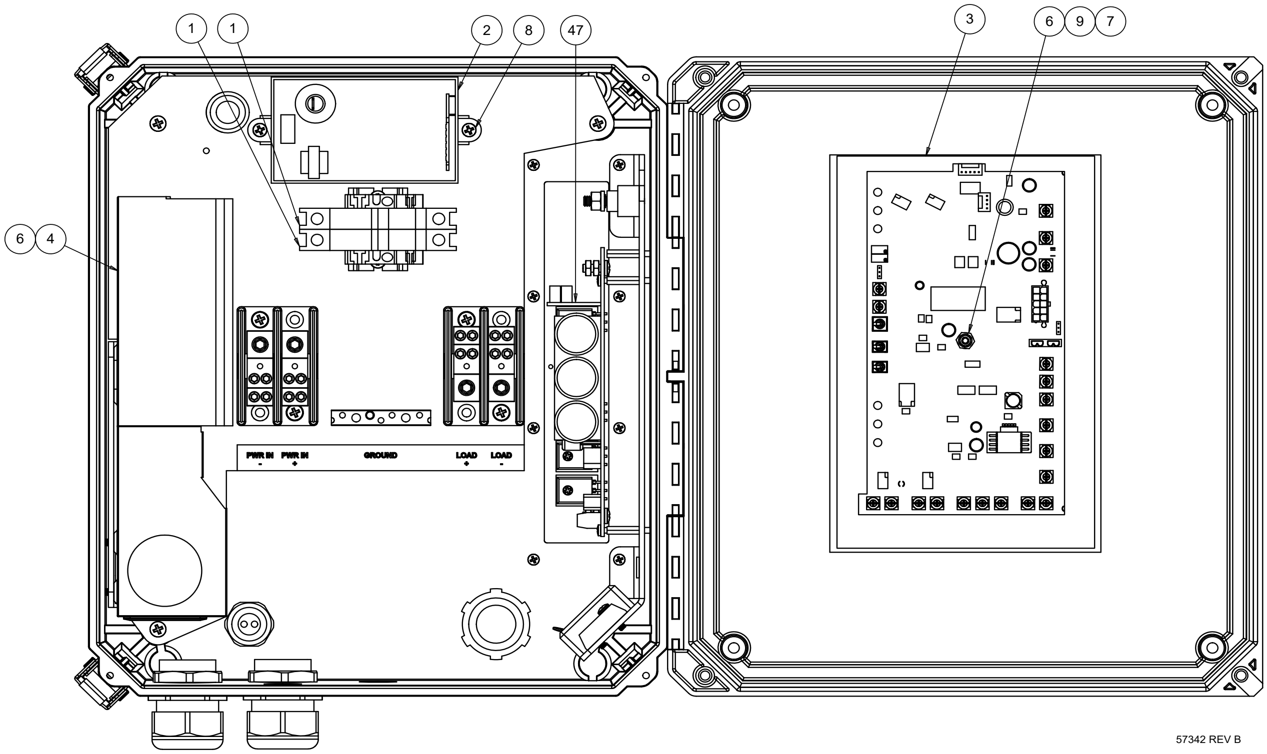


Figure 17-21 Control Box Parts List

Item	Qty.	Part No.	Description
1	2	2400-56865	CIRCUIT BREAKER, 20A, 150VDC, MIDNITE SOLAR MNEPV20
2	1	2400-63096	SI BOARD ASSY,CHANNEL PRODUCTS, 2021-90, 50N-12-3-3-7,10-0-P23062
3	1	2400-56207	PCB ASSY, TEG CHARGE CONTROLLER, 12V, RS
3	1	2400-56208	PCB ASSY, TEG CHARGE CONTROLLER, 24V, RS
4	1	4900-29674	MAIN BOARD ASSY, 220 WATT LIMITER/CONVERTER
4	4	2400-52674	FET, ISOLATOR (REQUIRED WITH PART 4900-29674)
5	1	2400-55252	CHARGE CONTROLLER, SOLAR, TRISTAR 45
6	1	2708-56922	NUT, NYLOCK, 8-32, SS
7	6	2508-07410	SCREW, MACH, P-H-P, 8-32 X 1/4, SS
8	1	2808-00553	WASHER, FLAT, #8, SST
9	2	2508-07324	SCREW, MACH, P-H-P, 8-32 X 1/2, SS
10	1	2508-07411	SCREW, MACH, P-H-P, 8-32 x 1, SS

