DEEP CYCLE BATTERY
USER MANUAL

Congratulations, on your purchase of U.S. Battery Mfg. Co., batteries.

We are the manufacturer of the world's most trusted deep-cycle lead-acid batteries. The batteries you purchased were created by U.S. Battery Manufacturing Company to deliver superior energy, performance, durability and reliability for use in a broad range of demanding applications.

This User's Manual was written by U.S. Battery Mfg. Co.'s technical staff and contains essential information regarding proper care and maintenance of your U.S. batteries. Please completely read and understand this manual. It will help you achieve the best battery operation and long life from your new investment.

If you have any questions or concerns contact us here:
WWW.USBATTERY.COM

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1 BEFORE YOU START

The following Safety and Equipment sections are provided to ensure safe and successful battery installation and maintenance:

1.1 SAFETY

Batteries can deliver an enormous amount of power that can result in injury and/or death, observing the following precautions is the difference between successful battery maintenance/installation and a night in the emergency room:

- **Batteries must be charged in a well ventilated area.**
- **Use all necessary protective equipment:** Acid Resistant gloves, safety goggles, and protective clothing.
- **Use insulated tools**: Small 6 inch wrench with rubber or taped handle.
- **Keep ignition sources away** from batteries: sparks, cigarettes, etc.
- **Remove all metal jewelry** or other objects when working on the batteries.
- **Clean all electrolyte spills** with baking soda and water.
- **Skin contact with electrolyte must be immediately flushed** with plenty of water.
- **Never place objects on top of batteries.** A short circuit can occur.
- **Always secure vent caps** after maintenance and before charging.
- **Never add anything besides distilled/deionized water to the battery, doing so will void the warranty.**

WARNING! Do not disassemble, heat above 158˚F (70ºC) or incinerate batteries! Risk of fire, explosion, and/or burns.

1.2 EQUIPMENT NEEDED

The following equipment is recommended to safely maintain/install your batteries:

- Personal Protective Equipment
- Hydrometer and Thermometer
- Distilled or deionized water
- Baking Soda, water, and microfiber rag
- Insulated Tools
- Terminal Protector Spray
- Voltmeter
- Torque Wrench
- Wire Brush
- Battery Charger

1.3 SAFETY DATA SHEETS (MSDS)

U.S. Battery has safety data sheets available for all product lines:

Flooded Deep-Cycle Lead Acid Safety Data Sheet

AGM Deep-Cycle Lead Acid Safety Data Sheet

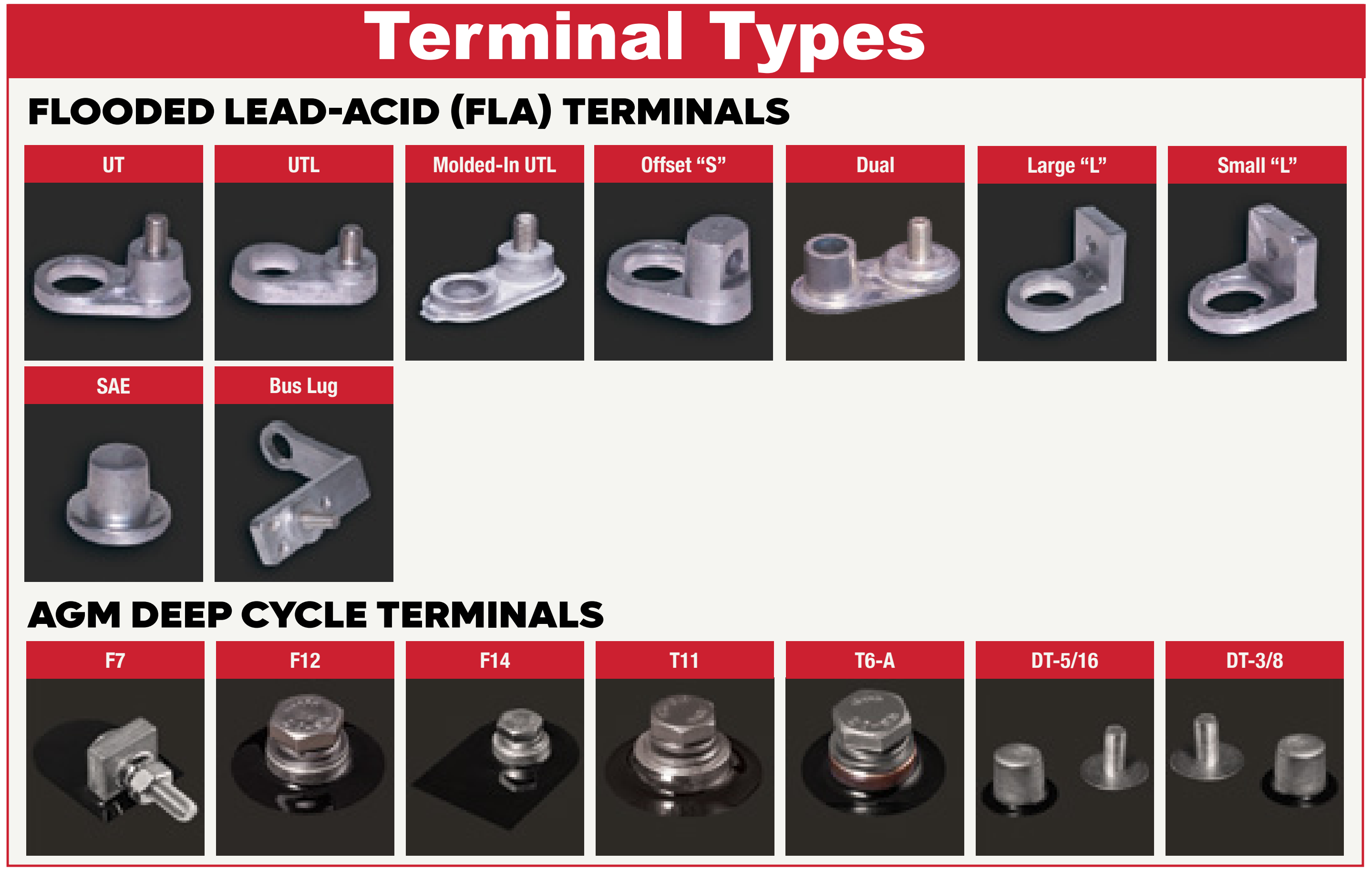
The following sections contain all necessary information for properly installing your U.S. Batteries:

2.1 CABLE SIZE AND BOLT NUT SPECIFICATION

Lead terminals require retightening every 30 – 60 days.

