BATTERY USER MANUAL

BATTERY ENGINEERING

Recommended installation, charging and maintenance procedures for Rolls deep cycle Flooded, VRLA AGM & OPzV GEL batteries.

FLOODED

AGM

GEL

RENEWABLE ENERGY

MARINE

MOTIVE POWER

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Rolls Battery has been manufacturing deep cycle lead-acid batteries since 1935. Experience and commitment to quality has helped us achieve an unmatched reputation in the industry. Our goal is to provide our customers with a premium product providing dependable performance and long-lasting cycle life. This manual provides the recommended setup, charging, Equalization and preventive maintenance procedures necessary to maximize the life of your Rolls batteries. If you have battery-related questions beyond the contents of this manual, we encourage you to visit our online Technical Support Desk (**support.rollsbattery.com**) for additional information or file a support ticket and our Technical Support team will be happy to assist you.

EQUIPMENT & SAFE HANDLING PROCEDURE

- Goggles, rubber gloves & rubber boots
- Distilled water
- Baking soda, soda ash
- hydrometer, refractometer
- voltmeter, ammeter
- battery charger

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 an acid spill 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. Perform a voltage check to confirm the battery polarity and marking 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 CHECK LIST

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!

DISPOSAL PROCEDURE

Batteries must **NEVER** be disposed of in household waste. To reduce environmental impact, bring your spent lead-acid batteries to a certified recycling depot. Lead-acid batteries are 97% recyclable and are the most recycled consumer product in the world. Closed-loop manufacturing and recycling programs allows nearly all of the components to be recycled or re-purposed. A credit by weight for lead may be offered by recycling depots or facilities for spent batteries.

When processed safely, recycling batteries reduces the release of lead to the environment and conserves natural resources. Recycled lead production takes only 35-40% of the energy necessary to produce primary lead from ore. Lead may be recovered and re-purposed multiple times.

For more information on lead-acid battery recycling, visit **https://batterycouncil.org**

PROVISIONS AGAINST ELECTROLYTE HAZARD

ELECTROLYTE AND WATER

Electrolyte used in lead-acid batteries is an aqueous solution of sulphuric acid.

Electrolyte used in NiCd and NiMH batteries is an aqueous solution of potassium hydroxide. Distilled or demineralised water is used when topping up the cells.

PROTECTIVE CLOTHING

In order to avoid personal injury from electrolyte splashes when handling electrolyte and/or vented cells or batteries, protective clothing shall be worn, such as

- protective glasses or face shields,
- protective gloves and aprons.

In the case of valve-regulated or gastight sealed batteries, at least protective glasses and gloves shall be worn.

ACCIDENTAL CONTACT, "FIRST AID"
GENERAL

Acid and alkaline electrolytes create burns in eyes and on the skin. A source of clean water, from tap or a dedicated sterile reservoir, shall be provided in the vicinity of the battery under charging or maintenance for removing electrolyte splashed onto body parts.

EYE CONTACT

In the event of accidental contact with electrolyte, the eyes shall be immediately flooded with large quantities of water for an extended period of time. In all cases immediate medical attention shall be obtained.

SKIN CONTACT

In the event of accidental skin contact with electrolyte, the affected parts shall be washed with large quantities of water or with adequate neutralising solutions. If irritation of skin persists medical attention shall be obtained.

BATTERY ACCESSORIES AND MAINTENANCE TOOLS

Materials used for battery accessories, battery stands or enclosures, and components inside battery rooms shall be resistant to or protected from the chemical effects of the electrolyte.

In the event of electrolyte spillage, the liquids shall be removed promptly from all surfaces with absorbing and neutralizing material.

Maintenance tools such as funnels, hydrometers, thermometers which come in contact with electrolyte shall be dedicated either to the lead-acid or NiCd-batteries and shall not be used for any other purpose.

BATTERY ORIENTATION

Flooded lead-acid batteries must be kept in an upright position at all times as electrolyte may spill if tilted more than 20 degrees. Rolls VRLA AGM batteries should be installed upright for best performance and may not be mounted upside down or horizontally on the end (shortest side) of the case. Models installed horizontally should not rest on the cover or case/cover seam and must be supported fully on the long side of the case.

Rolls OPzV GEL models must be installed upright unless otherwise specified. Special order models compatible with horizontal installation, as well as racking systems, are available upon request. Models installed horizontally may not be mounted on the end (shortest side), should not rest on the cover or case/cover seam, and must be supported fully on the long side of the case. Use caution not to cover or apply pressure to valves located on the top of the batteries when using strapping to install or secure cells as damage may occur.

CABLE SIZING

Cabling should be proportionate to the amperage of your system. The following table notes the maximum current carrying capacity based on cable gauge. Battery cables 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. When choosing interconnect cables or custom bus bars, size to allow adequate spacing between batteries for airflow as outlined above.

TABLE 1: Wire gauge sizing by amperage

Amperage	25	30	40	55	75	95	130	150	195	260
Wire Gauge	14	12	10	8	6	4	2	1	0	0000

TERMINALS & CABLE CONNECTIONS

All cable connections should be adequately sized, insulated and free of damage. The cable connectors should be clean and properly mated with the battery terminals to ensure a snug connection.

Electrolyte spills and corrosion buildup will damage cable connectors and terminals. It is recommended that terminal connections are disconnected, cleaned and re-torqued periodically as part of the regular maintenance routine. This also applies to connections using bus bars. Check and recalibrate the torque wrench for accuracy before use.

Visual inspections may not always detect poor connections. The use of an Infrared (IR temperature) sensor may assist in identifying poor connections when testing under load or during charge. Connections which have overheated and/or developed problems will often be welded to the terminal. Loose connections may result in ignition of hydrogen gas during charging or cause a short, melting the terminals.

Loose or overtightened connections may also cause high resistance. The result is an unwanted voltage drop as well as excessive terminal heating which causes 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.

As batteries are cycled and heat up during charge, under-torqued connections may become loose over time as the terminals heat & cool, causing possible arching and a risk of spark. Over-torqued connections may indent, crack or bend the terminal and/or washers or terminal connectors.

Damage to terminals and/or batteries caused by under/over-torque is often unrepairable and is not covered under manufacturer warranty. Follow the recommended torque settings for each terminal type. Battery distributors or dealers may offer replacement or repair, where possible, at the customer's expense.

TERMINALS

Inspection of battery terminal connections is also important. Loose connections may result in ignition of hydrogen gases or cause a short, melting the terminals. It is important to inspect, disconnect, clean and properly torque these connections on a regular basis. Use a proper torque wrench, noting the required torque setting for the particular terminal.

TERMINAL TORQUE SETTINGS

Refer to the chart below for the recommended torque setting for the battery terminal (see battery specifications). To prevent terminal damage, contact Rolls Battery Technical Support for torque recommendations if the specific terminal type is not listed. Calibrate the torque wrench before use to ensure accuracy.

NOTE: Damage to terminals and/or batteries caused by under/over-torque is often unrepairable and is not covered under manufacturer warranty. Distributors or Dealers may offer replacement or repair, where possible, at the customer's expense.

BATTERY	RECOMMENDED TORQUE SETTING	
FLOODED TERMINALS	N-m	lb-ft
FLAG, PADDLE RR	27 N-m (max: 33 N-m)	20 lb-ft (max: 25 lb-ft)
LT	24 N-m (max: 33 N-m)	18 lb-ft (max: 25 lb-ft)
DT	11 N-m (max: 16 N-m)	8 lb-ft (max: 12 lb-ft)
UTL	11 N-m (max: 16 N-m)	8 lb-ft (max: 12 lb-ft)
AGM TERMINALS	N-m	lb-ft
THREADED FEMALE F8 (M8)	10 N-m	7.4 lb-ft
THREADED FEMALE F10 (M10)	13 N-m	9.5 lb-ft
AP	7 N-m	5.1 lb-ft
LT	10 N-m	7.4 lb-ft
DT	7 N-m	5.1 lb-ft
M6 (TP06) BRASS	4.5 N-m	3.3 lb-ft
M8 (TP08) BRASS	10 N-m	7.4 lb-ft
OPzV GEL TERMINALS	N-m	lb-ft
THREADED FEMALE F10 (M10)	21 N-m	15 lb-ft

PARALLEL & SERIES CONNECTIONS

Applications often demand more voltage or more ampere capacity than the capacity of one battery. By connecting multiple batteries of the same make/model/capacity in series, parallel or series parallel configurations, output voltage or battery bank amperage may be increased 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.

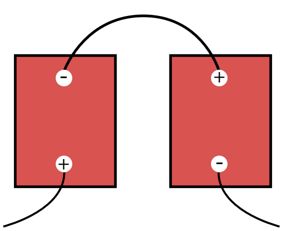


FIGURE 1:
Voltage Increase

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

EXAMPLE:

Battery = 6-volt (S6 L16-HC)
Battery Voltage = 6V each
Battery Capacity = 445 AH each
System Voltage = 12V System
Capacity = 890 AH total

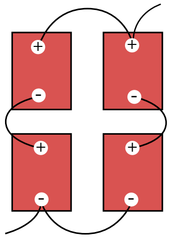


FIGURE 2:
Voltage/Capacity Increase

EXAMPLE:

Twenty-four (24) 2-volt batteries at 2527 AH each = 2527 AH at 48 Volts

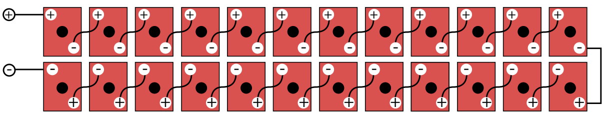


FIGURE 3:
Single Series String
+ "Best Option"

EXAMPLE:

Two (2) strings of eight (8) 6-volt batteries at 445 AH each
= 2 x 445 AH at 48 Volts = 890 AH at 48 Volts

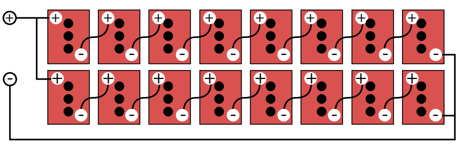


FIGURE 4:
Two Parallel Strings.
Series/Parallel

EXAMPLE:

Three (3) strings of four (4) 12-volt batteries at 371 AH each
= 3 x 371 AH at 48 Volts = 1113 AH at 48 Volts

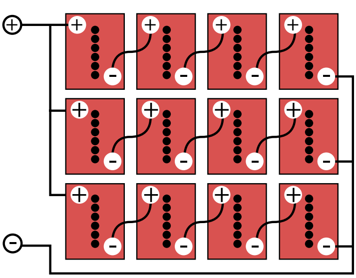


FIGURE 5:
Three Parallel Strings.
Series/Parallel

NOTE: Connecting more than three (3) series strings in parallel is not recommended. Multiple parallel connections increase resistance between batteries and strings, causing an imbalance of charge and discharge currents and may result in cell damage or premature failure which is not covered under Rolls Battery manufacturer warranty.