17.22 Junction (Breaker) Box Parts List

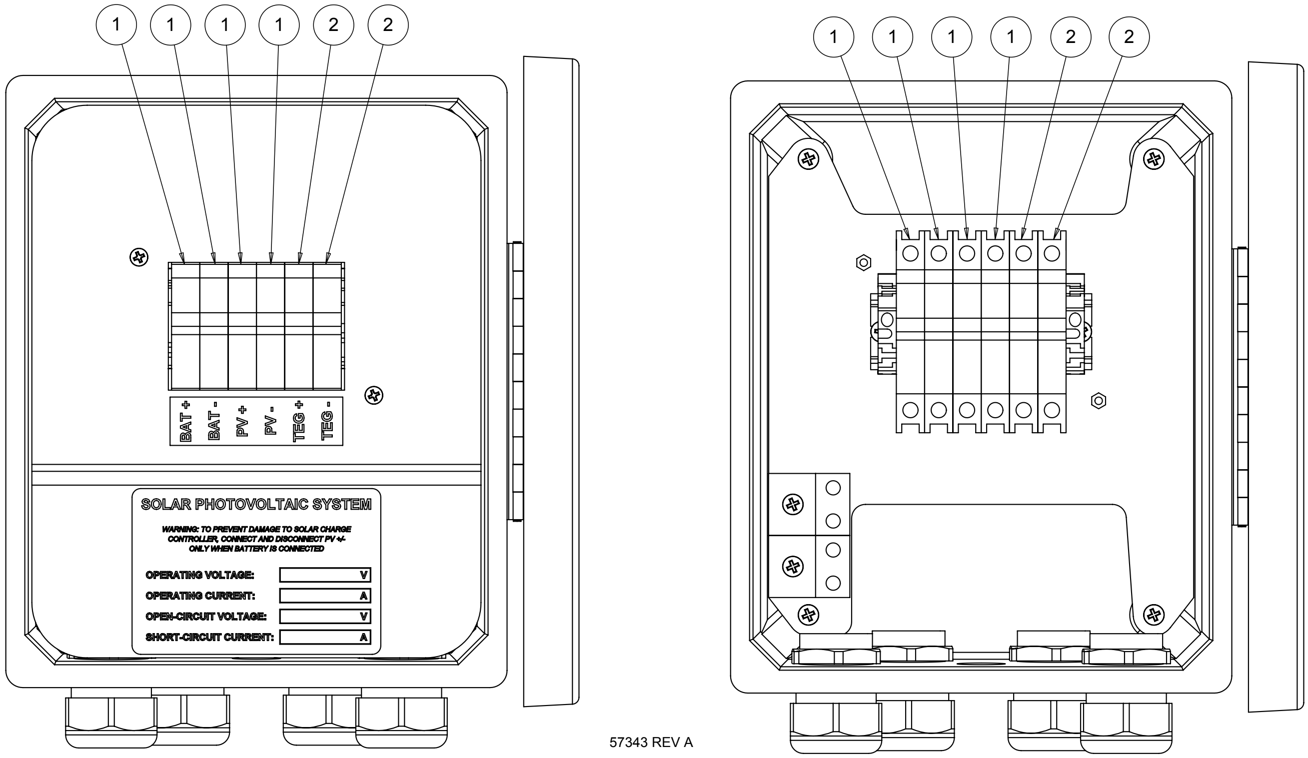


Figure 17-22 Junction (Breaker) Box Parts List

Item	Qty.	Part No.	Description
1	4	2400-57109	CIRCUIT BREAKER, 50A, 150VDC, MIDNITE SOLAR MNEPV50
2	2	2400-56865	CIRCUIT BREAKER, 20A, 150VDC, MIDNITE SOLAR MNEPV20

