

Powering Today. Sustaining Tomorrow.



# Safety. First.

**RENEWABLE POWER BATTERIES**

## BATTERY HANDLING, MAINTENANCE & TEST PROCEDURES





# PROVEN POWER STORAGE



When you rely on renewable energy for off-grid or grid-backup power, there's no alternative to proven power storage.

That's why businesses, homeowners, and those who count on renewable power systems to support their values turn to Crown for energy storage batteries.

The purpose of this Safety. First. best-practice manual is to help RE system owners and ESS service providers enhance their safety awareness, equipment life, and energy storage solution reliability.

Content takeaways are intended to help minimize safety risks, maintenance costs and unscheduled downtime, leading to mishap prevention, return on investment, and system productivity. And ultimately, an energy storage array that's second-to-none in delivering power when you need it.

## SAFETY IS YOUR RESPONSIBILITY:

The forward-looking innovation behind Crown Battery Flooded Lead Acid (FLA) and AGM Energy Storage batteries makes them ideal for renewable energy (RE) systems, resulting in the delivery of more power, longer life and best-in-class performance, and options for low- or no-maintenance to support your specific needs.

Combining the newest technology, manufacturing processes and tough, tested and proven designs, Crown Battery Renewable Power batteries deliver the storage capacity and power that RE and Energy Storage Solution (ESS) owners depend on – the world over.

Crown Renewable Power batteries require model-specific maintenance and charging protocols to ensure dependable service life.

**Regardless of battery type, owners and system managers must always follow these safety precautions when working with and charging batteries:**

- ▶ Wear appropriate protective gear including safety glasses, footwear and gloves to prevent electrical shocks and ensure fall protection when working from heights over 4 feet (1.2 meters). Battery electrolyte can cause severe burns or blindness. If exposed to electrolyte, immediately flush affected area with water and seek medical attention.
- ▶ Remove watches and jewelry and avoid causing sparks with tools. When possible, use tools with insulated or non-conductive handles when securing batteries or cabling in the application.
- ▶ Maintain good ventilation when working on or charging batteries.
- ▶ All lead batteries generate highly flammable hydrogen gas. Keep sparks, flames and cigarettes away from batteries (even sealed maintenance-free batteries) at all times.
- ▶ For Flooded Renewable Energy batteries, always verify that vent caps are tightly secured to batteries after cell inspections and watering service.
- ▶ AGM Renewable Power batteries rely on a sealed design, so the valves on the battery cover should never be opened. Doing so can damage the product and voids warranty.

# ESS & RENEWABLES APPLICATIONS

## PURPOSE & EXPECTED OUTCOMES

The information provided in this guide is general and intended as an overview only. Each RE project and corresponding energy storage array is unique and additional requirements may be identified or mandated as deemed appropriate.

This document outlines recognized best practices pertaining to the safe handling, installation, charging, maintenance, and testing of Crown Renewable Power batteries for use and practice by ESS owners and service providers.

### Upon review, you should:

- ▶ Gain a basic understanding of how to safely handle, install, and manage Crown Renewable Power batteries in various energy storage applications.
- ▶ Learn to recognize the differences between Flooded Lead Acid (FLA) Renewable Power batteries and Absorbent Glass Mat (AGM) Renewable Power batteries – and how to manage these differences during setup, charging service, routine maintenance intervals, and battery testing.
- ▶ Be able to identify ESS-associated safety issues.
- ▶ Become familiar with standards and codes pertinent to applications under your control.

## BEST PRACTICE ALERT:

### COMMITMENT & TRAINING ARE ESSENTIAL

- ▶ Just when you think you have all the information you need, there will be new developments. Stay engaged with your supplier and industry authorities to ensure you have the most current training and certifications available.
- ▶ Safety does not stop when a new or replacement battery system is commissioned; safety issues remain relevant through operation, periodic servicing, repair activities, and finally – decommissioning of the system.

**Contact Crown Battery to learn how we can help you stay in front of challenging and rapidly evolving training and application requirements.**

## INSPECTION, HANDLING & STORAGE

### EXAMINE BATTERIES UPON RECEIPT

When the batteries are delivered for your application, it is your responsibility to examine them for signs of impact or damage that occurred in shipping. It is not recommended to accept the shipment when indications of shipping damage appear on any products included with the shipment.

Shipping damage is not covered by Crown Battery's warranty guaranty and must be noted on the proof of receipt / proof of delivery when you receive a shipment with damaged goods. Otherwise, Crown Battery will not accept claims for reimbursement for goods damaged in shipment. Refer to Crown Battery's prepaid freight policy for additional details.



Following receipt of batteries, some common best practices for ensuring your batteries are ready for installation include the following actions:

1. Inspect battery open circuit voltage to confirm the state of charge (SOC) and general condition of your products before installation.
2. Regardless of their construction, lead batteries can be safely stored and maintained in your inventory with low risks. Store batteries in a cool and dry location that protects them from the elements. Take care to protect battery inventory from impact by storing products on the shipping pallet you received them on and to keep batteries free of any connections that may cause parasitic loads. The chemistry of deep cycle RE batteries allows gradual self-discharge when resting off charge, so batteries in storage should be charged when their SOC declines to 70 to 65%.
3. Storage in hot environments (ambient temperatures greater than 30°C / 86°F) can affect battery life. Battery owners should anticipate accelerated self-discharge at higher temperatures and should take precautions to avoid exposing batteries to heat sources. Hot temperature storage conditions will require more frequent maintenance charging and watering service.
4. Crown FLA Monoblock and Power Module batteries are regulated by the U.S. Department of Transportation, IATA, ICAO, and IMDG as UN2794 / Class 8 Corrosive Hazardous Materials. Both FLA and sealed AGM batteries are exempt from regulation as hazardous materials by US DOT when properly packaged for shipment by ground transport. Transport of flooded batteries by air is regulated by IATA packing instruction 870. Additionally, transport by sea is regulated by IMDG packing instruction P801.
5. Crown AGM Monoblock batteries are recognized as UN2800 Sealed and Non-Spillable batteries that are exempt from regulations by the U.S. the U.S. Department of Transportation, IATA, ICAO, and IMDG when they are blocked, braced, and protected against short-circuit in transportation.
6. FLA and AGM batteries can be recycled and should be returned to an authorized battery disposal agent for recycling. Refer to [www.batterycouncil.org](http://www.batterycouncil.org) for more information about battery recycling.

