BATTERY USER MANUAL

Rolls

BATTERY ENGINEERING

Recommended charging, equalization and preventive maintenance procedures for Rolls Batteries.

RAILROAD & DIESEL STARTER

MARINE

MOTIVE POWER

RENEWABLE ENERGY

AGM

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MANUAL

Rolls Battery has been manufacturing deep cycle lead-acid batteries since 1935. Experience gained has helped achieve an unmatched reputation along with specific measures to obtain the maximum performance and life from our product. This manual provides the recommended setup, charging, equalization and preventive maintenance procedures necessary to maximize the life of your Rolls batteries.

EQUIPMENT NEEDED

- Goggles, Rubber Gloves and Rubber Boots
- Distilled water
- Baking soda, Soda ash
- Voltmeter, Ampmeter
- Hydrometer, Refractometer
- Battery charger

SAFE HANDLING PROCEDURE

To prevent injury, always wear acid-resistant clothing, PVC gloves, goggles and rubber boots. Flooded batteries must be maintained in an upright position at all times. Always have plenty of water and baking soda on hand in the event of acid spillage during transport.

INSPECTION

When receiving shipment of your batteries, it is important to thoroughly inspect each pallet, battery and packaging. Before signing acceptance of the shipment, remove the shrink-wrap from the pallet and inspect each battery for damage (i.e. cracks, dents, punctures, deformations, acid leaks or other visible abnormalities).

Do not accept shipment if the batteries appear to have been damaged in any way. Confirm that connection terminals are secure and clean. If the battery is dirty, or if any minor amount of acid has spilled onto the case due to loose bayonets, refer to the cleaning instructions in this manual to properly neutralize and clean as necessary. Wet pallets or signs of acid leak on or around the batteries could indicate shipping damage or improperly sealed battery casing. Confirm the polarity of the terminals are accurate.

In the event of a suspected leak or damage, do not accept the shipment. Contact your battery retailer or Rolls Battery to determine whether the batter(ies) require replacement.

Battery shipments which are known to be damaged, but accepted, will not be replaced under the terms of Rolls Battery manufacturer warranty.

QUICK CHECKLIST

SHIPPING/RECEIVING (MUST INSPECT PRIOR TO DRIVER RELEASE!)

- All parts are included
- No acid spill
- No visual damage to the batteries
- Verify electrolyte levels

INSTALLATION

- Protective equipment should be worn
- All electrical components should be turned off
- Acid spill cleanup material should be readily available

INITIAL CHARGE

- Verify electrolyte levels (add distilled water as necessary)
- Measure specific gravity
- Set up battery charge voltage/current limits

GENERAL

- Safety first!

INSTALLATION

Rolls deep cycle batteries are manufactured for use in a wide variety of applications. No matter the use, it is important that the battery is installed securely, free of contaminants and that all connections are in good contact with the terminals. Excessive heat or cold temperatures will result in the reduction of the overall life of your batteries.

Flooded batteries should be installed in a temperature-controlled room or in an enclosure that insulates the batteries from freezing or overheating. Active ventilation is required in enclosures with both positive and negative flow installed to remove and replace hydrogen gas generated during charging. For all Rolls battery models, it is recommended that batteries are separated 1”- 3” inches apart to allow for ease of maintenance and proper airflow and cooling.

BATTERY ORIENTATION

Flooded lead acid batteries must be kept in an upright position at all times. Electrolyte in the battery may spill if tilted more than 20 degrees. AGM lead acid batteries may be mounted standing upright or on the longest side of the battery case. AGM batteries may not be mounted upside down.

CABLE SIZING

Cabling should be proportionate to the amperage of your system. The table below notes the maximum current carrying capacity based on cable gauge. Battery cabling should be selected allowing a maximum voltage drop of 2% or less across the entire length of the cable. Interconnection cables (battery to battery) should also be sized at the same gauge and of equal length between connections.

Wire Gauge Size	Amperage
14	25
12	30
10	40
8	55
6	75
4	95
2	130
1	150
00	195
0000	260

Table 1 – Wire gauge sizing “Free Air” Ratings

WARNING:

Loose or over-tightened connections may cause high resistance. The result is an unwanted voltage drop as well as excessive terminal heating, causing the terminal to melt or even catch fire. To limit the possibility of damage or fire, use a torque wrench to properly adjust terminal connections during your regular maintenance schedule.

Using an Infrared (IR) temperature sensor may assist in identifying poor connections when testing under load or during charge.

Connections that have overheated and/or developed problems will often be welded to the terminal. Visual inspections may not always detect poor connections. It is recommended that terminal connections are disconnected, cleaned and re-torqued periodically as part of the maintenance routine.

FLOODED LEAD ACID TERMINALS

Terminal connections should be tightened to 25 ft/lbs or 33 N.m for all flooded FS, 4000, 4500 & 5000 Series models.

AGM TERMINALS

Torque settings vary by terminal type, please refer to the chart below:

AGM Terminals	Torque N.m
Button Terminal (M8)	9.6-10.7
Button Terminal (M10)	12.2-14
AP	5.6-7.9
LT	9.6-10.7
DT (AP and stud terminal)	5.6-7.9
M6 (TP08)	3.9-5.4
M8 (TP08)	9.6-10.7

PARALLEL/SERIES CONNECTIONS:

Applications often demand more voltage or more ampere capacity than the capacity of one battery. By connecting multiple batteries in series, parallel or series parallel configurations, you are able to increase the output voltage or battery bank amperage as needed.

To increase voltage, batteries are connected in series. Capacity of the battery bank remains the same as voltage increases. To increase the available amount of current and capacity, batteries are connected in parallel. In this situation it is best to use lower voltage, higher capacity cells to minimize the amount of parallel strings.

To increase voltage, connect the batteries in series as shown in Figure 1.

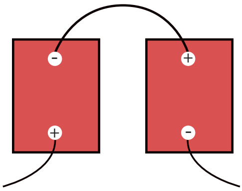


Figure 1
Voltage Increase

EXAMPLE:
Battery Voltage = 6V each
Battery Capacity = 400 AH each
System Voltage = 12V
System Capacity = 800 AH

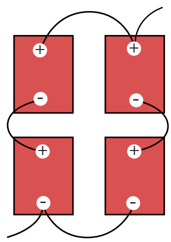


Figure 2
Voltage/Capacity Increase

To increase capacity and voltage, connect the batteries in series parallel as shown in Figure 2.

EXAMPLE:
twenty four (24) 2 Volt models at 2430 AH each = 2430AH at 48 Volts

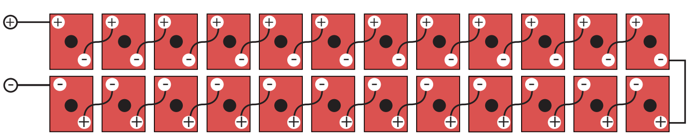


Figure 3
Single Series String
"Best Option"

EXAMPLE:
two (2) strings of eight (8) 6 Volt 428 AH each = 2 x 428 AH at 48 Volts = 856 AH at 48 Volts

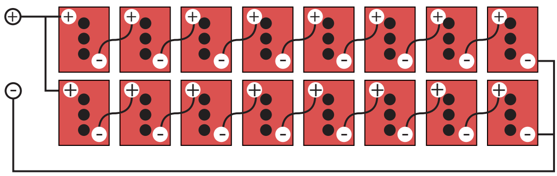


Figure 4
Two Parallel Strings.
Series/Parallel

EXAMPLE:
three (3) strings of four (4) Batteries at 357 AH each = 3 x 357 AH at 48 Volts = 1071 AH at 48 Volts

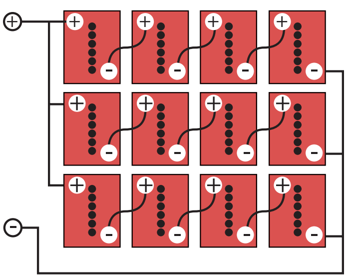


Figure 5
Three Series Strings in Parallel

NOTE: We do not recommend more than three (3) series strings. Multiple parallel connections create unequal string resistances. This may cause unequal charging and discharge currents resulting in cell damage or premature failure.