17.23 Solar Combiner Box Part List

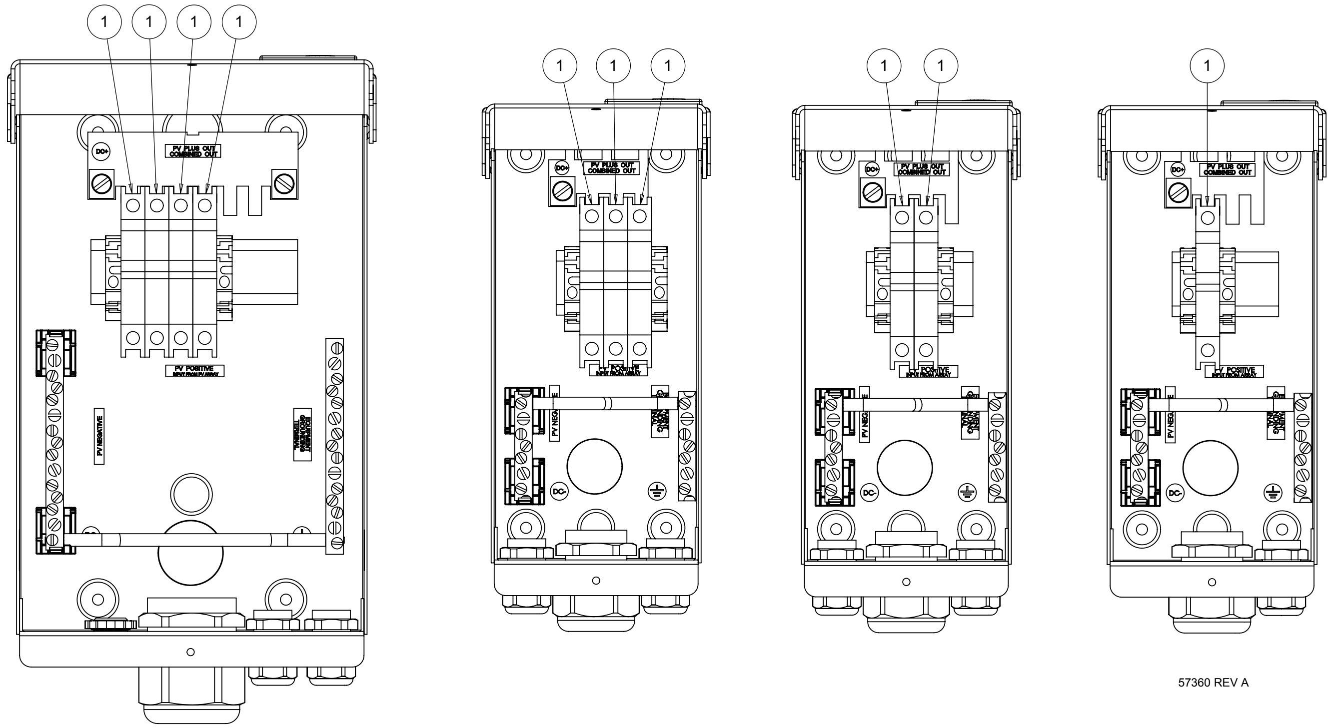


Figure 17-23 Solar Combiner Box Part List

Item	Qty.	Part No.	Description
1	4	2400-56865	CIRCUIT BREAKER, 20A, 150VDC, MIDNITE SOLAR MNEPV20
2	1	2108-57257	WIRE, 8 AWG, 7 STRAND, CSA RW90, 600V, GREEN, ECS RW08ST-04-LL, 5.75” LG
3	1	6300-57041	COMBINER BOX, 6 BREAKER, PV SYSTEMS, MIDNITE SOLAR-MNPV6
4	2	2400-23449	END BRACKET, DIN RAIL, EW35, WEIDMULLER 0383560000
5	4	2300-57048	STRAIN RELIEF, NYLON, 1/2” NPT, TWO 0.16-0.20” DIA CORDS, MCMASTER 7807K33
6	1	2300-57258	STRAIN RELIEF, NYLON, 1 1/4” NPT, 0.71-0.98” CABLE DIA, MCMASTER 69915K73
7	1	2900-57259	CABLE CONNECTOR, MULTICONDUCTOR, UL LISTED, 1/2” NPT, MCMASTER CARR 7798K41

