Fullriver Battery
Installation and Operation Manual

>> Your Clean-Green Energy Solution

fullriverdcbattery.com

Congratulations on your purchase of Fullriver batteries. Please be sure to read this manual thoroughly to achieve maximum performance from your batteries.

*Look for the battery **TIPS** and **MYTH BUSTERS** that are found throughout this manual.*

Table of Contents

1. Getting Started

Before installing your batteries, please adhere to the following safety guidelines and make sure that you have the proper equipment for installation, operation and diagnostic testing.

1.1 Safety

PROTECT YOURSELF AND PROTECT YOUR BATTERIES

- Wear protective gear, including gloves, when handling batteries
- Install and remove batteries using the lifting handles provided
- Use a wrench with a rubber coated handle for installing, tightening or removing battery connections
- Do not place any objects on top of batteries
- Do not smoke near batteries
- Keep flames, sparks and metal objects away from batteries
- Charge batteries in a ventilated area - although AGM batteries do not typically release gas, the safety valve may open to alleviate excessive pressure within the battery if the battery is over-charged

ALWAYS USE CAUTION AROUND BATTERIES

1.2 Equipment Check List

- ☑ Gloves
- ☑ Wrench with Insulated / Rubber coated handle
- ☑ Voltmeter
- ☑ Charger
- ☑ Discharger (if available)

2. Battery Installation

Proper battery installation is the first step in getting the best performance out of your batteries.

2.1 Selecting the Appropriate Cable Size

Cables must be sized to carry the maximum expected load. Under-sized cables can result in over-heating, melted connections and are a potential fire hazard.

Refer to **Table 1** for the current carrying capacity by cable size. These values are for cable lengths of 6 feet (1.83 m) or less. It is preferable that all cables in a series connection are the same length and all cables in a parallel connection are the same length.

Cable Gauge (AWG)	Ampacity (Amps)
14	25
12	30
10	40
8	55
6	75
4	95
2	130
1	150
1/0	170
2/0	265
3/0	360

Table 1

TIP: To significantly reduce the amount of heat generated at the terminals, use cables with solder-dipped ends.

2.2 Terminal Connections

Terminal connections must be tightened using the correct torque values as defined in **Table 2.** Over- or under-tightened connections can result in terminal breakage, over-heating and/or meltdown. Using the proper torque value will provide optimum conductivity. Use a wrench with an insulated or rubber coated handle when making terminal connections to avoid a short circuit. See **Diagram 1** for proper washer placement.

Terminal Type	lbs-in	Nm
M6	50-70	5.6-7.9
M8	85-95	9.6-10.7
M6M - Stud	50-70	5.6-7.9
M10M - Stud	110-125	12.4-14.1
FR45	70-90	7.9-10.2
TP07-AP	50-70	5.6-7.9
TP08-AP	50-70	5.6-7.9
AP	50-70	5.6-7.9
DT		
AP	50-70	5.6-7.9
STUD	110-125	12.4-14.1

Note: For values in lbs-ft, divide lbs-in by 12.

Table 2

TIP: Never place a washer between the mating surfaces of the terminals and cables; this will compromise electrical transmission and increase resistance, resulting in extreme heat generation and probable terminal melting.