# BATTERY INSTALLATION & SETUP

## GEARED FOR SUCCESS: TOOLS & MATERIALS FOR INSTALLERS



To ensure a successful project, installers should make sure they have the following tools, equipment, and supplies available:

- ▶ Personal Protection Equipment (Gloves, Eyewear, Protective Coverings, Protective Shoes)
- ▶ Insulated tools – including a Torque Wrench
- ▶ Voltmeter
- ▶ Hydrometer or Refractometer
- ▶ Anti-Corrosion Terminal Treatment Materials
- ▶ Soda Ash or Sodium Bicarbonate (for spill cleanup)
- ▶ Distilled Water
- ▶ 5-Gallon Containment Pail with Sealing Cover (for storing spilled acid or cleanup materials)
- ▶ Warning Signage or Safety Decals to communicate risks according to applicable standards such as ANSI Z535
- ▶ Lockout / Tagout Kits



## PRE-INSTALLATION: SAFETY CONSIDERATIONS

1. Prior to installation, project managers must take care to ensure that their approved plans, permits (if required), and installation instructions are posted at the worksite at time of startup.
2. Project planning elements must identify all potential or known hazardous energy sources before entry to the worksite is permitted and should include step-by-step instructions to ensure that all energy sources are turned off and isolated, including primary and auxiliary electrical sources and mechanical power sources.
3. Take care to verify that electrical panels have been de-energized prior to removing the dead-front. All equipment shall be open and show evidence of lockout/tagout. Installers should also have instructions on how to prevent accidental re-energization of lockout devices.

## BEST PRACTICE ALERT:

### LOCKOUT / TAGOUT PROCEDURES TRAINING

Anyone who performs installation, service, or repair work on equipment or systems with hazardous energy must be trained on how to lock out and tag out. In addition, anyone who supervises employees must also be trained on lockout/tagout procedures.

When it comes to who needs training in your business or workplace, employers should consult OSHA 29 CFR 1910.147 and NFPA 70E.

## INSTALLATION:

1. The designated installation area for the battery bank should include a copy of this manual stored in a protected enclosure along with manuals and operating and safety instructions for the total system.
2. Spaces about the battery area should be compliant with applicable codes such as NEC 2017, NFPA 70e and applicable local building and fire codes. A minimum clearance of 1 inch between batteries within a string or between the battery container and any wall or structure on sides not requiring access for maintenance is recommended.
3. While handling and/or positioning the batteries in the installation, installers must take care to guard batteries' terminals (or "live" terminal connections) from incidental short-circuit.
4. Batteries should be installed in an insulated and temperature-controlled structure or enclosure to protect them from freezing temperatures, and to prevent exposure to weather elements such as rain, snow, or direct sunlight. As high operating temperatures will reduce usable life, system owners should take care to ensure that battery installations include active ventilation to cool batteries.

Batteries should never be installed in sealed enclosures as they emit hydrogen gas during charging, or, in the case of AGM batteries, can be inadvertently overcharged. Ventilating batteries will also prevent hydrogen from accumulating in your energy storage system.

5. Installers must avoid lifting batteries via terminal posts as doing so will damage the terminal posts and internal post connections. The design of Crown Renewable Power batteries includes load-rated handles or lifting points to allow installers to safely handle and lift batteries at the jobsite. Installers must take care to avoid potential lifting or handling risks by knowing the weights of the products they will handle at the jobsite, and to ensure they have the required project labor or lifting apparatus equipment to safely move batteries into their final positions.
6. FLA Renewable Power batteries must be always installed in an upright position to avoid electrolyte spills. AGM batteries can be mounted on the long front-wall side of the battery, however, they will perform more reliably when installed in an upright orientation.



# CABLING & CONNECTIONS

Ampacity is the maximum current, measured in amperes or “amps,” that a conductor such as a cable can carry continuously under the conditions of use without exceeding its temperature rating. Installers should take care to confirm that cables used to complete battery bank connections are correctly sized for the systems maximum current (“load”) requirement to prevent overheating of cables within the battery bank.

The following table indicates nominal ampacity and nominal diameter measurement specifications of American Wire Gauge (AWG) sizes of solid round copper cables:

## AWG CABLE SIZING – COPPER WIRE & CABLE

AWG CABLE SIZE	CURRENT MAX AMPS	DIAMETER MILLIMETERS
4/0	260	11.68
3/0	225	10.40
2/0	195	9.27
1/0	170	8.25
1	145	7.35
2	130	6.54
4	95	5.19
6	75	4.12
8	55	3.26
10	40	2.59
12	30	2.05
14	25	1.63

