Discover®
Innovative Battery Solutions

User Guide

Discover RE Flooded Tubular Battery (SOPzS)

Contents

Flooded Lead Acid Battery

1. BATTERY 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.

1.1 CHARGE PARAMETERS

Regular Cycling /PSOC Recovery

Regular Cycling / PSOC Recovery		0°C (32°F)	10°C (50°F)	20°C (68°F)	25°C (77°F)	30°C (86°F)	40°C (104°F)
2V	Bulk & Absorption Charge Voltage	2.58 V	2.53 V	2.48 V	2.45 V	2.43 V	2.38 V
	Float Voltage	2.43 – 2.48 V	2.38 – 2.43 V	2.33 – 2.38 V	2.30 - 2.35 V	2.28 – 2.33 V	2.23 – 2.28 V
	Equalization Voltage	2.50 - 2.55 V					
12V	Bulk & Absorption Charge Voltage	15.45 V	15.15 V	14.85 V	14.70 V	14.55 V	14.25 V
	Float Voltage	14.55–14.85V	14.25 – 14.55 V	13.95 – 14.25 V	13.80 - 14.10 V	13.65 – 13.95 V	13.35 – 13.65 V
	Equalization Voltage	15.00 - 15.30 V					
24V	Bulk & Absorption Charge Voltage	30.90 V	30.30 V	29.70 V	29.40 V	29.10 V	28.50 V
	Float Voltage	29.10 – 29.70 V	28.50 – 29.10 V	27.90 – 28.50 V	27.60 - 28.20 V	27.30 – 27.90 V	26.70 – 27.30 V
	Equalization Voltage	30.00 - 30.60 V					
48V	Bulk & Absorption Charge Voltage	61.80 V	60.60 V	59.40 V	58.80 V	58.20 V	57.00 V
	Float Voltage	58.20 – 59.40 V	57.00 – 58.20 V	55.80 – 57.00 V	55.20 - 56.40 V	54.60 – 55.80 V	53.40 – 54.60 V
	Equalization Voltage	60.00 - 61.20 V					

TABLE 1 (a): Regular Cycling/Partial State of Charge (PSOC) Recovery

Infrequent Cycling/Backup System

Regular Cycling / PSOC Recovery		0°C (32°F)	10°C (50°F)	20°C (68°F)	25°C (77°F)	30°C (86°F)	40°C (104°F)
2V	Bulk & Absorption Charge Voltage	2.53 V	2.48 V	2.43 V	2.40 V	2.38 V	2.33 V
	Float Voltage	2.38 V	2.33 V	2.28 V	2.25 V	2.23 V	2.18 V
	Equalization Voltage	2.50 - 2.55 V					
12V	Bulk & Absorption Charge Voltage	15.15 V	14.85 V	14.55 V	14.40 V	14.25 V	13.95 V
	Float Voltage	14.25 V	13.95 V	13.65 V	13.50 V	13.35 V	13.05 V
	Equalization Voltage	15.00 - 15.30 V					
24V	Bulk & Absorption Charge Voltage	30.30 V	29.70 V	29.10 V	28.80 V	28.50 V	27.90 V
	Float Voltage	28.50 V	27.90 V	27.30 V	27.00 V	26.70 V	26.10 V
	Equalization Voltage	30.00 - 30.60 V					
48V	Bulk & Absorption Charge Voltage	60.60 V	59.40 V	58.20 V	57.60 V	57.00 V	55.80 V
	Float Voltage	57.00 V	55.80 V	54.60 V	54.00 V	53.40 V	52.20 V
	Equalization Voltage	60.00 - 61.20 V					

TABLE 1 (b): Infrequent Cycling/Backup System

1.2 BULK PHASE

Bulk charge is the first phase of the charging process and recharges the battery bank to approximately 80% state of charge. During this phase, the battery bank is charged at a constant maximum current until the set point voltage is reached.