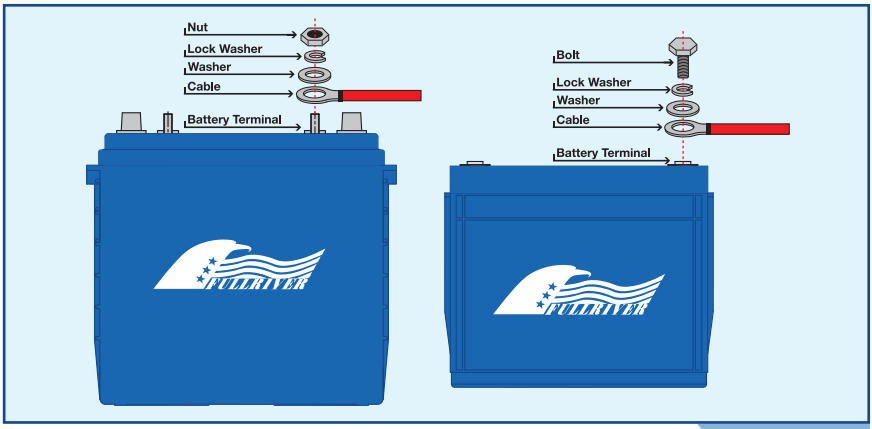


Diagram 1

2.3 Battery Orientation

The ideal placement of batteries is upright. AGM batteries can be placed on their side if necessary. It is preferred that all the batteries within a pack be placed in the same orientation.

TIP: Never place batteries in an inverted orientation.

2.4 Series Connections

There is more than one option to meet your voltage requirements. For example, for a 12 Volt system you may use one 12 Volt battery or two 6 Volt batteries wired in a series to make up the 12 Volts. You may use as many batteries as you need to make up the system voltage. Connect the positive of one battery to the negative of the next through the entire string. See **Diagram 2** for the proper series connection.

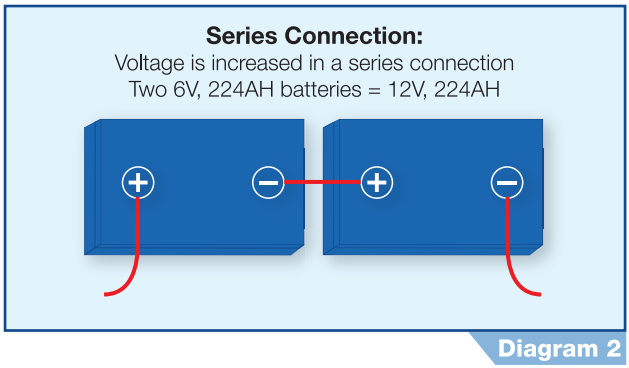
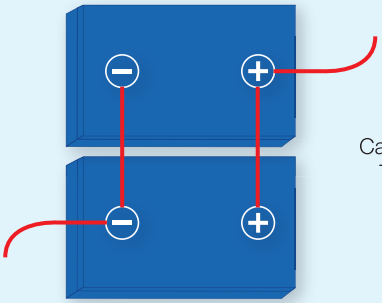


Diagram 2

2.5 Parallel Connections

There is more than one option to meet your energy requirements. For example, to meet the requirements for a 210 Amp-Hour system you may use one 210 Amp-Hour battery or two 105 Amp-Hour batteries wired in parallel to make up the 210 Amp Hours. Connect all the positive terminals together and all the negative terminals together in the string. See **Diagram 3** for proper parallel connection.

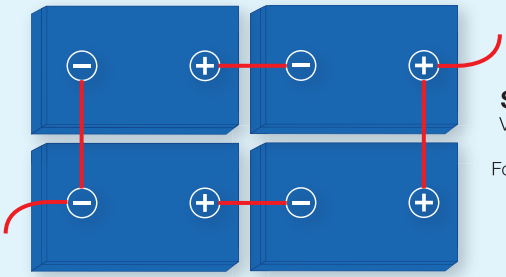


Parallel Connection:
Capacity is increased in a parallel connection
Two 12V, 105AH batteries = 12V, 210AH

Diagram 3

2.6 Series/Parallel Connections

Batteries can be connected in both series and parallel to attain the desired system voltage and energy requirements. See **Diagram 4** below for proper series/parallel connections.



Series/Parallel Connection:
Voltage and capacity are increased in a series/parallel connection
Four 12V, 115AH batteries = 24V, 230AH

Diagram 4

TIP: For optimum performance, the systems positive and negative leads should be connected diagonally opposite (catty-corner) from each other as shown in Diagram 4.

2.7 Cross Tying Batteries in Parallel Packs

In order to maintain balance in parallel battery packs it is best to cross tie the batteries. This method of connection will maximize the performance and life of your battery system. Cross-tying batteries means connecting positives to positives and negatives to negatives of each adjacent battery in the set. See **Diagram 5** for proper cross tying connections. The dotted lines represent the cross tied cables.

