Discover®

ENERGY STORAGE

SOPzS Flooded Tubular Plate Battery

Operating Manual

TUBULAR FLOODED SOPzS
12V BLOCK

REV A

Overview

Certain configuration, installations, service, and operating tasks should only be performed by qualified personnel in consultation with local utilities and/or authorized dealers. Qualified personnel should have training, knowledge, and experience in:

- Installing electrical equipment
- Applying applicable installation codes
- Analyzing and reducing hazards involved in performing electrical work
- Installing and configuring batteries

No responsibility is assumed by Discover for any consequences arising out of the use of this material.

Visit discoverbattery.com for the most recent version of published documents.

Read instructions carefully and place them close to the battery.

Use protective glasses, gloves and clothing when working on batteries. Always make safe working practices a priority.

No smoking. Do not expose batteries to flames, or sparks, as it may cause an explosion.

Clothing contaminated by acid should be washed in water.

Batteries with this symbol can be recycled.

Risk of explosion and fire. CAUTION: Battery terminals and connector are always under voltage. Do not place tools or other metal objects on the battery. Avoid short circuits!

Electrolyte is highly corrosive.

Batteries and cells are heavy. Ensure secure installation! Use only suitable handling equipment and lifting gear.

Dangerous Voltage!

Do not mix with other industrial or household waste. Contact your servicing Discover® dealer for proper battery return and recycling!

1. Safety

1.1 Do's

- Do protect terminals from short circuit before, during, and after installation
- Do wear electrically insulated gloves
- Do use electrically insulated tools
- Do wear eye protection
- Do wear safety toe boots / shoes
- Do read user manual for battery handling instructions
- Do secure battery safely
- Do have first aid kits and fire extinguishers easily accessible

1.2 Do Not's

- Do not operate or store battery outside of operating limits
- Do not short circuit battery
- Do not puncture battery
- Do not expose battery to flames, incinerate or electrostatic charge
- Do not disassemble battery
- Do not wear rings, watches, bracelets or necklaces when handling or working near battery
- Do not drop or crush battery
- Do not lift battery by the terminal cables
- Do not expose battery to water or other fluids
- Do not expose battery to direct sunlight
- Do not dispose of battery
- Do not connect with other types of batteries
- Do not expose battery to high temperatures

1.3 Sulfuric Acid

Batteries are safe when used properly. However, they contain sulfuric acid (H2SO4), which is extremely corrosive and can cause serious injury.

If sulfuric acid comes in contact with the skin:

- Remove contaminated clothing immediately.
- Dab off acid using a cotton or paper towel; do not rub.
- Rinse affected area of skin carefully using plenty of water.
- After rinsing, wash the area using soap.
- Avoid making contact with the affected areas of the skin.
- If necessary, contact a doctor.

If sulfuric acid comes in contact with your eyes:

- Carefully wash the affected eye with large quantities of water for 15 minutes (using running water or eye rinsing bottle).
- Avoid using high water pressure.
- Always contact an eye doctor immediately.

If sulfuric acid comes in contact with clothing or other material, immediately:

- Remove contaminated clothing.
- Wash clothing in sodium bicarbonate solution (bicarbonate or baking soda).
- When bubbles stop forming, rinse using clean water.

If electrolyte spills:

- Fix acid using a binding material such as sand and neutralize it using calcium carbonate, sodium carbonate or sodium hydroxide
- Dispose of the acid according to the official, local regulations
- Do not allow acid to escape into the sewage system, soil or water-
- The following table contains a list of chemicals recommended for neutralizing electrolyte in an approved system:

Nominal Electrolyte Density	Calcium Carbonate (kg) CaO	Sodium Carbonate (kg) Na_2CO_3	Sodium Hydroxide (l) NaOH 20% concentration	Sodium Hydroxide (l) NaOH 45% concentration
1.20 kg/l	0.19	0.36	1.36	0.6
1.24 kg/l	0.23	0.44	1.65	0.73
1.27 kg/l	0.26	0.5	1.88	0.83

Neutralization is complete when a pH value between 6 and 8 has been reached. If there is no suitable measuring device available, the degree of neutralization can be checked using common pH paper.