17.24 Solar Components Part List

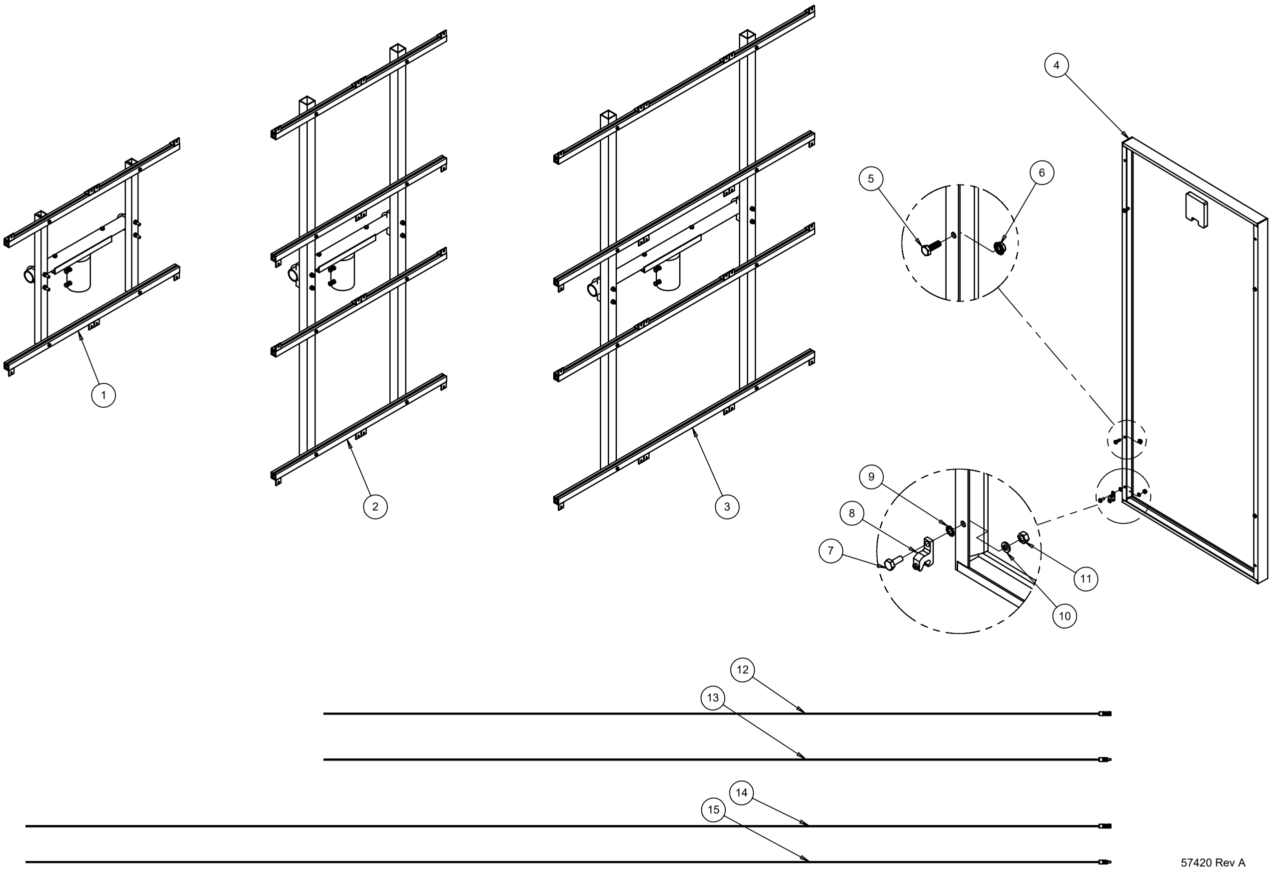


Figure 17-248 Solar Components Part List

Item	Qty.	Part No.	Description
1	1	4900-57091	MOUNT BRACKET, 2 SOLAR PANEL
2	1	4900-57089	MOUNT BRACKET, 2 x 2 SOLAR PANEL
3	1	4900-56818	MOUNT BRACKET, 2 x 3 SOLAR PANEL
4	1	4900-56686	PV PANEL, KYOCERA KD140GX-LFBS
5	4	----	INCL. WITH MOUNT BRACKET
6	4	----	INCL. WITH MOUNT BRACKET
7	1	2514-20535	SCREW, CAP, HEX-HD, 1/4-20 x 5/8, SS
8	1	2030-57095	LUG, GROUND, SOLAR PANEL
9	1	2814-20956	WASHER, LOCK, EXT, 1/4, 316SS
10	1	2814-00541	WASHER, LOCK, SPRING, 1/4, SS
11	1	2714-00611	NUT, HEX, 1/4-20, SS
12	1	4900-56704	CABLE ASSY, 13'XLPE, 10 GA, W/ MC4 SOCKET 1 END
13	1	4900-56705	CABLE ASSY, 13'XLPE, 10 GA, W/ MC4 PLUG 1 END
14	1	4900-57244	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 SOCKET 1 END
15	1	4900-57245	CABLE ASSY, LONG, XLPE, 10GA, W/ MC4 PLUG 1 END