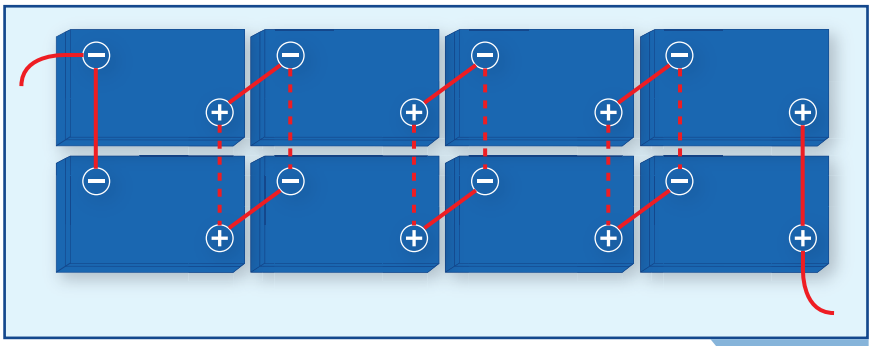


Diagram 5

TIP: Leave some space between batteries for airflow and minor battery expansion.

2.8 Charging Batteries before Use

New AGM batteries that have only been stored for up to 6 months will not need to be charged prior to being put into service.

If new AGM batteries have been stored for more than 6 months and/or in an exceptionally hot environment a charge may be necessary prior to being put into service.

Check the open circuit voltage (OCV) of each battery in the set and if any battery within the set is less than the values in **Table 3**, recharge the battery set.

Battery Nominal Voltage	Open Circuit Voltage (OCV)
6V	< 6.2V
8V	< 8.3V
12V	< 12.5V

Table 3

If the charger has a maintenance mode select that mode to boost charge the batteries. Otherwise run the normal charge cycle.

TIP: If the batteries are not charged prior to being put into service, you may experience a slight reduction in range on the first cycle.

3. Battery Operation

The performance and life of a battery will vary with application, usage, temperature and depth of discharge. AGM batteries tend to deliver higher than their rated capacity (up to 10-15% higher) for ~30 cycles until they are “broken in” and settle at their rated capacity.

3.1 Temperature effects on Battery Performance and Life

Operating batteries above 80°F (27°C) will yield runtimes above the rated capacity and operating batteries below 80°F (27°C) will yield runtimes below the rated capacity. Cold temperatures can significantly reduce battery capacity. See **Chart 1.**