2. Delivery and Storage

2.1 Receiving Inspection

- Inspect for missing components.
- Check against the shipping/packing documents.
- Inspect each package or pallet for integrity and electrolyte leakage.
- Record receipt date and inspection data results, and notify your servicing dealer of any damage. Take photographs if necessary.

2.2 Storage

- If the battery cannot be immediately installer, store in a dry, clean, ventilated, cool and frost-free location.
- Do not expose batteries to direct sunlight as damage to the container and cover may occur.
- Do not stack pallets on top of each other. DO NOT store unpacked batteries on sharp-edged supports. Storage on a pallet and wrapped in plastic material (shrink wrap) is permitted except in rooms where the temperature fluctuates significantly, or when high relative humidity can cause condensation under the plastic. With time this condensation can cause a whitish hydration on the terminals and current leakage leading to high self-discharge.
- Protect the batteries from any risk of electric shock from short- circuiting poles/terminals with conductive objects or from the building up of conductive dust.
- Maintain the same storage conditions for all batteries within the same batch. Batteries are normally supplied charged. Depending upon storage conditions, storage time may be limited. In order to prevent batteries from becoming over discharged during storage do not store them for more than 3 months below 25°C/77°F, 2 months between 25°C/80°F to 35°C/95°F, or 1 month at 35°C/95°F before performing a re-fresh charge. Failure to observe these conditions may result in significantly reduced capacity and service life
- Record dates and conditions for all charges during storage.

2.3 Unpacking and Handling

- Never lift battery by the terminal posts. Lifting batteries heavier than 25 kg/55 lb should be made with lifting belts
- Never drag or roll the battery!
- The batteries are fully charged before shipment. Do not short circuit.
- Check for evidence of leakage. All batteries with visible defects should be rejected.

3. Installation and Commissioning Charge

3.1 Installation and Battery Room Design

- All electrical protective measures, devices, accommodation and ventilation of the battery installation area must be in accordance with all local rules and governmental regulations.
- The battery should be installed in a clean and dry area and protected against dropped items and dirt.

- Avoid placing the battery in a hot place or in direct sunlight.
- The location or arrangement of batteries should result in no greater temperature difference than 3°C/5°F between batteries within a connected string at any given time.
- Avoid conditions that result in spot heating or cooling, as temperature variations will cause electrical imbalances in the battery. For better cooling and temperature management ensure the installation allows for adequate air flow around each battery. Keep 10mm/0.5in distance between batteries.
- The layout of the battery room or installation area must allow for easy access to the batteries. The recommended minimum distance between battery rows is 1.5 times the depth of the row.
- Racks or cabinets shall be located 100mm/4in from the wall.
- Be sure to provide adequate space and lighting for inspection, maintenance, testing, and battery replacement. Space should also be provided to allow the operation of lifting equipment and for taking measurements (battery voltage and temperature) during service.

3.2 Batteries in Parallel Strings

Discover® Tubular Flooded batteries may be connected in parallel to increase capacity, current capability and/or discharge durations. In the case of each parallel connected string, only use batteries of the same voltage, capacity, design and age.

The resistance and ampacity of the cables or connector bars in each string must be the same, e.g. same cross-section, same length and same conductor type (copper, aluminum). In addition, each string should be equipped with disconnect capabilities (circuit breakers) for maintenance and safety purposes.

Discover® recommends a maximum of 4 strings parallel. If the following steps are fulfilled it is possible to have more strings in parallel without reducing battery life or batteries getting out of balance if the following requirements are fulfilled:

- The same voltage drop must be realized from each string to the end connection (load and ground). This can be achieved by proper choice of cable lengths, cable diameters and arrangement for crosswise connection configurations
- The connector cables for positive and negative terminals of each battery string must have the same length
- It is a must that each string has a manually operated switching device that also automatically opens or breaks the circuit in the event of an over current (circuit breaker).
- Each string must have the same number of batteries
- Each string must be exposed to the same heat or temperature potential.
- Always connect the individual series strings first and then check that the different strings are at the same potential before connecting them together on the bus.

