

The Power Behind Performance



Crown deep cycle batteries employ a low-maintenance design. They do require periodic maintenance and effective charging service to ensure dependable service life. The purpose of this service guide is to help you understand the characteristics, operation and care of the batteries in your equipment so that all of their advantages may be fully realized.



Deep Cycle Battery

Safety. First.



Battery Handling, Maintenance & Test Procedures

The chemistry and plate design of deep cycle batteries are totally different than that of automotive starting batteries. The grid metal used in the deep cycle battery plate is specifically formulated to increase the adhesion of high-density active paste material. This provides the best available running time, cycle life and charge acceptance.



Crown Battery's heavy-duty plate design also protects against the stress of challenging Electric Vehicle (EV), motive power and RE (RE) applications – which includes vibration, heat and overcharge.



Inspection & Handling

1. Do not allow batteries in your equipment to tip or operate at a severe angle in any direction. This would allow the battery electrolyte to push through the battery vent assembly.
2. Charge the batteries in your equipment in a well-ventilated area.
3. Upon receipt of your equipment, examine the batteries for signs of wetness or impact (which may indicate damage in shipment or that the batteries were tipped beyond a 45° angle during transit).
4. If there is evidence of damage – notify Crown Battery or the OEM supplier to make a damage report.
5. Charge the batteries before placing the batteries in service. Simply connect the battery charger to your machine's charging port and allow it to run until it automatically shuts off.

Operating Guidelines

Deep cycle batteries supply all the power used in EV, motive power or RE system applications. One full cycle represents a full battery recharge followed by a complete battery discharge (as specified by the OEM). Battery life is usually measured in cycles – but in practical terms, your batteries should work well for three years from the beginning date of service.

However, battery maintenance and charging procedures will either prolong or shorten battery life, depending upon how well recommended practices are followed.



Other Factors That Affect Battery Life and Performance:

- ▶ Batteries are rated in ampere-hours (Ah) and are designed to perform a specific workload within an established period of time. Increasing either and/or both of these will over-discharge the batteries and result in shortened life.
- ▶ Limit discharging the batteries beyond 1.75 volts per cell – or 1.125 specific gravity per cell. 1.75 volts per cell corresponds to end-point voltages of 5.25 volts for 6-volt batteries, 7 volts for 8-volt batteries and 10.5 volts for 12-volt batteries.
- ▶ Batteries should always be recharged immediately following a complete discharge period. Never allow batteries to remain in a fully discharged condition, otherwise permanent damage will result.
- ▶ If daily or routine equipment operation results in only partial discharges (40% or less) and specific gravities are 1.225 or higher, recharging may be deferred to the next day, providing the workload is not expected to increase. Generally, user experience will determine the frequency of charging service under these circumstances.
- ▶ Under normal circumstance the temperature of the battery electrolyte must not exceed 110° F (43°C). If the battery is continuously operated at or above this point the service life of the battery will be severely diminished. Under normal conditions, battery electrolyte condition should range from 60° to 100° F (15° to 38°C). After charging, the battery should be allowed to cool-down or rest from 6 to 8 hours before the next discharge cycle begins.
- ▶ If a battery is ever hot to the touch, allow it to cool to ambient temperature before charging or discharging.
- ▶ Keep battery connectors and cabling in good condition. When disconnecting the battery connector from the equipment, pull on the connector – not the cable. Damage to the connectors and/or cables will result in poor battery performance.

Renewable Energy Charging Systems

To maximize performance and life batteries should be recharged fully after each discharge period. To verify full recharging, regularly monitor individual battery voltage and specific gravity. As a general rule, the total input amperes from your RE charging source should be between 10% and 20% of the total ampere-hours (20 Hour Rating) of the battery system capacity. Many RE charge controllers have adjustable equalization settings that ensure batteries are regularly restored to full capacity. Batteries used in RE systems should be equalized every thirty days at a minimum – with

more frequent equalization occurring for battery systems routinely discharged below 50% of their rated capacity. Please refer to the following chart for additional charge control setting information:

	System Voltage				
Voltage Setting	6 V	12 V	24 V	36 V	48 V
Daily Charge (Absorption)	7.3	14.5	29.0	43.6	58.1
Equalize	7.7	15.5	31.0	46.4	61.9
Float	6.8	13.5	27.0	40.5	54.0

Contact Crown Battery's technical support department for additional charging application information.