CROSS-TYING PARALLEL STRINGS IN A BATTERY BANK:

A cross-tied connection may be added to parallel series strings in a battery bank. These connections may assist in balance of charge and improve battery performance. Series connections are made between each battery in a string as well as connections from positives to positives and negatives to negatives in adjacent strings.

Caution should be made not to overdischarge the battery bank when cross-tying connections as this may cause cells to reverse polarity.

The dotted lines represent the cross-tied connections below.

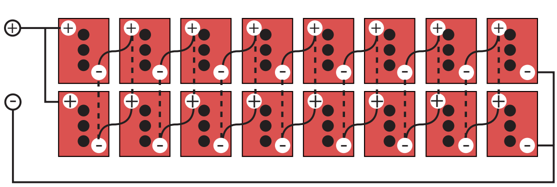
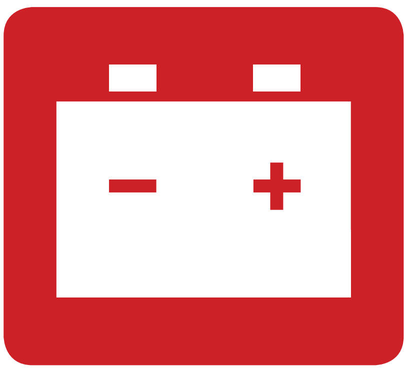


Figure 6
Two Parallel Strings.
Series/Parallel with
cross tie connections

FLOODED LEAD ACID BATTERIES



ACTIVATION OF A DRY BATTERY (LEAD ACID)

Special order batteries may be shipped dry (acid shipped separately). To activate these batteries, start by removing the vent caps. Using approved battery grade electrolyte (1.265), slowly fill each cell until the liquid level reached halfway between the plates and the bottom of the vent well tube. (See Figure 8.) It is important not to over fill the cells as the acid will expand upon charging. If the cells are too full, the acid will overflow and require cleanup. Allow electrolyte to saturate into the plates and separators for at least 90 minutes. The temperature of the electrolyte will rise and the specific gravity will drop. Once this is complete, place the batteries on charge at the finishing rate (5%-10% of the 20 hour rate). The rate may be increased if the battery does not begin to bubble and gas. Do not let the cell temperature exceed 125°F (52°C). If the temperature becomes excessive or the cells begin to gas vigorously, reduce the rate of charge. Continue charging until the cell (or cells) reaches within .005 points of the specific gravity of the filling electrolyte corrected for 77°F (25°C). We recommend allowing the charge to continue for an additional 60 minutes to insure no further rise in specific gravity. A longer lower charge rate is better than a higher heavier charge.

Top up or remove electrolyte as necessary for proper level. Never add electrolyte (only approved water) after activation. Replace vent caps and remove any spillage of electrolyte. If necessary, clean with bicarbonate of baking soda and water (100 grams of soda to one litre of water). Rinse with water and wipe dry. Ensure that the soda solution does not get into cells.

*Do not place on charge until electrolyte temperature is below 35°C.

LEAD ACID BATTERY CHARGING

	TEMPERATURE	SYSTEM VOLTAGE			
		2 VOLT	12 VOLT	24 VOLT	48 VOLT
BULK/ ABSORPTION	0˚C to 16˚C 32˚F to 60.8˚F	2.5 V	15.0 V	30.0 V	60.0 V
	17˚C to 27˚C 62.6˚F to 80.6˚F	2.4 V	14.4 V	28.8 V	57.6 V
	28˚C to 40˚C 82.4˚F to 104˚F	2.36 V	14.16 V	28.32 V	56.64 V
	TEMPERATURE COMPENSATION	2.45 V	14.7 V	29.4 V	58.8 V
FLOAT		2.19 V	13.14 V	26.28 V	52.56 V
EQUALIZATION		2.58-2.67 V	15.48-16.02 V	30.96 - 32.04 V	61.92 - 64.08 V

Table 2 – Flooded Battery Charge Parameters

NOTE: When temperature compensation is available, set the Bulk & Absorption charge voltages at 2.45 volts per cell (VPC). Programming higher or lower voltages may cause over/ undercharge as the charger makes adjustments to these settings based on temperature.

The most common type of charge method at present is a three phase charge plus equalization as outlined in the recommended charging parameters. Check with your charger manufacturer for specific programming instructions for this equipment.

Note: if the battery cells require watering more than once every two (2) months, the programmed charge settings may be too high. Adjust as necessary.

ACTIVATING INSTRUCTIONS/MAINTENANCE FOR A WET BATTERY (LEAD ACID)

Caution: Always wear the proper personal protective equipment (goggles, gloves, clothing) when handling batteries and electrolytes.

WARNING:

- WET BATTERIES MUST BE FULLY CHARGED BEFORE BEING DELIVERED TO THE END USER. PLEASE REFER TO THE “INITIAL CHARGE OF WET BATTERIES” SECTION OF THIS DOCUMENT.
- UNLESS INSTRUCTED BY ROLLS TECHNICAL SUPPORT, NEVER ADD ACID TO THE BATTERIES AT ANY TIME. USE DISTILLED WATER ONLY. ·
- **FAILURE TO FOLLOW THESE INSTRUCTIONS WILL RESULT IN MALFUNCTION AND VOID THE WARRANTY.**

CLEANING

Batteries should be kept clean at all times, including storage or usage. If stored in a dirty area, regular cleaning should be performed. Before doing so, ensure that all the vent caps are tightly fastened. Using a solution of water and baking soda (100g per litre), gently wipe the battery and terminals, then rinse with water.

INITIAL CHARGE OF WET BATTERIES (LEAD ACID)

1. Inspect batteries for damage. Important: read all warning labels on batteries before proceeding.

2. Wet batteries are fully charged and tested before shipping, however batteries will self-discharge when not in use during transportation and storage. The first charge brings the battery to an operational state. Before this charging process, the cell electrolyte level should be checked, making sure the electrolyte covers the plates. If this isn’t the case, add distilled water until all the plates are submerged. It is important not to over fill because the level will rise during the charge process.

3. Check for correct polarity. Attaching the positive and negative voltmeter lead to the positive and negative battery terminal should give a positive voltage reading. If it is negative, a reverse polarity condition exists and you should contact your dealer or Rolls Battery Technical Support.

4. Place batteries on charge. Please see Table 2 – charge parameters for required charging settings. Do not let the cell temperature exceed 52°C (125°F). If the temperature becomes excessive or the cells begin to gas vigorously, reduce the rate of charge. Continue charging until all cells reach the specific gravity of the filling acid. All cell specific gravities should be even (1.260 - 1.280).

5. See Initial Charge below.

INITIAL CHARGE

A battery may not be fully charged when received. An initial charge brings the battery to an operational state. Before charging, electrolyte level in each cell should be checked. Please ensure the electrolyte (liquid) covers the plates completely. It is normal for electrolyte levels to lower as the battery case will bulge slightly after filling. If the plates are exposed, add distilled water until all are just submerged. It is important not to overfill each cell as the electrolyte level will rise during the charging process. Charge voltages are indicated in Table 2.

The specific gravity of electolyte in a battery is the most accurate measurement to determine if the cells are in fact, fully charged. The specific gravity should be constant for 3 hours for an accurate full charge reading. Check the state of charge as related to specific gravity. Initial charging may take 10 hours. Once the battery is fully charged, verify the electrolyte level in the cell once more. The fluid should be 1/4" – 1/2" below the vent tube on each cell as shown in Figure 8. Carefully add distilled water to adjust the level if needed.