Notes:

- The combined performance data of all of the batteries will be realized at the end pole/terminal of each string.
- Battery life or reliability will not be negatively affected if this form of paralleling is done correctly.
- Parallel connection of strings with different capacities as well as different ages is possible (the age and capacity of the batteries within each string must be the same).
- The current during both discharge and charge will be split according to the capacity or age of the batteries respectively.

3.3 Batteries in Series Strings

- Discover® Tubular Flooded batteries may be connected in series to increase system voltage.
- In the case of each series connected string, only use batteries of the same voltage, capacity, design and age.
- The resistance of the cables or connector bars in each string must be the same, e.g. same cross-section, same length and same conductor type (copper, aluminum).
- Each string should be equipped with disconnect capabilities (breakers) for maintenance and safety purposes.

3.4 Pre-installation Control

- Check batteries for evidence of leakage.
- All batteries with visible defects such as cracked jars or containers, loose terminal posts, or other unrecoverable problems shall be rejected.
- Before installation, in cases where the battery container is dirty, wipe with a water-moistened anti-static cloth only.

3.5 Electrical Connections

- Ensure that the batteries are installed and connected in the correct polarity.
- Check that all contact surfaces are clean. If required, clean poles/terminals with a brass brush/pad.

- You may slightly lubricate terminal inserts and connections with silicone grease. Petroleum-based lubricants are not recommended.
- Tighten the terminal screws using a torque loading of 9 - 11 Nm or 6.6 – 8.1 Ft-lbs. Electrical connections between batteries on separate levels or racks should be made making sure to minimize mechanical strain on the battery poles/terminals.

Terminal Torque	9 - 11 Nm / 6.64 – 8.11 Ft-lbs

- For systems where the total battery voltage is measured at the controller, use oversized cables between the controller and the battery to minimize the voltage drop.
- Check the battery's total voltage. It should match the number of batteries connected in series. If the measurement is not as expected, recheck the connections for proper polarity.
- The installer of the battery is responsible for conformity to local electrical standards.
- For future identification, apply individual battery numbers in sequence starting from one end of the series string. Also apply identification letters or numbers for the parallel strings.
- Only connect the battery to the DC power supply after ensuring that the polarity is correct, the charger is switched off, and the load is disconnected.

3.6 Commissioning Charge

The initial charge is very important for the future battery operation and the battery's service life. It is performed as a "Commissioning charge" as listed in paragraph 3.8.1. Keep records in the battery's logbook. Discover Commissioning Logs are available online at discoverbattery.com/en/resources/

3.7 Discharging

It is recommended for a system to be sized for no greater than 50% Depth of Discharge (DOD). A deep discharge will provide more capacity to operate loads but exposes the battery to sulphation and reduces the service life. After a deep discharge, it is recommended to charge a battery back to full State of Charge (SOC) as soon as possible to preserve capacity life.

The longer the battery stays at a low Depth of Discharge, the greater the exposure to sulphation and capacity loss. If the battery is left at a low Depth of Discharge for extended periods of time, sulphation damages may become unrecoverable through equalization charges.

OVER-DISCHARGE PROTECTION

Maximum Depth of Discharge limits should not be managed solely based on Ah-counters (counting the ampere- hours into and out of the battery). Monitoring the battery voltage against the low- voltage disconnect setting (LVD) should always be included.

- The system designer or installer shall adjust and confirm the LVD settings based on the actual conditions of the system.
- For systems where the voltage is measured at the controller and not on the battery, the voltage drop on the connections to the battery shall be considered.