The constant current setting for the bulk phase is recommended to be set at 10%-15% of the C20 capacity rate [Ah] of the battery. For example, if the battery is rated at 220 Ah at C20, then the recommended charge current is 22 A to 33 A. When charging, if the battery temperature is unable to be maintained at the recommended 25°C ambient temperature, a voltage set point compensation is required as outlined in **Table 1 (a) & 1 (b) Flooded Charging Parameters**. Note, if the battery temperature cannot be maintained at 25°C, a temperature compensation of 5 mV/°C per 2V cell is required.

The batteries can be charged outside the recommended ranges, but damages incurred will be void of warranty coverage. Charging at higher currents than the recommended levels may cause the battery bank to overheat and incur damage. Charging at lower currents than recommended will prolong the charge time increasing the risk for sulphation build-up and performance loss.

1.3 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.

Depending on the charger, there may be the option to set the Absorption time which can be determined by a simple calculation. As mentioned in the previous section, the recommended charge current is 10%-15% of the capacity [Ah] of the battery bank based on the 20 Hour (C20) Amp-hour rate. We then apply some estimations to simplify the calculation. As the charge current decreases linearly as a function of time, the absorption charge rate can be assumed to be 50% of the maximum charge rate and at 90% efficiency to account for heat generation. An example calculation is given below using the lower and higher ranges of the recommended charging current.

Absorption Charge Time

$$T_{absorption}[h] = \frac{C_{absorption}[Ah]}{I_{absorption}[A]*efficiency}$$

Where:

$T_{absorption}$ = Absorption Charge Time [h]

$C_{absorption}$ = Absorption Capacity[Ah] (20% of total battery bank capacity at C20 rate)

$I_{absorption}$ = Absorption Charging Current [A](50% of maximum charge rate)

EXAMPLE: Operating with 4 parallel strings of 12VRE-3000TF batteries (12V, 215 Ah at C20).

Case A: Charger can output the minimum recommended charging current (10% of C20 discharge rate)
Case B: Charger can output the maximum recommended charging current (15% of C20 discharge rate)

Case A

$$T_{absorption}[h] = \frac{C_{absorption}[Ah]}{I_{absorption}[A]*efficiency}$$

Charger can output the minimum recommended charging current (10% of C20 discharge rate)

$C_{absorption}$ = 20% of 4 parallel strings of 215 Ah = 20%*4*215 Ah = **172 Ah**

Maxiumum charge rate = 10% of 4*215 = 86 A

$I_{absorption}$ = 50% of the maximum charge rate = 0.5*86 A = **43 A**

$$T[h] = \frac{172[Ah]}{43[A] * 0.90} = 4.44 \text{ hours}$$

Case B

Charger can output the maximum recommended charging current (15% of C20 discharge rate)

$C_{absorption}$ = 20% of 4 parallel strings of 215 Ah = 20%*4*215 Ah = 172 Ah

Maximum charge rate = 15% of 4*215 = 129 A

$I_{absorption}$ = 50% of the maximum charge rate = 0.5*129 A = 64.5 A

$$T[h] = \frac{172[Ah]}{64.5[A] * 0.90} = 2.96 \text{ hours}$$

1.4 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. The Float settings should be adjusted to the voltages as indicated in **Table 1 (a) & 1 (b) Flooded Charging Parameters.**

1.5 END AMPS (RETURN 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 C20 Ah rating. For example, if the battery is 220 Ah at the C20 rate, then the recommended End Amps setting is 4.4 Amps.

2. DEPTH OF DISCHARGE

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.

2.1 LOW VOLTAGE DISCONNECT

An electromagnetic device may be included into many charging systems which automatically disconnects and reconnects loads to the battery to preserve life based on the Low Voltage Disconnect (LVD) or Low Voltage Cut Off (LVCO) setting. The default setting may be set by the charger manufacturer at 1.75 volts per cell (VPC). To prolong battery cycle life, the recommended LVD setting is between 1.85 VPC to 1.96 VPC.