% Charge	Specific Gravity* (SG)
100	1.255 – 1.275
75	1.215 – 1.235
50	1.180 - 1.200
25	1.155 - 1.165
0	1.110 - 1.130

Table 3 – Specific Gravity vs State of Charge

NOTE: Specific Gravity is dependent on the electrolyte temperature. These values are for a temperature of 27°C (80°F). To adjust, add/subtract 0.003 for every 5°C (10°F) increase/decrease.

BULK CHARGE

The first phase of the charging process is the bulk charge. This is when the maximum amount of current flows into the battery bank until a desired voltage is reached. The recommended maximum current is 20% of the AH capacity of the battery bank, based on the 20 Hr AH rate (C20). Higher current levels may cause the battery bank to overheat. A lower current may be used, however this will prolong charge time. Bulk charge voltage set points are outlined in Table 2.

ABSORPTION CHARGE

The most important part of the charge cycle is the Absorption charge. The Bulk charge typically recharges the battery bank to approximately 80% state of charge, the Absorption charge then completes the charging cycle. Most three phase chargers include an Absorption time setting which allows the user to program the duration of time needed to reach a full state of charge. To set the Absorption time, a simple calculation is required. Using the 20 Hr AH rating of the battery bank (C20) and the charger output, it is possible to determine the time needed to fully charge the battery bank.

As stated previously, the Bulk charge phase brings the bank to approximately 80% state of charge. The remaining 20% charge is a function of time and current. The charger will maintain current level until the Bulk set point has been reached. The charger will then switch to the programmed Absorption voltage and timer. As the battery charge nears completion, the internal resistance in the battery increases and charge current begins to decrease. It is assumed that over the time of the Absorption charge that 50% of your maximum charge current will be available (this is factored into the equation). 0.42 = (20%/50%) + 5%. 5% is added due to losses.

ABSORPTION CHARGE TIME

Where : T = 0.42 x C /I
T = ABSORPTION CHARGE TIME
C = 20 hr RATED CAPACITY (of the Bank)
I = Charging Current (10% of C20 max)
0.42 = (20%/50%) + 5% (5% is added due to losses)

EXAMPLE

2 strings of 6 Volt 6 CS 25P models
20 hr AH rate = 820 AH x (2 strings) = 1640 AH
I = 10% of 1640 AH = 164 amps. If charger output is 120 amps max, 120 is used
T = 0.42 x 1640/164 = 4.2 hrs OR T = 0.42 x 1640/120 = 5.75 hrs

FLOAT CHARGE

When the Absorption charge is completed, the batteries require a certain amount of voltage to maintain a full charge when no load is applied. This Float voltage maintains the battery bank at a constant full state of charge. To prolong battery life, the Float settings on the power supply should be adjusted to the voltage indicated in Table 2. Higher or lower voltage settings may result in unnecessary overcharge or sulfation.

END AMPS OR RETURN AMPS

As batteries near full capacity the charge current drops. End Amps or Return Amps generally refers to the lowest amount of current (Amps) running from the charger when the batteries have reached full capacity and are no longer accepting a charge. Some charges will measure the actual current output. If the charge current drops to the End Amps or Return Amps setpoint, this will trigger the charger to shut off. This setting is typically 2%-3% of the 20 Hr AH rating (C20) of the battery bank. Rolls recommends setting this at 2% for new installations.

WARNING: This setting combined with a sulfated battery can confuse the charger and cause a state of charge reset prior to actually hitting 100% (SOC) state of charge.

LOW VOLTAGE DISCONNECT (LVD OR LVCO)

Many charging systems offer the ability to program a Low Voltage Disconnect (LVD) or Low Voltage Cut Off (LVCO), which triggers an alternate power source (often a generator) to turn on and begin charging the battery bank. When the programmed low voltage setting is reached, the system initiates the charge source which then safeguards from over-discharging the battery bank. By default, this may be set by the charger manufacturer at 1.75 volts per cell (VPC). Always verify the default settings and adjust as required.

Low Voltage Disconnect setting is a personal preference. Deep cycle batteries are intended to be discharged no more than 50%. Allowing the battery bank to discharge to a lower voltage will reduce over all cycle life. Alternatively, a higher set point may result in more frequent use of the charging source (ex: generator) when discharge reaches the low voltage cut-off.

To prolong battery cycle life, Rolls recommends setting the Low Voltage Disconnect (LVD) between 1.85 volts per cell (VPC) to 1.95 volts per cell (VPC). This may be adjusted up or down, depending how often you wish to run the charging source (generator or alternative power) when the voltage of the battery bank reaches the programmed set point.

WARNING: Low Voltage Disconnect only cuts off the draw from the inverter/ charger. It does not disconnect all loads from the battery bank. A prolonged connection will eventually lead to over-discharge and battery collapse.

OTHER CHARGER MODES

Many Inverter and Charge Controller manufacturers design and include other operational modes to enhance their products. It is recommended that you contact the manufacturer to better understand how these operate and properly program the Rolls recommended charging parameters (see Table 2 - Charging parameters).

EQUALIZATION - PREVENTATIVE

Individual cell readings will vary slightly in specific gravity after a charging cycle. Equalization or a "controlled overcharge" is required to bring each battery plate to a fully charged condition. This will reduce stratification and build-up of sulfation on the plates; two circumstances that shorten battery life. Equalization of the battery bank is recommended every 60 to 180 days, depending on the usage of the individual system. To equalize the battery bank, charge the batteries until the voltage elevates to the "Equalization" voltage as shown in **Table 2. Flooded Battery Charging Parameters** and maintain for 2 to 3 hours per bank. When specific gravity remains constant for 45-60 minutes this generally indicates completion. Monitor electrolyte levels and add distilled water as necessary. If the cells require watering, it is recommended this be done during the equalization process to allow sufficient mixing with the existing electrolyte.

One of the most commonly asked questions is "When is it time to equalize my battery bank?" The answer will depend on several factors, including depth of discharge, cycle frequency, operating temperature and charging voltage and current. Regular monitoring of specific gravity should indicate when this is necessary. An equalization should be completed when the specific gravity of individual cells within the battery bank are varied by more than .025 -.030 (Ex. 1.265, 1.265, 1.235...). If specific gravity readings are balanced, but consistently lower than recommended, it may be necessary to adjust Bulk/Absorption voltages and/or Absorption time to increase charge time.

FREQUENCY

A corrective equalization may need to be performed if symptoms arise such as a constantly running generator (low capacity) or the battery bank will "not hold a charge". These symptoms are typical of heavy, accumulated sulfation. If a battery is not being fully charged on a regular basis or limited equalization is performed using a generator, sulfating will occur from "deficit" cycling'. This undercharge will lower capacity gradually, which may take months to reach a point where the drop in capacity is noticeable.

NOTE: Properly charging a battery bank with sufficient voltage and current on each cycle is essential to long cycle life. Periodic equalizations may be required to balance and desulfate, but should not be relied on to compensate for insufficient charging sources. Periodic equalizations may not recover a loss of capacity from a build-up of sulfation over time. Alternatively, frequent equalizations will deteriorate the active plate material, reducing cycle life. Repeated equalizations may be required in situations where the battery bank has been consistently undercharged. Recovered capacity, generally partial, may take 1-3 months with battery banks low specific gravity measurements.

EQUALIZATION METHOD

Equalization can take a very long time depending on the degree of sulfation, and the available charging source.

1. Recombination caps (Hydrocaps) should be removed during the equalization process to allow increased hydrogen gas to escape.

2. Equalization voltage should be set to the recommended parameter based on system voltage. See Figure 2 Flooded Battery 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 a DC source with sufficient current when possible. At high voltages, charging with a generator may be difficult and hard on the inverter.

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 115ºF (46ºC) and approaches 125ºF (52ºC), terminate the equalization cycle. You may need to give the batteries a chance to cool off and attempt the cycle again. Check individual cell temperatures using an IR temp sensor to isolate possible damaged cells.

5. If severely sulfated, it may take many hours 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 46ºC. If the charge controller was bypassed, it should now be used or put back in line.