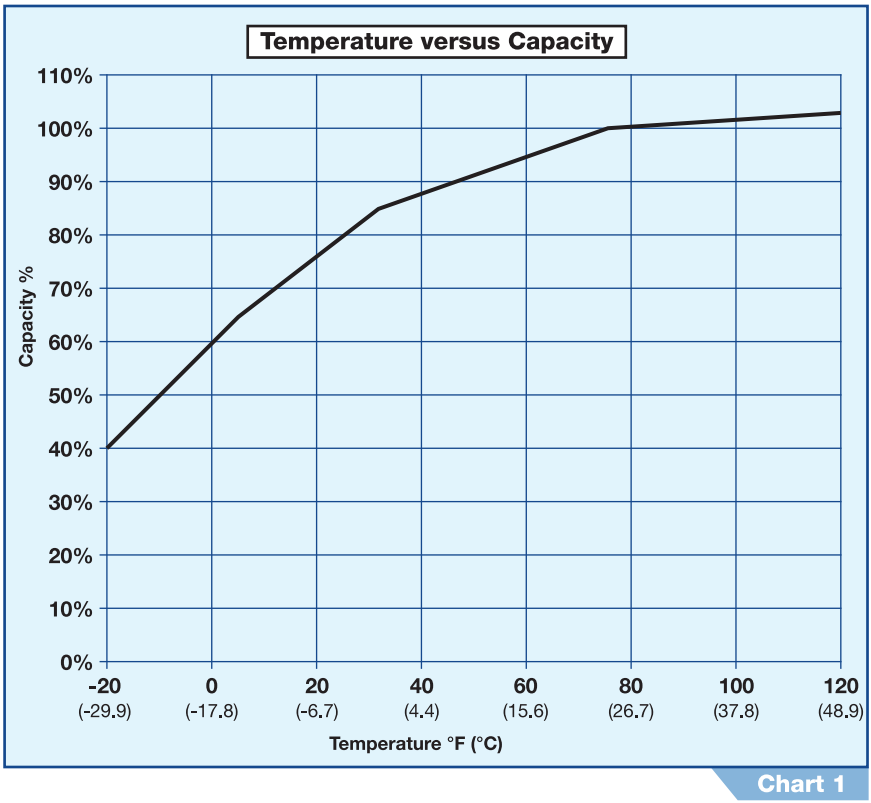


Chart 1

Although higher temperatures increase the battery capacity they also accelerate corrosion and reduce overall battery life. For example, batteries operating continuously at 100°F (37.8°C) could experience as much as 25% reduction in life.

3.2 Operating Temperature Range

Recommended	Maximum
5°F to 104°F (-15°C to 40°C)	-40°F to 160°F (-40°C to 71°C)

Table 4

3.3 Depth of Discharge versus Battery Life

Battery cycle life will vary significantly depending on the depth of discharge. The deeper the depth of discharge the fewer cycles a battery will deliver. Conversely, the shallower the depth of discharge the more cycles a battery will deliver. See **Chart 2.**

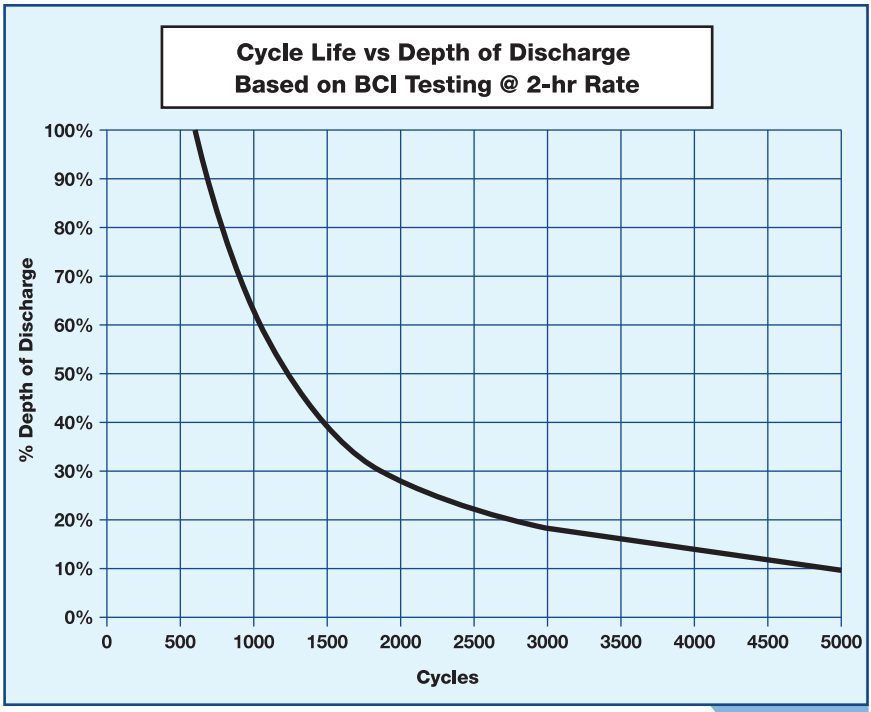


Chart 2

TIP: To optimize the health of your battery, limit discharge to 80%.

4. Battery Charging

Using the proper charger is critical to the performance and life of your battery. If you are not sure if you have the right charger for AGM batteries call technical support at 800-522-8191 or email technical@fullriverdcbattery.com for verification.