3. EQUALIZATION

3.1 CORRECTIVE EQUALIZATION

Equalization is an additional stage that functions as a battery upkeep step. Equalization is a controlled overcharge for a specified time period to reduce acid stratification and sulphation which are two conditions that shorten battery life. Completion is indicated when the specific gravity remains constant for two hours. During equalization, the electrolyte levels should be monitored and distilled water added as necessary to maintain above the indicated minimum level on the battery case.

Equalization may also be used to normalize the cells as after numerous cycles, the individual cell readings may begin to vary in specific gravity from one another. It is important to conform the specific gravities of the battery cells to a uniform profile as any variation may cause some cells to be overcharged and others to be undercharged. This may cause problems such as sulphation and will require an equalization charge to bring all the cells back into alignment.

Understanding when to perform an equalization charge depends on several factors including depth of discharge, cycle frequency, operating temperature, and charging voltage and current. Another indicator to perform an equalization charge is when the specific gravity of the individual cells within the battery bank vary by more than 0.025-0.030 (Ex. 1.255, 1.255, 1.225, 1.255, 1.255) from one another.

Depending on the cycling frequency, equalization of the battery bank is recommended every 60 to 180 days. To equalize the battery bank, charge the batteries until the voltage increases to the Equalization voltage as shown in **Table 1 (a) & 1 (b) Flooded Charging Parameters** and maintain for several hours. Equalization time will vary depending on the charge balance and sulphation levels.

3.2 PREVENTATIVE EQUALIZATION

Preventative equalization is an option included in most charge controllers and schedules a shorter 1-2 hour equalization every 30, 60, or 90 days. Preventative equalization does not substitute the requirement for Corrective Equalization and instead functions to balance and remove small amounts of accumulated sulphation on a regular basis.

Although equalization helps to balance cells and de-sulphate plates, frequent equalization will deteriorate the cells and shorten the life of the battery. For this reason, we recommend monitoring the specific gravity and voltage on a regular basis to ensure scheduling equalization times are appropriately set. An equalization charge may need to be performed if symptoms such as low capacity or difficulty holding charge occurs. These symptoms are typical of accumulated sulphation.

NOTE: Equalization should not be depended on as a fallback solution to correct capacity loss as consistent exposure to sulphation may cause permanent damage to the battery. The best practice to maintain and prolong battery longevity is to consistently monitor and provide sufficient voltage and charging currents during the charge cycles.

3.3 CORRECTIVE EQUALIZATION INSTRUCTIONS

Equalization time will vary depending on the degree of sulphation and output of the available charging source.

1. Vent caps should be removed before the equalization process to allow hydrogen gas formation to escape.
2. Equalization voltage should be set to the recommended parameter as described in **Table 1 (a) & 1 (b) Flooded Charging Parameters.**
3. Charge at a low DC current (5-10% of C20 battery capacity). If grid power is not available, use solar panels or another DC source with sufficient current
4. Measure and record the specific gravity of each cell in the battery bank and temperature of a test cell. If the temperature rises above 45ºC (113ºF) and approaches 50ºC (122ºF), terminate the equalization cycle. Allow the batteries to cool off before attempting the cycle again.
5. If cells are severely sulphated, it may take several hours of equalization for the specific gravity to rise.
6. Once the specific gravity begins to rise, the bank voltage will most likely drop, or the charging current will increase. The charging current may need to be lowered if temperature approaches 45ºC (113ºF). If the charge controller has been bypassed, it should now be used or put back in line.
7. Continue to measure specific gravity until 1.255-1.260 is reached.
8. Charge the battery bank for another 2 to 3 hours, adding distilled water as required to maintain the electrolyte above the plates.
9. Allow the battery bank to cool - check and record the specific gravity of each cell. The gravities should be 1.255 ± 0.005 or lower. Check the cell electrolyte levels and add water if necessary.

It is recommended to measure and record the specific gravity reading of one pilot cell on a regular basis to closely monitor whether the bank is fully charged. If the measurement is lower than the previous reading, a longer absorption time and/or higher voltage setting should be used.