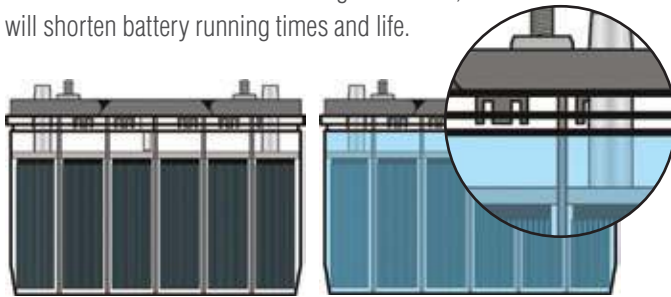
Watering Service

Deep cycle batteries begin service consuming relatively low amounts of water. In electric vehicle, motive power or RE service, the real need to add water to batteries may vary from weekly service to monthly service depending upon the operating environment and other external factors. As batteries age they will use more water, and in warmer climates batteries will require more frequent service. Equipment owners and users must be vigilant in performing regular watering service to ensure premium performance and life.

There are two conditions when watering can be harmful to your batteries:

- ✔ Over-Watering
- ✔ Under-Watering

Over-Watering dilutes the sulfuric acid levels inside the battery – which results in poor battery performance. Under-Watering batteries leads to a service-related overcharge condition, which will shorten battery running times and life.



You can prevent watering-service related problems by using the illustration shown above as a reference point. Maintain battery liquid levels above the top of the battery plates – but no higher than the battery cover vent well. Never fill batteries to the brim of the cell or to a point where they overflow.

Several other rules apply when watering:

- ▶ USE ONLY DISTILLED or DE-MINERALIZED WATER.
- ▶ Never add battery acid, commercial additives or other foreign material to the batteries.
- ▶ Watering service should occur only after charging service is completed. Watering before charging service will result in overflow of the battery's electrolyte – causing a dangerous chemical spill condition and loss of battery capacity.

- ▶ Never charge batteries if the battery plates are found to be uncovered/ un-submerged in electrolyte. If this condition is detected before charging service, fill the battery only until the top of the battery plates are covered with liquid.



Many Crown deep cycle batteries feature the PROeye indicator that shows users when watering service is required. When the color of the eye is:

- ✔ Green = No water service is required
- ✔ Clear or White = Watering service is required

The PROeye is an indicator only – and is designed to aid users with determining when individual cell inspection and/or watering service is required. Because watering service is most effective at the completion of charging service – the PROeye should be inspected at the completion of charge or before the start of duty cycle. Contact Crown Battery's technical department for more information regarding this product feature.

SAFETY PRECAUTIONS:

- CAUTION:** All lead-acid batteries generate highly flammable hydrogen gas. If ignited, the gas may explode violently. When working near batteries, always wear safety glasses, do not smoke or use open flame near the batteries, remove watches and jewelry, and avoid causing sparks with tools.
- Battery electrolyte is corrosive and can cause blindness or severe burns. If exposed to battery electrolyte, immediately flush with water and seek medical attention.
- The batteries in your equipment are electrically live at all times. Keep the top of the batteries clean and dry to prevent ground shorts and corrosion.
- Do not tip a battery beyond a 45° angle in any direction. This would allow battery electrolyte to push through the battery vent assembly.

Preventative Maintenance

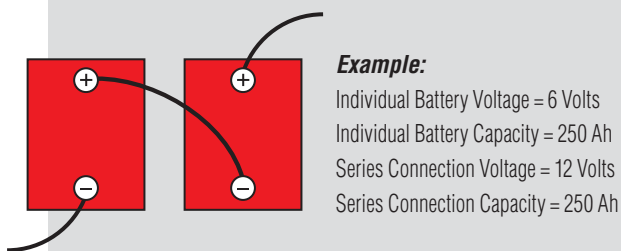
- ▶ Battery covers and terminals should be kept clean, dry and free of corrosion. Battery vent caps must be secured to the batteries during use and charging period. Remove vent caps only to inspect electrolyte levels or specific gravities.
- ▶ When batteries or terminals require cleaning, use only biodegradable cleaner-neutralizer solutions that can be safely applied and disposed of through a common sanitary sewer. Other chemical-based solutions are often dangerous, ineffective and cannot be disposed of in an environmentally safe manner.
- ▶ If electrolyte is spilled onto batteries or the battery compartment area, neutralize it with a cloth moistened with a solution of baking soda and water mixed in the proportion of one pound of baking soda to one gallon of water. When the electrolyte is neutralized, wipe the affected area with a water-moistened cloth to remove all traces of soda.
- ▶ Inspect cable-to-terminal connections to ensure connections are tight and free of corrosion. Battery cables must be intact with no exposed wires.
- ▶ Preventative maintenance practices should include periodic inspection of battery specific gravity and open circuit voltage. An imbalance of specific gravity and open circuit voltage is usually a sign of improper charging, service infrequency, or a bad cell condition.