INSTALLATION

Rolls deep cycle batteries are manufactured for use in a variety of applications. In all cases, it is important that the battery is installed securely, free of contaminants and that all connections are in good contact with the terminals.

For all Rolls models it is recommended that the batteries are separated 2.5cm-7.5cm (1"-3”) inches apart to allow proper airflow, cooling and ease of maintenance. Flooded batteries should be installed in a temperature-controlled room or enclosure with adequate battery spacing to allow cooling and/or insulating to prevent freezing in very cold temperatures. Excessive heat will reduce cycle life due to cell degradation. Batteries should never be installed in a completely sealed enclosure. Enclosures for Valve Regulated batteries (VRLA) such as sealed AGM & GEL models, should, at minimum, be passively ventilated. Enclosures for Flooded models should be actively ventilated with both positive and negative airflow installed to remove and replace any hydrogen gas generated during charging (produced as cell voltage reaches 2.25 VPC or above. Every effort should be made to avoid hydrogen accumulation as concentrations in excess of 2-4% may ignite with electrical spark and are explosive.

The outer container of Rolls Series 5000 models is molded with handles to safely lift and transport the battery. This also provides structural support to maintain cell shape and offers an added layer of protection. Rolls individual 2V industrial cells are typically housed in steel or plastic trays. These cells must be properly supported on each side to protect against puncture, prevent bulging and should not be lifted by the terminals as this may damage the posts or compromise the cells internally. When moving, support straps should be used to safely and securely lift the cell from the bottom.

Dual-container models are better-suited and strongly recommended over industrial cells for use in Renewable Energy and Marine applications as the stand-alone case design allows easier transport and the ability to install the batteries with adequate spacing for airflow. Series 5000 dual-container models are backed by a 5-year (60 month) full replacement warranty, offering an additional 2 years of coverage over the equivalent 2V industrial cell.

BATTERY ENCLOSURES FOR RESIDENTIAL BATTERY-BASED PV SYSTEMS

Residential battery-based PV systems have been installed by certified PV Professionals for decades. With rising utility costs and system components becoming more readily available and affordable, off-grid and grid-connected backup systems have become more popular than ever.

A battery bank that is properly sized, maintained and installed in a well-designed enclosure will provide many years of service. Following guidelines and the manufacturer's recommendations for proper design and placement of the battery enclosure, while adhering to all code requirements and necessary precautions, will ensure the system operates efficiently and safely.

Lead-acid batteries, like other battery technologies, will offer the best performance when operating temperatures are maintained at 20°C (68°F). Higher operating temperatures cause cell degradation which shortens the cycle life of the battery. Lower operating temperatures will reduce capacity.

Flooded lead-acid batteries off-gas hydrogen while charging. This includes the Bulk and Absorption phase of a 3-phase charge profile and any routine corrective equalizations. Hydrogen is explosive and may ignite if exposed to open flame or spark and is also corrosive to electronics. For this reason, active ventilation must be installed in the battery enclosure to prevent the buildup of hydrogen gas.

When operating at 20°C (68°F) ambient temperature, sealed (VRLA) batteries such as AGM or GEL models do not require active ventilation as hydrogen off-gassing during charge is minimal. However, passive airflow in the enclosure is required, at a minimum, as these batteries will off-gas small amounts of hydrogen during heavy charging. At higher ambient temperatures, ventilation also prevents overheating which accelerates cell degradation and shortens battery life.

CONSIDERATIONS:

Location:

- Review and follow all local code requirements.

- Flooded lead-acid batteries required active ventilation to remove hydrogen off-gassing. Sealed VRLA batteries require passive airflow at a minimum. In an installation where ambient temperatures are greater than 25°C (77°F) active ventilation should also be installed.

- The location of a battery enclosure should always be the first consideration. The battery bank should not be installed in a living space.

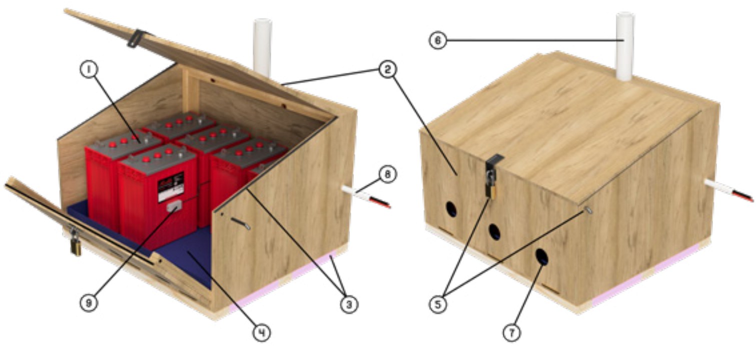
- If the battery enclosure is located inside a storage room or garage, the active ventilation system must exhaust outside, away from windows, doors or fresh air intake. Please consult your local codes and standards for specific requirements as you are exhausting gasses that are potentially explosive.

- Ventilation systems must exhaust outside and may exit via a ceiling or wall-mounted vent. Wall-mounted exhaust should be as close to the ceiling height as possible.

- Fire code requires that flooded lead-acid batteries are not installed in the same room as the inverter or any other electrical device, appliance, pilot light or heating system which may pose a risk of spark or fire. Although an active ventilation system will be installed, do not install the battery enclosure directly below a wall-mounted charger or inverter as hydrogen is corrosive and may damage this equipment.

- If the battery enclosure is on the exterior wall of a home or other structure it must not be positioned in direct sunlight to prevent overheating.

Zephyr Industries offers a variety of 12V, 24V & 48V power vent fans specifically designed for battery enclosures. These fans may be operated from the auxiliary relay on high-end charge controllers or by a voltage-controlled switch. When connected to a voltage-controlled relay, the fan operates only when the batteries are being charged and blows gas vapours out. These units also include a built-in damper when not in use to minimize back drafting.



1. SIZE: When building a custom battery enclosure or purchasing a pre-built cabinet it is essential that the enclosure allows sufficient spacing around and between the batteries. Most lead-acid battery manufacturers recommend a minimum of 1”-3” spacing on each side of the battery to allow adequate cooling as the batteries heat up during charge, to allow proper airflow for removal of hydrogen off-gassing, and ease of maintenance. The height of the enclosure should also allow adequate space for easy installation/removal, routine inspection, watering and space for battery cabling.

2. DESIGN & ACCESS: Easy access to the battery bank is important as routine maintenance such as watering (flooded models) and cleaning & re-torquing terminal connections will be required. The enclosure should have a hinged slanted lid to ensure easy access and discourage placing or storing items on top of the lid. When working with larger, heavier batteries, a removable or hinged front entry is also preferred as this will allow easier access for installation & future battery replacement.

3. INSULATION: foam or rubber weather stripping should be used around all openings at the top to seal and prevent hydrogen gas from escaping the enclosure as well as preventing rodents from getting inside. Batteries will self-discharge when not in use which poses a risk of damage due to freezing in cold temperatures. If the enclosure will not be in a climatized space and the system operates in very cold temperatures, rigid foam insulation may be installed under the bottom of the enclosure and/or around the interior, as well as the space between the batteries to reduce the risk of freezing. Insulation should be removed in warmer months to prevent overheating.

4. SPILL CONTAINMENT: a spill-proof liner should be installed in the enclosure. This will contain any electrolyte overflows due to leaks from the batteries in the case of overfilling, puncture or cracked cases from freezing.

5. SAFETY: For safety, the enclosure must include a latch and/or lock. Removable pin(s) may be used to secure the hinged front wall in place when unlocked and the lid is open.

6. VENTILATION: when using flooded lead-acid batteries the enclosure must have active ventilation. If the battery enclosure is located inside a storage room or garage, the active ventilation system must exhaust outside via a ceiling or wall-mounted vent, a minimum 2m (6.5 ft) from any opening (doors or windows) or fresh air intake. Wall-mounted exhaust should be as close to the ceiling height as possible.

7. AIR INTAKE: intake vents should be installed along the bottom 1/3 of the enclosure to allow proper airflow when the fan is active. Installing screen or vent inserts is recommended to keep rodents out of the enclosure.

8. WIRING: use conduit to run wiring in/out of the enclosure, including battery connections and the battery temperature sensor, to protect wiring.

9. TEMPERATURE SENSOR: most charge controllers and inverters use a battery temperature sensor to regulate charge voltage. This sensor should be mounted on the side of a battery cases in the middle of battery bank, as shown. See detailed installation instructions TEMPERATURE COMPENSATION & SENSOR INSTALLATION on pg. 14

BATTERY CAPACITY & TEMPERATURE

Ideal operating temperature for deep cycle lead-acid batteries is 25°C (77°F). Battery capacity and cycle life is affected by operating temperature. Operating at higher temperatures will reduce cycle life due to cell degradation. A cycle life reduction of ~50% for every 10°C over 25°C (77°F) is expected. Loss of cycle life is not recoverable.

Ex. Continuous operation at 35°C (95°F) will typically reduce battery cycle life by 50%.

OPERATING TEMPERATURE	25°C	30°C	35°C
EXPECTED LOSS OF CYCLE LIFE	0%	25%	50%

Cooler operating temperatures will prolong cycle life. However, low temperatures will reduce available battery capacity. Capacity is regained as operating temperatures rise.

OPERATING TEMPERATURE	25°C	0°C	-15°C
PERCENTAGE OF AVAILABLE CAPACITY	100%	75%	50%

Operating temperature is considered when sizing a battery bank to meet a required available Amp-Hour (AH) capacity. As continuous operating temperature drops, the required rated AH capacity of the battery bank will increase to meet the equivalent capacity. To calculate the adjusted capacity, use the multiplier in the table below.

°C	°F	MULTIPLIER
25°	77°	1.00
20°	68°	1.02
15°	59°	1.06
10°	50°	1.13
5°	41°	1.21
0°	32°	1.35
-5°	23°	1.49
-10°	14°	1.65
-15°	5°	1.95
-20°	-4°	2.21
-25°	-11°	2.25

TABLE 3: Cold Temperature Capacity Multiplier

EXAMPLE: Calculated loads require 500 AH usable capacity. With an operating temperature of 25°C (77°F), a battery bank with 1000 AH rated capacity is needed. (max 50% DOD)

1000 AH capacity battery bank with a continuous operating temperature of -10°C (14°F)
1000 AH x 1.65 = 1650 AH adjusted capacity

NOTE: as operating temperatures may vary considerably over a 12-month period, the average temperature and corresponding multiplier may be used to calculate an adjusted capacity. Cycling frequency, seasonal changes in loads & desired depth of discharge (DOD) should also be considered when sizing a battery bank to meet a required Amp-Hour capacity.