17.25 Solar Panel Mounting Pole Parts List

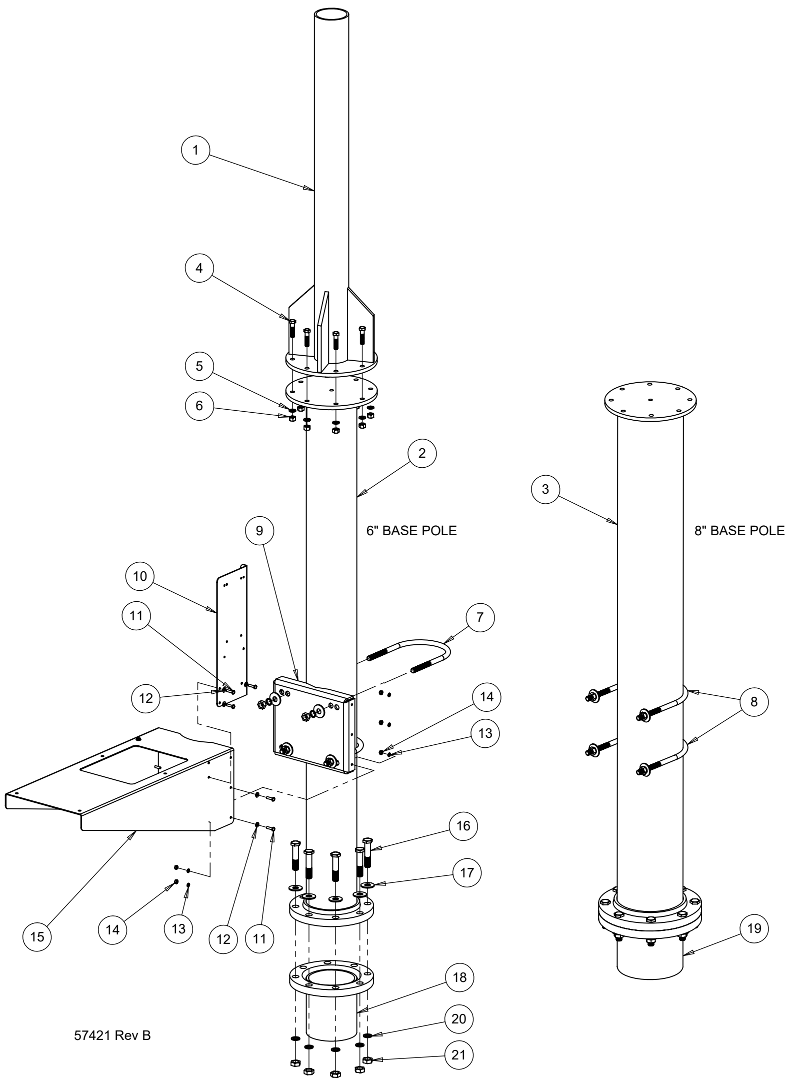


Figure 17-25 Solar Panel Mounting Pole Parts List

Item	Qty.	Part No.	Description
1	1	4900-56933	TOP POLE, WELDMENT, GLOBAL HYBRID
2	1	4900-56937	BASE POLE, 6”, WELDMENT
3	1	4900-56938	BASE POLE, 8”, WELDMENT
4	8	2508-56939	SCREW, HEX HD, 1/2 X 2, ZINC CHROMATE PLATE
5	8	2812-21853	WASHER, LOCK SPRING, 1/2, CAD/P
6	8	2712-29659	NUT, HEX, 1/2, CAD/P
7	2	2900-56976	U-BOLT, 6” PIPE, 5/8-11. C/W NUTS/WASHERS
8	1	2900-56978	U-BOLT, 8” PIPE, 5/8-11. C/W NUTS/WASHERS
9	1	4900-56977	TEG MOUNT, BASE, SOLAR HYBRID
10	1	4900-57040	BRACKET, COMBINER BOX, SOLARY HYBRID
11	9	2514-02413	SCREW, HEX-HD, 1/2-20 X 1, SS
12	9	2814-00557	WASHER, Flat, 1/4”, SS
13	11	2814-00541	WASHER, Lock, Spring, 1/4, SS
14	11	2714-00611	NUT, Hex, 1/4-20, SS