Connecting Multiple Batteries

Crown deep cycle batteries are available in various BCI group sizes, voltages and electrical capacities. Certain systems require the installation and connection of multiple batteries to accommodate minimum voltage or capacity specifications to ensure expected performance. Users and technicians should always confirm that batteries are oriented in proper position according to battery terminal polarity – as indicated by the raised polarity mark on the battery cover. Cables and connectors should be secured with the appropriate terminal hardware and tightened to the torque values specified by Crown Battery.

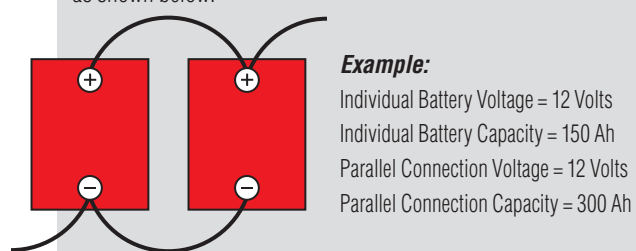
Series Connection:

To increase voltage, connect batteries in “series” as shown:



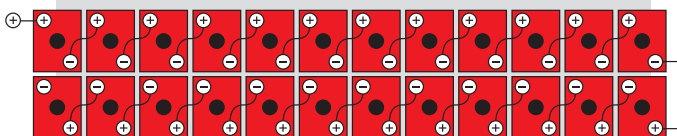
Parallel Connection:

To increase electrical capacity, connect the batteries in “parallel” as shown below:



Series Connection:

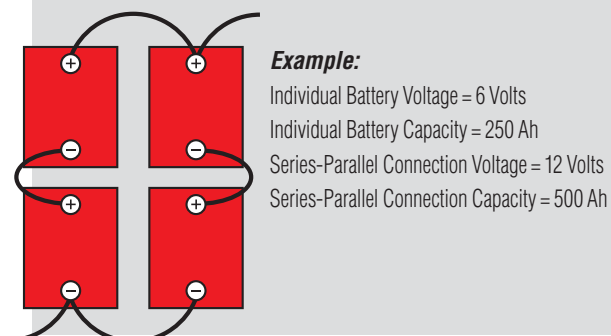
Single String Series Connection of twenty-four 2 Volt batteries



Example:
Individual Battery Voltage = 2 Volts
Individual Battery Capacity = 3690 Ah
Series Connection Voltage = 48 Volts
Series Connection Capacity = 3690 Ah

Series-Parallel Connection:

To increase both voltage and electrical capacity, connect the batteries in a “series-parallel connection” as shown below:



Charging Guidelines – EV or Motive Power Service

Original equipment systems usually include an automatic charging system for battery charging. To maximize battery life and performance, batteries should be charged as outlined in the operating instructions included with the charging equipment. In the event of a charging-related battery performance problem, consult the OEM or Crown Battery service department to seek technical support. Extra care spent in proper charging will ensure battery performance.

Battery charging equipment varies in terms of output and overall charging performance. For new or replacement chargers used in EV or motive power service, Crown Battery recommends electronically controlled automatic chargers that are programmed to deliver a high constant current rate of 12 to 18 amperes per 100 ampere-hours (20 Hour Rating) of battery capacity. The constant voltage phase begins after the gassing point is achieved (2.37 volts per cell). This stage of charge will last approximately 5 hours for a fully discharged battery. During the constant voltage phase the charger voltage is limited to the

gassing level (2.37 volts per cell), and the input current is allowed to gradually diminish. When the input current falls to the finish rate setting of 3 to 4 amperes per 100 ampere-hours (20 Hour Rating) of battery capacity, the charge phase will change from constant voltage to constant current at 3 to 4 amperes per 100 ampere-hours (20 Hour Rating) of battery capacity – with a maximum charging voltage of 2.65 volts per cell. The charge will be terminated approximately 3.5 hours from the gassing point by an approved charge termination method such as DV/DT. Please note that fixed ferro-resonant chargers using this profile must have finish voltages set at 2.58 volts per cell or higher.

Batteries should always be recharged immediately following a complete discharge period. A weekly equalization charge – with the finish rate charge time extended 3 hours for a total of 6 hours from the gassing point – will ensure reliable discharge time and battery life. The charge factor of the standard recharge cycle should be equal to or greater than 1.08 (108%), while the charge factor of the equalization cycle should be equal to or greater than 1.15 (115%). To ensure optimum battery performance, total recharge time should in all cases be limited to 10 hours.