Terminal Types

U.S. Battery offers a variety of terminal options for Flooded lead-acid batteries with various benefits for your specific application. Consult U.S. Battery or your local battery dealer for more information.



Recommended Torque Specifications and Connection Hardware

The use of all included hardware and the specified torque is strongly recommended. Over-tightening can break terminals and loose connections can cause a terminal meltdown or fire. The use of hardware not listed below is not recommended and may void your warranty.

TABLE 1

U.S. Battery FLA Recommended Terminal Torque and Connection Hardware			
U.S. Battery Terminal Type	Recommended Torque (in-lb)	Recommended Torque (ft-lb)	Recommended Connection Hardware
UTL	95-105	7.9-8.8	[1]SS Hexnut with Lock Washer
UT	95-105	7.9-8.8	[1]SS Hexnut with Lock Washer
FLAT BLOCK	95-105	7.9-8.8	[1]SS Hexnut with Lock Washer
DUAL	95-105	7.9-8.8	[1/6]SS Hexnut with Lock Washer
DC MARINE	95-105	7.9-8.8	[2]SS Hexnut with Lock Washer
OFF SET "S"	100-120	8.3-10	[3]Zn or SS Bolt w/Hexnut & Lock Washer
FLAG	100-120	8.3-10	[4]Zn or SS Bolt w/Hexnut & Lock Washer
LARGE "L"	100-120	8.3-10.0	[4]Zn or SS Bolt w/Hexnut & Lock Washer
SMALL "L"	100-120	8.3-10.0	[4]Zn or SS Bolt w/Hexnut & Lock Washer
BUS LUG	120-180	10.0-15.0	[5]SS Hexnut with Lock Washer
SAE	50-70	4.2-5.8	[6]No Hardware Supplied
U.S. Battery AGM Recommended Terminal Torque and Connection Hardware			
F7	88-106	7-9	M6 Bolt w/hexnut & lock washer
F12	89 - 106	7.5 - 9	M8 hexbolt & lock washer
F14	89 - 106	7.5 - 9	M8 hexbolt & lock washer
T11	130 - 173	11 - 14	M8 hexbolt & lock washer
T6-A	130 - 173	11 - 14	M8 hexbolt & lock washer
DT-5/16	176 - 203	15 - 17	5/16" hexnut & lock washer
DT-3/8	176 - 203	15 - 17	3/8" hexnut & lock washer

Proper connection is to position a lock washer between the nut and the connector (never between the connector and lead terminal) and apply the recommended torque or enough torque to completely compress the lock washer without deforming the lead terminal

U.S. Battery provides the recommended hardware with each battery. All hardware must be stainless steal or zinc plated

[1]Stainless Steel Hexnut with Stainless Steel Split-Ring Lock Washer (5/16" Positive & Negative)

[2]Stainless Steel Hexnut with Stainless Steel Split-Ring Lock Washer (3/8" Positive & 5/16" Negative)

[3]Square-Head, SS or Zinc-Plated Bolt with SS or Zinc-Plated Hexnut & Split-Ring Lock Washer

[4]Square-Head or Hex-Head, SS or Zinc-Plated Bolt with SS or Zinc-Plated Hexnut & Split-Ring Lock Washer

[5]Stainless Steel Hexnut with SS Split-Ring Lock Washer (1/2" Positive or 3/8" Positive & 3/8" Negative)