7. Continue measuring the specific gravity until 1.265 is reached.

8. Charge the batteries for another 2 to 3 hours. Add water to maintain the electrolyte above the plates.

9. Allow bank to cool - check and record the specific gravity of each cell. The gravities should be 1.265 ± 0.005 or lower. Check the cell electrolyte levels and add water if necessary.

It is recommended that a specific gravity reading of one pilot cell is measured and recorded on a regular basis when it is thought that the bank is fully charged. The measurement should be compared to previous readings. If the measurement is lower than the previous reading, a longer absorption time and/or higher voltage setting should be used. The longer the absorption time and the higher the bulk voltage, the more water will be consumed but less equalization will be required.

NOTE: The specific gravity should rise as the cells use water. Look for trends in the specific gravity over a period of time and make small adjustments as necessary.

TEMPERATURE PROBE

For additional data and safety, many people choose to install temperature probes inside the battery banks. Regardless of the size of the battery bank, the probe should be installed on the side of one of the battery cells, below the liquid level on a battery placed in the center of the bank. The main factor to look for is maximum temperature. The battery bank should not exceed an operating temperature of 125°F (52°C)

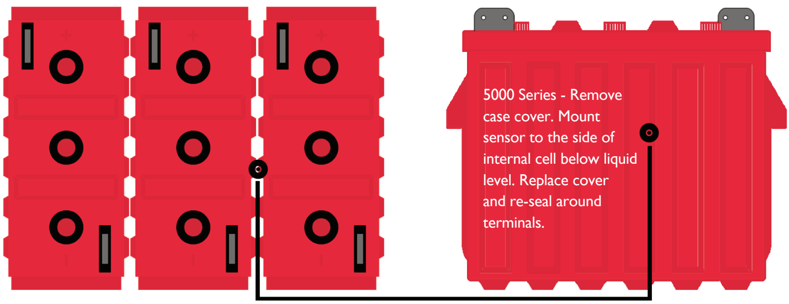


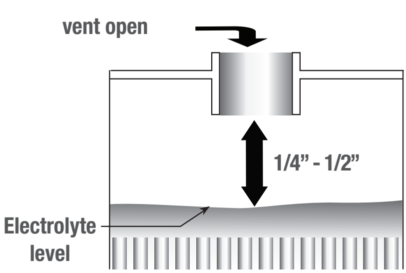
Figure 7 – Temperature Probe
Sensor should be mounted to the side of the battery cell, middle of the bank and below the liquid level. If the battery case has a dual-container construction (Series 5000) it is recommended that the case cover be removed to mount the sensor directly to the side of an internal cell.

CLEANING AND BATTERY MAINTENANCE

Batteries should be kept clean at all times. If stored in a dirty location, regular cleaning should be performed. Before doing so, assure that all the vent caps are tightly fastened. Using a solution of water and baking soda (100g per litre), gently wipe the battery and terminals with a damp sponge, then rinse with water.

A major issue with all flooded battery systems is poor maintenance. Very often systems are installed and then left to owners that don't understand, or just don't perform the correct maintenance. Flooded batteries need to be checked for specific gravity and watered regularly. Often customers will neglect this and over-water, resulting in loss of electrolyte, and or corrosion issues. Under-watering can cause plate exposure, overheating, and possible explosion.

Maximum electrolyte level specified by the battery manufacturer.



Electrolyte should be kept at 1/2" below vent tube.

Caution: Do not add water or electrolyte to cells before initial charging unless plates are exposed. If so, add distilled water until plates are submerged. Please contact Rolls Technical Support if you have any questions or concerns.

Figure 8 – Electrolyte level

Battery connections can also be an issue. Loose connections may result in ignition of hydrogen gasses or cause a short, melting the terminals. It is important to inspect, disconnect, clean and properly torque these connections on a regular basis.

MAINTENANCE SCHEDULE

For the first 6-12 months of a systems life you should check the following things:

Monthly

- Measure and record resting/loaded voltage.
- Check and record electrolyte levels.
- Check and record specific gravity measurements.
- Record ambient temperature of battery room.
- Inspect cell integrity for corrosion at terminal, connection, racks or cabinets.
- Check battery monitoring equipment to verify operation.
- Top off with distilled water as necessary.

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 of 60-90 cycles. Changes to charging parameters may be necessary during this time. Battery performance and requirements will depend on the specific usage. Following these recommendations should keep the batteries in good condition. Normally a typical maintenance routine will be established after 9-12 months of service.

The Series 4000 and 4500 battery models typically need to be maintained on average every 30-60 days. Series 5000 batteries need to be maintained on average every 60-90 days as these models are designed with a higher electrolyte reserve.

PULSE CHARGING

Pulse charging has shown that the banks do not get as sulfated as one with the traditional 3-Stage charging, but will not eliminate the need for controlled, preventive equalization. The benefit of pulse charging is that the bank will suffer less overcharge and hence less maintenance.

BATTERY ADDITIVES

Most battery additives are mainly a form of a common preservative, EDTA. These additives help to increase the solubility of the sulfate in the electrolyte (common salt effect). Some additives contain cadmium sulfate, which could cause disposal problems in the future. These additives are not beneficial and are not recommended.

STORAGE PROCEDURE

Keep the batteries clean and always store in a cool, dry area. Where acid is stored or handled, good ventilation is necessary. Keep the bungs on the containers at all times.

SPILLAGE PROCEDURE

Small spills may be neutralized using water. Spray the spill from a windward location wearing protective equipment. Direct the jet to the outside of the spillage, working your way inward towards the center. Larger spills should be contained using soda ash, sand or dirt and finally washed down with water once absorbed.

DISPOSAL PROCEDURE

Batteries must NEVER be disposed of in household waste. To reduce environmental impacts, bring your battery to a certified recycling depot at the end of its life.

NOTE: Lead-acid batteries are 97% recyclable. Rolls Batteries have >66% recycled lead.

SPECIFIC GRAVITY & VOLTAGE READINGS

BATTERY CELL READINGS				DATE:	
CELL #	SPECIFIC GRAVITY	VOLTAGE	CELL #	SPECIFIC GRAVITY	VOLTAGE
1			25		
2			26		
3			27		
4			28		
5			29		
6			30		
7			31		
8			32		
9			33		
10			34		
11			35		
12			36		
13			37		
14			38		
15			39		
16			40		
17			41		
18			42		
19			43		
20			44		
21			45		
22			46		
23			47		
24			48		

INSPECTION			
CHECKLIST	CHECK ☐	CHECKLIST: (CONT'D)	CHECK ☐
BATTERIES CLEAN & DRY	☐	TERMINALS CONNECTIONS	☐
VENT CAPS TIGHT	☐	HYDROCAPS	☐
ELECTROLYTE LEVELS CHECK & TOP	☐	SPECIFIC GRAVITY	☐
TERMINALS CLEAN	☐	VOLTAGE	☐

AGM VRLA BATTERY

ROLLS AGM BATTERY CHARGING INSTRUCTIONS

To maximize the life of your Rolls AGM battery, it is important that it is properly charged. Over and under-charging a Rolls AGM battery will result in shortened service life. The best protection from improper charging is the use of a quality charger and routinely checking that the charger current and voltage settings are maintained. Please review the following Rolls Battery Charging Instructions.

AGM CHARGER INSPECTION

The charger cabling should be insulated and free of breaks or cuts. The cable connectors should be clean and properly mated with the battery terminals to ensure a snug connection. The charger's AC cord should be free of breaks or cuts and the wall plug should be clean.