Reference LVD / I10	20% DOD	12.20 V
	50% DOD	11.90 V
	80% DOD	11.50 V

3.8 Charging

The most common type of charging method can be grouped into three phases: bulk, absorption, and float charge. An additional equalization phase can be performed on a routine maintenance-as-required basis.

The Bulk charge accounts for charging the battery from anywhere between 0% up to 80% state of charge. The absorption phase charges the battery from 80% to nearly 100% state of charge. Lastly, a float charge supplies a controlled voltage and amperage to bring the battery to a complete full charge.
For specific charge programming instructions, please refer to the documents provided by the charger manufacturer.

The battery temperature must be monitored during charge. It should never exceed 55°C/131°F. If the upper temperature limits are reached, the charge shall be interrupted or the charge voltage should be reduced to float voltage for a period of time sufficient enough to allow the battery to cool down. Operation can continue once the temperature stabilizes below 45°C/113°F.

SUPERIMPOSED ALTERNATING CURRENTS

Depending on the charger type and charging characteristic curve, alternating currents flow through the battery during charging and are superimposed onto the charging direct current. These superimposed alternating currents and the reaction of the loads lead to additional heating of the battery or batteries and create a cyclical strain on the electrodes. This might result in premature aging of the battery. These alternating currents (AC ripple current) must not exceed 5A per 100 Ah of C10 nominal capacity. In order to achieve the optimum service life on float charge, a maximum effective value of the alternating current of 2 A per 100 Ah nominal capacity is recommended.

TEMPERATURE-RELATED ADJUSTMENT OF THE CHARGE VOLTAGE

- Operating temperature between 15°C and 35°C; no adjustments necessary
- Operating temperature <15°C; temperature correction factor + 18 mV/battery/K
- Operating temperature >35°C; temperature correction factor – 18 mV/battery/K

3.8.1 Commissioning Charge

Batteries lose charge while in transit or during storage. For this reason, a refresh charge should be given before putting the battery into service. The battery should be considered fully charge when individual battery voltages and/or specific gravity have not risen for a period of 4 hours. The surface temperature must not exceed 55°C (131°F). Recommended charge settings are as follows:

Commissioning Charge Settings

Constant Voltage	2.35 V/Cell at 20°C/(68°F)
Current Limit	15A per 100Ah C10 rating
Time Limitation	Max. 12 hrs

If the electrolyte has been set below the upper level before commissioning, top up with sulfuric acid to bring electrolyte level to the upper electrolyte level mark.

During commission, measure the battery voltage before and after commissioning, measure the battery voltage and surface temperature of each battery and log this data. Discover Commissioning Logs are available online at https://discoverbattery.com/en/resources/

3.8.2 Charge Parameters

- The charge voltage should be set as shown in the table below.
- The battery should be considered fully charged when the individual battery voltages have not risen for a period of 4 hours and the inverter/charger adjust to float voltage.

Nominal System DC Voltage	12V	24V	48V
Bulk & Absorption Charge Voltage	14.4V	28.8V	57.6V
Float Voltage	13.5V	27.0V	54.0V
Equalization Voltage	15.3V	30.6V	61.2V

Standby Use (20°C / 68°F)

Nominal System DC Voltage	12V	24V	48V
Bulk & Absorption Charge Voltage	14.7V	29.4V	58.8V
Float Voltage	13.8V	27.6V	55.2V
Equalization Voltage	15.3V	30.6V	61.2V

Cyclic Use (20°C / 68°F)

BULK PHASE
The constant current setting for the bulk phase is recommended to be set at 10-20% of the C10 capacity rate [Ah] of the battery. For example, if the battery is rated at 185 Ah at C10, then the recommended charge current is 18.5 A to 37.0 A. Charging at higher currents than the recommended levels may cause the battery bank to overheat and incur damage.

ABSORPTION PHASE
After the battery has been charged to 80% state of charge, the charger will switch to the programmed Absorption settings for the remaining 20% charge. In this phase, as the battery approaches full charge, the current begins to decrease in response to the increasing internal resistance of the battery.