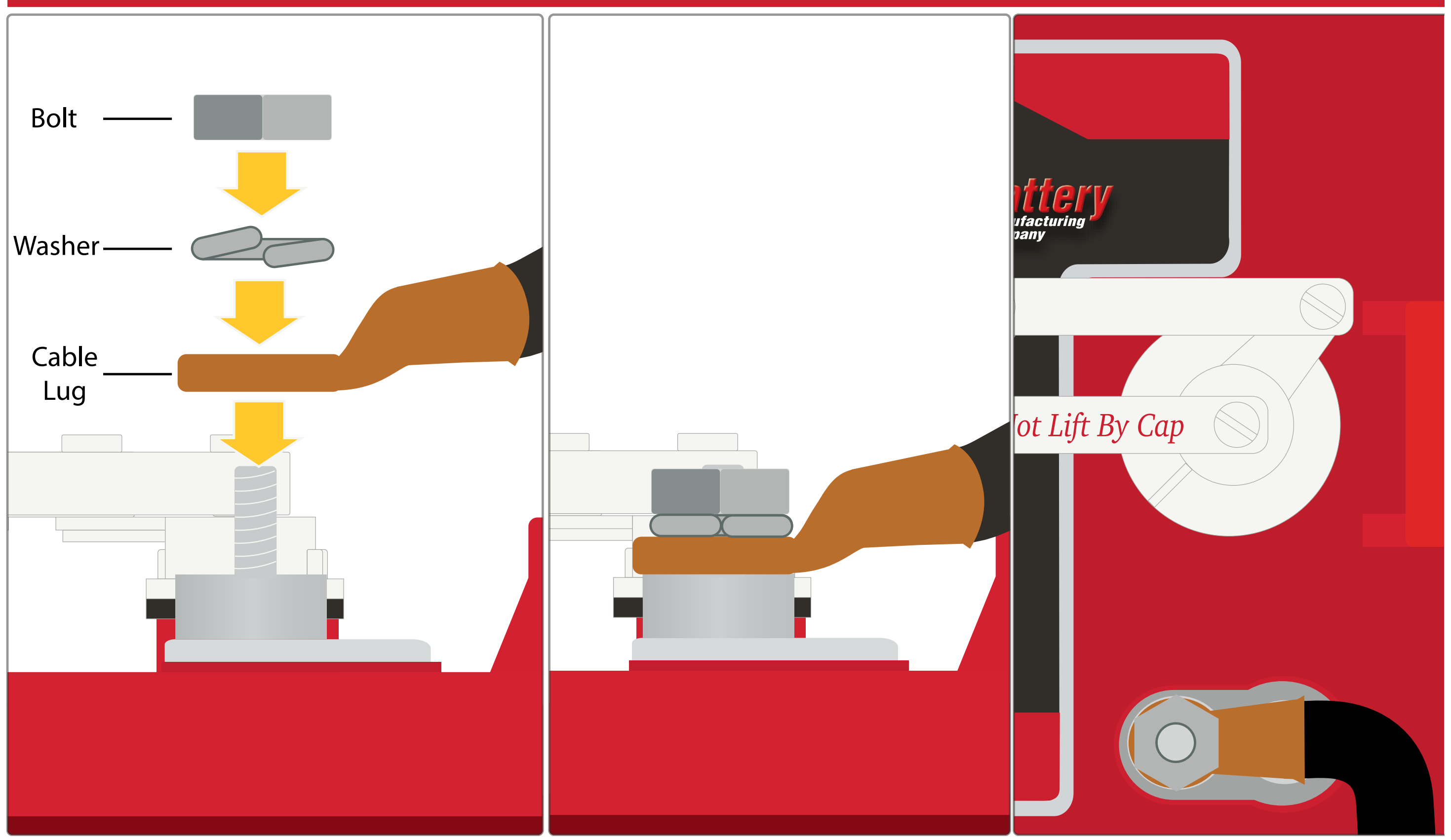
[6]No Hardware Supplied - Application Uses SAE Clamp for Positive & Negative Tapered Post

Note: The use of flanged nuts and other types of nuts with captive washers or other hardware not listed above is not recommended by US Battery and their use may void the battery warranty.

Warning! **Never put the lock washer between the cable and the terminal. The cable end must be directly in contact with the terminal. Failure to do so may result in a melted terminal and voiding of your warranty.**

DIAGRAM 1

Connecting Cables to Terminals



- **Cable Size with Max Ampacity Table**
  Cable size has a direct influence on the voltage drop across the system. The following are guidelines. An electrician should verify that your system is correctly sized and installed. Cables must be sized according to the expected load using the following table:

QUICK TIP

INSULATED TOOLS: THE USE OF LARGE CRESCENT WRENCHES OR OTHER LARGE WRENCHES >6 INCHES LONG CAN RESULT IN OVER-TIGHTENING OF TERMINALS CAUSING TERMINAL DAMAGE. SMALL 6 INCH WRENCHES ARE RECOMMENDED TO PREVENT TERMINAL DAMAGE. WRENCHES CAN BE TAPED WITH INSULATING TAPE OR DIPPED IN INSULATING MATERIAL.

Table values are from NEC table 310.16 for copper cables rated at 167˚F (75˚C), operating at an ambient temperature of no more than 86˚F (30˚C). Lengths in excess of 6 feet (1829mm) may require heavier gauge wire to avoid unacceptable voltage drop. In series/parallel banks, it is preferable for all series cables to be the same length, and all parallel cables to be the same length.

Refer to the national Electrical Code for correct wire sizing which can be located at http://www.nfpa.org/.