AGM CHARGING GUIDELINES

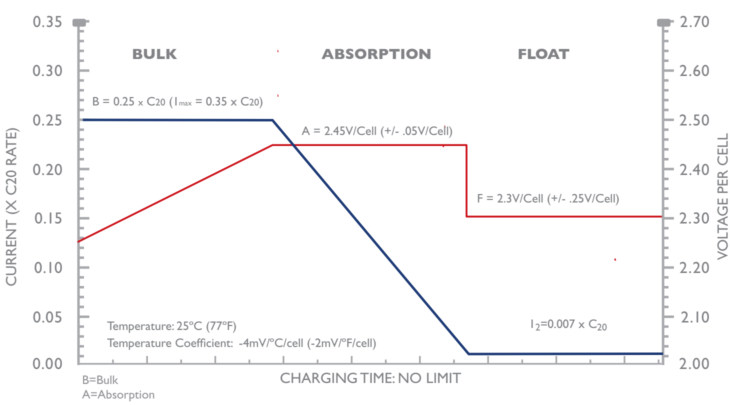
Fully charge batteries after each use. Charge in a ventilated area as gasses may be released through the pressure relief valve if the batteries are excessively over-charged. Never charge a frozen battery. Ideal charging temperatures: 32°F – 104°F (0°C – 40°C).

AGM CHARGING CHARACTERISTICS

If the charger has a specific setting for AGM type batteries, Rolls recommends using this charge setting. To maximize your battery life, a voltage regulated charger with temperature compensation is strongly recommended. See Figure 1 for the recommended voltage regulated charge profile.

If using battery temperature compensation it should be .04mv / Degree C / Cell. Charger voltages should be set to 2.45vpc to allow the proper voltage adjustment by the charger.

VOLTAGE REGULATED CHARGER – UU



AGM BULK STAGE

The charger should deliver the initial current B until the voltage limit A is reached. Absorption Stage – the charger should maintain the voltage A until the current tapers to B. The initial charge current is recommended to be set at B = 0.25 X C20 (Imax = 0.35 X C20) in order to fully charge the batteries within a reasonable amount of time. It can be set lower, however; please be aware that charge time will increase so make sure the batteries have enough time to fully charge before being put back into service. Rolls batteries have a low internal resistance allowing them to be charged at a higher current, therefore, faster than conventional flooded/wet batteries.

AGM FLOAT STAGE AND TERMINATION

The charger can maintain the current B indefinitely or until the charger is shut off or unplugged. This stage is ideal to maintain battery state of charge. Make sure the temperature compensation is programmed as specified in Figure 1 (-4mV/°C/cell or -2mV/°F/cell) or manually adjust the voltage setting for temperatures varying from 25°C (77°F). As the temperature decreases, the voltage should be increased and as the temperature increases the voltage should be decreased. The profile in Figure 1 can be used with or without the float stage. Without the float stage, recharge can be terminated based on time (this will need to be determined as it will vary with depth of discharge and charge current) or percentage recharge (105%-110%)

AGM CHARGE VOLTAGE QUICK REFERENCE

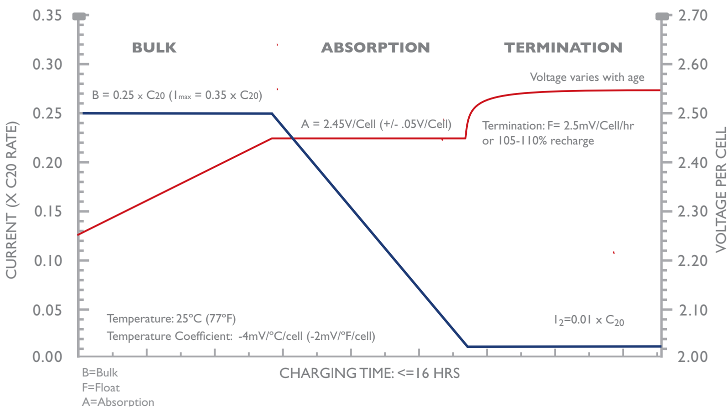
		32°F (0°C)	50°F (10°C)	68°F (20°C)	77°F (25°C)	86°F (30°C)	104°F (40°C)
2V	Charge Voltage	2.55V	2.51V	2.47V	2.45V	2.43V	2.39V
	Float Voltage	2.38V	2.34V	2.30V	2.28V	2.26V	2.22V
12V	Charge Voltage	15.30V	15.06V	14.82V	14.70V	14.58V	14.34V
	Float Voltage	14.25V	14.01V	13.77V	13.65V	13.53V	13.29V
24V	Charge Voltage	30.60V	30.12V	29.64V	29.40V	29.16V	28.68V
	Float Voltage	28.50V	28.02V	27.54V	27.30V	27.06V	26.58V
48V	Charge Voltage	61.20V	60.24V	59.28V	58.80V	58.32V	57.36V
	Float Voltage	57.00V	56.04V	55.08V	54.60V	54.12V	53.16V

NOTE: With the use of battery temp compensation be sure to set the charge voltage at 2.45 volts per cell, setting a lower or higher voltage, and with the use of battery temp compensation on your charger will cause incorrect charging voltages.

If a temperature compensation sensor is not used, then you must manually adjust charging voltages based on the battery temperature when in use, not just ambient temperatures.

AGM CONSTANT CURRENT CHARGER – IUI

A constant current charger may also be used. However, it is important to adhere to the termination criteria mentioned below to minimize the chance of excessive over-charge. See Figure 2 for the recommended constant current charge profile.



AGM BULK STAGE

The charger should deliver the initial current B until the voltage limit A is reached. Absorption Stage – the charger should maintain the voltage A until the current tapers to B.

AGM TERMINATION

If the charger can be programmed, the charge should terminate when the voltage stops increasing over time. This is called a float termination. The charge should terminate when the float is equal to 2.5mV/cell/hour. The charge time in the final phase should not exceed 8 hours and the total charge time should not exceed 20 hours. The percentage recharge should be between 105%-110%.

AGM REFRESH CHARGE

If Rolls AGM batteries are properly charged they should never require an equalizing charge. If they were not properly charged and there is a decrease in capacity, recharge the batteries and make sure they complete the entire charge cycle. If the batteries are stored for extended periods of time, recharge them as follows

Storage Temperature	Refresh Charge Interval
Below 68°F (20°C)	9 Months
68°F (20°C) - 86°F (30°C)	6 Months
Higher than 86°F (30°C)	3 Months

RENEWABLE ENERGY APPLICATIONS

RENEWABLE ENERGY APPLICATIONS

Most deep cycle batteries used in the Renewable Energy Industry were originally designed and manufactured for use in Industrial applications, where consistent charge cycles are carried out from six to twelve hours until the batteries reach a full state of charge. In Renewable Energy (RE) applications, a lengthy charge time is not typical and in most instances a maximum of 4-6 hours of peak charge is achieved each day due to limited daylight and varying weather conditions. To ensure the batteries received sufficient charge, charging systems must be adequately sized or additional charge sources added to prevent deficit charging and premature battery failure.

There are two definitive types of battery-based systems used in Renewable Energy applications; Off-Grid and Grid-Connected. Off-Grid systems are often used where a customer chooses not to connect or there is no available connection to a public utility. This customer may live remotely and have chosen to install a renewable energy system from a single or combination of renewable sources to generate and store adequate power to run all electrical requirements within the home.

With Grid-Connected systems, a customer typically lives in an area where they may experience frequent or extended service interruptions from their public utility. This may be a result of poor weather conditions, an unreliable power grid or natural disasters. The renewable energy system is used as a backup power supply, meant to supplement power during brief outages and/or to reduce energy costs by selling excess power generated from the system back to the utility.