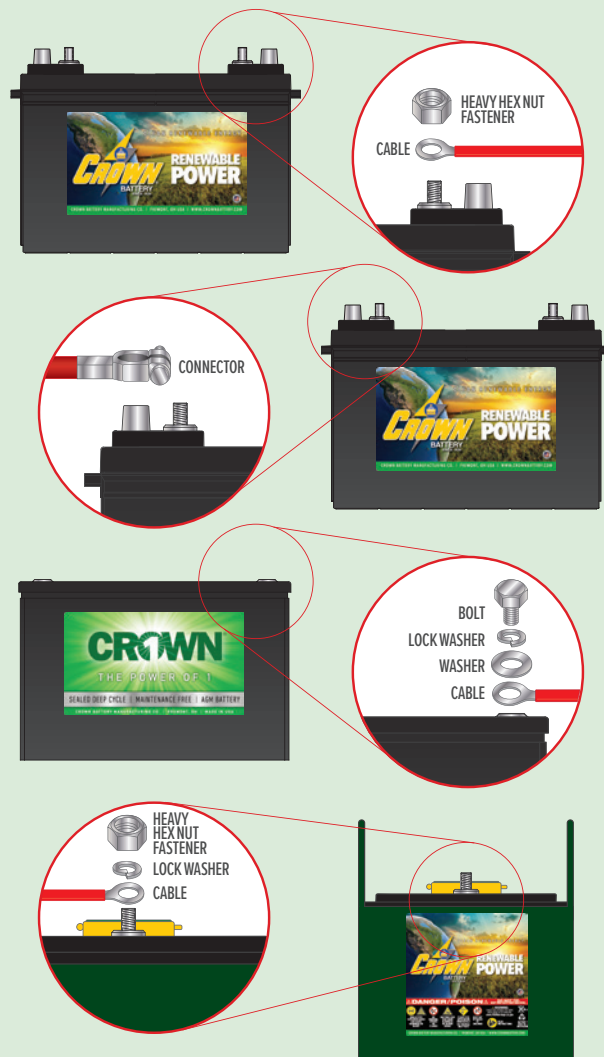
## TERMINAL CONNECTIONS

In existing systems, verify that terminal connections are always secure and tight during routine inspection. When installing batteries for replacement or in a new system, take care to visually inspect bolted terminal connectors for damage from impact, over-torque, or short-circuiting faults in previous use installations. Replace any connectors showing damage or physical indicators of fault (discoloration, scaling, etc.) to avoid problems after the systems start-up.

Regardless of connector type, terminal connections must be tightened using the specified torque values below:

TERMINAL TYPE	In-lbs	Nm
Monobloc SAE / Top Post Terminal	50 – 70	6 – 8
Monobloc SS Threaded Terminal	100 – 120	11 – 14
Monobloc Inserted Terminal	62 – 88	7 – 10
Power Module Inserted Terminal	100 – 120	11 – 14
Power Module HD SS Threaded Terminal	100 – 120	11 – 14

Cables should be secured to battery terminals following the installation diagrams below:



The battery terminal surface should be clean and dry prior to installation and torquing of the connectors to the terminals. Never place a washer or terminal treatment material between the battery terminal surface and the connector surface, as this will increase electrical resistance – which affects battery and charger performance and can create potential safety hazards.

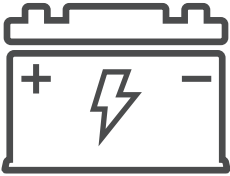
## BEST PRACTICE SUGGESTIONS:

### BATTERY BANK CABLING

- ▶ Cables should be sized uniformly regardless of their purpose (Master Cables or Interconnecting Cables)
- ▶ Interconnecting battery cables (“jumper cables” used to connect batteries within a string or bank) must be the same dimension for length and gauge size.
- ▶ The same standard for dimension and sizing apply to systems using solid copper interconnecting bars.
- ▶ When sizing interconnection cables, system designers or installers should ensure the cables will allow at least 1 inch of space between batteries for air circulation.
- ▶ To ensure peak efficiencies during use, system designers should specify cables that limit voltage drop to no more than 2% across the battery’s total cable length.
- ▶ Installers should visually inspect all cables before final installation to verify sizing and cable integrity. Final verification inspections should look for cable with torn or deteriorating cables with exposed copper wires. Replace cables found in this condition.

# CHARGING, MAINTENANCE & OPERATION BEST PRACTICES

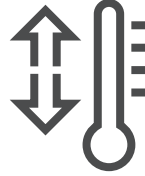
## GENERAL USE BEST PRACTICES:



### CHARGING SERVICE AT RECEIPT OF INVENTORY

Ambient temperatures above 80°F / 27°C during shipment will affect the state of charge (SOC) of Crown Renewable Power batteries. Customers who are in hot weather regions should verify battery voltage at the time of shipment receipts to determine if inventory requires charging before storage.

After installation (but before first use), connect the battery bank to the system's charging source to ensure the batteries are in full charge condition prior to first use.



### EFFECT OF AMBIENT TEMPERATURE ON BATTERY PERFORMANCE & LIFE

Battery capacities and projected life are based upon operating temperatures of 80°F / 27°C. The recommended operating temperature range for Crown Renewable Power batteries should not exceed -40°F to 120°F (-40°C to 49°C) and appropriate temperature compensation controls must be programmed into the charging system hardware. Battery users and owners should consider that battery life is reduced as operating temperature increases.

**APPLICATION NOTE:** Maintain a state of charge greater than 60% when operating batteries at temperatures below 32°F (0°C).



### DUTY CYCLE CHARGING SERVICE

Effective charging service delivers optimal life and a strong return on investment for Crown Renewable Power battery users. Take care to verify that your system's charging source has been configured or is programmable for application with Crown Renewable Power batteries. More importantly, recognize the differences between FLA and AGM batteries and do not use charging equipment that is not designed for your batteries specific charging requirements.

Contact Crown Battery via email at [commercial@crownbattery.com](mailto:commercial@crownbattery.com) if you require support with verifying your charging system's capabilities.



# RENEWABLE ENERGY BATTERY CHARGING

To ensure reliable RE system and battery bank performance, it's important to take a few simple steps during installation of the battery bank to set up the system's charge controller voltage and timer settings for optimal performance. To maximize performance and life, batteries should be fully charged after each discharge period.

**NOTE:** Fully charged State of Charge is achieved when **BOTH** the "float" voltage on the charge control meter **AND** specific gravity readings (via hydrometer) indicate full float charge conditions:

**2.25 Volts per Cell, and specific gravity density of at least 1.265**

Refer to the following suggested Renewable Energy charge control settings and information to achieve the best performance and ROI from Crown Battery's FLA Monobloc products in your application:

## CHARGE CONTROL VOLTAGE SET POINTS

	SYSTEM VOLTAGE			
	VPC	12 Volts	24 Volts	48 Volts
Bulk	2.44	14.52	29.05	58.15
Absorption	2.42	14.50	29.00	58.10
Float	2.25	13.50	27.00	54.00
Equalization*	2.59	15.50	31.00	62.00

## TIMER SET POINTS

Bulk	N/A
Absorption	2 hours per parallel "string" in the battery bank Suggest no more than 2 parallel strings within the battery bank
Float	N/A
Equalization*	2-3 hours maximum

\*Refer to equalization charge service instructions below.