TEMPERATURE COMPENSATION & SENSOR INSTALLATION

For charge accuracy and safety, many systems use a sensor mounted to the battery to measure cell temperature and adjust charge voltage accordingly. Temperature sensors should be installed directly on the side of a cell or battery in the center of the bank and must be securely mounted below the electrolyte level to determine accurate cell temperature. See Figure 6 Temperature Sensor below. When using chargers that do not feature temperature compensation, voltage settings should be monitored and adjusted based on actual cell temperature. Failure to use or properly install the provided sensor may cause damage due to over/undercharge which is not covered under Rolls Battery manufacturer warranty. As a precaution, this sensor may also trigger a programmed safety charge cut-off as the battery bank should not exceed an operating temperature of 52°C (125°F).

NOTE: FOR ACCURACY, THE TEMPERATURE SENSOR SHOULD NOT BE MOUNTED TO THE BATTERY TERMINAL OR TOP OF THE BATTERY CASE.

Series 4000, 4500, VRLA AGM & OPzV GEL models – the temperature sensor should be mounted on a battery in the middle of the string or battery bank. To ensure an accurate reading of cell temperature, the sensor must be mounted below the liquid level on Flooded models and not attached to a terminal or top of the battery case as these areas are generally cooler than the internal cell. For traditional Flooded, VRLA AGM & OPzV GEL models, Rolls recommends attaching the sensor half way down the side of the battery and/or 10-12cm (4-5”) from the top of the case for the most accurate temperature reading.

Dual-Container Models – If the battery has a modular, dual-container construction, such as Series 5000 models, the temperature sensor must be mounted directly to the side of an internal cell. To access the cell, disconnect the terminal connections and remove the outer cover which snaps on to the case or may use small removable plastic pins. Mount the sensor to the internal cell and run the connecting cable between the case, being careful not to pinch or damage the wire when placing the cover back on. Automotive silicone is used to seal around each terminal to protect against spills, dust & debris. This may be reapplied when the case has been reassembled.

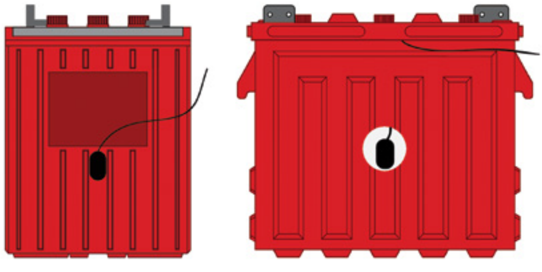


FIGURE 6: Temperature Sensor

Dual-Container Models - Remove case cover. Mount sensor to the side of internal cell below liquid level. Replace the cover and re-seal around terminals with silicone.

END AMPS OR RETURN AMPS

As batteries near full capacity, charge current decreases. End Amps, Return Amps or Tail Current refers to the lowest output of current (Amps) flowing to the batteries as they have reached full capacity. Some chargers will determine this set point has been reached by monitoring current output to the battery bank. If the charge current drops, reaching the End Amps/Return Amps/Tail Current set point before the programmed Absorption time has completed, this will trigger the charger to shut off or switch to the Float voltage phase which holds the battery bank at 100% SOC. The charger will complete the full programmed Absorption time if this set point is too low or programmed at 0%.

The recommended End Amps/Return Amps/Tail Current set point for Rolls Flooded models is 2% of the 20 Hr AH rating (C/20) of the battery bank. Typically, when current drops to the 2% set point for 1 hour, the battery bank has reached 100% SOC. Rolls Flooded models with Advanced NAM may have a slightly higher End Amps/ Return Amps/Tail Current set point as the cells are less resistant to charge and current output will remain slightly higher at 100% SOC. (2% recommended, 2-5% range) An adjustment to this set point may be required when these models replace other Flooded batteries. Test specific gravity at Float Charge to confirm 100% SOC.

The recommended End Amps/Return Amps/Tail Current set point for Rolls VLRA AGM and OPzV GEL models is 3-4%.

WARNING: The End Amps/Return Amps/Tail Current setting, combined with sulfated batter(ies), may confuse the charger as added resistance will reduce the flow of current. This may falsely trigger the charge to end the Absorption charge prior to reaching 100% SOC. Test specific gravity regularly to confirm the battery bank has reached 100% SOC and adjust this set point and/or Absorption time as necessary.

LOW VOLTAGE DISCONNECT (LVD OR LVCO)

Many charging systems offer the ability to program a Low Voltage Disconnect (LVD) or 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-discharge. 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.

LVD/LVCO setting is often 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 alternate charging source (ex: generator) when discharge reaches the low voltage cut-off. To maintain cycle life and prevent heavy-discharge, Rolls recommends setting LVD/LVCO between 1.90-1.95 volts per cell (VPC). This may be adjusted up or down, depending how often you wish to run the alternate charging source (generator or alternative power) when the voltage of the battery bank reaches the programmed set point.

WARNING: LVD/LVCO only cuts off the draw from the inverter/ charger. It does not disconnect all loads from the battery bank. A prolonged draw will eventually lead to over-discharge and possible battery failure or damage.

OTHER CHARGER MODES

Inverter and charge controller manufacturers may include additional settings. Rolls recommends contacting the manufacturer for guidance and to better understand how these settings function. Default settings are typically not in line with the required charge voltages and time. Charge & Float voltages and Absorption time calculations are provided by the battery manufacturer and are specific to the make & model.

See Table 2 (a & 2 (b Flooded Charging Parameters for Flooded Models
See Table 6: VRLA AGM Charge Voltage for AGM Models
See Table 8: OPzV GEL Charge Voltage for GEL Models

FLOODED LEAD-ACID BATTERY - CHARGE EFFICIENCY / CHARGE FACTOR

Charge efficiency is a measure of the energy you may take out of a charged battery divided by the energy required to charge it. Charge efficiency will depend on a number of factors including the rate of charging or discharging. Charge efficiency for traditional Flooded deep cycle models is typically 80%. This should be reduced 1% per year after the third (3) year of operation.

FLOODED LEAD-ACID BATTERIES

INSPECTION & INITIAL CHARGE OF FLOODED LEAD-ACID BATTERIES

WARNING

- ALWAYS WEAR THE PROPER PERSONAL PROTECTIVE EQUIPMENT (GOGGLES, GLOVES, CLOTHING) WHEN HANDLING FLOODED BATTERIES AND ELECTROLYTE.
- WET BATTERIES MUST BE FULLY CHARGED BEFORE BEING DELIVERED TO THE END USER.
- UNLESS INSTRUCTED BY ROLLS TECHNICAL SUPPORT, NEVER ADD ACID TO THE BATTERIES AT ANY TIME. USE DISTILLED WATER ONLY.

FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN MALFUNCTION AND WILL VOID WARRANTY.

A battery may not be fully charged when received. An initial charge brings the battery to an operational state. Before charging, inspect for physical damage, check polarity and electrolyte levels in each cell. Ensure the electrolyte (liquid) covers the plates completely. It is normal for electrolyte levels to lower as the battery case will relax (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 (a) & 2 (b) Flooded Charging Parameters**.

INITIAL INSPECTION & CHARGING

1. Inspect the batteries for damage. Important: read all warning labels on batteries before proceeding.
2. Flooded batteries are fully charged and tested before shipping. However, deep cycle batteries will self-discharge when not in use during transportation and storage. Upon installation, the initial charge brings the battery to an operational state. Before this charging process, electrolyte levels should be checked, making sure the plates are covered in each cell. If required, add distilled water until the plates are fully submerged. It is important not to overfill as the electrolyte level will rise slightly during charge.
3. Check for correct polarity. Attaching the positive and negative voltmeter lead to the positive and negative battery terminal should provide a positive voltage reading. If it is negative, a reverse polarity condition exists, and you should contact your dealer or Rolls Battery Technical Support to advise.
4. Place batteries on charge. Please see **Table 2(a) & 2(b) Flooded Charging Parameters** for required charging parameters. 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) when resting at full charge.

FLOODED LEAD-ACID BATTERY CHARGING

INITIAL CHARGE

Although all Rolls batteries are tested and charged prior to shipping, batteries will self-discharge when stored and not in use. Upon installation, the initial charging may take 10+ hours or more depending on the size of the battery bank and charge current. Once the battery is fully charged, recheck the electrolyte level in the cell. The fluid should be 6-13mm (1/4”-1/2”) below the vent tube on each cell as shown in Figure 7. Carefully add distilled water to adjust as needed.

MULTI-PHASE CHARGING

The most common charge method for Flooded deep cycle batteries is a three-phase charge cycle with periodic equalizations. Always be sure to follow the recommended charging parameters as these will vary. Often, pre-programmed default settings are not in line with the battery manufacturer's recommended voltage settings. Using these may result in damage or battery failure which is not covered under the manufacturer warranty. Refer to the charger manufacturer for specific programming instructions.

BULK CHARGE

The first of the three-phase charging process is the Bulk charge. During this stage the maximum amount of current flows into the battery bank until a desired programmed voltage is reached. For Flooded models, the recommended Bulk charge current is 10% of the AH capacity of the battery bank, based on the 20 Hr AH rate (C/20) (min 5%, max 20%). Higher charge current may cause the battery bank to overheat or damage the cells. A lower charge current may be used, however, this will prolong the required charge time and increase the potential for sulfation buildup. Bulk charge voltage set points are outlined in **Table 2 (a) & 2 (b) Flooded Charging Parameters**.

ABSORPTION CHARGE

The second and most important phase of the charge cycle is the Absorption charge. The Bulk charge typically brings the battery bank to approximately 80% SOC. Once reached, the charger will then switch to the programmed Absorption voltage to complete the charging cycle. Most three-phase chargers include an Absorption charge time setting allowing the user to program the duration of time needed to reach a full state of charge (100% SOC). To set the Absorption charge time, a calculation is done using the 20 Hr AH rating of the battery bank (C/20) and the actual measured charge current and/or max charger output. As the battery bank nears 100% SOC, 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. The Absorption Charge Time calculation uses a multiplier of 0.42 for Flooded models which factors in assumed loss of current during the Absorption charge phase.