4. BATTERY MAINTENANCE

4.1 TERMINALS

The battery terminal connections should be regularly inspected, cleaned, and tightened properly with a torque wrench. Loose connections may cause arcing and shorts which will generate excessive heat and damage to the terminals.

Over time, dirt or corrosion may accumulate on the terminals. To clean, the connections should be removed. Using a neutralizing solution such as baking soda and water (100g per litre), wipe the terminals and connections to remove debris and any corrosion. Rinse the terminals and connections with distilled water to remove any remnants of the neutralizing solution. Allow sufficient time to dry, then apply a conductive coating agent such as petroleum jelly which acts as a safeguard against corrosion. Lastly, reconnect the battery terminals using a torque wrench.

4.2 SPECIFIC GRAVITY

The specific gravity (SG) of flooded batteries should be checked regularly and cells topped up with distilled water as needed. The SG increases as the battery charges and decreases as the battery discharges. It is the most accurate measurement to determine charge level as it is a linear function of the amp-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 **Table 2: Specific Gravity vs State of Charge.**

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.

Percentage Charge	Specific Gravity	2V Cell [Volt]	12V Block [Volt]
100%	1.255-1.260	2.10	12.60
75%	1.220-1.225	2.08	12.48
50%	1.200-1.205	2.05	12.30
25%	1.175-1.180	2.02	12.12
0%	1.145-1.150	1.98	11.88

TABLE 2: State of Charge as a Measure of Specific Gravity and Open-Circuit Voltage

4.3 ELECTROLYTE LEVEL

Common causes of failure include an extended neglect for battery maintenance and over-watering the cells resulting in corrosion issues and a loss of electrolyte from overflow. The electrolyte level may decrease over time and require distilled water to bring the electrolyte levels back to the appropriate water levels. Maintaining the electrolyte level between the minimum and maximum water levels as indicated on the battery casing is required to prolong battery life. If the electrolyte levels are nearing the indicated minimum levels, the battery should be refilled with distilled water when the battery is at full charge.

If the battery cells require 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 cells, then there may be a charge imbalance in the battery bank caused by resistance and/or cell failure.

NOTE: Do not add distilled water or electrolyte to the cells 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.

4.4 TEMPERATURE

Temperature is important to monitor as it affects the specific gravity and voltage readings. Depending on the battery temperature, the voltage set points may require adjustment. For an accurate temperature measurement, the temperature sensor, if included with the charge equipment, must be properly mounted to the side of the cell casing below the electrolyte. Attaching the sensor to other parts of the battery may provide an inaccurate representation of the battery temperature. Failure to monitor the temperature accurately may cause overcharging or undercharging. The operating temperature should not exceed 50ºC. As a precaution, there should be a charge cut-off to prevent the battery bank from operating at temperatures greater than 50ºC (122ºF).

4.5 STORAGE AND MAINTENANCE

When storing the batteries for a longer period, ensure to check the charge levels periodically as a low state of charge will cause sulphation. At ambient temperature conditions, the self-discharge is 4-5% per month. To maintain the battery at a high state of charge, the batteries should be recharged every 3 months to prevent sulphation.

If possible, the batteries should be stored at room temperature and in a controlled humidity environment (ie. indoors or sheltered). Depending on the temperature, the electrolyte levels may decrease in a colder environment and increase in a warmer environment. As a result, caution should be taken to monitor and maintain the electrolyte between the indicated minimum and maximum levels as plate exposure will have negative effects towards battery life.

4.6 WINTER STORAGE

The battery should be monitored closely in cold climates. If the electrolyte freezes, it may cause unrepairable damage such as case cracking. A discharged battery is more likely to freeze than a fully charged battery.

A higher specific gravity freezes at a much lower freezing temperature. For example, at a low state of charge such as at 1.100 specific gravity, the battery may freeze when stored below -7°C (20°F). When the battery is at a higher state of charge and a higher specific gravity such as at 1.280, the freezing temperature is at -69°C (-92°F). Table 3 details the relationship between specific gravity and freezing temperatures.