## EQUALIZATION CHARGE SERVICE

Equalization (Eq) charging service is a regularly scheduled charge cycle. Eq Charge frequency is primarily dependent on daily DOD:

<b>Below 50% DOD:</b>	<b>Biweekly schedule</b>
<b>50% and above DOD:</b>	<b>Monthly schedule</b>

The suggested Eq charge is 2-3 hours and should be done using a generator. Confirm Eq charge effectiveness with the use of a hydrometer after termination of charge. Specific gravity readings of at least 1.265 or higher are required for a successful equalization phase.

**NOTE:** For a proper Eq charge to occur, the battery bank must have successfully completed the absorption phase of charging and be at true "float" voltage (confirmed with hydrometer readings of at least 1.265).

## THE SUGGESTED CHARGE SETTINGS ARE BASED ON SEVERAL TECHNICAL ASSUMPTIONS:

1. A depth of discharge (DoD)/low-voltage disconnect (LVD) setting of no more than 50% of C/20 battery bank overall Ah capacity:
  - a. 1.96 volts per cell (open circuit voltage) is 50% DoD.
  - b. System owners should note that lighter DoD settings **WILL** extend battery bank longevity
2. The total input amperage from the charging source is at least 10 amps per 100 Ah (C/20) of battery bank capacity.
3. DoD LVD settings beyond 50% and/or charge input of less than 10% overall battery bank capacity (C/20) will likely result in additional changes to the stated voltage / timer set points here.

The constantly changing dynamics of off-grid renewable power energy storage require a strong system owner commitment to regular monitoring of batteries' SOC to verify charge control voltage meter readings. Regular verification will ensure that your system is calibrated to properly charge the battery bank.

## BEST PRACTICE ALERT:

### VALIDATING SOC AT END OF CHARGE

Do **NOT** assume the battery bank is at full state of charge (SOC) when the charge control meter indicates battery bank is at "float" voltage.

True 100% SOC should be confirmed on a regularly scheduled basis (at least monthly) with the use of a battery hydrometer to measure specific gravity readings after the system charge control meter shows batteries at "float voltage."

**IMPORTANT:** WHEN CHARGE CONTROL METER IS SHOWING BATTERY BANK IS AT "FLOAT" VOLTAGE – THE SPECIFIC GRAVITY READINGS **MUST** BE AT A DENSITY OF LEAST 1.265 FOR THE BATTERY BANK TO BE VALIDATED AT FLOAT VOLTAGE AND FULLY CHARGED.

## MISCELLANEOUS RE BATTERY TIPS

"End Amps Setting" (if required):  
2%-3% of battery bank's C/20 overall Ah capacity

Temperature Compensation:  
3mV per 1°C





# RENEWABLE ENERGY BATTERY CHARGING

CONTINUED

## IMPORTANT BEST PRACTICE:

### UNDERSTANDING & USING A BATTERY HYDROMETER



A battery hydrometer is used to test and determine the state of charge of a battery cell by measuring the density of sulfuric acid that is present in the electrolyte after charging service.

The greater the concentration of sulfuric acid within the electrolyte solution, the denser the electrolyte becomes (and thus the higher the measurement of the specific gravity) - which equates to a higher battery state of charge (Full Charge = 1.265 Specific Gravity).

The specific gravity readings of the electrolyte solution in the cells will increase and decrease as the battery state of charge goes up and down.

As batteries discharge; sulfuric acid is absorbed by the active mass on the positive plates within the battery – reducing the concentration of sulfuric acid in the electrolyte.

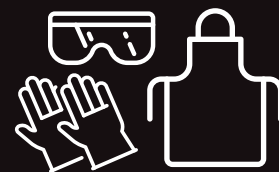
A fully discharged (100% depth of discharge) battery's specific gravity will measure 1.040 to 1.145 with a hydrometer, depending upon the discharge rate.

During recharge service, the electrical current entering the battery “breaks the bonds” between the sulfuric acid and the battery plate material, allowing the sulfuric acid to re-blend with the electrolyte solution. Batteries are fully recharged when all of the sulfuric acid is transferred from the plates to the electrolyte fluid. This can be verified via the use of a hydrometer.

The specific gravity reading is the best / most accurate way to determine battery state of charge as it allows system owners to verify the voltage-based state of charge meter reading.

### IMPORTANT SAFETY ALERT:

**WHEN USING A BATTERY HYDROMETER: ALWAYS WEAR PERSONAL PROTECTIVE EQUIPMENT WHEN INSPECTING BATTERY ELECTROLYTE.**



## SEASONAL STORAGE



### For a part-time or seasonal residence with an off-grid system:

Consider two options to address the battery bank when residence is uninhabited for no longer than 3-4 months.



### IF NO POWER REQUIRED WHEN RESIDENCE IS UNINHABITED:

- ▶ Perform an equalization charge on day of departure (after normal daily charge is complete)
- ▶ Confirm full charge with hydrometer specific gravity readings of at least 1.265 (100% SOC)
- ▶ If the battery bank is at 100% SOC, shut the system down and eliminate possibility for parasitic draws from the battery bank (disconnect inverter charge controller leads from battery bank)
- ▶ Upon return; perform complete normal/daily recharge as well as an Eq charge – confirming specific gravity readings of at least 1.265 after completion of equalization

### IF POWER IS REQUIRED WHEN RESIDENCE IS UNINHABITED:

- ▶ Determine the energy budget required from the system when the residence is uninhabited (assuming reduced loads)
- ▶ Perform an Eq charge on the day of departure (after normal daily charge is complete)
- ▶ Confirm full charge with hydrometer specific gravity readings of at least 1.265 (100% SOC)
- ▶ If battery bank is 100% SOC, adjust absorption timer setting accordingly to account for revised energy budget (with reduced loads; absorption timer setting should be reduced)
- ▶ Upon return; perform complete normal/daily recharge as well as an Eq charge – confirming specific gravity readings of at least 1.265 after completion of equalization



# RENEWABLE ENERGY BATTERY CHARGING

To ensure reliable RE system and battery bank performance, it's important to take a few simple steps during installation of the battery bank to set up the system's voltage and timer settings for optimal performance. To maximize performance and life, batteries should be fully charged after each discharge period. Refer to the following suggested settings and information to get the most out of Crown Battery AGM products used in RE applications.