ABSORPTION CHARGE TIME - FLOODED

Where: **T = 0.42 x C /I** **T = ABSORPTION CHARGE TIME**
C = 20 hr RATED CAPACITY (total AH capacity of battery bank)
I = Charging Current (Amps) (*see Note: **CHARGING CURRENT** below)
0.42 = (factors in assumed current loss during Absorption charge phase)

EXAMPLE:

2 strings of 6 Volt **6 CS 25P** models
C = 20 hr AH rate = 853 AH x (2 strings) = 1706 AH
I = 10% (recommended) of 1706 AH = 170 Amps
T = 0.42 x 1706/170 = **4.2 hrs**
However, if actual measured current is less (~160 Amps), or maximum charger output is limited to 160 Amps, 160 is used. (Ex. 2 x 80 Amp controllers)
T = 0.42 x 1706/160 = **4.48 hrs**

NOTE: **CHARGING CURRENT** - Actual measured current output (Amps) to the battery bank should be used in this calculation. Recommended charge current for Flooded models is 10% of the 20 Hr AH rating of the battery bank (C/20) (min 5%, max 20%) Charge source(s) and chargers should be properly sized, based on the rated capacity of the battery bank, to ensure adequate charge output. Maximum charger output applies when the generated output meets or exceeds this threshold.

FLOAT CHARGE

When the Absorption charge phase has completed and the batteries have reached 100% SOC, the charger will continue to output at a lower voltage setting known as Float. Float voltage maintains the battery bank at a constant 100% SOC until the charge output diminishes (Ex: solar) and/or a load is applied which begins to discharge the battery bank. To prolong battery life, the Float settings on the power supply should be adjusted to the voltage indicated in **Table 2 (a) & 2 (b) Flooded Charging Parameters**. Higher or lower voltage settings may result in unnecessary overcharge or sulfation buildup.

FLOODED LEAD-ACID BATTERY - CHARGE EFFICIENCY / CHARGE FACTOR

Charge efficiency is a measure of the energy you may take out of a charged battery divided by the energy required to charge it. Charge efficiency will depend on a number of factors including the rate of charging or discharging. Charge efficiency for traditional Flooded deep cycle models is typically 80%. This should be reduced 1% per year after the third (3) year of operation.

ROLLS FLOODED BATTERY CHARGE VOLTAGE PARAMETERS

NOTE: Use the **highlighted** voltage set points when charge equipment is supplied with a temperature sensor. **Set at 5mV/°C/Cell...(+/- 120mV per °C from a 25°C Delta - 48V System)**

REGULAR CYCLING		0°C (32°F)	10°C (50°F)	20°C (68°F)	25°C (77°F) TEMP SENSOR	30°C (86°F)	40°C (104°F)
2V	BULK & ABSORPTION	2.63 V	2.55 V	2.53 V	2.50 V	2.48 V	2.41 V
	FLOAT	2.38 V	2.30 V	2.28 V	2.25 V	2.23 V	2.16 V
	EQUALIZATION				2.60 - 2.65 V		
12V	BULK & ABSORPTION	15.75 V	15.30 V	15.15 V	15.00 V	14.88 V	14.46 V
	FLOAT	14.28 V	13.80 V	13.68 V	13.50 V	13.38 V	12.96 V
	EQUALIZATION				15.6 - 15.9 V		
24V	BULK & ABSORPTION	31.50 V	30.60 V	30.30 V	30.00 V	29.76 V	28.92 V
	FLOAT	28.56 V	27.60 V	27.36 V	27.00 V	26.76 V	25.92 V
	EQUALIZATION				31.2 - 31.8 V		
48V	BULK & ABSORPTION	63.00 V	61.20 V	60.60 V	60.00 V	59.52 V	57.84 V
	FLOAT	57.12 V	55.20 V	54.72 V	54.00 V	53.52 V	51.84 V
	EQUALIZATION				62.4 - 63.6 V		

TABLE 2 (a): Flooded Charging Parameters: Regular Cycling - daily to 48-hour cycling (max 50% DOD) with limited charge time (solar). Example: full-time off-grid applications and Partial State of Charge (PSOC) recovery.

INFREQUENT CYCLING		0°C (32°F)	10°C (50°F)	20°C (68°F)	25°C (77°F) TEMP SENSOR	30°C (86°F)	40°C (104°F)
2V	BULK & ABSORPTION	2.58 V	2.50 V	2.48 V	2.45 V	2.43 V	2.40 V
	FLOAT	2.38 V	2.30 V	2.28 V	2.25 V	2.23 V	2.16 V
	EQUALIZATION				2.60 - 2.65 V		
12V	BULK & ABSORPTION	15.48 V	15.00 V	14.88 V	14.70 V	14.58 V	14.40 V
	FLOAT	14.28 V	13.80 V	13.68 V	13.50 V	13.38 V	12.96 V
	EQUALIZATION				15.6 - 15.9 V		
24V	BULK & ABSORPTION	30.96 V	30.00 V	29.76 V	29.40 V	29.16 V	28.80 V
	FLOAT	28.56 V	27.60 V	27.36 V	27.00 V	26.76 V	25.92 V
	EQUALIZATION				31.2 - 31.8 V		
48V	BULK & ABSORPTION	61.92 V	60.00 V	59.52 V	58.80 V	58.32 V	57.60 V
	FLOAT	57.12 V	55.20 V	54.72 V	54.00 V	53.52 V	51.84 V
	EQUALIZATION				62.4 - 63.6 V		

TABLE 2 (b): Flooded Charging Parameters: Infrequent Cycling - infrequent cycling with grid-connected charging (Marine/RV/Industrial), off-season/part-time off-grid solar applications or grid-tied battery-backup systems.

SPECIFIC GRAVITY

The specific gravity of electrolyte in a battery is the most accurate measurement of actual state of charge. To determine if the batteries have reached full SOC, testing should be done when the charge cycle has been completed and the battery bank is resting a Float voltage. The specific gravity (SG) reading should remain constant for 3+ hours for an accurate 100% SOC reading.

*Test and record specific gravity readings regularly to confirm charging parameters are properly programmed and to avoid possible over/undercharge, cell damage and/or battery failure. Rolls Battery provides a **Flooded Deep Cycle Battery Maintenance** log book to track these readings and includes reminders to perform regular system inspections. Request a copy from your Rolls Battery Distributor or Dealer.

Recommended testing: every 45-60 days
Minimum: every 90 days

Routine testing of specific gravity in Flooded models provides an opportunity to quickly identify any notable changes in battery performance caused by charge-related issues such as over/undercharging, sulfation buildup, capacity loss or cell/battery performance or failures. Regular testing and tracking offers peace of mind and is expected as part of the normal maintenance procedures. When monitored, necessary system adjustments may be made to quickly correct & prevent any further issue or damage.

NOTE: Failure to adhere to ongoing maintenance requirements, including routine testing and logging of specific gravity and voltage readings, may result in denial of a filed warranty claim where the performance history and cause of cell/battery failure cannot be determined.

% 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 4: Specific Gravity vs State of Charge @ 25°C (77°F)

NOTE: Specific Gravity is dependent on the temperature of electrolyte. The values noted in the table above are based on an electrolyte temperature of 25°C (77°F). Some refractometers will factor temperature correction automatically.

Refer to the article "Specific Gravity Temperature Correction" found on Rolls Battery Technical Support page for correction values. Alternatively, add/subtract 0.003 for every 5°C (10°F) increase/decrease from 25°C (77°F) as a general guideline.

BATTERY MAINTENANCE & STORAGE

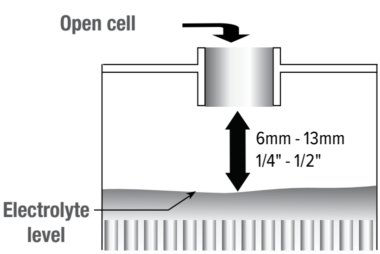
Batteries should be kept clean at all times. If installed or stored in a dirty location, regular cleaning should be performed. Before doing so, assure that all the vent caps are tightly fastened. Using a solution of water and baking soda (100g per litre), gently wipe the battery and terminals with a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

A common cause of failure with Flooded battery banks is poor maintenance. Systems are often professionally installed and maintenance left to homeowners who are unaware of the requirements or simply choose not to complete the proper maintenance procedures. To maintain cycle life and protect your investment, Flooded batteries should be inspected regularly and, if required, cells should be topped up with distilled water as they near full state-of-charge. Customers will often neglect this for extended periods of time, and when doing so, over-water the cells resulting in loss of electrolyte, overflow during charging and/or corrosion issues. Failing to top up cells may result in plate exposure, overheating and possible explosion.

ELECTROLYTE - ADDING DISTILLED WATER

Only distilled (preferred), deionized or reverse osmosis water should be used in Flooded battery cells. cells. As required, water should be added to each cell as the batteries near full state-of-charge. Improper watering may cause internal cell damage. Test water to confirm a PH reading of 7 or less and no Total Dissolved Solids (TDS < 5 PPM).

NOTE: Do not add sulfuric acid to Flooded battery cells during normal top up. In the case of accidental spill, premixed electrolyte may be used to refill cells. 1.265 S.G. for Series 4000, 4500 & 5000 models. 1.280 S.G. for FS models.



Electrolyte level should be kept below vent tube to prevent overflow during charge.

FIGURE 7: Electrolyte level

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.

NOTE: If the battery cells require watering more than once every two (2) months the programmed charging voltages may be too high. Adjust and monitor accordingly. If a particular cell requires significantly more water than others this may be a sign of charge imbalance in the battery bank caused by resistance and/or cell failure. Typically, Series 4000 & 4500 models will require watering every 30-60 days. Series 5000 batteries generally require watering every 60-90 days as these models are designed with a higher electrolyte reserve allowing longer watering intervals. However, watering frequency may vary considerably due to operating temperature, depth of discharge, cycle frequency and humidity.

MAINTENANCE SCHEDULE

For the first 12 months of usage, the following tests should be completed:

MONTHLY

- Measure and record resting/loaded voltage
- Check electrolyte levels and top up with distilled water as necessary
- Test and record specific gravity measurements in Float charge
- Record ambient temperature where the batteries are installed
- Inspect to ensure temperature sensor is securely attached
- Inspect cell integrity for corrosion at terminal, connection, racks or cabinets
- Check battery monitoring equipment to verify operation

QUARTERLY

- Test Ventilation
- Check terminals/connections, remove corrosion and properly re-torque
- 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. Adjustments to charging parameters may be necessary during this time. Battery performance, charging and maintenance requirements will depend on usage. Following the break-in period, a regular maintenance routine will be established after 9-12 months of service.