4.1 Charger Inspection

1. The charger cable should be insulated and free of breaks or cuts.

2. The cable connectors should be clean and properly mated with the battery terminals to ensure a snug connection.

3. The charger's AC cord should be free of breaks or cuts and the wall plug should be clean.

4.2 Charging your Batteries

1. Use an AGM charger or setting when available.

2. Never use a Gel charger or setting on an AGM battery, as it will undercharge the battery and significantly reduce battery capacity and life.

3. Many, but not all, wet battery chargers will work for AGM. Call technical support at 800-522-8191 or email technical@fullriverdcbattery.com to verify your charger. Be prepared to provide the make and model of your charger.

4. Batteries should be fully charged after each use. Opportunity charging can be done but the batteries should be fully charged at least every other day if they are used daily.

5. Charge in a ventilated area as gasses may be released through the pressure relief valve if the batteries are excessively over-charged.

6. If the charger does not have temperature compensation, avoid charging at temperatures above 122°F (50°C).

4.3 Charging Temperature Range

Temperature Compensation	Recommended	Maximum
Yes	5°F to 122°F (-15°C to 50°C)	-40°F to 160°F (-40°C to 71°C)
No	32°F to 104°F (0°C to 40°C)	5°F to 122°F (-15°C to 50°C)

Table 5

4.4 Charging Parameters

Most chargers come pre-set from the factory. If your charger is pre-programmed use the information below to check if the settings are compatible with AGM batteries. If you have a programmable charger or inverter, use the following information for settings.

4.4.1 Current

The recommended bulk current is 20% of the 20 Hr. AH capacity or 0.20 x C20 (20 Hr Capacity in AH).

Example: DC115-12 is rated at 115 AH @ 20Hrs. recommended bulk current is 0.20 x 115 = 23 Amps

The maximum allowable bulk current is 35% of the 20 Hr. AH capacity or 0.35 x C20 (20 Hr Capacity in AH), unless otherwise stated.

Example: DC115-12 is rated at 115 AH @ 20Hrs. maximum bulk current is 0.35 x 115 = 40 Amps

4.4.2. Voltage Settings

Charge Stage	12V Battery Voltage	24V Battery Voltage	36V Battery Voltage	48V Battery Voltage
Bulk	14.7V	29.4V	44.1V	58.8V
Absorption	14.7V	29.4V	44.1V	58.8V
Float	13.7V	27.3V	41.0V	54.6V

Table 6

4.4.3. Temperature Compensation

If you have a programmable charger or inverter that has a temperature compensation setting, it should be set to -4mV/°C/cell or -2mV/°F/cell.

Table 7 has the temperature compensated voltage values for a 12V battery. For a 24V, 36V or 48V system, multiply the values in the table by 2, 3 or 4 respectively.

Charge Stage	32°F (0°C)	50°F (10°C)	68°F (20°C)	77°F (25°C)	86°F (30°C)	104°F (40°C)
Bulk & Absorption	15.30V	15.06V	14.82V	14.70V	14.58V	14.34V
Float	14.25V	14.01V	13.77V	13.65V	13.53V	13.29V

Table 7

MYTH BUSTER: AGM batteries do not have a memory effect so there is no need to fully discharge batteries prior to charging.

5. Battery Storage

AGM batteries have a much longer shelf life than wet lead-acid batteries. With a self-discharge of only 1-3% per month, AGM batteries can be stored for a year or longer without needing to be charged.

5.1 Battery Storage Procedure

1. Charge batteries before they are placed in storage.

2. Disconnect the batteries from the equipment and charger to eliminate any parasitic loads.

3. Check the batteries based on conditions and schedule in **Table 8.**

Storage Temperature	Storage Time Period
Below 68°F (20°C)	9 Months
68°F to 86°F (20°C to 30°C)	6 Months
Above 86°F (30°C)	3 Months

Table 8

4. Check the open circuit voltage (OCV) of each battery in the set and if any battery within the set is less than the values in **Table 9**, recharge the battery set.

Battery Nominal Voltage	Open Circuit Voltage (OCV)
6V	< 6.2V
8V	< 8.3V
12V	< 12.5V

Table 9

5. If the charger has a maintenance mode select that mode to boost charge the batteries. Otherwise run the normal charge cycle.