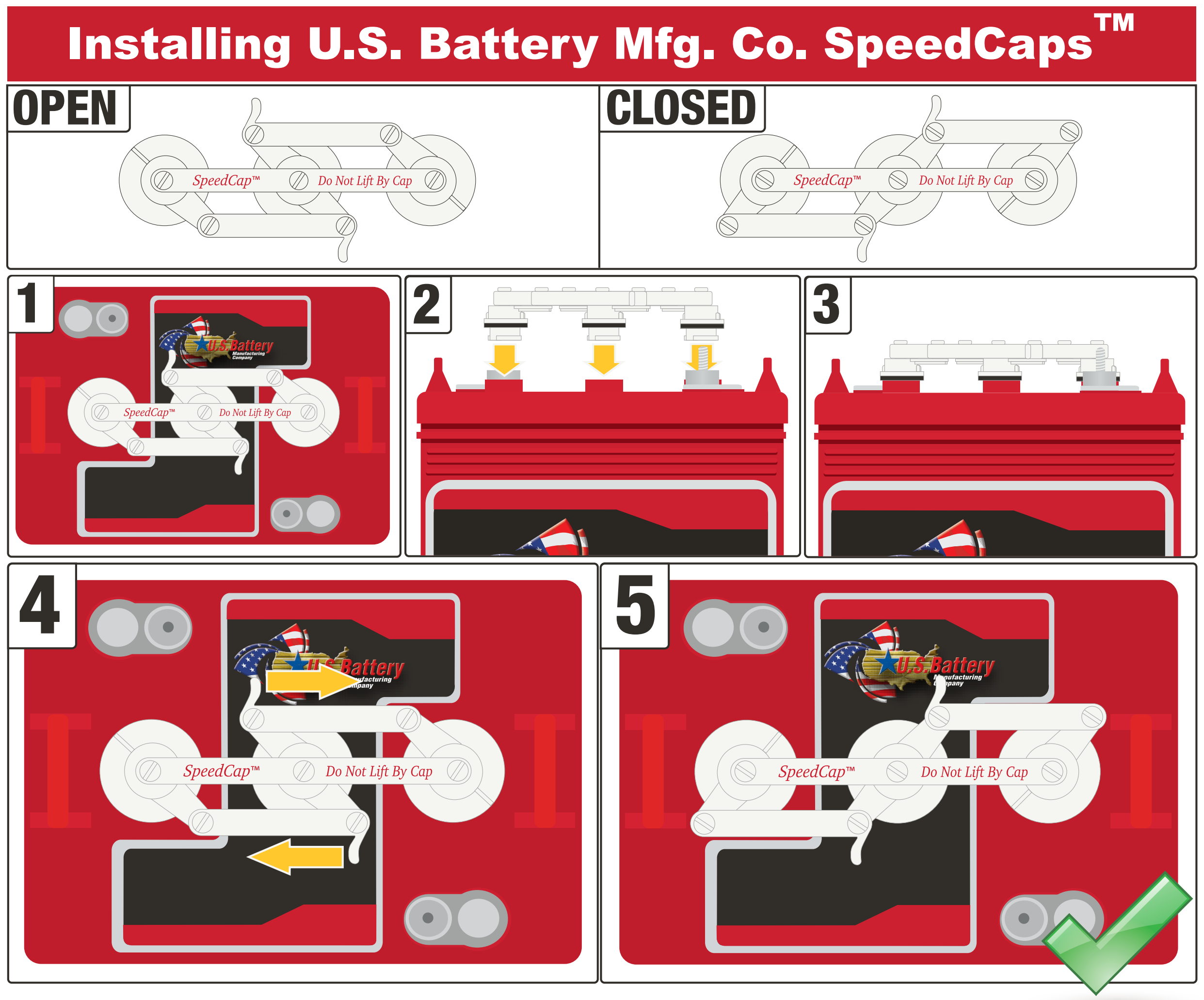
TABLE 2

CABLE/WIRE GAUGE SIZE (AWG)	AMPACITY(Amps)
14	20
12	25
10	35
8	50
6	65
4	85
2	115
1	130
1/0	150
2/0	175
4/0	230

2.2 SPEEDCAPS™ AND VENT CAPS

SpeedCaps must remain securely installed at all times unless topping off cells with distilled water or checking the specific gravity of the electrolyte. At no point should the caps be left on the battery in the open position. Always securely close the caps. Follow the infographics below to ensure that your SpeedCaps and/or vent caps are securely installed.