## VOLTAGE SET POINTS

	SYSTEM VOLTAGE			
	VPC	12 Volts	24 Volts	48 Volts
<b>Bulk</b>	2.44	14.64	29.28	58.56
<b>Absorption</b>	2.42	14.52	29.04	58.08
<b>Float</b>	2.20	13.20	26.40	52.80
<b>Conditioning*</b>	2.42	14.52	29.04	58.08

\*See information on conditioning charge service at right

## TIMER SET POINTS

<b>Bulk</b>	N/A
<b>Absorption</b>	2 hours per parallel "string" in the battery bank Suggest no more than 2 parallel strings within the battery bank
<b>Float</b>	N/A
<b>Conditioning*</b>	4 hours maximum

\*See information on conditioning charge service at right

## THESE SUGGESTED SETTINGS ARE BASED ON TWO ASSUMPTIONS:

1. A depth of discharge (DoD)/low-voltage disconnect (LVD) setting of no more than 50% of C/20 battery bank overall Ah capacity; 2.04 volts per cell (open circuit voltage) is 50% DoD.

Note that lighter DoD settings though WILL enhance battery bank performance/longevity.

2. The total input amperage from the charging source is at least 10 amps per 100 Ah (C/20) of battery bank.

DoD/ LVD settings beyond 50% and/or charge input amperage of less than 10% of overall battery bank capacity (C/20) may/will result in necessary changes to the above stated voltage/timer set points.

Again, these are suggested settings as off-grid dynamics are subject to constant change. Regular monitoring of batteries' voltage conditions using a digital multimeter tool to verify charge control meter readings is recommended during the first 2-4 weeks of operation after installation. Doing this will ensure that your system is calibrated to properly charge the battery bank.

## CONDITIONING CHARGE SERVICE\*

The "conditioning" charge phase is a biweekly or a monthly scheduled charge cycle, dependent upon DoD/ LVD setting on inverter

- ▶ Below 50% DoD; biweekly schedule
- ▶ 50% and above DoD; monthly schedule

Most charge controllers will have an "equalization phase" as a programmable option. Crown suggests programming the "conditioning charge" into the equalization phase within the charge controller to keep it separate from the daily charge cycle settings.

**NOTE:** It is recommended to remove surface charge/voltage from the battery bank prior to the "conditioning" charge. Allowing the surface charge/voltage to dissipate on its own may take several hours to an entire day. See the next page for details.

At completion of a normal /daily charge cycle, remove surface voltage and "condition charge" the battery bank per settings in the Voltage Set Points chart on this page.





## REMOVING SURFACE VOLTAGE

1. Discharge at rate of 1% of battery capacity and allow battery to sit for 10 minutes – OR – Discharge battery at a load approximately 33% of Ah capacity for 5 minutes and then allow battery to sit for 10 minutes
2. Run “conditioning” charge using the generator, so that there is no interruption during the charge cycle

**AGAIN:** Remove surface charge/voltage and confirm actual/open circuit voltage (OCV) readings across each individual battery.

Fully charged AGM batteries will indicate open circuit voltage readings of at least 2.14 VPC after surface charge/voltage has been removed.

Any AGM battery that exhibits VPC readings of less than 2.14 requires more charging.

If the OCV readings have “plateaued” (below 2.14 volts per cell) after several “conditioning” charges, the battery has more than likely sustained some type of damage.

## IMPORTANT RE BATTERY GUIDELINES

Do NOT assume the battery bank is at full state of charge (SOC) when the charge meter indicates “float.”

True 100% SOC should be confirmed on a regularly scheduled basis (at least monthly) with the use of an independent multimeter, after system is showing “float” and surface voltage has dissipated (see the surface voltage removal protocol above).

In the first 2-4 weeks after installation, spot check open circuit voltage (OCV) readings every few days after system has gone to “float” and surface voltage has dissipated. Note that OCV readings that fail to attain at least 2.14 VPC, may/will require additional charging and may result in modification of charge control settings. Also repeat this process — during the change of seasons (spring/summer/fall/winter) as solar/photovoltaic availability changes throughout the year.

### MISCELLANEOUS RE BATTERY TIPS

- ▶ “End Amps Setting” (if required): 2% – 3% of battery bank’s C/20 overall Ah capacity
- ▶ Temperature Compensation: 3mV per 1C°

### SEASONAL STORAGE

For a part-time residence with an off-grid system: there are two options to address the battery bank when residence is uninhabited (for not longer than 3-4 months)

#### 1. IF NO POWER REQUIRED WHEN RESIDENCE IS UNINHABITED:

- a. Perform a conditioning charge protocol on day of departure (after normal daily charge is complete)
- b. Confirm full charge (remove surface voltage and take multimeter readings to confirm battery voltages are 100% SOC)
- c. If the battery bank is at 100% SOC, shut the system down and eliminate possibility for parasitic draws from the battery bank (disconnect inverter charge controller leads from battery bank)
- d. Upon return; perform complete normal/daily recharge as well as a conditioning charge protocol