6. If the batteries are stored less than the time periods in **Table 8**, they do not need to be recharged prior to being put back into service.

MYTH BUSTER: Batteries CAN be safely stored on concrete floors without any negative effects. Concrete floors DO NOT drain batteries.

5.2 Temperature effects on Self-Discharge

If the storage environment is hot, batteries will self-discharge faster than in a cold environment. See **Chart 3.**

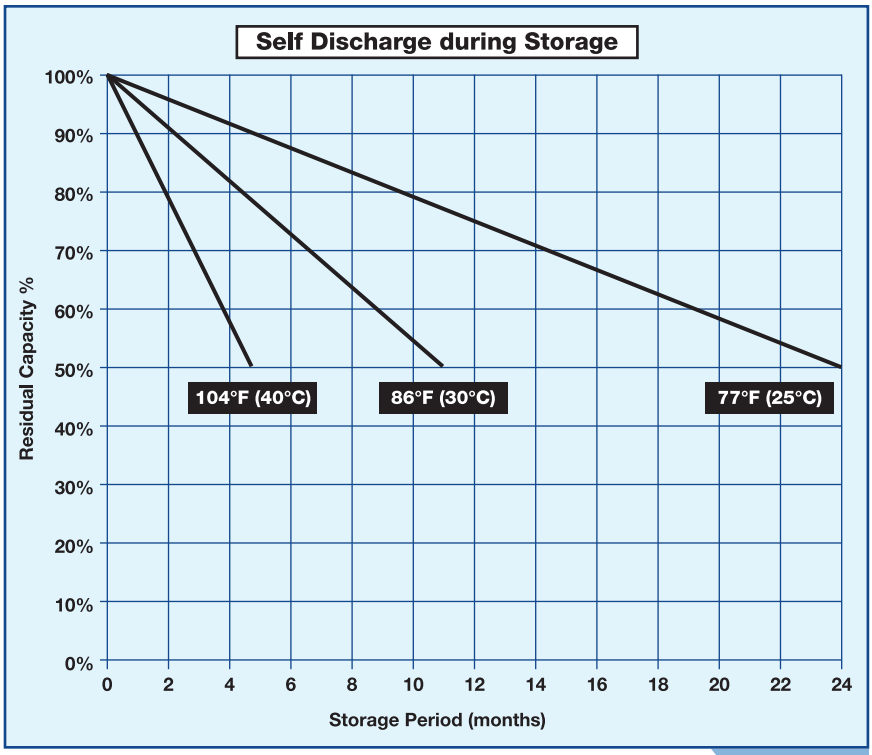


Chart 3

5.3 Storage Temperature Range

Recommended	Maximum
5°F to 122°F (-15°C to 50°C)	-40°F to 160°F (-40°C to 71°C)

Table 10

TIP: Store batteries in a cool, dry environment to minimize self discharge.

6. Battery Testing

Testing batteries can be complex and there are many application specific variables that cannot be considered in one simple test. This section is a guide to help you determine the overall condition of your batteries. Contact your local Fullriver distributor for assistance.

6.1 Test Preparation

1. Check that battery cables are in good condition. Replace any damaged or broken cables.

2. Check that all terminal connections are tightened to proper torque specification. See **Table 2.**

3. Fully charge batteries.

4. Let batteries rest for at least 8 hours once the charge is complete.

6.2 Open Circuit Voltage Test

1. Check and record open circuit voltage (OCV) of each battery.

2. If all the batteries are below 6.1V (6V battery), 8.1V (8V battery) or 12.2V (12V battery) the set is failed. Replace the entire set of batteries. In this situation the battery set had either provided all its available energy or was severely abused.

3. Otherwise any battery that is 0.25V lower than the highest battery voltage (6V battery), 0.35V lower than the highest battery voltage (8V battery) or 0.5V lower than the highest battery voltage (12V battery) might have failed. Make note of these batteries.