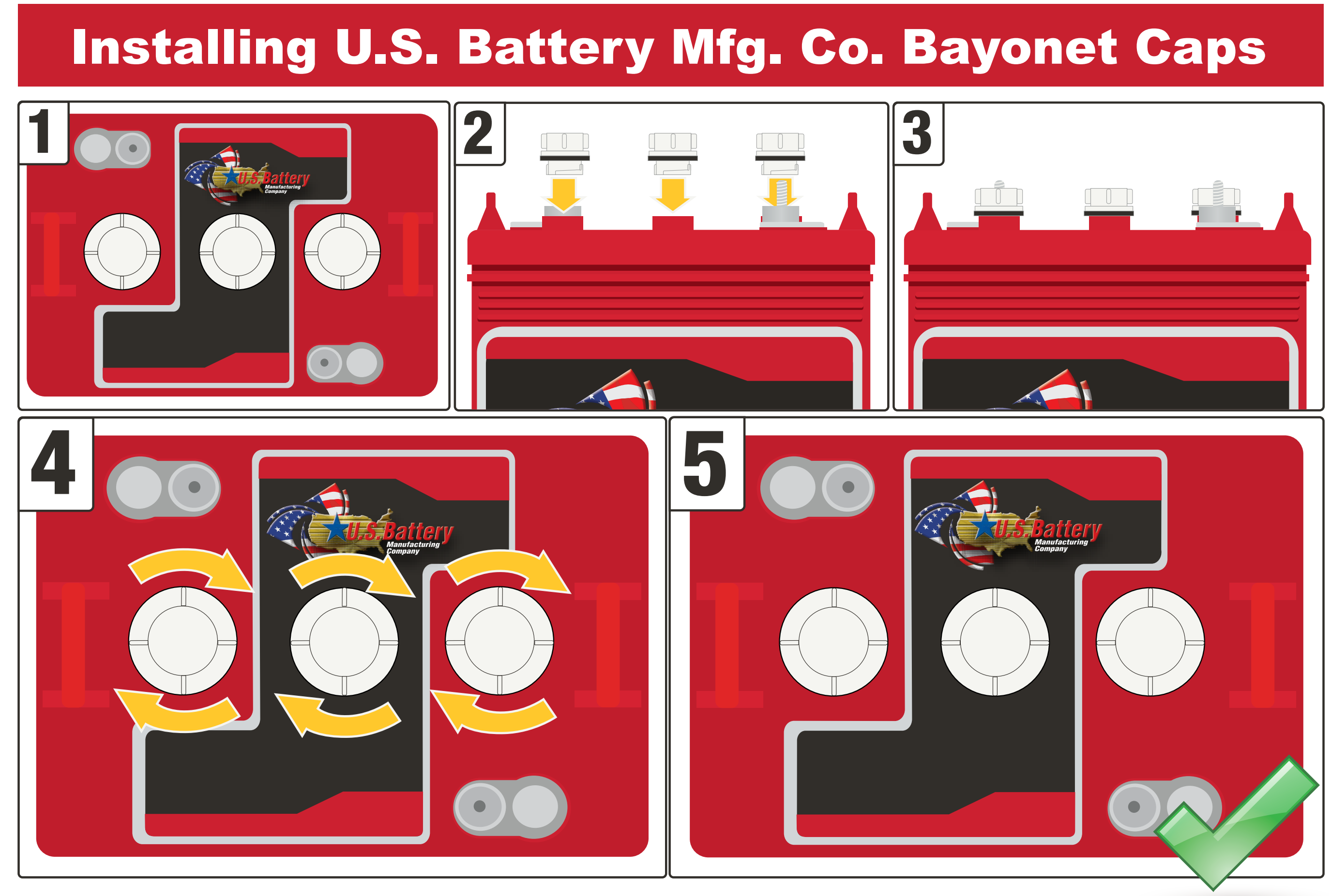
DIAGRAM 2



SPEEDCAP INSTALLATION STEPS

1. Make sure the SpeedCap is in the open position illustrated above.
2. Line up the caps with the vent wells
3. Make sure the caps sit flat within the vent wells.
4. Using your thumb and index finger, move the SpeedCap levers to the closed position.
5. If all steps were followed correctly, your battery will look like step 5.
6. Gently pull on SpeedCap to ensure a secure fit but never lift battery by SpeedCap.

DIAGRAM 3



BAYONET CAP INSTALLATION STEPS

1. Line up the Bayonet caps with the vent wells.
2. Make sure the caps sit flat within the vent wells.
3. Using your thumb and index finger, twist the cap clockwise until the cap stops.
4. If all steps were followed correctly, your battery will look like step 5.
5. Gently pull on Bayonet Caps to ensure a secure fit but never lift battery by Bayonet Caps.

2.3 TERMINAL CLEANING AND PROTECTION

All terminals should be cleaned before installation and then periodically as a regular maintenance. Use a metal bristle brush on the terminal until the dull metal shines again, do the same to the cables. Install cable and hardware properly and then spray down both with terminal protection spray. The protective coating will protect the terminal from any electrolyte that escapes the battery.

2.4 BATTERY ORIENTATION

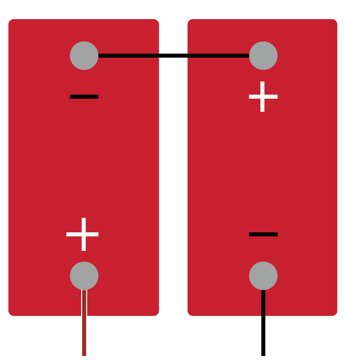
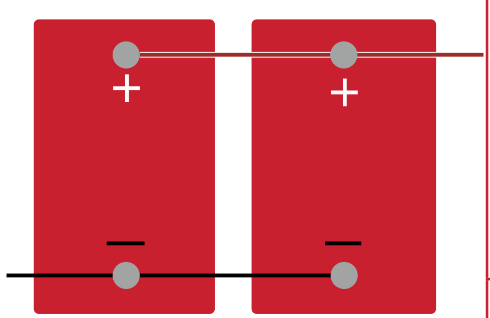
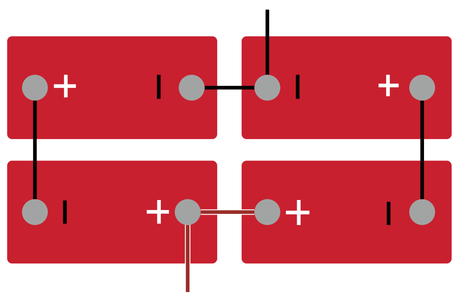
Flooded lead acid batteries must be oriented upright at all times due to the liquid electrolyte. Tipping of the battery more than 15 degrees may result in electrolyte spilling from the vent caps. Battery spills are not covered by warranty.

AGM batteries can be oriented in any direction except upside down. If AGMs are to be oriented on their side, it is preferable that they rest on the **short side**.

2.5 BATTERY BANK CONNECTIONS

You can increase the voltage and/or capacity depending on how your batteries are connected:

TABLE 3

SERIES	PARALLEL	SERIES/PARALLEL	
		 Note: Maximum of 3 parallel strings	
To increase voltage without increasing capacity	To increase capacity without increasing voltage	To increase both voltage and capacity	
Two US2200s, 6Vs rated at 232AH each connected in series	Two US2200s, 6Vs rated at 232AH each connected in parallel	Four US2200s, 6Vs rated at 232AH connected in series/parallel	EXAMPLE
System Voltage: 12V System Capacity: 232AH	System Voltage: 6V System Capacity: 464AH	System Voltage: 12V System Capacity: 464AH	

Visit our configurations webpage for additional configurations

2.6 BATTERY ENVIRONMENT

- **Ventilation**
  Flooded lead acid batteries release small amounts of gas during usage, primarily during charging. AGMs also release gas during charging, but at a highly reduced rate. Due to the release of flammable gases, it is critical that batteries are charged in a well ventilated area. For guidance concerning ventilation requirements, contact US battery or your local battery dealer.

- **Environment**
  Batteries should always be installed or stored in a clean, cool, and dry place. Keep water, oil, and dirt away from the batteries. If these materials are allowed to accumulate on the batteries, current leakage can occur resulting in self-discharge and possible short-circuits. For the same reason, relative humidity should be kept below 90%.

- **Temperature**
  The recommended temperature range for charging both FLA and AGM US Battery deep cycle batteries is 0'F to 120'F (-18'C to 49'C). The recommended temperature range for discharging both FLA and AGM US Battery deep cycle batteries is -20'F to 120'F (-29'C to 49'C). Batteries discharged at temperatures below 32'F should be recharged immediately to avoid freezing. Batteries dis charged at temperatures above 120'F should be allowed to cool before recharging.Temperature plays a major role in battery usage. Hot batteries will deliver more capacity, but with diminished cycle life. Cold batteries deliver less capacity and are harder to charge. The use of a calibrated temperature probe is highly recommended for flooded batteries. A temperature probe is required to be used with AGMs in order to qualify for the warranty. Temperature variations between cells can also have a negative effect on battery capacity and life. Avoid restricting airflow by placing the batteries at least 0.50" (12.7mm) apart.