Power off the charger before connection to the battery to avoid sparking. To avoid battery explosion, never charge a frozen battery – warming the battery to room temperature before charging service begins. Charging service should be terminated if batteries become excessively hot or if violent gassing or discharge of electrolyte occurs during charge.

Troubleshooting

When properly maintained and charged, Crown deep cycle batteries will provide many years of trouble-free service. However, failure to follow the operating and maintenance guidelines listed above may result in poor performance or premature failure. The following addresses some of the typical errors in operation and maintenance:

Condition	Check For
Poor Battery Performance	Undercharged Battery
	Sulfated Battery
	Cold Operating Environment <i>(Less than 32°F / 0°C Temperature Reduces Usable Battery Capacity)</i>
	Defective Connectors or Cables
	Low Electrolyte
	Old Batteries
Unequal/Low Specific Gravities	Defective Charge-Level Gauge
	Over-filling
Excessive Water Service	Undercharging
	Overcharging
	Container Leak
Odor During Charging	Old Batteries
	Low Electrolyte
	Overcharging
High Temperature	Overcharging
	Battery Overworked
	Opportunity Charging



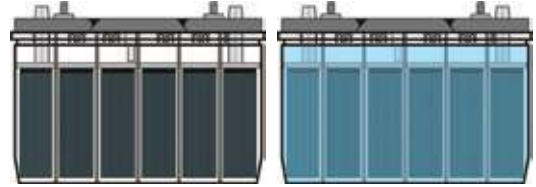
Troubleshooting

A common procedure for troubleshooting battery performance involves a three-point procedure:



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 the top of the fluid level indicator:

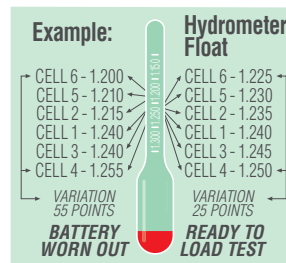
If the battery is sufficiently filled with electrolyte - proceed to step 2. If the top of the battery's plates are not covered with liquid, add water, replace vent caps and place the battery on charge. Be sure no open flame or spark is near while the battery's vent caps are removed from the battery.



2. Specific Gravity Inspection: Hydrometer reading of 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, but some cells read less than 1.225: recharge the battery.

Replace the vent caps during recharge. Charge the battery using a properly matched automatic charger until all cells measure a specific gravity of 1.265 to 1.275. If charging won't bring up specific gravity, replace the battery.



State of Charge Level	Specific Gravity
100%	1.265 or Greater
75%	1.225 - 1.230
50%	1.185 - 1.190
25%	1.140 - 1.175
Discharged	1.125 or Less

3. Open Circuit Voltage and Electrical Load Test: Battery open circuit voltage is an effective indication of battery state of charge. Determine the approximate state of charge from the following chart:

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% - 100%	12.30 - 12.60	8.21 - 8.40	6.16 - 6.30
50% - 75%	12.10 - 12.30	8.00 - 8.21	6.00 - 6.16
25% - 50%	11.90 - 12.10	7.87 - 8.00	5.90 - 6.00
0 - 25%	11.60 - 11.90	7.73 - 7.87	5.80 - 5.90
0%	11.60 or Less	7.73 or Less	5.80 or Less

Chart Assumes a Fully Charged Gravity of 1.265.

State of Charge	Battery Voltage Under 15 Second Load			
	12 Volt	8 Volt	6 Volt	Specific Gravity
100%	12.60	8.40	6.30	1.270
75%	12.00	7.87	5.90	1.225

*If the test voltage is above the minimum, return the battery to service.
If test voltage is below the minimum, replace the battery.*

Electrical load testing is an effective troubleshooting technique for identifying batteries with internal defects - but it is not an approved method for measuring deep cycle battery capacity. For this reason Crown Battery recognizes load test results as useful only for identifying batteries having bad cell conditions.

Batteries with less than 75% state of charge should be charged 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 free of corrosion and dirt.

For batteries having stainless threaded stud terminals, attach a lead charging post to the threaded stud terminal before testing. Using a carbon pile load tester, apply a 50 to 75 ampere load for 15 seconds; remove the load. Refer to the chart at the left to determine the minimum passing voltage.

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Crown Battery Manufacturing Co.

1445 Majestic Drive | P.O. Box 990
Fremont, OH 43420-0990
419.334.7181 | Fax 419.334.7124
commercial@crownbattery.com
www.crownbattery.com

Made in the USA