#### 2. IF POWER IS REQUIRED WHEN RESIDENCE IS UNINHABITED:

- a. Determine the energy budget required from the system when the residence is uninhabited (assuming reduced loads)
- b. Perform a conditioning charge protocol on the day of departure (after normal daily charge is complete)
- c. Confirm full charge (remove surface voltage and take multimeter readings to confirm battery voltages are 100% SOC)
- d. If battery bank is 100% SOC, adjust absorption timer setting accordingly to account for revised energy budget (with reduced loads; absorption timer setting should be reduced)

**UPON RETURN: PERFORM COMPLETE NORMAL/DAILY RECHARGE — AS WELL AS A CONDITIONING CHARGE PROTOCOL**



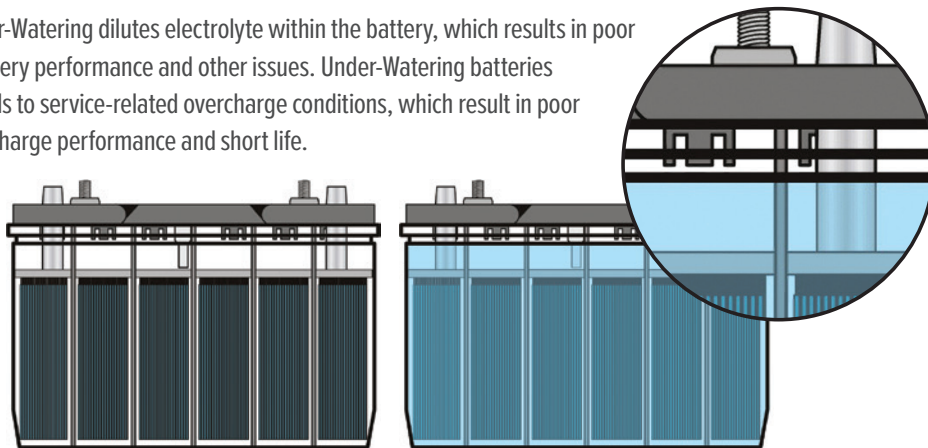
# WATERING SERVICE GUIDELINES

FLA Deep Cycle batteries begin service consuming low amounts of water. Deep Cycle battery applications vary, so watering service frequency will vary according to battery use frequency, charging service, the operating environment temperature, and battery age. New batteries should be inspected at a two-week interval to establish a baseline for watering frequency. As your batteries age, or if their use frequency changes, batteries should be inspected weekly as they will need more frequent watering service.

## THERE ARE THREE SCENARIOS WHEN WATERING SERVICE CAN BE HARMFUL TO YOUR BATTERIES:

❌ **Over-Watering**   ❌ **Under-Watering**   ❌ **Use of Non-Distilled Water**

Over-Watering dilutes electrolyte within the battery, which results in poor battery performance and other issues. Under-Watering batteries leads to service-related overcharge conditions, which result in poor discharge performance and short life.



As demonstrated in the above image, maintain battery electrolyte levels above the top of the battery plates – but no higher than battery cover vent well. Never fill batteries to the brim of the cell or to a point where fluid overflows out of the cell.

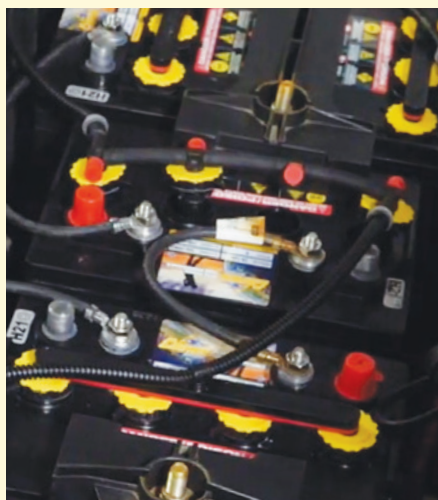


## WATERING CRITICAL REQUIREMENTS

- ▶ Always wear safety glasses, gloves, and other protective gear when servicing batteries
- ▶ **USE ONLY DISTILLED OR DE-MINERALIZED WATER**
- ▶ Never add battery acid or other foreign materials to battery electrolyte
- ▶ Watering service should occur only after charging service is completed
- ▶ Never charge batteries if their plates are exposed or not submerged in electrolyte. When this condition is detected, fill the battery only until the tops of plates are covered with fluid
- ▶ After service is completed – always check that vent caps are tightly secured onto batteries

## WATERING BEST PRACTICE RECOMMENDATION

A Single-Point Battery Watering Systems (SPW) is the safest, easiest, and most cost-effective solution for optimizing battery performance and overall life. Crown Battery's FLA Deep Cycle battery array is engineered to integrate with Flow-Rite Controls' Pro-Fill and Qwik-Fill systems as well as other SPW products available from battery maintenance suppliers.



And thanks to proprietary innovations, Crown Deep Cycle batteries can accommodate SWP injectors manufactured by other battery companies which until this point were only compatible for use with their products.

Our preferred Flow-Rite Pro-Fill system also integrates with additional bolt-on solutions that help equipment owners take control of battery management:

- ▶ Advanced Battery Steward allows users to track information from their battery set wirelessly to let you know exactly when your battery requires service – along with battery condition.



- ▶ The Eagle Eye Electrolyte Fluid Level Indicator monitors and displays the status of cell electrolyte levels via highly visible LED signal lighting.

Contact Crown Battery for more information regarding Single-Point Watering maintenance accessories at [commercial@crownbattery.com](mailto:commercial@crownbattery.com).

# BATTERY ANALYSIS

Battery testing is most effective as a diagnostic resource when employed at scheduled intervals. An effective testing program can also identify conditions that affect battery performance in normal as well as abusive conditions – including situations that may result in premature failure. Crown Battery utilizes several FLA battery test procedures that can be performed to verify battery serviceability. These tests do not determine the battery's actual capacity – but can indicate a need for replacement or a more complete assessment of battery integrity.