OFF-GRID SYSTEMS

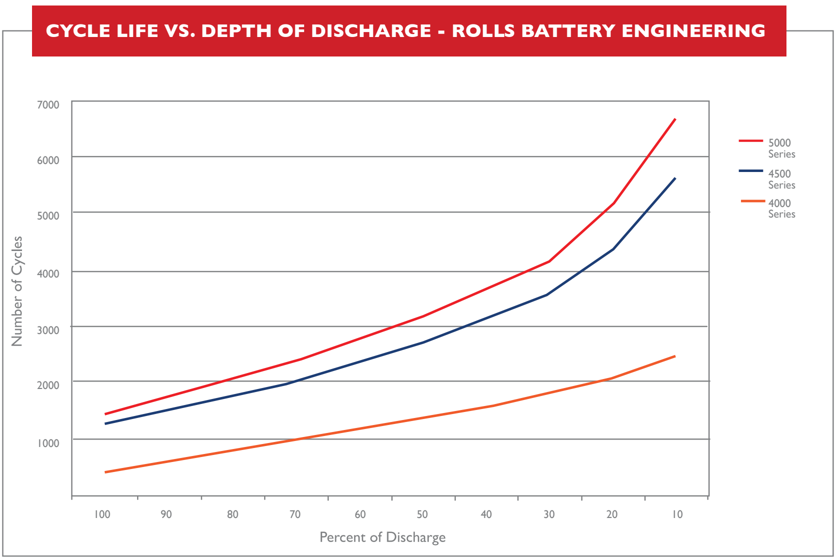
When sizing a battery bank it is important to determine the appropriate capacity requirement to meet the load which will be supported and not oversize for the application. A battery bank which is too large for the charging source often leads to sulfation issues due to lack of proper charging as well as frequent supplemental charging from another source. (ex. generator)

DEPTH OF DISCHARGE

Depth of Discharge (DOD), is used to describe how deeply the battery has been discharged. A battery which is 100% fully charged would have a DOD of 0%. A battery which has been discharged by 20% of its capacity, maintaining 80% of its capacity, would have a DOD of 20%. If a battery has been completely discharged with no remaining capacity, the DOD is 100%.

CYCLE LIFE

Battery manufacturers rate the cycle life of their batteries by comparing the level of discharge on the battery and the frequency of cycling. Higher battery discharge will result in shorter cycle life. In reverse, a smaller discharge percentage will extend the expected cycle life of the battery as the battery will provide more charge/discharges. To provide an example of cycle life, a 48V string of 8 x 6 volt S-550 models in series (428 AH capacity @ C20) which are consistently discharged to 50% state of charge (214 AH of capacity drawn) and consistently recharged to a full state of charge should provide approximately 1280 cycles before end of life.



With traditional off-grid Renewable Energy systems, DOD is set to operate between 20% and 50% to maximize the life of the batteries. Battery-based systems are designed to allow a maximum 50% DOD as this offers a balance between capacity vs. cycle life, also taking into consideration the cost of replacement.

For grid-connected backup systems, Installers will typically design battery banks to operate to a greater DOD percentage to lower initial installation costs. Cycling with grid-connected systems is significantly less frequent than with off-grid, where this may occur daily, a lower DOD is acceptable as long as the customer understands that the overall cycle life is affected when they cycle their battery bank beyond a 50% state of charge.

BATTERY SELECTION

Choosing the appropriate battery for the application is key to long battery life and performance. Once the load is determined a battery bank should be selected to meet the system design. If a battery bank of a specific capacity is needed, it is important to select a battery model which offers sufficient capacity, but also minimizes the number of parallel strings required to accomplish the desired voltage and capacity.

Systems with multiple parallel strings of batteries will often experience an imbalance of charge. These systems will also require additional maintenance as this increases the number of terminal connections requiring cleaning as well as the number of cells to water. When charge imbalance is not addressed through adjustments in charge time and periodic equalizations this will eventually lead to premature failure of the battery bank.

Determining the capacity requirement for off-grid systems is done by completing an audit of energy consumption based on actual load requirements. The load is calculated by the total amount of power necessary to support the load for a 1 day period and then factors in how many days it may be required before recharging. In a typical Renewable Energy system the 20 hr AH rate (C20) is used when sizing systems to cover three days of autonomy or less. The 100 hr AH rate (C100) is used when designing systems to cover more than 3 days of autonomy.

Most systems are designed for a 1-2 day rate, due to the cost of batteries verses the cost of adding a generator and/or additional renewable energy sources. This is also most typical for solar applications as these systems allow the battery bank to be charged each day.

Deep cycle batteries will perform best when they are maintained at a full charge. By holding at a full state of charge this will extend the overall life of the battery bank. For float applications, such as backup systems, it is also important to use the battery bank on occasion as this will prevent stratification and sulfation.

It is important to be aware that as load profiles change this too will affect how quickly battery capacity will be reduced. Often a backup system is sized to meet the load requirement at the time of install, but this demand will increase with every small addition to the load.

DISCHARGE RATES

Discharge and recharge rates should be considered when selecting and sizing a battery bank. Battery manufacturers publish multiple discharge rates for each battery model, which range from 100 hrs to 1 hr. These are often referenced for various type of applications. The most common in Renewable Energy applications is the 20 hr rate as this closely matches a 1 day period. The rating, (ex C20) refers to a controlled load (amps) which can be placed on the battery for a period of time before the battery voltage reaches 1.75 VPC (volts per cell). A high amp draw may be run for a shorter period of time and vice versa.

As an example, a 400 AH battery can support a controlled 20 Amp draw for 20 hours (C20). Alternatively, the same battery can support a controlled 34 Amp draw over a 10 hour period (C10), meaning it supplies 340 AH capacity for that period of time.

Batteries which are discharged should be recharged as promptly as possible. A Renewable Energy PV system should be designed to provide a charge current that is capable of recharging the batteries quickly, efficiently and within the window of time when the system is generating peak power (peak sun). The charge current should be within 10-20% of the 20 Hr AH rate (C20) rate of the battery bank, or the C4, C5, or C6 rate of the battery. Using the Absorption charge time calculation (charge current of 10% of the C20 rate of the battery bank will take approximately 4.2 hours, plus the untimed bulk phase (usually about 1-2 Hours) to bring the bank from 50%-100% state of charge. This is an ideal scenario as a lower charge current will often result in deficit charging as this increases the required Absorption charge time and/or the use of supplemental charging such as a generator. Often customers who need to supplement charge with a generator do not run it long enough to allow the batteries to reach a full state of charge on a regular basis. This often causes sulfation problems and capacity loss which then needs to be addressed through corrective equalizations.

Finally the last issue with some systems, after installing/commissioning end users will inadvertently add more loads after the installation causing problems with how often the battery bank needs to be recharged, thus increasing cycle life usage. This needs to be avoided, and can be by properly educating the customer at the time of sale.

GRID-CONNECTED BACKUP

There are two distinct uses for a grid-connected battery bank. The first, and the most common is a power backup system. The purpose is to provide temporary power in the instance of grid loss. This is simular to a UPS system, but is typically on a much larger scale with higher storage capacity.

The second is a grid-tied system with battery backup. The purpose of this system setup is to generate and sell excess power produced by a renewable source to your utility provider when you are connected to the grid. In the event of a grid failure, the battery bank then provides storage power for the critical loads during the outage. Systems are configured according to how much power is to be sold to the utility vs. how much will be stored. If a higher percentage of the power generated is pushed to the utility, this will decrease the remaining amount available for backup and vice versa. This may be determined by personal preference or may be limited or regulated by the utility.

For grid-tied battery backup systems, the battery bank should only be sized to handle the loads supported for the duration of a temporary outage. These systems are commonly used to run household necessities such as limited lighting, refrigeration, etc. It is important to limit the size of the supported load to essential service only as higher capacity battery banks require more maintenance as well as power usage to hold at full charge, reducing the amount of generated power which can be sold to the utility.

Typically, because outages are infrequent and occur only a few times per year in most regions, these systems are designed for greater depth of discharge than off-grid. In some cases they may be designed to discharge as much as 20% state of charge over a relatively short period of time.

In areas where the grid may not be reliable and extended or intermittent outages occur frequently, it would be necessary to size the battery bank and charging source(s) to support a larger load over a longer period of time. This would prevent the battery bank from over-discharging and/or insufficient charging between cycles.