QUICK TIP

HYDROMETERS: ARE INTRUMENTS USED TO DETERMINE THE SPECIFIC GRAVITY(SG) OF A FLOODED LEAD-ACID BATTERY. KNOWING THE SG OF A BATTERY ENABLES USERS TO DETERMINE THE BATTERIES' STATE OF CHARGE (SOC)"TABLE 8" ON PAGE 39.

3 CARE AND MAINTENANCE

The following information will help prevent the majority of issues that are known to cause premature failure. Follow these instructions frequently to get the most out of your investment!

For a quick list of important topics visit our care and maintenance webpage.

3.1 INSPECTION

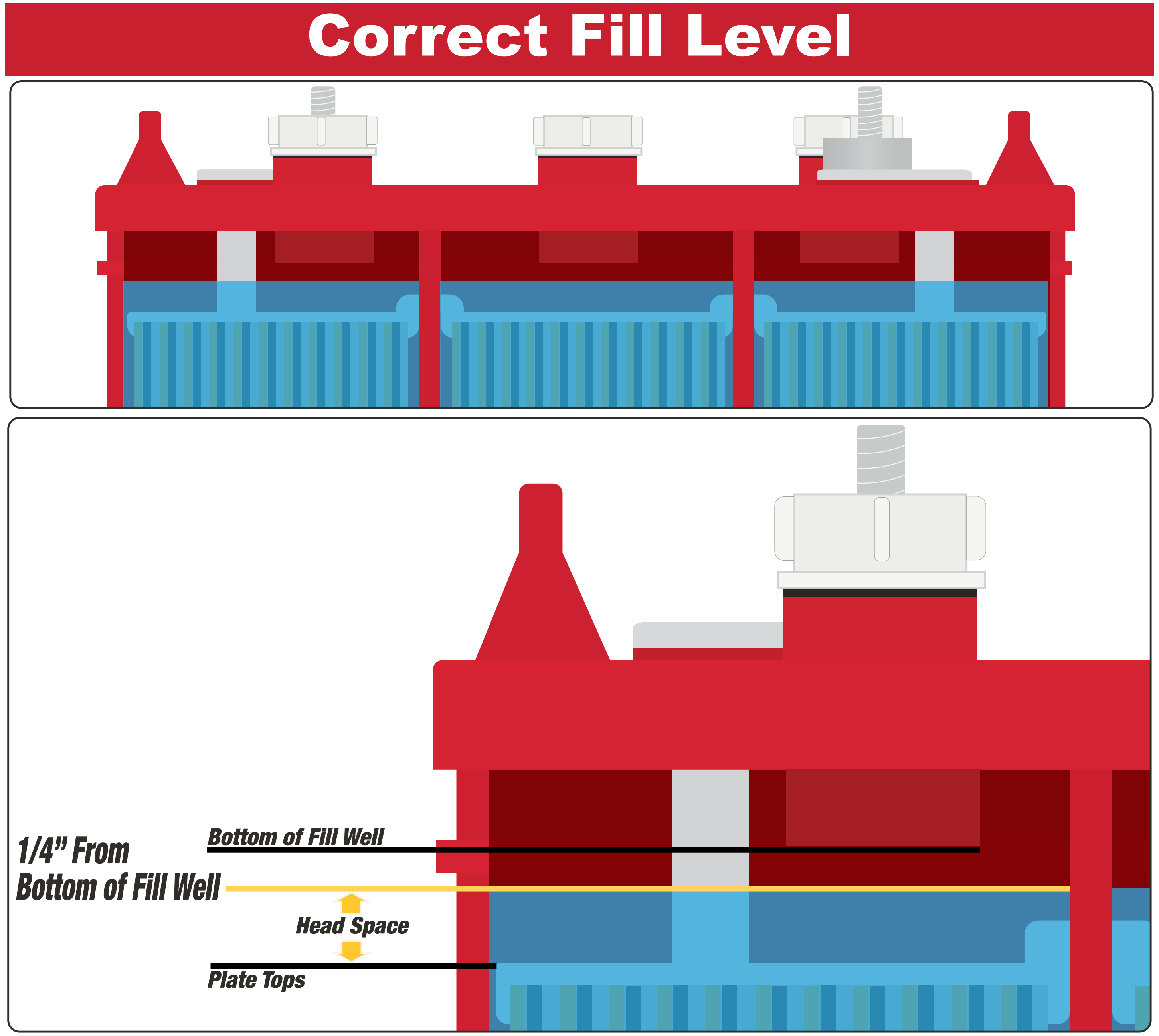
- **Check the outside of the battery.** The tops of the batteries and terminal connections should be clean, free of dirt and corrosion, and dry. Refer to Cleaning section 3.3.
- **If you notice any fluid** on the top of a deep-cycle flooded/wet battery, it may mean that the battery is being overfilled with water or overcharged. Refer to Watering section 3.2 for the proper watering procedure.
- **If fluid is on the top of a deep-cycle AGM battery** this means that the battery is being overcharged and the performance and life will be reduced.
- **Check battery cables and connections**. Replace any damaged cables. Tighten any loose connections. Refer to Torque Values section 2.1 Cable Size and Bolt Nut Specification on page 6.

3.2 WATERING (FLOODED BATTERIES ONLY)

Never attempt to remove the caps on an AGM battery. Deep-cycle flooded/wet batteries need to be watered periodically. The frequency depends upon battery usage and operating temperatures. Check new batteries every few weeks to determine the watering frequency for your application. It is normal for batteries to need more watering as they age.