Specific Gravity	Freezing Temperature
1.280	-69ºC (-92ºF)
1.265	-57.4ºC (-72.3ºF)
1.250	-52.2ºC (-62ºF)
1.200	-26.7ºC (-16ºF)
1.150	-15ºC (5ºF)
1.100	-7ºC (19ºF)

TABLE 3: Specific Gravity vs Freezing Temperature

5. COMMISSIONING AND MAINTENANCE CHECKLIST

5.1 COMMISSIONING

Within the first week of operation, the following parameters should be recorded at full charge (baseline readings):

- Charger voltage and amperage output
- Absorption voltage at battery system terminals
- Measure and record the resting/loaded individual battery voltage
- Ambient temperature

Allow the battery system to discharge until it reaches the Low Voltage Disconnect and record the following parameters:

- Runtime
- Capacity delivered (amp-hours)
- Average DC load (amperes)
- Endpoint voltage at battery system terminals

After discharging, the battery should be fully charged as soon as possible to prevent sulphation.

5.2 SCHEDULED MAINTENANCE

The following should be monitored for the first 6-12 months:

MONTHLY

- Measure and record the resting/loaded individual battery voltage.
- Check and record electrolyte.
- Test and record specific gravity measurements.
- Record ambient temperature where the batteries are installed.
- Inspect cell integrity for corrosion at terminal, connection, racks or cabinets.
- Check battery monitoring equipment to verify operation.

QUARTERLY

- Test Ventilation.
- Check for high resistive connections.
- Check cabling for broken or frayed cables.
- Verify Charge Output, Bulk/Absorption voltage of Inverter/Charge Controller.
- Check cells for cracks or indication of a possible leak.
- Check Ground connections.

Deep cycle batteries will increase in capacity during the initial break-in period. Adjustments to charging parameters may be necessary during this time. Following these recommendations will ensure the batteries to reach their rated capacity and be maintained in good working order.

6. TROUBLESHOOTING & 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 cells in the battery bank indicate a very low state of charge? The readings vary by cell, but not greater than 0.020 between the cells.

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…)

1) 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.
- Increase Bulk/Absorption/Boost Voltage by 0.2V increments and monitor for improvements

2) There may be connection issues within each series connection or parallel strings.

- Clean and inspect all cabling and connections
- As the batteries are at varying specific gravities, they will need to be balance charged. 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.

*Specific gravity readings that vary more than 0.030 in multiple strings of batteries indicate an imbalance of charge. If the specific gravity readings continue to vary after charging each string individually an equalization charge may be necessary.

Why do the Specific Gravity readings at full charge vary significantly? (greater than 0.030)

The Specific Gravity variance may be caused by operating multiple parallel battery strings, which often results in a charge imbalance. It may also indicate failing or dead cell(s) in the battery bank. It is not recommended for a system to exceed three parallel strings of batteries.

- The charge voltage settings may be too low. Verify that the settings meet the recommended charging parameters
- An increase in Absorption charge time may be necessary. Increase the charge time in 15 to 30 minute increments

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 capacity, the charge is essentially complete. (ex. 220 AH battery bank. Charge current is reduced to 4.4 Amps). Check the specific gravity with a hydrometer to confirm.
- If specific gravity readings are at 1.255 or greater, the battery is fully charged.
- If the specific gravity is lower than 1.255 following a charge,perform a load test to ensure all cells are operating correctly.

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%-15% of the Amp Hour capacity 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 cell. 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 cell and voltage reading for each battery in the bank.

What do I do if the battery temperatures are very high?

- If at or nearing 50˚C (122˚F), shut off the charger and allow the batteries to cool.
- If a single battery or cell in a string is hot, this may indicate a cell failure or short. Verify the specific gravity for all cells, take the voltage readings from each battery, and perform a load test to identity any cell 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 cell. If the battery case has split or cracked along the sides, the battery may have frozen in the past.