WARRANTY GLOSSARY

FREQUENTLY ASKED QUESTIONS

WARRANTY

We build one mean battery and we back them with comprehensive warranties that lead the industry in length of coverage. We're confident that our batteries will perform time after time, year after year. But should a problem arise, you can be confident that you're covered better than any other battery warranty in the business.

Rolls, herein referred to as the Company, warrants that batteries sold by it are merchantable and free of defects in workmanship and material at the time they are shipped from the Company's factory.

In the event that the Company makes a drop shipment to a distributor's customer, that customer must be instructed to perform an inspection of the goods BEFORE signing the delivery slip. The Company is not responsible for damaged product reported after shipment has been signed "Received in Good Condition". **NOTE: ALL SHIPMENTS SHOULD BE THOROUGHLY INSPECTED FOR DAMAGE BEFORE SIGNING THE DELIVERY SLIP.** The Company will replace or, at its option, repair any Rolls Battery sold by it that fails to conform to the warranty stated above on a NO CHARGE BASIS as follows:

For warranty terms and conditions, please refer to the Products section on the website for model-specific details: www.rollsbattery.com. A warranty claim form may be found on the website.

To claim a manufacturing warranty, proof of purchase must be presented, showing the date of purchase and the battery's serial number. The battery must be tested by an authorized battery outlet for actual defect, and upon confirmation of the defect, the warranty will be administered.

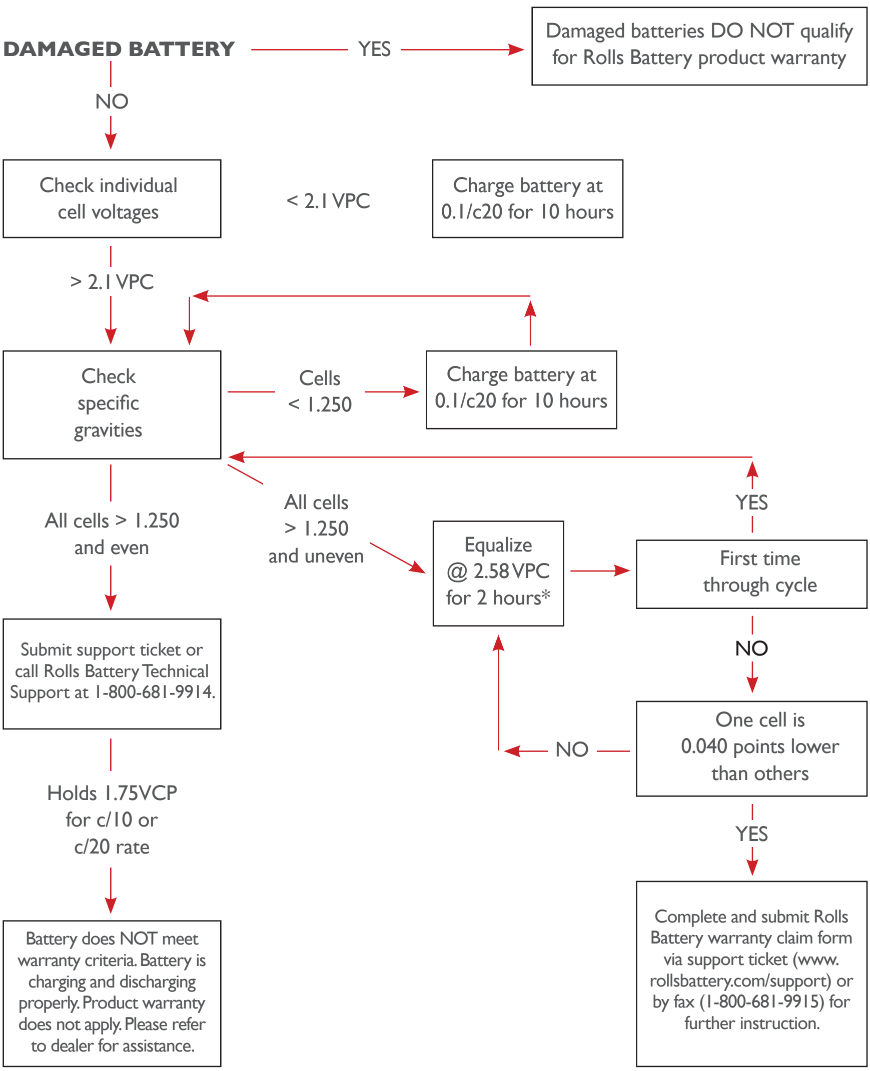
The warranty does not cover shipping damage, cracked covers, cracked cases, bulged cases from heat, freezing or explosion, discharged batteries or the use of undersized batteries damaged from electrical equipment. This warranty covers only manufacturing defects.

The Company makes no warranty with respect to its batteries other than the warranty stated above. All implied warranties of merchantability and all expressed and implied warranties of any other kind are hereby excluded.

ROLLS BATTERY WARRANTY PROCEDURE

Please refer to product warranty for the specific model as terms and conditions may vary.

For warranty requests and inquiries, please submit your request via support ticket (www.rollsbattery.com/support) or by email to support@rollsbattery.com



LEAD ACID BATTERY GLOSSARY

ABSORBED (OR ABSORPTIVE) GLASS MAT
A technique for sealed lead-acid batteries. The electrolyte is absorbed in a matrix of glass fibers, which holds the electrolyte next to the plate and immobilizes it, preventing spills. AGM batteries tend to have good power characteristics, low internal resistance, and good behavior during charging.

AMP, AMPERE
Unit of electrical current. Abbreviated "A".

AMP-HOUR
Unit of electrical energy, one amp of current flowing for one hour. Abbreviated Ah.

CELL
A single battery canister usually grouped together with other cells to form battery packs of different voltages and amperages. Example: One lead acid cell is 2.1 volts; therefore, six cells packaged together makes a 12.6 volt battery pack.

CYCLE
A "cycle" is a somewhat arbitrary term used to describe the process of discharging a fully charged battery down to a particular state of discharge. The term "deep cycle" refers to batteries in which the cycle is from full charge to 80% discharge. A cycle for an automotive battery is about 5%, and for telephone batteries is usually 10%.

ELECTROLYTE
An electrically conductive medium in which current flow is due to the movement of ions. In a lead-acid battery, the electrolyte is a solution of sulfuric acid. In other batteries, the electrolyte may be very different.

FLOODED CELL
A design for lead-acid batteries. The electrolyte is an ordinary liquid solution of acid. Flooded cells are prone to making gas while being charged. They must be periodically checked for fluid level and water added as necessary. Flooded cells are also typically less expensive than AGM or gel type lead-acid batteries.

HYDROMETER
A tool for testing the specific gravity of a fluid, such as the electrolyte in a flooded battery. Typically, a squeeze-bulb is used to suck up a sample of the fluid, and a float indicates the specific gravity.

SPECIFIC GRAVITY

The density of a material, expressed as the ratio of the mass of a given volume of the material and the mass of the same volume of water; a specific gravity greater than 1 means heavier than water, less than 1 means lighter than water. The specific gravity of the electrolyte in a battery can be used to measure the state of charge of the battery.

SULFATION

Even though lead sulfate is created in the materials of plates during normal discharging, this term is used to describe the generation of a different form (large crystals) of lead sulfate which will not readily convert back to normal material when the battery is charged. Sulfation occurs when a battery is stored too long in a discharged condition, if it is never fully charged, or if electrolyte has become abnormally low due to excessive water loss from overcharging and/or evaporation.

VOLT

The unit of measurement of electrical potential or “pressure”. Most batteries come in 2, 4, 6, 8 or 12 volt configurations.

TROUBLESHOOTING & FREQUENTLY ASKED QUESTIONS

The following is a list of common scenarios, questions and concerns 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.