Following these recommendations will ensure the batteries reach their rated capacity and operate in good working order.

STORAGE

When not in use, it is normal to expect 10-12% self-discharge per month at 25ºC (77ºF) for Flooded models. This rate slows as ambient temperatures decrease and increases at higher temperatures. Stored Flooded batteries should be recharged every 3 months until the battery is put in service to avoid sulfation buildup and possible freezing in cold temperatures.

Rolls Flooded models with Advanced NAM carbon additive may see an increased self-discharge rate of 20-25% per month at 25ºC (77ºF) when not in use. A refresher charge may be necessary every 2-3 months.

NOTE: battery damage or failure caused by over-discharge, sulfation buildup, electrolyte stratification or excessive electrolyte loss while in extended storage without proper charging is not covered under the manufacturer warranty.

WINTER STORAGE

Prior to placing Flooded batteries into winter storage, charge to 100% SOC and make certain the liquid level is approximately 13 mm (1/2”) above the top of the separators. Electrolyte in a very cold battery will be lower than normal. Allow the battery to warm to a normal ambient temperature before judging electrolyte levels. Self-discharge rate will vary by ambient temperature. Apply a refresher charge as necessary when stored for extended periods.

Example: Electrolyte may freeze if the batteries become discharged to approximately 50% SOC at -20°C (-4°F).

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

TABLE 5: Specific Gravity vs Freezing

CLEANING VENT CAPS:

You might notice a sticky dark gray residue on the inside of the standard 1/4-turn bayonet, R-Caps or Watermiser vent caps on Flooded battery cells. This buildup of dirt and dried electrolyte is fairly common and may clog the vent holes, preventing the release of hydrogen off-gas during charge. Inspect the caps and clean using a neutralizing baking soda and water solution as necessary.

CLEANING STEPS:

1. Clean the caps by soaking in a solution of water and baking soda (100g per litre) in a bucket or small bowl. Let the vents sit overnight to neutralize and break down any electrolyte in the caps.
2. Flush the caps clean by forcing water through the vent holes. Water should drip freely. A trickle of water should flow from all vent holes, indicating the cap is clear of debris.
3. Allow the vents to dry completely. Once dried, shake recombination caps to make sure the condensing beads on the inside of the cap rattle slightly. If you do not hear the beads, let the cap dry for an additional 12 hours or repeat the process above.

EQUALIZATION

Over time, individual cell readings may vary slightly in specific gravity due to charge imbalance or sulfation buildup. 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 reduces stratification and buildup of sulfation on the plates; two circumstances that shorten battery life.

One of the most commonly asked questions is “When is it time to equalize my battery bank?“ As usage is unique for each system, this will depend on several factors including depth of discharge, cycle frequency, operating temperature, charging voltage and current. Monitor specific gravity and voltage regularly as these readings will indicate when an Equalization may be necessary.

NOTE: Running frequent equalizations on batteries that do not require balancing or desulfation will overcharge and deteriorate the cells prematurely, shortening the life of the battery.

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, 1.235, 1.260, 1.210...) Do not attempt to equalize a battery bank with failed cells or missing batteries as this will force an overcharge on the remaining cells which may cause permanent damage.

When resting in Float charge, if specific gravity readings are consistently lower than recommended it may be necessary to adjust Bulk/Absorption voltages slightly and/or Absorption time to increase charge time.

To properly equalize the battery bank, follow the Correction Equalization procedure using the recommended Equalization set point in **Table 2 (a) & 2 (b) Flooded Charging Parameters** starting at the lower end of the provided voltage range.

CORRECTIVE EQUALIZATION

Corrective Equalizations should be performed when the battery bank is at 100% SOC. Review and complete the provided preparations before initiating the Equalization charge.

Equalization time will vary depending on the level of sulfation, balance of charge, size of the battery bank and available charging source. Typically, a corrective Equalization is necessary every 60 to 180 days to desulfate and balance a battery bank in systems which are deficit cycled and/or charged at lower charge currents. If multiple parallel strings show charge imbalance it may be necessary to equalize each string individually.

It is important to monitor specific gravity and voltage throughout the Equalization process. When specific gravity readings remain constant for 45-60 minutes this generally indicates completion.

NOTE: Series 4000, 4500 & 5000 models are shipped with electrolyte reaching 1.265 specific gravity at full charge. Rolls FS models are shipped with electrolyte reaching 1.280 at full charge. This is noted on the battery label for reference.

PREPARATION:

- Required Equipment: protective goggles, rubber gloves & rubber boots, hydrometer or refractometer, voltmeter, distilled water, baking soda or soda ash for possible overflow or spills
- Standard 1/4-turn bayonet caps and Rolls R-Cap flip-top recombination caps may be left on during this procedure. Dirty or clogged caps may prevent the release of hydrogen gas. Inspect and clean caps as necessary. Hydrocaps must be removed.
- Check each cell for low electrolyte levels and/or exposed plates and top up with distilled water as necessary. If the cells require watering, do so before starting the Equalization process to allow sufficient mixing with the existing electrolyte. Be careful not to overfill as the electrolyte will bubble and may overflow during the process.
- Program the Equalization voltage as recommended in **Table 2 (a) & 2 (b) Flooded Charging Parameters** starting at the lower end of the voltage range for newer models.

PROCEDURE:

1. Complete a Bulk & Absorption charge to bring the battery bank to 100% SOC before starting a corrective Equalization.
2. Measure the temperature of a test cell and record the specific gravity of each cell in the battery bank. Identify cells with high/low readings.

NOTE: Do not attempt to equalize a battery bank with known failed batteries or cells as this may force a severe overcharge, damaging the remaining cells.

3. Initiate the Equalization charge mode at a steady low DC current (5-10% of C/20 battery capacity). If grid power is not available, use a DC power source (generator) or PV array with sufficient current when possible.

4. Specific gravity will rise across the battery bank, ideally 1.265-1.270 (Series 4000/4500/5000) or 1.280-1.285 (FS models) in each cell upon completion. Readings in some cells may be slightly elevated due to electrolyte temperature (+0.05) and will return to normal when cooled but should not exceed 1.30. If the cell temperature rises above 46°C (115°F) and approaches 52°C (125°F), terminate the Equalization process and allow the batteries to cool. If available, check individual cell temperatures using an IR temp sensor to isolate any possible damaged cells.

5. If cells are severely sulfated it may take several hours for the specific gravity to rise and/or balance. If the readings plateau for 45-60 minutes, but do not reach the

ideal range of 1.265-1.270 (Series 4000/4500/5000) or 1.280-1.285 (FS models), stop the process to prevent cell damage and allow the batteries to cycle normally for 2-4 weeks before repeating. The cells will continue to desulfate following an Equalization as sulfate dissolves during normal charging.

Allow the battery bank to cool for 1-2 hours. Check and record the specific gravity of each cell. The gravities should be 1.265-1.270 (Series 4000/4500/5000) or 1.280-1.285 (FS models) or lower. Check electrolyte levels and add distilled water as 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.

PREVENTATIVE EQUALIZATION & FREQUENCY

Most multi-phase charge controllers offer pre-programmed Equalization schedules commonly referred to as preventative equalizations. These are typically set to run for a shorter 1-2 hour period every 30, 60 or 90 days and may be beneficial in balancing and removing small amounts of accumulated sulfation on an ongoing basis.

It should be noted that running frequent equalizations on batteries which do not require balancing or desulfation will overcharge and deteriorate the cells prematurely, shortening the life of the battery. For this reason, Rolls recommends monitoring specific gravity and voltage on a regular basis to ensure scheduled Equalization times are appropriately set. Alternatively, a corrective Equalization may be necessary if symptoms arise such as running a backup generator more frequently (low capacity) or the battery bank will “no longer 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 or inadequate Equalization is performed using a generator, sulfating will occur from “deficit” cycling‘. This undercharge and buildup will gradually lower available capacity. It is best to monitor the condition of the bank regularly as accumulation of sulfation may take months to reach a point where the loss is noticeable.

NOTE: Properly charging a battery bank with sufficient voltage and current on each cycle is essential to long cycle life. Equalizations may be required periodically to balance and desulfate but should not be relied on to compensate for insufficient charging sources. This procedure may not fully recover a loss of capacity from a buildup of sulfation over time. 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 monitoring and repeated procedures in battery banks with consistently low specific gravity measurements.

VRLA AGM BATTERIES

ROLLS VRLA AGM BATTERY CHARGING INSTRUCTIONS

To maximize the life of your Rolls VRLA AGM battery, it is important that it is properly charged. Over or undercharging a VRLA AGM battery will result in shortened cycle life. The best protection from improper charging is to use a quality charger and routinely checking that the charge current and manufacturer-recommended voltage settings are properly maintained.

VRLA AGM CHARGING GUIDELINES

To maintain good health, VRLA AGM batteries should be brought to a full charge on each cycle or, at minimum, once every 6-7 days. Charge should be completed in a ventilated area as hydrogen gas may still be released through the pressure relief valve if the batteries are excessively overcharged. Never charge a frozen battery. Ideal charging temperatures: 0°C-40°C (32°F-104°F).

VRLA AGM CHARGING CHARACTERISTICS

To maximize your battery life, a voltage regulated charger with temperature compensation is strongly recommended. Refer to **Table 6 VRLA AGM Charge Voltage** for the recommended charging parameters. Charge voltage should be set to 2.45vpc @ 25°C (77°F) to allow the charger to properly adjust voltage with temperature compensation. Temperature compensation should be programmed as specified in Table 6 with adjustment in increments of 4mv/ºC/Cell. Without temperature compensation, voltage settings should be manually adjusted for temperatures varying from 25°C (77°F). As temperature decreases, the voltage should increase and vice versa. If the charger has a preset charge profile for VRLA AGM type batteries, verify that these voltage settings follow the battery manufacturer's specific charging parameters.

VRLA AGM BULK & ABSORPTION CHARGE

VRLA AGM batteries have a lower internal resistance than Flooded models, allowing them to accept current more efficiently. It is recommended that the initial charge current is set at 20% of C/20 of the battery bank (min 10% / max 30% of C/20) in order to fully charge the batteries within a reasonable amount of time. It may be set lower; however, this will increase the required charge time. Refer to the recommended & maximum charge current noted on the product label as these may be lower than 20% of C/20 / max 30% on larger 2-volt AGM models. It is very important that VRLA AGM batteries are brought to a full charge frequently to prevent capacity loss. It should also be noted that, unlike Flooded models, these batteries should **NOT** be equalized to recover capacity loss. This program setting should be disabled in the charge controller to prevent accidental overcharge.