TIP: All batteries in a good set should be above 6.4V (6V battery), 8.5V (8V battery) and 12.7V (12V battery) when fully charged after at least 8 hours of rest.

6.3 Discharge Test *(if you do not have a discharger proceed to section 6.4)*

1. Connect and start discharger.

2. Record minutes (runtime) when discharge is complete.
   Correct runtime minutes for battery temperature using the following formula:
   Mc = Mr [1 - 0.009 (T-27)] where Mc is the corrected minutes, Mr is the minutes recorded and T is the temperature at the end of discharge in °C.

3. If the set runs more than 50% of its rated capacity, the batteries are good - test is complete.

4. If the set runs less than 50% of its rated capacity, reconnect the discharger and while under the discharge load; record the end of discharge voltage of each battery.

5. The batteries that are 0.5V lower than the highest end of discharge voltage should be noted.

6. If the set delivered less than 50% of its rated capacity, and the same batteries that were noted in section 6.2., Step 3 were also the ones noted in section 6.3., Step 5, those batteries are most likely failed and should be replaced. Follow the replacement instructions in 6.5.

   Otherwise, please contact your local Fullriver distributor or technical support at **800-522-8191** or email **technical@fullriverdcbattery.com** to review your data in detail. Additional testing may be required depending on your specific application.

6.4 Optional Test

After completing sections 6.1 and 6.2 follow these steps:

1. Operate the vehicle/equipment until battery performance decreases.

2. Record voltages during and after operation.

3. Record time and distance of operation.

4. Provide the voltage, time and distance data to a Fullriver distributor or technical support at technical@fullriverdcbattery.com.

5. This data will be analyzed in comparison to what is expected of the vehicle/equipment.

6.5 Battery Replacement Instructions

Charge the set of batteries before replacing the failed ones, as long as it is safe to do so, to make sure the good batteries are fully charged.

If possible, replace failed batteries with good batteries around the same age from another piece of equipment. Try to avoid mixing new batteries in equipment with old batteries. Put all new batteries in the same piece of equipment.

For battery replacement, follow the installation instructions in section 2.

7. Your Clean-Green Energy Solution

7.1 Fullriver Products

Fullriver Battery produces sealed, maintenance-free batteries that are non-hazardous and non-spillable and are made from ~80% recycled materials. During normal operation our batteries will not release any harmful gasses and will not leak any acidic electrolyte into the environment.

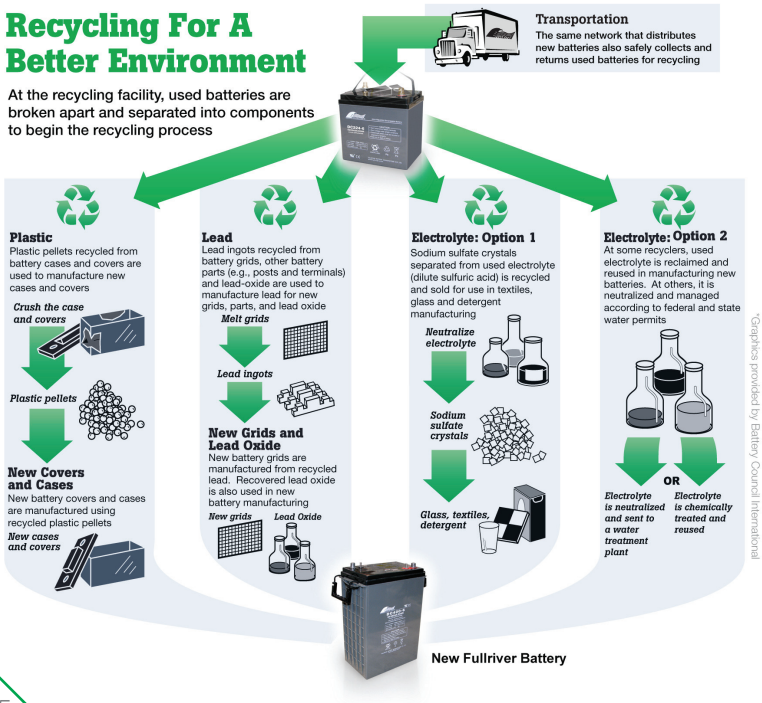
Fullriver batteries are classified as safe for air, sea and ground transportation as they meet the requirements of: the International Air Transport Association (IATA), the International Civil Aviation Organization (ICAO), the International Maritime Dangerous Goods (IMDG) and the Department of Transportation (DOT).