FLOAT PHASE
The float phase is the third phase in the charging process. A float charge is required to maintain a battery at full charge as there may be some minor self-discharge.

END AMPS
End Amps or Return Amps is the current when the battery is fully charged and no longer accepts a charge. When the current reaches the End Amps set point, the charger will turn off. The recommended setting is 2% of the C10 Ah rating. For example, if the battery is 185 Ah at the C10 rate, then the recommended End Amps setting is 3.7 Amps.

3.8.3 Equalizing charge
To avoid permanent capacity loss and acid stratification in cycling operation the goal is to achieve a complete recharge (100% SoC) after every discharge. Capacity loss and acid stratification will threaten the battery's state of health.

The less complete the daily recharge is, the more frequently a balance charge will be required to protect the battery from sulphation and lagging batteries. Depending on the cycling frequency, equalization of the battery bank is recommended every 60 to 180 days. When short charging times are used then equalizing charges are required at frequent intervals, preferably every month.

Equalization charges are also required after incidents of excessive stress for the battery (deep discharges with inadequate charges) or when the individual battery voltages show excessive deviation from the average (lagging batteries and sulphation problems). Should the voltage in individual batteries deviate from the average value more than the following limits, perform a balance charge. Equalizing charge is generally required when the total spread between batteries is greater than 0.04V and or the specific gravity differs from the target value by 0.02 kg/l under float charge conditions.

Perform the balance/boost charge as follows:
Equalization time will vary depending on the degree of sulphation and output of the available charging source.
1. Equalization voltage should be set to 15.30V per battery
2. Charge at a low DC current (5-10% of C20 capacity). If grid is not available, use solar panels or another DC source with sufficient current.
3. Measure and record the specific gravity of each cell in the battery bank and temperature of a test cell. If the temperature rises above 45°C (113°F) and approaches 50°C (122°F), terminate the equalization cycle. Allow the batteries to cool off before attempting the cycle again.
4. If cells are severely sulphated, it may take several hours of equalization for the specific gravity to rise.
5. Once the specific gravity begins to rise, the bank voltage will most likely drop, or the charging current will increase. The charging current may be lowered if temperature approaches 45°C (113°F).
6. Continue to measure specific gravity until 1.255-1.260 is reached.
7. Charge the battery bank for another 2 to 3 hours, adding distilled water as required to maintain the electrolyte above the plates.
8. Allow the battery bank to cool - check and record the specific gravity of each battery. The specific gravity of the fully charged battery should be 1.255 – 1.260. Check the battery electrolyte levels and add water if necessary.

3.9 Temperature Limits
The battery is designed to perform optimally at temperatures between 20-30°C. At lower temperatures the battery capacity is lower and at elevated temperatures the life is reduced. The electrolyte temperature must not exceed 55°C; if necessary, the charge operation must be interrupted, until the electrolyte temperature drops below 45°C.

Sub-zero temperatures may cause electrolyte freezing and irreversible damage with decreasing specific gravity. The minimum safe temperature versus the specific gravity:

Specific Gravity	1.100	1.150	1.200	1.250	1.260
Freezing Point	-7°C / -19°F	-15°C / -5°F	-27°C / -16°F	-52°C / -62°F	-58 / -92°F

To counter low temperature operation the system designer shall consider thermal insulation, increasing battery capacity or increasing the minimum system voltage. It is recommended to use controllers with adjustable Low Voltage Disconnect (LVD) settings for the battery temperature (higher LVD for lower temperature).

3.10 Charge Current Limits

The maximum charging current during bulk charging in general should not exceed 30A/100Ah C10 rating while the battery voltage is below the gassing voltage of 2.40Vpc. Using a charging current during bulk/absorption of 10A to 20A per 100Ah C10 rating is recommended.

3.11 Specific Gravity

One of the key operating parameters of battery operation is the specific gravity of the electrolyte. Specific gravity is the ratio of the weight of a solution to the weight of an equal volume of water at a specific temperature. Specific gravity is used as an indicator of the state of charge of a battery. Specific gravity cannot determine a battery's capacity. During discharge the specific gravity decreases linearly with the ampere-hours discharged.

