

CROWN

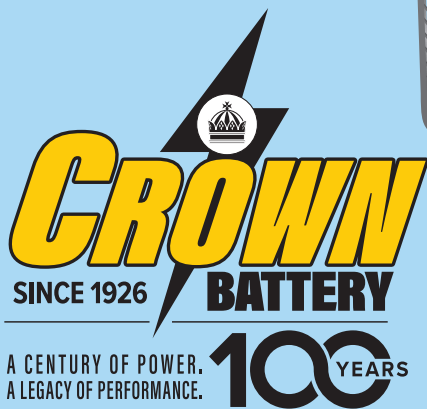
THE POWER OF 1

Safety is Your Responsibility

CROWN AGM batteries are sealed, clean and high performance energy storage products. The valve-regulated design of AGM batteries suspends electrolyte within the construction of the cell to minimize the potential for exposure to corrosive materials during normal use. However – AGM batteries are not free of hazard. Customers need to be familiar with the risks connected with commissioning, operation and disposal of these batteries.

When working with batteries you need to wear proper protective gear such as safety glasses, protective footwear and gloves to prevent electrical shocks and ensure fall protection. Remove watches and jewelry and avoid causing sparks with tools. When possible, use tools with insulated or rubber coated handles when securing batteries or cabling in the application.

Do not tamper or attempt to remove vents, and keep sparks, flames and cigarettes away from batteries at all times. Maintain good ventilation when working on or charging batteries.



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Safety First.



Battery Handling, Maintenance & Test Procedures

CROWN AGM batteries are sealed and valve-regulated and do not require watering service. They can be oriented in a traditional upright position or placed on their side where fitment is an issue. These batteries are constructed with heavy duty plates, high-performance absorbent glass mat separators, massive top lead connections and premium self-sealing valves that enable recombinant performance – which retains moisture within the battery during normal operation.

Because the batteries rely on a sealed design, the valves should never be opened. Doing so damages the product and voids the warranty.



Crown Battery innovates to find solutions and the benefits delivered by **CROWN** AGM batteries include powerful reliability and a solid return on investment.

While free of watering service requirements, the batteries do require periodic inspection and effective charging service and the purpose of this guide is to help you understand the characteristics, operation and care of these batteries so that all of their advantages may be fully realized.

INSPECTION & HANDLING

- 1 Upon receipt of your batteries or new equipment fitted with batteries, examine the batteries for signs of moisture or impact (which may indicate damage in shipment).
- 2 If there is evidence of damage – notify Crown Battery or the equipment supplier to make a damage report.
- 3 Charge the batteries before deploying the products to service. Charge the batteries in a well-ventilated area using the battery charger that is matched to the battery application.
- 4 AGM batteries can be stored safely for up to a year before requiring inventory maintenance. With a self-discharge rate of 2 to 3% per month and sealed design, the product can be stored in ambient temperatures below 80°F / 27°C with full retention of product integrity. Take precautions to ensure batteries are fully charged prior to storage, are kept clean and dry – and are protected from impact and free of any connections that may cause parasitic loads.
- 5 **CROWN**® AGM batteries are certified non-spillable batteries and are not restricted for transportation by Air (IATA / ICAO), Surface (DOT) and Water (IMDG).
- 6 AGM batteries can be recycled and should be returned to an authorized battery disposal agent for recycling. Refer to www.batterycouncil.org for more information about battery recycling.

MAXIMIZING YOUR INVESTMENT

AGM batteries deliver all of the power required by EV, motive power or Renewable Energy systems. One full cycle represents a full battery recharge followed by a complete battery discharge period.

Battery life is usually measured in cycles or in terms of ampere-hour throughput delivered to the application – but in practical terms your batteries will deliver reliable performance and a strong R.O.I. when maintained with proper charging and attention to the best practices identified in this document.

GENERAL AGM BATTERY CARE & PREVENTATIVE MAINTENANCE

Keep batteries and terminal connections clean, dry and free of dirt and corrosion. Check battery connections and cables. Re-torque connections and replace any torn or damaged cabling or connectors. Avoid thermal shock to batteries by never spraying batteries with pressurized water from a hose or pressure jet. Charge batteries after the completion of work or duty cycle – never leaving batteries in a discharged state.

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.

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.