17.25 Solar Panel Mounting Pole Parts List

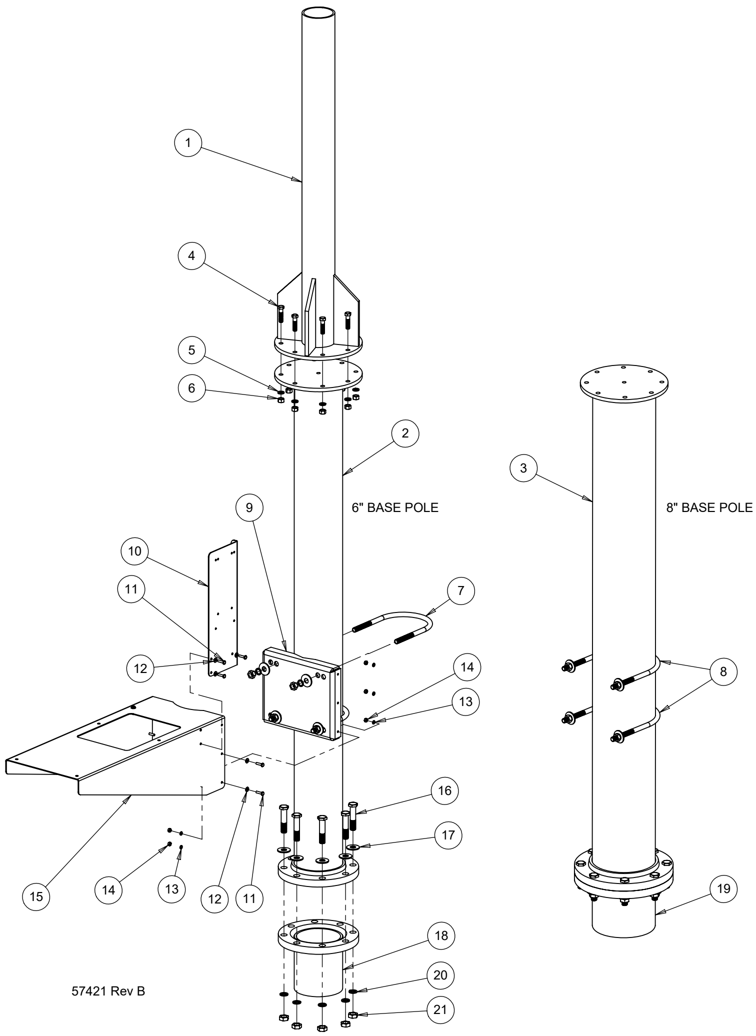


Figure 17-26 Solar Panel Mounting Pole Parts List

Item	Qty.	Part No.	Description
15	1	4900-57100	TEG MOUNT, BRACKET, SOLAR HYBRID
16	8	2534-57433	SCREW. HEX-HD, 3/4-10 X 3.5” LG GRADE 5, ZINC PLT
17	8	2834-57436	WASHER, FLAT, 3/4, ZINC PLT
18	1	4900-57439	GROUND POLE, 6”, WELDMENT, GLOBAL HYBRID
19	1	4900-57432	GROUND POLE, 8”, WELDMENT, GLOBAL HYBRID
20	8	2834-57437	WASHER, LOCK SPRING, 3/4, ZINC PLT
21	8	2734-57435	NUT, HEX, 3/4-10, GR 5, SINC PLT