For accurate readings, a hydrometer should be used to measure the SG when the battery is at full charge and the readings have stabilized for three hours. The state of charge can be determined from the SG measurements at 25°C as noted in the table below.

State of Charge	Specific Gravity	12V Battery OCV
100%	1.255-1.260	12.60
75%	1.220-1.225	12.39
50%	1.200-1.205	12.25
25%	1.175-1.180	12.00
0%	1.145-1.150	11.80

State of Charge as a Measure of Specific Gravity and Open-Circuit Voltage 25°C (77°F)

The specific gravity is a function of temperature. At higher temperatures, SG decreases due to a lower density and at lower temperatures, SG increases due to a higher density. For specific gravity temperature compensation, if the temperature is greater than 25°C (77°F), subtract 0.003 for every 5°C (10°F) difference. If the temperature is less than 25°C (77°F), add 0.003 for every additional 5°C (10°F) difference.

EXAMPLE
An SG reading of 1.230kg/l at +35°C corresponds to an SG of 1.239kg/l at 20°C.

The electrolyte levels must be within the limits shown on the side of the container. The density increases when the electrolyte level becomes low due to water decomposition. If the levels are low, they must be topped up with demineralized water.

If the battery requires frequent charging such as watering more than once every two (2) months, the charging voltages may be too high causing electrolyte water loss. If the electrolyte levels vary between the batteries, then there may be a charge imbalance in the battery bank caused by resistance and/or battery failure

Errors can occur if the electrolyte has stratified, meaning the concentration of acid is lighter on top than lower down in the battery. An equalization charge can be performed after topping up to assist with the homogenization of the electrolyte. Make sure that the electrolyte has stabilized after charge and discharge before taking final specific gravity readings.

Note:
Do not add distilled water or electrolyte to the battery when the battery is not at full charge. The only exception is when the plates are exposed as operating in this condition will cause plate damage. If the plates are exposed, distilled water should be immediately used to fill the electrolyte until the plates are submerged. The battery should then be fully charged. Once the battery is at full charge, continue to add distilled water as normal to the appropriate electrolyte levels as marked on the battery case.

4. Battery Maintenance

VISUAL INSPECTION AND CLEANING INSTRUCTIONS
Check for any visible defects such as cracked jars, loose terminal posts and oxidized connectors. To avoid leakage currents and the associated risk of fire, keep the battery dry and clean. Do not use any solvents or detergents. Avoid electrostatic charges. Discover Maintenance Logs are online available at discoverbattery.com/en/resources/

WATER TOPPING UP
Electrolyte levels must be kept between the MIN and MAX levels at all times. If the levels are low, the battery must be topped up with demineralized water. Only purified water with a maximum electrical conductivity of 30 µS/cm must be used.

BI-ANNUAL MAINTENANCE
- Check and record the battery voltage
- Check and record the electrolyte density and level
- Deviation testing of battery voltages and electrolyte density readings (deviations signal imbalance batteries)
- Deviation testing of battery temperatures (deviations signal short circuit)
- Check if equalization charge is applied
- Confirm daily DoD per battery
- Confirm max DoD per battery does not exceed the allowed limit
- Confirm that charge settings correspond to recommendations

ANNUAL MAINTENANCE
- Further to the bi-annual maintenance, do the following:
- Check and record if connectors are firmly tightened.
- Inspect/record the racks for corrosion or loss of integrity
- Check and record if ventilation is sufficient.
- Check and record battery room temperature

5. Storage
If filled lead acid batteries are to be taken out of operation for extended periods of time, they must be placed fully charged in a dry, frost-free room. To avoid damage, perform periodical charging or permanent float charging.

6. Transport
Be sure that all cells are protected against short-circuit. Be sure to document and transport all cells or batteries according to local department of transportation rules and regulations.