The charger should deliver the initial max current at the programmed Bulk voltage until the voltage limit is reached, then switching to the Absorption charge phase. The charger should maintain the Absorption voltage until current tapers to the programmed End Amps/Return Amps/Tail Current set point (3% is recommended for VRLA AGM models). To set the Absorption charge time, a calculation is done using the 20 Hr AH rating of the battery bank (C/20) and the actual measured charge current and/or max charger output.

VRLA AGM ABSORPTION CHARGE TIME

Where: **T = 0.38 x C /I T = ABSORPTION CHARGE TIME**
C = 20 hr RATED CAPACITY (total AH capacity of battery bank)
I = Charging Current (Amps) (***see Note: CHARGING CURRENT** on pg 11 for details)
0.38 = (factors in assumed current loss during Absorption charge phase)

EXAMPLE:

2 strings of 6 Volt **S6-460AGM-RE** models
C = 20 hr AH rate = 415 AH x (2 strings) = 830 AH
I = 20% (recommended) of 830 AH = 166 Amps
T = 0.38 x 830/166 = **1.9 hrs**

NOTE:
If actual measured current is 120 Amps, or the maximum charger output is limited to 120 Amps, 120 is used.
(Ex. 2 x 60 Amp controllers)
T = 0.38 x 830/120 = **2.6 hrs**

VRLA AGM FLOAT STAGE AND TERMINATION

To maintain 100% SOC, the charger continues output to the battery bank at the programmed Float voltage and End Amps/Return Amps/Tail Current indefinitely or until the charger is shut off or unplugged. The profile in **Table 6: VRLA AGM Charge Voltage** may be used with or without the Float stage. Without the Float stage, recharge may be terminated based on time. This will vary by depth of discharge and charge current, or percentage recharge (105-110%).

ROLLS VRLA AGM BATTERY CHARGE VOLTAGE PARAMETERS

VRLA AGM CHARGING		0℃ (32℉)	10℃ (50℉)	20℃ (68℉)	25℃ (77℉) TEMP SENSOR	30℃ (86℉)	40℃ (104℉)
2V	CHARGE VOLTAGE	2.55 V	2.51 V	2.48 V	2.45 V	2.42 V	2.39 V
	FLOAT VOLTAGE	2.40 V	2.36 V	2.32 V	2.30 V	2.28 V	2.24 V
12V	CHARGE VOLTAGE	15.30 V	15.06 V	14.84 V	14.70 V	14.55 V	14.34 V
	FLOAT VOLTAGE	14.40 V	14.16 V	13.94 V	13.80 V	13.68 V	13.44 V
24V	CHARGE VOLTAGE	30.60 V	30.12 V	29.69 V	29.40 V	29.10 V	28.68 V
	FLOAT VOLTAGE	28.80 V	28.32 V	27.89 V	27.60 V	27.36 V	26.88 V
48V	CHARGE VOLTAGE	61.20 V	60.24 V	59.38 V	58.80 V	58.20 V	57.36 V
	FLOAT VOLTAGE	57.60 V	56.64 V	55.78 V	55.20 V	54.62 V	53.76 V

TABLE 6: VRLA AGM Charge Voltage

NOTE: Use the **highlighted** voltage set points when charge equipment is supplied with a temperature sensor. **Set at 4mV/°C/Cell...(+/- 96mV per °C from a 25°C Delta - 48V System)** Higher or lower settings may cause incorrect adjustments in charge voltage. Without a temperature sensor, charge settings must be adjusted manually based on the battery temperature when in use, not just ambient temperatures.

VRLA AGM CHARGE EFFICIENCY/CHARGE FACTOR

Charge efficiency is a measure of the energy you may take out of a charged battery divided by the energy required to charge it. Charge efficiency will depend on a number of factors including the rate of charging or discharging. VRLA AGM batteries have an average charge efficiency of ~80%. This should be reduced 1% per year after the third (3) year of operation.

VRLA AGM REFRESH CHARGE

If Rolls VRLA AGM batteries are properly charged they should not experience varied capacity loss or require balancing. If they were not properly charged and there is a decrease in capacity, fully recharge the batteries at the recommended voltage. It is important to prevent heavy-discharge. If the batteries will be stored for extended periods of time, apply a periodic refresh charge. Frequency will depend on storage temperature as noted below.

STORAGE

NOTE: When not in use, it is normal to expect 2% self-discharge per month (at 25°C (77°F) for sealed VRLA AGM models. This rate slows as ambient temperatures decrease and increases at higher temperatures. Stored batteries should be recharged every 3-4 months until the battery is put in service to avoid sulfation buildup and possible freezing in cold temperatures.

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

TABLE 7: VRLA AGM Storage Temperature & Refresh Charge

DISPOSAL PROCEDURE

Batteries must **NEVER** be disposed of in household waste. To reduce environmental impact, bring your spent VRLA AGM batteries to a certified recycling depot to be recycled.

VRLA AGM BATTERY CAPACITY & TEMPERATURE

Ideal operating temperature for VRLA AGM batteries is 25°C (77°F). Note that higher operating temperatures will reduce cycle life due to cell degradation. Cycle life loss is not recoverable.

Ex. Continuous operation at 35°C (95°F) will typically reduce cycle life by 50%.

Cooler operating temperatures will reduce battery capacity. Capacity is regained as operating temperatures rise. To calculate the adjusted capacity, refer to **Table 3: Cold Temperature Capacity Multiplier**

OPzV GEL
BATTERIES

ROLLS OPzV GEL BATTERY INSTALLATION & CHARGING

Designed and well-suited for regular cycling as well as float and backup applications, Rolls sealed OPzV GEL batteries have a low internal resistance than Flooded deep cycle models allowing quick recharge and a low self-discharge rate (2% per month). Rolls OPzV GEL batteries perform well in installations requiring frequent cycling even under extreme operating conditions and offer more than 20-year cycle life in float applications at 25°C (77°F).

INSTALLATION

Rolls OPzV GEL batteries should be installed upright unless otherwise specified and should not be mounted upside down or horizontally on the end (shortest side) of the case. Models compatible with horizontal installation (longest side) as well as custom racking systems are available upon request. Contact your Rolls Battery Distributor or Dealer for more information.

Use caution not to cover or apply pressure to valves located on the top of the batteries when using strapping to move or secure the batteries as damage may occur.

OPzV GEL BATTERY CHARGING

Rolls OPzV GEL batteries have similar installation and charging requirements as VRLA AGM models with the exception of unique Bulk, Absorption and Float voltage set points.

ROLLS OPzV GEL BATTERY CHARGE VOLTAGE PARAMETERS

OPzV GEL CHARGING		0℃ (32℉)	10℃ (50℉)	20℃ (68℉)	25℃ (77℉) TEMP SENSOR	30℃ (86℉)	40℃ (104℉)
2V	CHARGE VOLTAGE	2.48 V	2.44 V	2.40 V	2.38 V	2.35 V	2.32 V
	FLOAT VOLTAGE	2.38 V	2.34 V	2.30 V	2.28 V	2.26 V	2.22 V
12V	CHARGE VOLTAGE	14.88 V	14.64 V	14.40 V	14.28 V	14.10 V	13.92 V
	FLOAT VOLTAGE	14.28 V	14.04 V	13.80 V	13.68 V	13.56 V	13.32 V
24V	CHARGE VOLTAGE	29.76 V	29.28 V	28.80 V	28.56 V	28.20 V	27.84 V
	FLOAT VOLTAGE	28.56 V	28.08 V	27.60 V	27.36 V	27.12 V	26.64 V
48V	CHARGE VOLTAGE	59.52 V	58.56 V	57.60 V	57.12 V	56.40 V	55.68 V
	FLOAT VOLTAGE	57.12 V	56.16 V	55.20 V	54.72 V	54.24 V	53.28 V

TABLE 8: OPzV GEL Charge Voltage

NOTE: Use the highlighted voltage set points when charge equipment is supplied with a temperature sensor. **Set at 3mV/°C/Cell...(+/- 72mV per °C from a 25°C Delta - 48V System)** Higher or lower settings may cause incorrect adjustments in charge voltage. Without a temperature sensor, charge settings must be adjusted manually based on the battery temperature when in use, not just ambient temperatures.

OPzV GEL 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.

OPzV GEL CHARGING GUIDELINES

To maintain good health, OPzV GEL batteries should be brought to a full charge on each cycle or, at minimum, once every 6-7 days. Charge should be completed in a ventilated area as gasses may still be released through the pressure relief valve if the batteries are excessively overcharged. Never charge a frozen battery. Ideal charging temperatures: 0°C-40°C (32°F-104°F).

OPzV GEL CHARGING CHARACTERISTICS

To maximize your battery life, a voltage regulated charger with temperature compensation is strongly recommended. Refer to **Table 8 OPzV GEL Charge Voltage** for the recommended voltage regulated charge profile. If using battery temperature compensation, charger voltage should be set to 2.38vpc - 25°C (77°F) to allow the proper voltage adjustment by the charger (3mv/°C/Cell). If the charger has a preset charge profile for OPzV GEL type batteries, verify that these voltage settings follow the battery manufacturer's specific recommendations.

OPzV GEL BULK & ABSORPTION CHARGE

OPzV GEL batteries have a lower internal resistance than Flooded models, allowing them to accept current more efficiently. It is recommended that the initial charge current is set at 20% of C/20 of the battery bank (min 10% / max 30% of C/20) in order to fully charge the batteries within a reasonable amount of time. It may be set lower; however, this will increase the required charge time. It is very important that OPzV GEL batteries are brought to a full charge frequently to prevent capacity loss. It should also be noted that, unlike Flooded models, these batteries should NOT be equalized to recover capacity loss. This program setting should be disabled in the charge controller to prevent accidental overcharge.

The charger should deliver the initial max current at the programmed Bulk voltage until the voltage limit is reached, then switching to the Absorption charge phase. The charger should maintain the Absorption voltage until current tapers to the programmed End Amps/Return Amps/Tail Current set point (3-4% is recommended for OPzV GEL models). To set the Absorption charge time, a calculation is done using the 20 Hr AH rating of the battery bank (C/20) and the actual measured charge current and/or max charger output.

OPzV CHARGE EFFICIENCY/CHARGE FACTOR

Charge efficiency is a measure of the energy you may take out of a charged battery divided by the energy required to charge it. OPzV GEL batteries have an average charge efficiency of ~85%. This should be reduced 1% per year after the third (3) year of operation.