17.26 Battery Cabinet Parts List

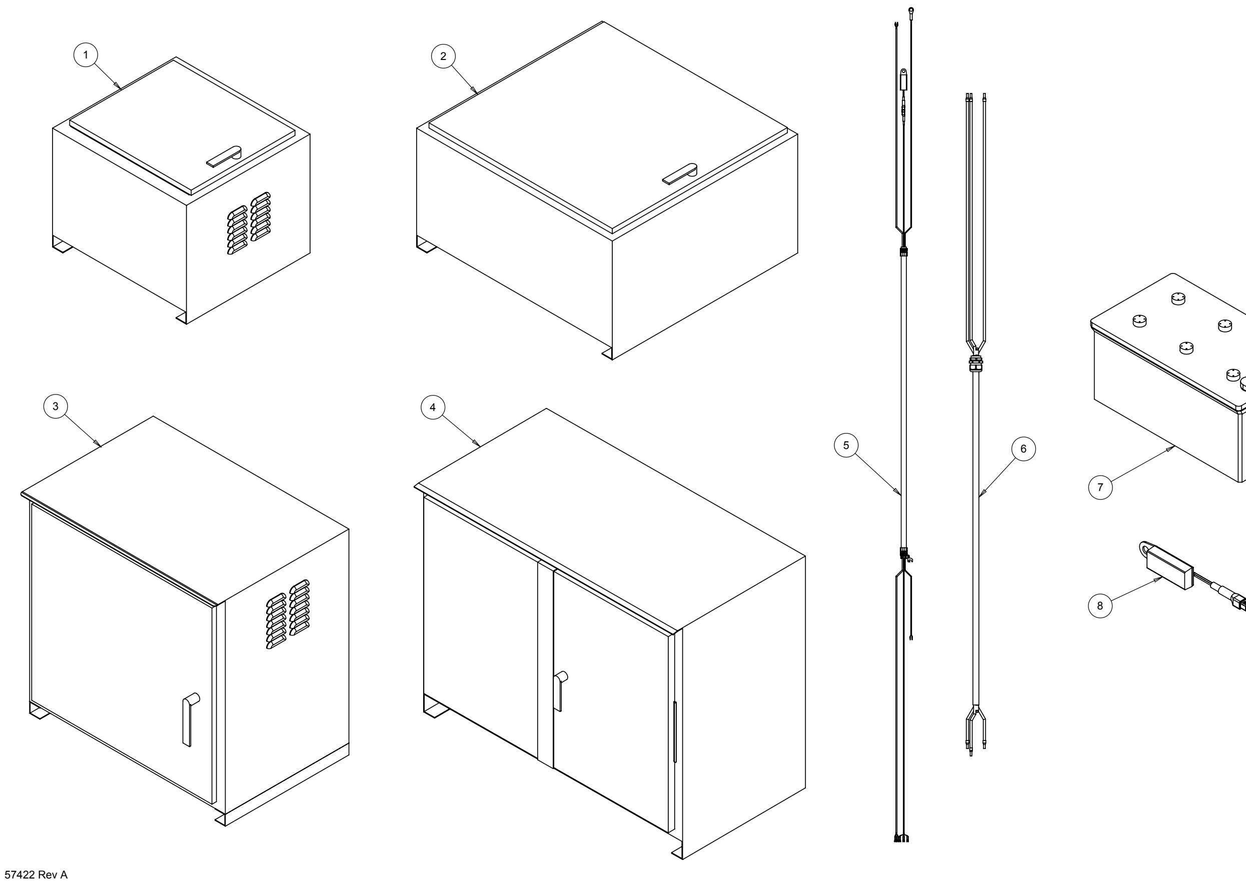


Figure 17-27 Battery Cabinet Parts List

Item	Qty.	Part No.	Description
1	1	4900-56692	ENCLOSURE, BATTERY, 2 X 8G8D
2	1	4900-56694	ENCLOSURE, BATTERY, 4 X 8G8D
3	1	4900-56696	ENCLOSURE, BATTERY, 6 X 8G8D
4	1	4900-56698	ENCLOSURE, BATTERY, 8 X 8G8D
5	1	4900-57151	CONDUIT ASSY, CONTROL BOX TO BATTERY BOX
6	1	4900-57113	CABLE ASSEMBLY, BATTERY BOX
7	1	2400-56642	BATTERY, 12V GEL, 200 AH
8	1	2400-56355	TEMPERATURE SENSOR, POTTED EDGE CONNECTOR, REMOTE START

18 TEG PERFORMANCE LOG

MODEL NO: ______________________________

TEG SERIAL NO: ______________________________

FUEL TYPE: ______________________________

LIMITER/CONVERTER SERIAL NO: ______________________________

DATE	TIME	AMBIENT TEMP °C	REQUIRED POWER (W)	REQUIRED V_{SET} (V)	MEASURED V_{SET} (V)	MEASURED POWER (W)	FUEL PRESSURE	OPEN CIRCUIT VOLTAGE (V)		MAINTENANCE REMARKS

19 BATTERY BANK PERFORMANCE LOG

HYBRID SYSTEM MODEL NO: ______________________________

DATE OF SYSTEM INSTALL: ______________________________

Date	Ambient Temp	Battery State	Battery Bank Voltage	Individual Battery Voltages											
				1	2	3	4	5	6	7	8	9	10	11	12

Battery State: Note if the battery bank is being charged, discharged or is isolated and sitting at rest.