- 1. VISUAL INSPECTION:** Check battery age or length of service if available. Inspect battery for damage – when physical damage to the battery container or terminals is present, replace the battery. If none, check the battery's cell electrolyte levels. Fluid levels should be above the top of plates in all cells, and no higher than 1/4" (6 mm) below the cell opening's vent well:

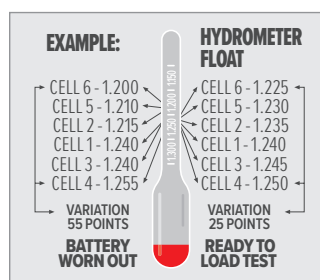
If the battery is sufficiently filled with electrolyte – proceed to step 2. If the top of the battery's plates are not covered with liquid, add water, replace vent caps and place the battery on charge. Be sure no open flame or spark is near while the battery's vent caps are removed from the battery.

- 2. SPECIFIC GRAVITY INSPECTION:** Using a reliable Hydrometer, all cells should be at least 1.225 and show less than 50 points difference between high and low.

- ▶ More than 50 points difference: replace the battery
- ▶ Less than 50 points difference, but some cells read less than 1.225: recharge the battery

Secure the vent caps during recharge. Charge the battery using a properly matched charger until all cells measure a specific gravity of 1.265.

If charging will not restore specific gravity levels, replace the battery.



## Safety.First.

### BATTERY INSPECTION PROCESS

1. VISUAL INSPECTION
2. FULLY CHARGE BATTERIES –  
Followed by an 8-Hour Rest Period
3. OPEN CIRCUIT VOLTAGE TEST
4. BATTERY DISCHARGE TEST

STATE OF CHARGE LEVEL	SPECIFIC GRAVITY
100%	1.265 or Greater
75%	1.225 – 1.230
50%	1.190 – 1.205
25%	1.150 – 1.175
Discharged	1.125 or Less

STATE OF CHARGE LEVEL	12 VOLT BATTERY OPEN CIRCUIT VOLTAGE	8 VOLT BATTERY OPEN CIRCUIT VOLTAGE	6 VOLT BATTERY OPEN CIRCUIT VOLTAGE
100%	12.60 or Greater	8.40 or Greater	6.30 or Greater
>75%	12.30	8.20	6.15
>50%	12.00	8.00	6.00
>25%	11.64	7.76	5.82
0 – 10%	11.46 – 11.52	7.64 – 7.68	5.73 – 5.76

Specifications require a fully charged specific gravity of 1.265

STATE OF CHARGE	BATTERY VOLTAGE UNDER 15 SECOND LOAD		
	12 VOLT BATTERY	8 VOLT BATTERY	6 VOLT BATTERY
100%	12.60 or Greater	8.40 or Greater	6.30 or Greater
75%	12.00 – 12.30	7.87 – 8.20	5.90 – 6.15

- 3. OPEN CIRCUIT VOLTAGE (OCV) TEST:** Batteries with less than 75% state of charge should be charged and rested for at least 8 hours before recording OCV conditions for the battery or batteries in the set. If the voltage readings differ by more than 0.3 volts from full-charge OCV or from other batteries in the set, conduct an equalization charge and re-test batteries. Recorded voltages showing differences greater than 0.3 volts from full charge or from other batteries in the set usually indicate a damaged or failed battery.
- 4. ELECTRICAL LOAD TEST:** Electrical load testing is an effective troubleshooting technique for identifying batteries with internal defects – but is not an approved method for determining deep cycle battery capacity.

Batteries with less than 75% state of charge should be charged and rested for at least 8 hours before an electrical load test is applied to the battery. When load testing batteries, remove all battery cables, disconnecting the negative cables first. Make sure the battery terminals are clean and free of corrosion. Always connect the load tester to a lead terminal, or lead charging post for batteries with stainless steel terminals. Using a carbon pile load tester, apply a 50 to 75 ampere load for 15 seconds; remove the load. Refer to the chart above to determine the minimum passing voltage.

## PREVENTATIVE MAINTENANCE TIP:

If electrolyte is spilled onto batteries or the battery compartment, neutralize it with a solution of baking soda and water mixed in the proportion of one cup of baking soda to one gallon of water (60 ml of baking soda to one liter of water).

Use a cloth or disposable towel to clean the area. Do not allow the solution to contaminate the battery electrolyte.





# BATTERY ANALYSIS & TROUBLESHOOTING

Battery testing is most effective as a diagnostic resource when employed at scheduled intervals.

An effective testing program can also identify conditions that affect battery performance in normal as well as abusive use conditions – situations that may result in premature failure. Crown Battery utilizes several AGM battery test procedures that can be performed to verify battery serviceability. These tests do not determine the battery's actual capacity – but they can indicate a need for replacement or a more complete assessment of battery integrity.

## 1. VISUAL INSPECTION

Check battery age or length of service if available. Inspect battery for physical condition – looking for damage to the terminals, container and cover. The following points cover many of the conditions and typical errors in operation that can be observed during a visual inspection:

CONDITION	ROOT CAUSE
Fluid or Moisture Present on Battery Cover	Evidence of overcharging.
Bulging End Walls – Slight Bulge	Normal condition for batteries with large cell structures. More prevalent in high temperature conditions.
Bulging End Walls – Severe Bulge	Abnormal – indicates overcharging or a blocked valve.
Inward / Concave End Walls or Cover	Normal condition that does not compromise product integrity. The condition is affected by a combination of changing operating temperatures and internal battery gas pressures – and typically self-corrects with regular cycling / charging.
Terminal Meltdown	Evidence of a loose or incomplete cable connection to the battery terminal.

## 2. FULLY CHARGE BATTERIES

Connect the battery pack to its matched charger and fully recharge the batteries. Allow the batteries to rest / cool for at least 8 hours following termination of charge.