OPzV GEL ABSORPTION CHARGE TIME

Where: **T = 0.38 x C /I** **T = ABSORPTION CHARGE TIME**
C = 20 hr RATED CAPACITY (total AH capacity of battery bank)
I = Charging Current (Amps) (***see Note: CHARGING CURRENT** on pg 11 for details)
0.38 = (factors in assumed current loss during Absorption charge phase)

EXAMPLE:

1 string of 2-Volt **S2-690GEL** models
C = 20 hr AH rate = 785 AH
I = 20% (recommended) of 785 AH = 157 Amps
T = 0.38 x 785/157 = 1.9 hrs

NOTE:

If actual measured current is 120 Amps, or the maximum charger output is limited to 120 Amps, 120 is used.
(Ex. 2 x 60 Amp controllers)
T = 0.38 x 785/120 = **2.5 hrs**

OPzV GEL FLOAT STAGE AND TERMINATION

To maintain the battery bank at 100% SOC, the charger continues to apply a Float charge to the battery bank at the End Amps/Return Amps/Tail Current indefinitely or until the charger is shut off or unplugged.

OPzV GEL REFRESH CHARGE

If Rolls OPzV GEL batteries are properly charged they should not experience varied capacity loss or require balancing. If they were not properly charged and there is a decrease in capacity, fully recharge the batteries at the recommended voltage. It is important to prevent heavy-discharge. If the batteries will be stored for extended periods of time, apply a periodic refresh charge. Frequency will depend on storage temperature as noted:

Storage Temperature	Refresh Charge Interval
Below 20ºC (68ºF)	9 Months
20ºC (68ºF) - 30ºC (86ºF)	6 Months
Higher than 30ºC (86ºF)	3 Months

TABLE 9: OPzV GEL Storage Temperature & Refresh Charge

DISPOSAL PROCEDURE

Batteries must **NEVER** be disposed of in household waste. To reduce environmental impact, bring your spent OPzV GEL batteries to a certified recycling depot to be recycled.

OPzV GEL BATTERY CAPACITY & TEMPERATURE

Ideal operating temperature for OPzV GEL batteries is 25°C (77°F). Note that higher operating temperatures will reduce cycle life due to cell degradation. Cycle life loss is not recoverable.

Ex. Continuous operation at 35°C (95°F) will typically reduce cycle life by 50%.

Cooler operating temperatures will reduce battery capacity. Capacity is regained as operating temperatures rise. To calculate the adjusted capacity, refer to **Table 3: Cold Temperature Capacity Multiplier**

RENEWABLE ENERGY APPLICATIONS

RENEWABLE ENERGY APPLICATIONS

NOTE: To ensure the proper sizing, installation and ongoing maintenance of your battery bank, and that your system installation follows all code requirements and manufacturer recommendations and warranty terms, we recommend working with a reputable boardcertified PV Professional.

Most deep cycle batteries used in the Renewable Energy Industry were originally designed and manufactured for use in commercial and 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 undercharge, deficit cycling 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 does not have access or chooses not to connect 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 to support critical loads (e.g. lighting and refrigeration) during brief outages and/or to reduce energy costs by selling excess power generated from the system back to the utility.

DEPTH OF DISCHARGE

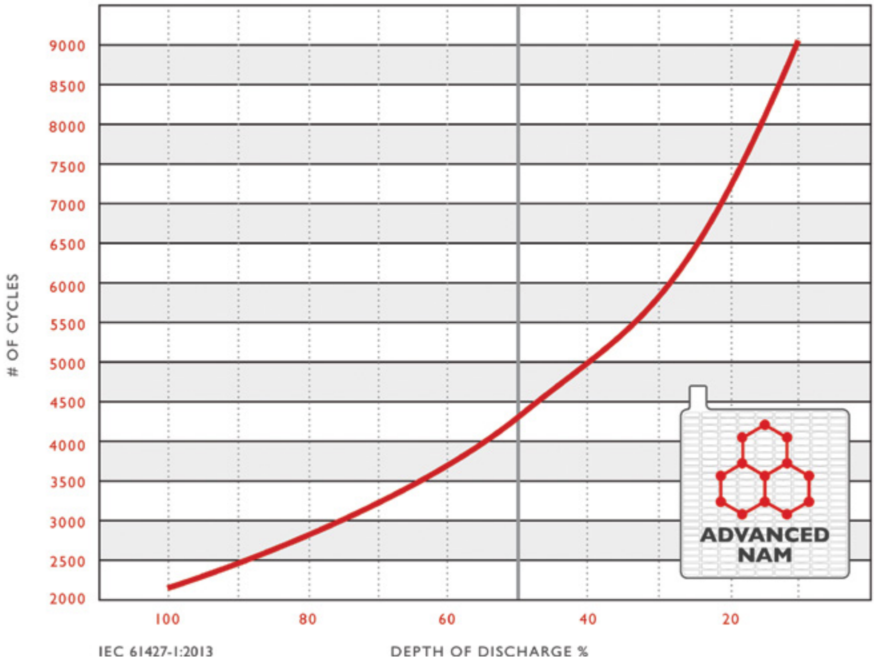
Depth of Discharge (DOD), is used to describe how deeply the battery has been discharged. A battery which is 100% fully charged would have a DOD of 0%. A battery which has been discharged by 20% of its capacity, maintaining 80% of its capacity, would have a DOD of 20%. If a battery has been completely 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 S6 L16-HC models in series (445 AH capacity @ C/20) which are consistently discharged to 50% state of charge (222 AH of capacity drawn) and consistently recharged to a full state of charge should provide approximately 1995 cycles before end of life.

CYCLE LIFE VS. DEPTH OF DISCHARGE – ROLLS BATTERY ENGINEERING

SERIES 5000 WITH ADVANCED NAM



Off-grid Renewable Energy systems are typically sized to operate between 20% and 50% DOD. Deep cycle batteries should be used to 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 size battery banks to operate to a greater depth of discharge to lower initial installation costs. Cycling of grid-connected systems is significantly less frequent than off-grid applications where this typically occurs on a daily basis. With infrequent cycling, a maximum 80% DOD is acceptable as long as the customer understands that the overall cycle life is affected when the battery bank is discharged beyond 50% SOC. These systems should not be designed to fully discharge the battery bank.

BATTERY SELECTION FOR OFF-GRID SYSTEMS

Choosing the appropriate battery for the application is key to long battery life and performance. Once the load is calculated, a battery bank should be selected to meet the system design as well as installation requirements. Flooded lead-acid models using lead-antimony plates require frequent cycling to maintain capacity and prevent sulfation buildup.

Lead-Calcium plates used in VRLA AGM and GEL models are more tolerant and better suited to float applications where the battery may not be cycled as often. If a battery bank of a specific capacity is needed, it is important to select a battery model which offers sufficient capacity, without oversizing, and also minimizes the number of parallel strings required to accomplish the desired voltage and capacity.

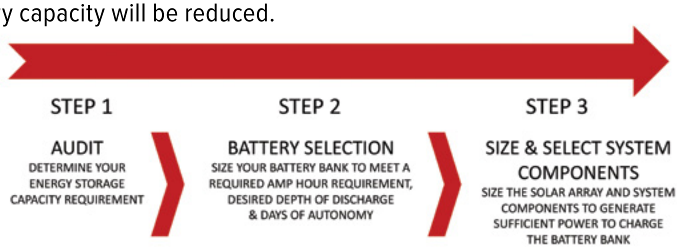
Systems with multiple parallel strings will often experience an imbalance of charge. These banks will also require additional maintenance as this increases the number of terminal connections requiring cleaning as well as the number of Flooded cells to inspect, test and water. When a charge imbalance is not addressed through adjustments in charge time and corrective Equalizations this will lead to capacity loss and premature battery failure.

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 Renewable Energy system, the 20 hr AH rate (C/20) 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 1-2 days of autonomy 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 maintained at a full charge. By holding at a 100% SOC this will extend the overall life of the battery bank. For float applications such as backup systems, it is important to discharge and charge the battery bank periodically to exercise the battery bank as this will prevent stratification and sulfation buildup.

Backup systems are often sized to meet the load requirement at the time of install. It is important to note that as load profiles change this will also affect how quickly battery capacity will be reduced.



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 C/20) 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 (C/20). Alternatively, the same battery can support a controlled 34 Amp draw over a 10-hour period (C/10), meaning it supplies 340 AH capacity for that period of time. Batteries which are discharged should be recharged as promptly as possible.

An off-grid 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 (C/20) rate of the battery bank, or the C/4, C/5, or C/6 rate of the battery. Using the Absorption charge time calculation (charge current of 10% of the C/20 rate of the battery bank will take approximately 4.2 hours, plus the Bulk phase (usually 1-2 hours) to bring the bank from 50% to 100% SOC. This is an ideal scenario as a lower charge current will often increase the required charge time beyond the available sun hours causing deficit cycling 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 100% SOC on a regular basis, causing sulfation problems and capacity loss which then needs to be addressed through corrective equalizations.

In some situations, after and energy audit has been completed and the system is sized and installed, the customers will inadvertently add additional and/or unexpected loads. As system size is calculated with a desired depth of discharge and charge requirement based on expected usage, this increases both the storage needs and subsequent charge source to bring the battery bank to a full charge.
It will often cause problems as a result of deficit cycling and over-discharge which will shorten cycle life.

To avoid this, the customer should be made aware of the importance of properly sizing the system to meet their specific needs. Discuss any expected short/long-term changes in usage and set the expectation that storage and charging needs may increase to meet their changing requirements.

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 similar 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. This system setup is used 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 and refrigeration, etc. It is ideal to limit the size of the supported load to essential services 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 many regions, these backup systems are designed for greater depth of discharge than a typical off-grid application. In some cases, the system may be designed to discharge the battery bank as low as 80% DOD over a relatively short period of time.

In regions where the grid may not be reliable and extended or intermittent outages occur frequently, it is necessary to size the battery bank and charging source(s) to support a larger load over a longer period of time. This prevents the battery bank from overdischarging and/or deficit cycling.

WARRANTY GLOSSARY & FAQ'S

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. However, should a problem arise, you may be assured that you're covered better than any other battery warranty in the business.

Surrette Battery Company warrants that Rolls-branded batteries sold by it are quality tested, 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, conditions and model-specific details, please refer to the warranty document found on the Rolls Battery website.

www.rollsbattery.com/technical-resources

A copy of the **Rolls Battery Warranty Claim Form & Battery Test Sheet** is also available for download in PDF format.