- **Fully charge the batteries** prior to adding water. **Water should be added if the plates are exposed regardless of the charge state.** If discharged batteries show exposed plates, add just enough water to cover the plates and then charge the batteries and continue with the watering after the full charge as indicated below.
- **Remove the vent caps and place them upside down** to prevent contamination on the underside of the caps and to prevent the acid on the caps from getting elsewhere. Check the electrolyte level.
- **If the electrolyte level is more than ¼" below the bottom edge of the fill well tube** then add distilled or the approved water to a 1/4" (6 mm) below the bottom edge of the fill well tube as shown in the illustration below:

DIAGRAM 4



- **After adding water**, firmly install vent caps back on batteries.(See section 2.2 SpeedCaps™ and vent caps)
- **Tap water** may be used if the levels of impurities are within acceptable limits.

3.3 CLEANING

Observe the battery for cleanliness at regular intervals and keep terminals and connectors free of corrosion by using a wire brush as necessary. Terminal corrosion may adversely affect the performance of the battery, and could be a safety hazard.

- **Make sure that all vent caps are properly installed** on the battery.(Flooded Batteries only)
- **Clean the top of the battery, terminals and connections** with a cloth or brush and a solution of baking soda and water (1 cup of baking soda to 1 gallon of water/60ml of baking soda per liter of water). **Do not allow cleaning solution to get inside the battery.**
- **Rinse with water and dry** with a clean microfiber cloth.
- **Apply a thin coat** of terminal protector spray or terminal protection grease that can be purchased through your local battery dealer. Apply after installation of cables, not before. A coating between the terminal and the cable can cause resistance.
- **Keep the area around batteries clean and dry.**

4.1 BEFORE CHARGING

Proper charging is critical to maximize battery capacity and life. Both under- or overcharging batteries can significantly reduce the life of the battery. For proper charging, refer to the instructions that came with your equipment. Most chargers are automatic and pre-programmed. Some chargers allow the user to set the voltage and current values. Refer to Table 4: for charging guidelines and to US Battery's recommended deep-cycle flooded/wet charging guidelines (Section 4.2.1). Refer to the deep-cycle AGM charging guidelines (Section 4.2.2) and to Diagram 6 for US Battery's recommended deep-cycle AGM charging guidelines.

- **Deep-cycle lead acid batteries should be charged** before their first use due to self-discharging.
- **Make sure the charger is set** to the appropriate program for deep-cycle flooded/wet or AGM depending on the type of battery you are charging.
- **Fully charge the batteries** at the first available opportunity after each use.
- Lead-acid batteries (deep-cycle flooded/wet, AGM or gel) do not have a memory effect and therefore do not need to be fully discharged before recharging.
- **Charge only in well-ventilated areas.**
- **Check electrolyte level** to make sure plates are covered with water before charging (deep-cycle flooded/wet batteries only). Refer to 3.2 Watering (flooded batteries only).
- **Check that all vent caps are secured properly on the battery before charging.** It is dangerous and an explosion hazard to remove caps for (or while) charging.
- **Deep-cycle flooded/wet batteries will gas (bubble)** towards the end of charge to ensure the electrolyte is properly mixed.
- **Never charge a frozen battery.**
- **Avoid charging at temperatures above 120°F (49°C).**

4.2 CHARGING RECOMMENDATIONS

U.S. Battery Manufacturing Company, Inc. recommends the use of 'opportunity charging' or charging batteries and battery packs at every opportunity while in storage or service. Following this recommendation will assure that batteries are always at the highest possible State of Charge (SOC) to maximize performance and range and to minimize the battery's Depth of Discharge (DOD) to optimize performance and life. The charging process is intended to fulfill several objectives. First, the charging process should replace the capacity (in amp-hours) removed from the battery during previous discharges. Second, the charging process should return additional capacity (in amp-hours) to offset the thermodynamic inefficiencies inherent in the charging process. This additional capacity can be measured as a charge factor calculated by: charge Ah in / discharge Ah out. The charge factor varies with temperature, condition and age of the battery but is usually in the range of 105 - 150%. Third, the charging process should charge the battery at a voltage and/or charge rate at the end of charge that will result in controlled gassing of the electrolyte. This gassing is required to mix the electrolyte to prevent stratification. Without proper mixing of the electrolyte, the heavier acid generated during charging can sink to the bottom of the cell and will adversely affect performance and life of the battery. Finally, the charging process should result in a fully charged battery with electrolyte specific gravity that is constant over several end-of-charge readings, consistent between and among the cells of the battery pack, and within the proper range for the battery type per U.S. Battery's specifications.

U.S. Battery is active in the development of new charging methods and regularly tests and evaluates new charger technologies. As part of U.S. Battery's charging recommendations, charging methods are categorized into three basic methodologies based on the number of charge stages used in the charging process. It should be noted that the basic charge stages should result in a fully charged battery at the end of the final charge stage. Using this criterion; float charging, maintenance charging, and equalization charging are not considered to be one of the basic charge stages. These basic charge stage methodologies can be defined as follows:

1. Three-Stage Charging – Charging using bulk charge, absorption charge, and finish charge (usually constant current - constant voltage – constant current). Diagram 5
2. Two-Stage Charging – Charging using bulk charge and absorption charge only (Usually constant current - constant voltage). Diagram 6

U.S. Battery's charging recommendations for deep cycle flooded lead-acid (FLA) and sealed absorptive glass mat (AGM) batteries are found below. Note that the charging parameters recommended for each of these depend on both the battery type and charger type. These charging parameters are often controlled by specific charge algorithms that can be selected or programmed by the user. Users should consult the charger manufacturer and/or U.S. Battery for proper selection or programming of algorithm controlled chargers. U.S. Battery prefers the use of Three-Stage Charging with dV/dt charge termination to minimize the charge time required for full charge and to reduce the risk of abusive undercharging or overcharging of batteries and battery packs.