7. Recycling
Discover's lead acid batteries are recyclable products. All Discover Factory Warehouses and servicing dealers are qualified to accept and handle all used lead acid batteries. Contact Discover® or your servicing dealer for details.

8. Troubleshooting and Frequently Asked Questions
The following is a list of common concerns and questions regarding system setup, battery charging and maintenance procedures. Please refer to these as general guidelines. For further assistance with your specific system setup, please contact your installer.

WHAT CAUSES THE BATTERY TERMINAL TO MELT?
Battery terminals melting is most common because of improper connections causing high resistance and heat generation.
- Loose connections
- Over-tightened connections
- Improper sized cables (too small).
- Corroded connections
- Improper use of washers/lock washers.
- Too many connections on the same terminal

WHY DO THE BATTERIES BULGE?
Some case bulging is normal from the weight of electrolyte. New battery cases tend to "relax" after filling with electrolyte.
- If case bulging is a concern upon receipt of a new product, please notify your Distributor immediately
- In the case of excessive bulging- your batteries may have been exposed to temperatures of over 50°C (122°F). The high

temperature may cause the plates/chassis to swell and expand. If this occurs, the batteries may fail prematurely
- The batteries may have frozen due to excessive exposure to cold temperatures. A fully charged battery (specific gravity of 1.255) may freeze at -52.2°C(-62°F) or lower. A battery that is at 50% state of charge (specific gravity of 1.200) may freeze at temperatures below -26.7°C (-16°F)

WHAT CAUSES A BATTERY TO LOSE CAPACITY?
The capacity loss may be due to sulphation, overheating, or over-discharging. If there is capacity loss, the battery bank may no longer support an increase in load.
- A balance charge and/or equalization may be necessary
- Verify the temperature sensors are properly mounted and the operation settings are adjusted to the appropriate battery temperature.

WHAT DO I DO IF THE SPECIFIC GRAVITY READINGS OF ALL THE BATTERIES IN THE BATTERY BANK INDICATE A VERY LOW STATE OF CHARGE?
The battery has been severely discharged and prone to sulphation and needs to be recharged. The low SOC may be from insufficient charging due to the charging voltages being too low and/or the Absorption time needing to be increased. The usage load may have also increased causing the battery to discharge to a lower DOD.
- Increase Bulk/Absorption/Boost Voltage in 0.2V to 0.4V volts increments and monitor for SOC improvements
- Increase Absorption Time by 15 to 30-minute increments as necessary
- Decrease DC load usage

WHAT DO I DO IF THE SPECIFIC GRAVITY READINGS ARE CONSISTENTLY HIGHER THAN RECOMMENDED?
The battery has been overcharged causing a higher specific gravity. Overcharging may be caused by the charging voltages being too high. If the load on the battery has been decreased, the Absorption time should also be decreased to prevent overcharge as less recharge time will be required.
- Decrease Bulk/Absorption/Boost Voltage in 0.2V to 0.4V increments
- Decrease Absorption Time by 15 to 30-minute increments as necessary

WHAT DO I DO IF THE SPECIFIC GRAVITY READINGS ON INDIVIDUAL BATTERIES IN A BATTERY BANK WITH MULTIPLE SERIES STRINGS VARY MORE THAN 0.020? (EX 1.250, 1.250, 1.225, 1.260)
There may be an imbalance of charge between the parallel strings of batteries
- Disconnect the parallel strings and charge each string individually to balance charge. For systems with more than two parallel strings of batteries you may find this to be necessary 1-2 times a year to maintain balanced charging.

There may be connection issues within each series connection or parallel strings.
- Clean and inspect all cabling and connections

WHY IS THE CHARGING CURRENT TO THE BATTERY BANK SO LOW?
The charging current will decrease as the batteries become fully charged. If the charge current is low, the end of charge cycle may have been reached. Verify that the charger is near the end of the Absorption phase or in Float voltage phase. If so, low current is normal at this stage of charging.
- The battery bank self-regulates charge current. The voltage can be controlled and adjusted to a high or low setting, however the amp output to the battery bank cannot be controlled and will drop as the batteries reach a full state of charge.
- When the charge current decreases to 2% of the battery C10 capacity, the charge is essentially complete.
- If specific gravity readings are at 1.255 or greater, the battery is fully charged.