To claim a manufacturing warranty, proof of purchase must be presented, showing the date of purchase and the battery's model & date of manufacture (date code). A completed Rolls Battery Warranty Claim Form & Battery Test Sheet must also be provided. Upon review, it may be necessary to have the battery returned to the manufacturer or inspected and tested by an authorized battery outlet for actual defect. All valid claims must be approved by Rolls Battery Technical Support before replacement product may be issued.

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.

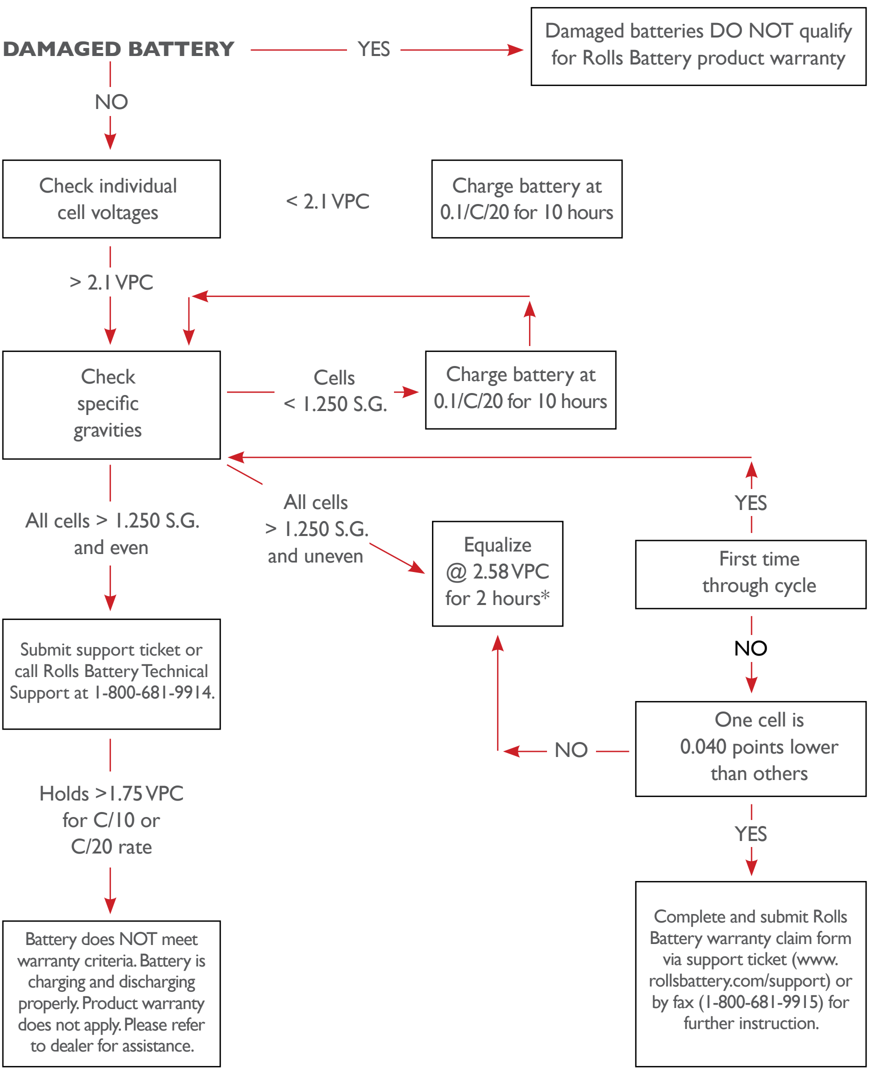
This warranty covers only manufacturing defects.

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 type of 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 offer good power characteristics, low internal resistance and high charge efficiency.

AMP, AMPERE

Unit of electrical current. Abbreviated “A”.

AMP-HOUR, AMPERE-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 batteries of various voltage configurations. Open circuit voltage (OCV) of a charged and rested lead-acid battery is 2.1V/cell.

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 Flooded lead-acid battery the electrolyte is a solution of sulfuric acid and water.

FLOODED CELL

A traditional lead-acid battery. The electrolyte is an ordinary liquid solution of acid and water. Flooded cells are prone to off-gassing hydrogen during charge. They must be periodically checked for fluid level and distilled water added as necessary. Flooded cells are also typically less expensive than AGM or GEL-type lead-acid batteries.

GEL

A sealed VRLA lead-acid battery. The gel electrolyte used in these models is a mixture of sulfuric acid and fumed silica. GEL batteries typically offer extended cycle life over sealed VRLA AGM batteries when operating in higher temperatures and are better suited to slower, deep discharge applications.

HYDROMETER

A tool for testing the specific gravity of a fluid such as the electrolyte in a Flooded battery. Hydrometers use a squeeze-bulb to suck up a sample of the fluid and a float indicates the specific gravity of the electrolyte.

REFRACTOMETER

A tool for testing the specific gravity of a fluid such as the electrolyte in a Flooded battery. Refractometers are hand-held devices which provide a visual reading of specific gravity using a sample of the electrolyte placed on a glass slide. Refractometers are generally thought to provide a more accurate measurement of specific gravity than traditional hydrometers.

OPzV

O = Ortsfest (stationary) Pz = PanZerplatte (tubular plate) V = Verschlossen (closed)
A sealed VRLA GEL battery offered in individual 2-volt cell options, typically used for stationary backup and cycling applications.

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.

VRLA

Valve-regulated lead-acid battery which is sometimes referred to as a sealed or maintenance-free battery. VRLA batteries may be sealed wet cell, Absorbed Glass Mat (AGM) or GEL (ex: OPzV models).

TROUBLESHOOTING & FREQUENTLY ASKED QUESTIONS

The following is a list of common scenarios, questions and concerns relating to system setup, battery charging and maintenance procedures. Please refer to these as general guidelines. For assistance with your specific system setup, please contact your Installer.

NOTE: specific gravity readings should be taken at full charge after the batteries have cooled and are resting in a Float voltage charge for 1-2 hours.

- **Specific Gravity readings vary significantly when charge has completed and the bank has been resting at Float voltage for 1 hour. (greater than .030)**
  - This may be caused by multiple parallel strings of batteries in a bank as this often results in charge imbalance. It is not recommended that a battery bank exceed 3 series strings of batteries connected in parallel.
  - Charge voltage settings may be too low. Verify they meet Rolls-recommended charging parameters for Flooded 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. Test individual battery voltage and specific gravity of each cell to identify weak or failed cells.
- **Specific gravity readings taken for all cells in the battery bank indicate low state of charge while resting at Float voltage. 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.
  - Increase Bulk/Absorption/Boost Voltage in .2v to .4v volts increments.
  - Increase Absorption Time by 15 to 30 minutes increments as necessary.
  - Decrease DC load usage.
- **Specific gravity readings are consistently higher than recommended while resting at Float voltage. (Ex 1.300, 1.295, 1.295, 1.290, 1.300…)**
  - Decrease DC load usage.
  - Charging voltages may be too high. End Amps/Return Amps/Tail Current set point may not be properly programmed to trigger Float charge. Absorption time may need to be reduced to prevent overcharge. Usage (load) may have decreased, reducing depth of discharge (DOD) and the time required to recharge, causing the batteries to overcharge.

- Confirm End Amps/Return Amps/Tail Current is programmed to the recommended 2% of C/20. Models with Advanced NAM may require a slightly higher set point. (2-5% range)
- Decrease Bulk/Absorption/Boost Voltage in .2v to .4v volts increments.
- Decrease Absorption Time by 15 to 30 minutes increments as necessary. Clean and inspect all cabling and connections. Physically disconnect cable, inspect for terminal concaving (Over torqued), grease and re-torque connections.

- **Specific gravity readings on individual cell(s) in a battery bank with multiple series strings vary more than .020 while resting at Float voltage. (Ex 1.265, (1.265, 1.240, 1.265...)**
  - Indicates there may be an imbalance of charge between parallel strings of batteries.
  - 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.
  - Indicates there may be connection issues within each series connection or parallel strings.
  - Increase Bulk/Absorption/Boost Voltage by 0.2V increments.
  - Clean and inspect all cabling and connections. Physically disconnect cable, inspect for terminal concaving (Over torqued), grease and re-torque connections.

***Specific gravity readings varying 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 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(s) temperatures are very high.**
  - If at or near 51˚C (125˚F) 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 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 51°C (125°F). 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 and require replacement.
  - Your batteries may have frozen due to excessive cold temperatures. A fully charged battery (specific gravity of 1.265) may freeze at -70°C (-94°F) or more. A battery at 50% SOC may freeze at -20ºC (-4ºF).

- **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 case has split or cracked originating from the sides.**
  - The battery may have frozen in the past, which has weakened the case structure.

- **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.
- **A battery and/or cell(s) in the battery bank does not require watering.**
  - The battery may have a cell that has failed and no longer accepts a charge.
  - Verify specific gravity of all cells and voltage reading of each battery.
  - Perform a load test to identify any cell failures.
- **While charging, the battery bank does not reach the programmed Bulk voltage.**
  - 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, AGM or GEL 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 for Flooded battery banks. (Example: 1200AH 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 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.**
- This is often an indication of sulfated batteries which may be causing alower than normal impedance in reference to the charger. Capacity of the bank will be reduced and may be confirmed by running a load test.
- An increase in Absorption time may be necessary to desulfate the battery bank.
- 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. Battery case has split or cracked originating from the sides.

- **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 the battery bank 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 100% SOC. When the charge current reaches the programmed End Amps/Return Amps/Tail Current set point (recommended 2% of the 20 Hr AH rate (C/20) capacity of a healthy Flooded battery bank) for a 1-hour period the charge is complete. (Ex. 500 AH battery bank. Charge current is reduced to 10 Amps). This set point may be programmed in the charge controller to trigger Float charge if the battery bank reaches 100% SOC before the Absorption Time has been completed.
  - Test specific gravity.
    - If specific gravity readings are at 1.250 or greater the batteries are nearing completion or finished the Absorption charge phase.
    - If the specific gravity is lower than 1.250 following a charge, perform a load test to ensure all cells are operating correctly.
    - Varying specific gravity readings may indicate a buildup of sulfation. Perform a corrective Equalization to balance and desulfate and monitor changes in specific gravity.

- **When performing a corrective Equalization, the battery bank does not reach Equalization voltage.**
  - Complete a full Bulk & Absorption charge prior to initiating an Equalization.
  - Indicates the charge output may be too low. Verify the voltage and charge output meet Rolls-recommended charging parameters for Flooded models.
  - 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.

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