More than 98% of the lead in batteries is recycled, placing lead-acid batteries at the top of the list of the most highly recycled consumer product. The recycling loop of a lead-acid battery goes on indefinitely. See the Recycling Diagram below.

7.2 Fullriver Manufacturing

Fullriver Battery manufactures batteries in accordance with the international environmental regulations. We continually improve our processes in order to minimize waste, recycle all waste that is recyclable and discard waste that is not recyclable in accordance with the local disposal regulations. We strictly enforce the use of proper ventilation and protective gear to minimize exposure of lead to our employees well below the suggested levels.

7.3 Battery Recycling



8. Transportation Information

Fullriver batteries are sealed lead acid batteries made with Absorbed Glass Mat (AGM) technology. The electrolyte is absorbed into the fiberglass separator material rather than in a free-flowing liquid form.

Fullriver batteries are non-spillable electric storage batteries. They are excepted from the requirements of DOT's hazardous materials regulations, since they adhere to the requirements of code 49 CFR Section 173.159(D) which states:

A non-spillable wet electric storage battery is excepted from all other requirements of this sub chapter under the following conditions:

- **The battery must be protected against short circuits and securely packaged**
- **The battery and outer packaging must be plainly and durably marked "NON-SPILLABLE" or "NON-SPILLABLE BATTERY"**
- **The battery must be capable of withstanding the Vibration and Pressure Differential test specified in 49 CFR 173.159(d)(3)(i) and 49 CFR 173.159(d)(3)(ii); and**
- **At a temperature of 550C (1310F), the battery must not contain an unabsorbed free-flowing liquid, and must be designed so that electrolyte will not flow from a ruptured or cracked case.**

Fullriver batteries are protected against short circuits and are securely packaged. Both the batteries and the outer packaging are clearly marked "NON-SPILLABLE". Fullriver batteries were tested by a third party lab and determined to be in compliance to the DOT regulations stated in code 49 CFR Section 173.159(D). Since Fullriver batteries meet all the requirements they are considered non-hazardous and therefore do not require a UN number or additional DOT hazardous material labeling.

This notice is to clarify to shippers and transporters that our batteries are packaged and marked in accordance to 49 CFR 173.159(D) and are determined to be in compliance with DOT HMR49 Non-Hazardous Materials, and the International Air Transportation Association (IATA), Special Provisions S.P. A67 & A48.

Therefore, Fullriver batteries are not restricted for shipment by air or any other means of transportation and are exempt from the hazardous material category.

Appendix

Temperature Ranges

Condition	Recommended	Maximum
Storage	5° F to 122°F (-15°C to 50°C)	-40°F to 160°F (-40°C to 71°C)
Operation	5° F to 104°F (-15°C to 40°C)	-40°F to 160°F (-40°C to 71°C)
Charge with TC	5° F to 122°F (-15°C to 50°C)	-40°F to 160°F (-40°C to 71°C)
Charge w/o TC	32° F to 104°F (0°C to 40°C)	5°F to 122°F (-15°C to 50°C)

A.1

TC = Temperature Compensation

State of Charge (SOC) versus Open Circuit Voltage (OCV)

State of Charge (SOC)	Open Circuit Voltage		
	6V	8V	12V
100	6.42	8.56	12.83
90	6.36	8.48	12.72
80	6.30	8.40	12.60
70	6.24	8.32	12.47
60	6.17	8.23	12.34
50	6.10	8.14	12.20
40	6.03	8.04	12.06
30	5.96	7.94	11.91
20	5.88	7.84	11.76
10	5.81	7.74	11.61

A.2

At 80°F (27°C)

Notes

Notes

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