***Note that specific gravity readings should be taken at full charge, after the batteries have been allowed to cool and are resting in a Float voltage charge for 1-2 hours.**

- Specific gravity readings of all cells in the battery bank indicate low state of charge. Readings vary by cell, but not greater than .020 between the cells.
    - Charging voltages may be too low and/or Absorption time may need to be increased. Usage (load) may have increased, resulting in increased depth of discharge (DOD) and sulfation.
        1. Increase Bulk/Absorption/Boost Voltage in .2v to .4v volts increments.
        2. Increase Absorption Time by 15 to 30 minutes increments as necessary.
        3. Decrease DC load usage.

- Specific gravity readings are consistently higher than recommended. (Ex 1.300, 1.300, 1.300…)
    - Charging voltages may be too high and/or Absorption time should be decreased to prevent overcharge. Usage (load) may have decreased, reducing depth of discharge (DOD) and the time required to recharge, causing the batteries to overcharge.
        1. Decrease Bulk/Absorption/Boost Voltage in .2v to .4v volts increments.
        2. Decrease Absorption Time by 15 to 30 minutes increments as necessary.

- Specific gravity readings on individual cell(s) in a battery bank with multiple series strings vary more than .020 (Ex 1.265, (1.265, 1.240, 1.265…)
    - Indicates there may be an imbalance of charge between parallel strings of batteries.
        1. Disconnect parallel strings and charge each string individually to balance charging. For systems with more than two parallel strings of batteries you may find this is necessary 1-2 times a year to maintain balanced charging.
        2. Increase Bulk/Absorption/Boost Voltage by .2v increments.

- Indicates there may be connection issues within each series connection or parallel strings.
    1. Clean and inspect all cabling and connections. Physically disconnect cable, inspect for terminal concaving (Over Torqued), grease and re-torque connections.

***Specific gravity readings vary more than .030 in multiple strings of batteries indicates an imbalance of charge. If specific gravity readings continue to vary after charging each string individually a corrective equalization charge may be necessary.**

- Capacity of the battery bank has decreased.
    - Capacity loss may be due to sulfation. A balance charge and/or equalization may be necessary.
    - Capacity loss may be due to overheating. Verify that temperature sensors are properly mounted and verify cell temperatures.
    - Capacity loss may be due to over-discharging the battery bank. Capacity of the battery bank may no longer support an increase in load.

- Battery cases are bulging on the sides.
    - If case bulging is a concern upon receipt of new product, please notify your Distributor and/or forward clear photos via a Technical Support Ticket or email to support @rollsbattery.com for review.
    - Due to the weight of electrolyte, some case bulging is normal. New battery cases will “relax” after filling. Verify that electrolyte levels have not dropped below the top of the plates before attempting to charge and top up with distilled water as necessary.
    - In the case of excessive bulging- your batteries may have been exposed to temperatures of over 125°F (51°C). This high temperature has caused the plates/chassis to swell and expand. There is no fix for this and eventually the batteries will fail prematurely.
    - Your batteries may have frozen due to excessive cold temperatures. A fully charged battery (specific gravity of 1.265) may freeze at -94°F (-70°C) or more. A battery that is at 50% state of charge (specific gravity of 1.200) may freeze at 20°F (-7°C).

- When a charge is initiated the voltage of the battery bank rises very quickly and the charger goes quickly into the Absorption charge cycle or shuts off charge to the batteries completely.
    1. This is often an indication of sulfated batteries which may be causing a lower than normal impedance in reference to the charger. Capacity of the bank will be reduced and may be confirmed by running a load test.
    2. An increase in Absorption time may be necessary to de-sulfate the battery bank.
    3. If the battery bank is heavily sulfated, a corrective equalization may be necessary. Perform a corrective equalization if specific gravity readings vary by more than .030 between cells.

- Charging current to the battery bank (Amp output) is low.
    - Charging current will decrease as the batteries become fully charged. If charge current is low they may have reached the end of the charge cycle. Verify that the charger is nearing the end of Absorption time or in Float voltage phase. Low current is normal this stage of charging.
    - The battery bank self-regulates charge current. Voltage settings may be forced (too high/low), however amp output to the battery bank cannot be forced and will drop as the batteries reach a full state of charge. When the charge current reaches 2-3% of the capacity of a healthy battery bank the charge is essentially complete. (ex. 500 AH battery bank. Charge current is reduced to 10-15 Amps)
    - Check your Specific Gravity.
        1. If specific gravity readings are at 1.250 or greater, the batteries are in the Absorption charge phase.
        2. If the specific gravity is lower than 1.250 following a charge, perform a load test to ensure all cells are operating correctly.

- Specific Gravities readings at full charge vary significantly, (greater than .030)
    - This may be caused by multiple parallel strings of batteries in a bank, which often result in charge imbalance. It is not recommended that a system exceed 3 strings of batteries connected in parallel.
    - Charge voltage settings may be too low. Verify they meet Rolls recommended charging parameters for Flooded or AGM models.
    - An increase in Absorption charge time may be necessary. Increase in 15 to 30 minute increments.
    - Indicates there may be failing or dead cell(s) in the battery bank causing a charge imbalance.

- While charging, the battery bank does not reach Bulk voltage setting.

- If the system is not reaching bulk voltage the charge voltage and/ or Amp output to the battery bank may be too low. Verify that these meet Rolls recommended charging parameters for Flooded or AGM models and that charge output (Amps) is sufficient to meet the capacity of the battery bank. To ensure sufficient charge, output should be approximately 10% of the Amp Hour capacity of the battery bank. (Ex1200AH Battery Bank = 120 A charge output)
- Indicates that DC loads running on the system during the charge cycle may be reducing the charge output to the battery bank, slowing down the charging process.

- When performing a corrective equalization, the battery bank does not reach equalization voltage.
    - Before doing an EQ you should do a full Absorb Charge prior to initiating an EQ charge.
    - Indicates the charge output may be too low. Verify the voltage and charge output meet Rolls recommended charging parameters.
    - Indicates the possibility of a failed or dead cell which may be causing resistance. Verify specific gravity of each cell and voltage reading for each battery in the bank.

- Battery(s) temperatures are very high.
    - If at or near 125oF (51oC) shut off charge and allow batteries to cool.
    - If a single battery or cell in a string is hot, this may indicate a cell failure or short. Verify specific gravity for all cells and take voltage readings from each battery and perform a load test to identity any cell failures and verify proper cell operation.

- Battery Terminal has melted
    - This is most common with loose connections, causing a highly resistant connection. This resistance has caused heat buildup and melted the terminal connection.
        - This can be caused by:
            - 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

- Battery cover has cracked, shattered and/or dislodged from the case (Not affecting positive and negative terminals or connections)

    - Ignition of hydrogen gas may have caused the battery cover to crack or explode.
    - This sometimes occurs during a charge where a loose connection at the terminal sparked, igniting hydrogen gas from the cell.
    - This may be the result of low electrolyte levels causing high cell temperature and increased hydrogen gas. Check each cell and top up with distilled water as necessary.
    - Battery case has split or cracked originating from the sides.
    - The battery may have frozen in the past, which has weakened the case structure.

- Battery and/or cell(s) do not require watering.
    - The battery may have a cell that has failed and no longer accepts a charge
        1. Verify specific gravity of all cells and voltage reading of each battery.
        2. Perform a load test to identify any cell failures and verify proper cell operation.

CONTACTS

Surrette Battery Company Ltd.
PO Box 2020, 1 Station Road
Springhill, Nova Scotia
B0M 1X0
Canada

Phone: +1 902 597 3767
(+1 800 681 9914)
Fax: +1 902 597 8447
(+1 800 681 9915)
sales@rollsbattery.com

CUSTOMER SERVICE

Ashley Livingston
+1 902 597 4005
ashley@surrette.com

SALES

Phone: +1 902 597 3767
(+1 800 681 9914)
sales@rollsbattery.com

TECHNICAL SERVICE

Phone: +1 902 597 3767
(+1 800 681 9914)
support@rollsbattery.com

Technical Support Ticket
support.rollsbattery.com