## 3. OPEN CIRCUIT VOLTAGE TEST

Inspect open circuit voltage of each battery in the battery pack. Review and record battery voltage conditions. Evaluate and compare battery voltages with the following State of Charge voltage points:

	100% S.O.C.	75% S.O.C.	50% S.O.C.	25% S.O.C.	0% S.O.C.
6 Volt Battery	6.42	6.27	6.12	5.97	5.82
8 Volt Battery	8.56	8.36	8.16	7.96	7.76
12 Volt Battery	12.84	12.54	12.24	11.94	11.64

# Safety.First.

## BATTERY INSPECTION PROCESS

### 1. VISUAL INSPECTION

### 2. FULLY CHARGE BATTERIES – Followed by an 8-Hour Rest Period

### 3. OPEN CIRCUIT VOLTAGE TEST

### 4. BATTERY DISCHARGE TEST

Batteries in a good or acceptable condition should be above 6.4 Volts (6 Volt Battery); 8.5 Volts (8 Volt Battery); and, 12.7 Volts (12 Volt Battery) after receiving a full charge and an 8 hour rest / cool down period.

If batteries in the pack are below 6.1 Volts (6 Volt Battery); 8.1 Volts (8 Volt Battery); and, 12.2 Volts (12 Volt Battery) after receiving a full charge – the pack has failed as a result of age, abuse or normal duty cycle demands.

Any battery within the pack that is 0.25 Volts lower than the highest battery voltage (6 Volt Battery); 0.35 Volts lower than the highest battery voltage (8 Volt Battery); 0.50 Volts lower than the highest battery voltage (12 Volt Battery) has likely failed. Repeat a pattern of Charge – Discharge – Charge – Discharge (with intermittent voltage inspections) to verify the failure condition.

## 4. DISCHARGE TEST

Qualified battery and equipment technicians can utilize approved battery discharge testing equipment to verify battery integrity. Discharge testing should be performed by applying a 25, 56 or 75 ampere load condition to a fully charged battery pack.

After commencing the discharge test, record the number of battery runtime minutes until the discharge is complete. Battery packs which deliver discharge times of at least 50% of their rated RC Minutes specification, batteries are good and acceptable for service.

Battery packs which do not deliver discharge times of at least 50% of their rated RC Minutes specification require individual battery inspections to verify battery integrity. At the termination of testing – record the end-of-discharge voltage for each battery in the pack.

*Any battery within the pack that is 0.25 Volts lower than the highest battery voltage (6 Volt Battery); 0.35 Volts lower than the highest battery voltage (8 Volt Battery); 0.50 Volts lower than the highest battery voltage (12 Volt Battery) has likely failed and should be replaced.*

# LIMITED WARRANTY



## 1. SCOPE OF LIMITED WARRANTY – FREE REPLACEMENT PERIOD:

All Crown Renewable Power FLA and AGM batteries are warranted to the original purchaser to be free from defects in material and workmanship. Any battery which demonstrates a defect in material and workmanship (discharged or sulfated batteries do not apply) within a Free Replacement Period specified by Crown Battery Manufacturing Company will be replaced or repaired at the option of Crown Battery, free of charge, except for the cost of transportation of the battery. Please reference your current Crown Renewable Power Batteries Price Group to determine the Free Replacement Period available for Crown Battery's lineup of Renewable Power battery products. The Free Replacement Period begins to run at the time of purchase. If the original receipt of purchase is not available, the Free Replacement Period will be based on Crown Battery's date code on the subject battery. There will be no Free Replacement Period for Renewable Power batteries for which the proof of purchase is more than six months after Crown Battery's date code on the subject battery. Batteries that are repaired or replaced during the Free Replacement Period will be warranted only for the remainder of the original Free Replacement Period. This limited warranty is non-transferrable.

**2. LIMITATIONS:** In all sales other than direct retail sales by the seller of batteries considered to be consumer products to individual consumers, the foregoing warranty is in lieu of all other warranties not expressly set forth herein, whether express, implied or statutory, including those of merchantability or fitness for a particular purpose. The seller's liability for breach of this warranty or for any other purpose is limited, at seller's option, to the replacement of the battery or a refund of the purchase price of the battery. In any event, the seller's maximum liability shall be limited to the refund of the price paid for the battery.

THE SELLER IS NOT RESPONSIBLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL COSTS, INCLUDING ANY EXPENSES FOR INSTALLATION, TOWING, ELECTRICAL SYSTEMS TESTS, CHARGING A BATTERY OR LOSS OF TIME. PLEASE NOTE: SOME STATES DO NOT ALLOW LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, OR EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU. THIS LIMITED WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS AND YOU MAY HAVE OTHER RIGHTS THAT VARY FROM STATE TO STATE.

**3. EXCLUSIONS:** The limited warranty does not apply to batteries that are only discharged, have broken containers, covers or damaged terminals, have battery vents that are broken or tampered with in any way, have been frozen, overcharged or sulfated, or when evidence of neglect or abuse is present. The warranty does not apply if Crown Battery's proprietary manufacturing code markings have been tampered with or destroyed, if the battery is used in applications for which it is not designed, or if it was installed or charged in reverse. The limited warranty does not apply to batteries sold more than six months after Crown Battery's date code on the subject battery. Batteries installed in renewable power applications must not be used to run auxiliary loads that are unaccounted for by the battery charging system, and such use will void the warranty.

**4. WARRANTY SERVICE:** Return the suspect battery and the original receipt of purchase to the place of purchase or to any factory authorized representative. If an authorized representative cannot be located, please contact Crown Battery's Customer Service Department via phone (+1.419.334.7181) or through email ([commercial@crownbattery.com](mailto:commercial@crownbattery.com)). An authorized factory representative will be appointed to perform warranty service.

Because Crown Battery is continually improving its products, specifications are subject to change without notice. The most current specifications are listed on the seller's website at [www.crownbattery.com](http://www.crownbattery.com). The information included on the website may amend and supersede the information in this pamphlet. Purchasers are encouraged to visit the website to view the most current specifications.



**NOTES:**

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The U.S. Environmental Protection Agency recognizes Crown Battery as a Green Power Partner and among the nation’s leading green power users. We are the only battery manufacturer to achieve this status and use enough green power to meet 100% of our electricity needs. By choosing green power, Crown Battery is helping to lead the transition to a clean energy future.



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