OTHER FACTORS THAT AFFECT BATTERY LIFE & PERFORMANCE:

- ▶ Batteries are rated in ampere-hours (Ah) and are designed to perform a specific workload within an established period of time. Increasing battery depth-of-discharge has a direct effect on cycle and life performance – with frequent deep discharge resulting in shortened battery life.
- ▶ Optimize the battery life by limiting duty cycle depth-of-discharge to 75% or less of available discharge. A 75% depth-of-discharge corresponds to end-point voltages of 1.84 Volts per Cell – or 5.52 Volts for 6-volt batteries, 7.36 Volts for 8-volt batteries and 11.04 Volts for 12-volt batteries.
- ▶ Batteries should always be recharged immediately following the completion of a duty cycle discharge. Never allow batteries to remain in a fully discharged period, otherwise permanent damage will result.
- ▶ Opportunity charging service can be performed when batteries are no more than 50% discharged. Batteries must be fully recharged after the termination of duty cycle usage.
- ▶ **CROWN** AGM batteries can operate within a maximum temperature limit of -40°F to 120°F (-40°C to 49°C) with proper temperature compensation controls.

Application Note: Maintain a state of charge greater than 60% when operating batteries at temperatures below 32°F (0°C).
- ▶ After regular charging service, batteries should be allowed to cool-down or rest for 6 to 8 hours before the next duty cycle. If a battery is ever hot to the touch, allow it to cool to ambient temperature before discharge or charging service.
- ▶ Keep battery connectors and cabling in good condition. Replace damaged or torn cabling or connectors as damage to these components will result in hazardous operation and poor performance.

INSTALLATION BEST PRACTICES

ORIENTATION & INSTALLATION IN THE APPLICATION

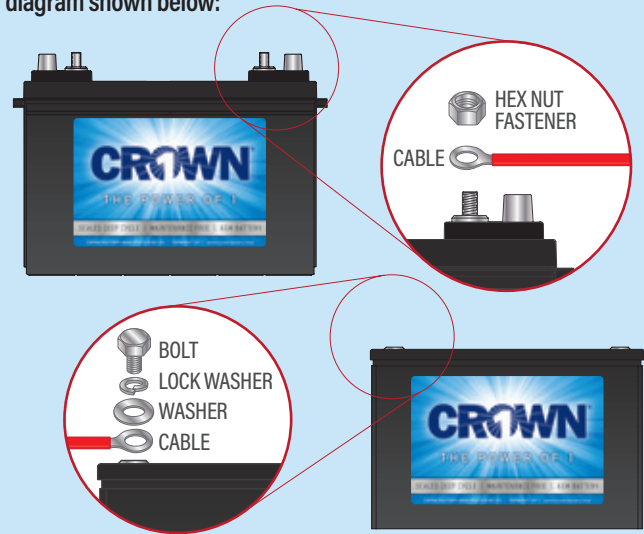
For all applications, follow the machine manufacturer or system designer recommendations for installation and orientation of replacement batteries. The most effective placement of batteries is usually upright; if necessary — AGM batteries can be oriented on their side or end walls if required. Never install batteries in an inverted position; always provide adequate ventilation to allow battery gassing in a potential overcharge condition. Never install lead batteries in a sealed battery box or compartment.

TERMINAL CONNECTIONS

Battery terminal connections should be secured and tight at all times. Replace torn or damaged cabling or connectors upon discovery of damage. Terminal connections must be tightened using the specified torque values below:

TERMINAL TYPE	In-lbs	Nm
Inserted M6	100 - 120	11 - 14
SAE / Automotive Terminal	50 - 70	6 - 8
Stainless Threaded Terminal	100 - 120	11 - 14

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



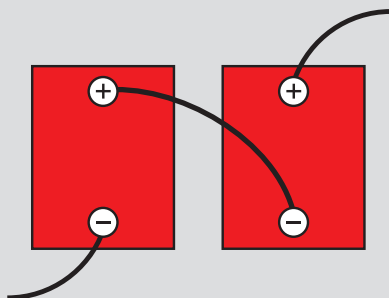
The battery terminal surface should be clean and dry prior to installation and torquing of the connectors to the terminals. Never place a washer or terminal treatment material between the battery terminal surface and the connector surface as this will increase electrical resistance — which affects battery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

CONNECTING MULTIPLE BATTERIES

CROWN® AGM batteries are available in various BCI group sizes, voltage 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 polarity mark on the battery cover. Cables and connectors should be secured following the torque values specified above.

Series Connection:

To increase voltage, connect batteries in "series" as shown:

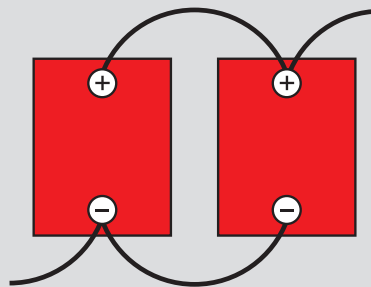


Example:

Individual Battery Voltage = 6 Volts
 Individual Battery Capacity = 390 Ah
 Series Connection Voltage = 12 Volts
 Series Connection Capacity = 390 Ah

Parallel Connection:

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

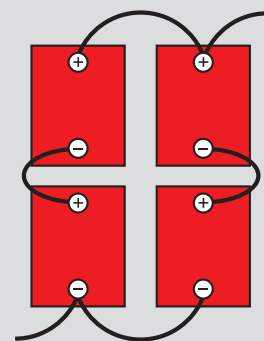


Example:

Individual Battery Voltage = 12 Volts
 Individual Battery Capacity = 150 Ah
 Parallel Connection Voltage = 12 Volts
 Parallel Connection Capacity = 300 Ah

Series-Parallel Connection:

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



Example:

Individual Battery Voltage = 6 Volts
 Individual Battery Capacity = 390 Ah
 Series-Parallel Connection Voltage = 12 Volts
 Series-Parallel Connection Capacity = 780 Ah

CHARGING, MAINTENANCE & OPERATION BEST PRACTICES

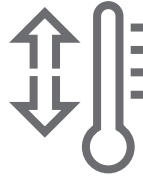
GENERAL USE BEST PRACTICES:



Charging Service Before Use

New AGM battery inventory should not require charging service prior to installation. Check the battery voltage and manufacturer date code to verify battery conditions before deploying the products. After installation has been completed (but before first use), connect the batteries to the charger supplied with the application or system and allow the batteries to charge overnight or until the charging source powers off automatically.

For information on AGM batteries used in renewable energy storage applications, refer to "Renewable Energy Battery Charging" on pages 5-6.



Effect of Ambient Temperature on Battery Performance & Life

Battery capacities and projected life are based upon operating temperatures of 80°F / 27°C. Temperature increases of 15°F / 10°C over the baseline will cause the rate of internal chemical reactions to double – something that will reduce battery life due to accelerated deterioration of internal components. Corresponding reductions in operating temperatures will create a reverse effect — extending life — however with a reduced efficiency as temperatures decrease.

Contact Crown Battery to discuss any minimal requirements for battery life and performance.



Charging Service

Effective charging service delivers optimal life and a strong return on investment for AGM battery users. Use charging equipment that has been configured for application with AGM batteries; do not use chargers that are configured for GEL battery service as they will undercharge batteries and cause premature failure. Certain Flooded Lead Battery chargers are properly configured to recharge AGM batteries.

If you require support with verifying your charger's capabilities, contact Crown Battery via email at commercial@crownbattery.com (providing the make and model of the charger).

WHEN TO CHARGE?

Batteries should be fully recharged after each discharge event. To optimize battery life, charge batteries after they have been discharged for 25% of their specified running time (example — charging batteries with an application specification of 2 hours running time after 30 minutes of use). When charging batteries following the completion of a duty cycle — connect the charger to the battery pack and allow the equipment to operate until charging is terminated and the charger automatically powers off.

"Opportunity Charging" is a concept that recharges batteries at every opportune time possible (operator breaks, scheduled machine downtime, etc). Opportunity charging service can be performed when batteries are no more than 50% discharged. Batteries must be fully recharged after the completion of work or duty cycle.

CYCLIC CHARGING CONSTANT VOLTAGE CHARGING

MODE	6 VOLT	8 VOLT	12 VOLT
Cycle Charge:	7.20 – 7.41	9.60 – 9.88	14.40 – 14.82
Float Charge:	6.60	8.80	13.20
Recommended Current:	10% of C/20 Rating		
Maximum Current:	25% of C/20 Rating		
Temperature Correction:	1.6 mV (F°)	3.0 mV (C°)	

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
Bulk	2.44	14.64	29.28	58.56
Absorption	2.42	14.52	29.04	58.08
Float	2.20	13.20	26.40	52.80
Conditioning*	2.42	14.52	29.04	58.08

*See information on conditioning charge service at right

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
Conditioning*	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

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.
Severe Concave Cover or End Walls	Evidence of severe over-discharge and chronic undercharge.
Minor Concave Cover or End Walls	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 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 Battery Price Schedule to determine the Free Replacement Period available for Crown Battery's lineup of AGM 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 AGM batteries for which the proof of purchase is more than six months after Crown Battery's date code on the subject battery. AGM 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, undercharge 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 electric vehicle or motive powered equipment 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 within 30 days of battery failure. If an authorized representative cannot be located, contact Crown Battery's Customer Service Department via phone (+1.419.334.7181) or email (commercial@crownbattery.com). An authorized factory representative will be appointed to perform warranty service.

BATTERY REPLACEMENT BEST PRACTICE

Where possible — avoid mixing new batteries in applications with older batteries. New batteries should be replaced in whole packs to ensure the best success for equipment owners and operators.

Contact Crown Battery via email at commercial@crownbattery.com for additional instructions.



A CENTURY OF POWER. A LEGACY OF PERFORMANCE.

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