WHY DOES THE VOLTAGE RISE VERY QUICKLY CAUSING THE CHARGER TO SHUT OFF WHEN I BEGIN TO CHARGE MY BATTERY BANK?
This is often an indication of sulphated batteries which can be confirmed by completing a load test.
- An increase in Absorption time may be necessary to sufficiently charge the battery to full SOC.
- If the battery bank is heavily sulphated, an equalization charge may be necessary.

WHY DOES THE BATTERY BANK NOT REACH THE BULK VOLTAGE SETTING WHEN CHARGING?
If the system is not reaching the Bulk voltage, the charger voltage and/or Amp output to the battery bank may be too low. To ensure sufficient charge, the output should be approximately 10%-20% of the C10 capacity rating of the battery bank. Another cause may be from DC loads running on the system during the charge cycle and reducing the current supplied to the battery bank.
- Verify that the charging settings meet the recommended charging parameters and that the charger output (Amps) is sufficient to meet the capacity requirements of the battery bank.

WHY DOES THE BATTERY BANK NOT REACH EQUALIZATION VOLTAGE WHEN PERFORMING AN EQUALIZATION CHARGE?

The charge output may be too low or there may be a possibility of a failed or dead battery. Before initiating equalization, a full Absorption Charge should be performed.

- Verify that the voltage and charge output is capable meeting the recommended charging parameters.
- Verify the specific gravity of each battery and voltage reading for each battery in the bank

WHAT DO I DO IF THE BATTERY TEMPERATURES ARE VERY HIGH?

- If at or nearing 55˚C (131˚F), shut off the charger and allow the batteries to cool.
- If a single battery or battery in a string is hot, this may indicate a battery failure or short. Verify the specific gravity for all batteries, take the voltage readings from each battery, and perform a load test to identity any battery failures.

WHAT CAUSES THE BATTERY COVER TO CRACK, SHATTER AND/OR DISLODGE FROM THE CASE? (NOT AFFECTING THE POSITIVE AND NEGATIVE TERMINALS OR CONNECTIONS)

The ignition of hydrogen gas may have caused the battery cover to crack. This sometimes occurs during a charge where a loose connection at the terminal creates a spark and ignites hydrogen gas produced from the battery. If the battery case has split or cracked along the sides, the battery may have frozen in the past.

9. Definitions and Abbreviations

- Ampacity: The allowable current-carrying capacity of a conductor measured in amps. Ampacity is the current, in Amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.
- Battery Capacity: The power a battery can deliver from full charge at standard temperature, and at a specified (usually C10) discharge rate.
- Circuit Breaker: Is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow. Unlike a fuse which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.
- DoD: Depth of Discharge or how deeply the battery has been dis-charged. Like the fuel gauge of your car, DoD is the measure of how much fuel you have used.
- I10: The constant current (I) discharge rate that can be maintain for 10 hours (10).
- MDDoD: Maximum Daily Depth of Discharge allowable
- MDoD: Maximum allowable Depth of Discharge
- OCV: Open Circuit Voltage: The voltage across the cell/ block or battery terminals with no load applied. The maximum possible voltage across a PV array, module, or cell with no load.
- SoC: State of Charge or how much energy is still available to be discharged. Like the fuel gauge of your car, SoC is the measure of how much gas you have left.
- V: The unit of measure for voltage. Voltage is the electrical pressure which forces the current to flow in a conductor such as a wire.
- VPC: Volts per Cell. The voltage of each individual cell, each cell in a block or each cell in a battery. The system voltage of your battery is the sum of the individual volts per cell.
- 100AH C10: Battery has a capacity (C)of 100 amp hours (AH) when rated at the 10 hour (C10) rate.