- **FLOODED LEAD ACID CHARGING RECOMMENDATIONS**

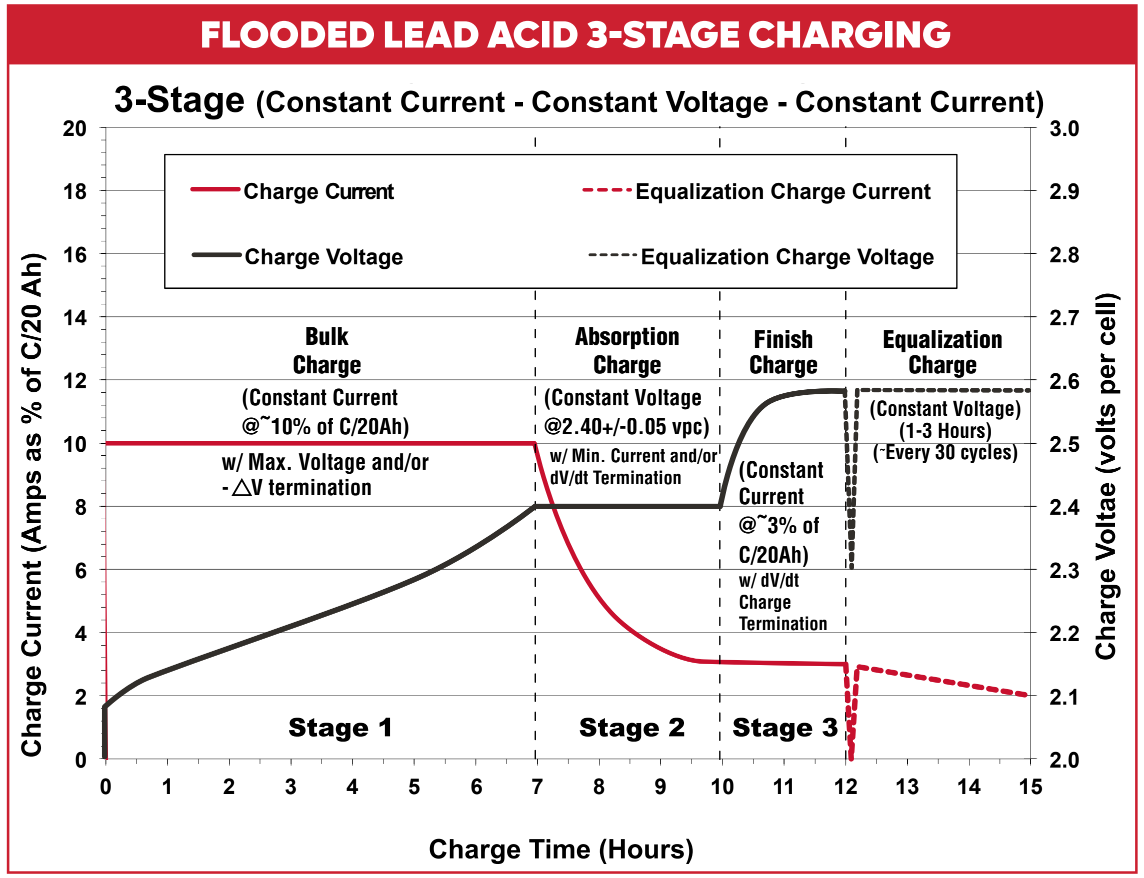
Three-Stage Charger (Constant Current-Constant Voltage-Constant Current)*

Following is the charging recommendation and charging profile using 3 stage chargers for US Battery deep cycle products.
*Equalization and float charge modes are not considered to be one of the stages in a charging profile.

Bulk Charge	Constant current @~10% of C/20 Ah in amps to 2.40+/-0.05 volts per cell (e.g. 7.20 volts +/-0.15 volts per 6 volt battery)
Absorption Charge	Constant voltage (2.40+/-0.05 vpc) to 3% of C/20 Ah in amps then hold for 2-3 hours and terminate charge. Charge termination can be by maximum time (2-4hr) or dV/dt (4 mv/cellper hour)
Finish Charge	Constant current at 3% of C/20 Ah to 2.55+/-0.05 volts per cell (e.g. 7.65 volts +/-0.15 volts per 6 volt battery). Charge termination can be by maximum time (2-4 hr) or dV/dt (4 mv/cell per hour.)
(Optional Float Charge)	Constant voltage 2.17 vpc (6.51 volts per 6 volt battery) for unlimited time
Equalization Charge	Constant voltage (2.55+/-0.05 vpc) extended for 1-3 hours after normal charge cycle (repeat every 30 days)

Notes: Charge time from full discharge is 9-12 hours.
Absorption charge time is determined by the battery but will usually be ~3 hours at 2.40 volts per cell. Float time is unlimited at 2.17 volts per cell. Specific gravity at full charge is 1.270 minimum

DIAGRAM 5



Two-Stage Charger (Constant Current-Constant Voltage)*

Following is the charging recommendation and charging profile using 2 stage chargers for US Battery deep cycle products.
*Equalization and float charge modes are not considered to be one of the stages in a charging profile.

Bulk Charge	Constant current @~10% of C/20 Ah in amps to 2.45+/-0.05 volts per cell (e.g. 7.35 volts +/-0.15 volts per 6 volt battery)
Absorption Charge	Constant voltage (2.45+/-0.05 vpc) to 3% of C/20 Ah in amps then hold for 2-3 hours and terminate charge. Charge termination can be by maximum time (2-4hr) or dV/dt (4 mv cell per hour)
(Optional Float Charge)	Constant voltage 2.17 vpc (6.51 volts per 6 volt battery) for unlimited time
Equalization Charge	Constant voltage (2.55+/-0.05 vpc) extended for 1-3 hours after normal charge cycle (repeat every 30 days)

Notes: Charge time from full discharge is 9-12 hours.
Absorption charge time is determined by the battery but will usually be ~3 hours at 2.45 volts per cell. Float time is unlimited at 2.17 volts per cell. Specific gravity at full charge is 1.270 minimum

DIAGRAM 6

FLOODED LEAD ACID 2-STAGE CHARGING

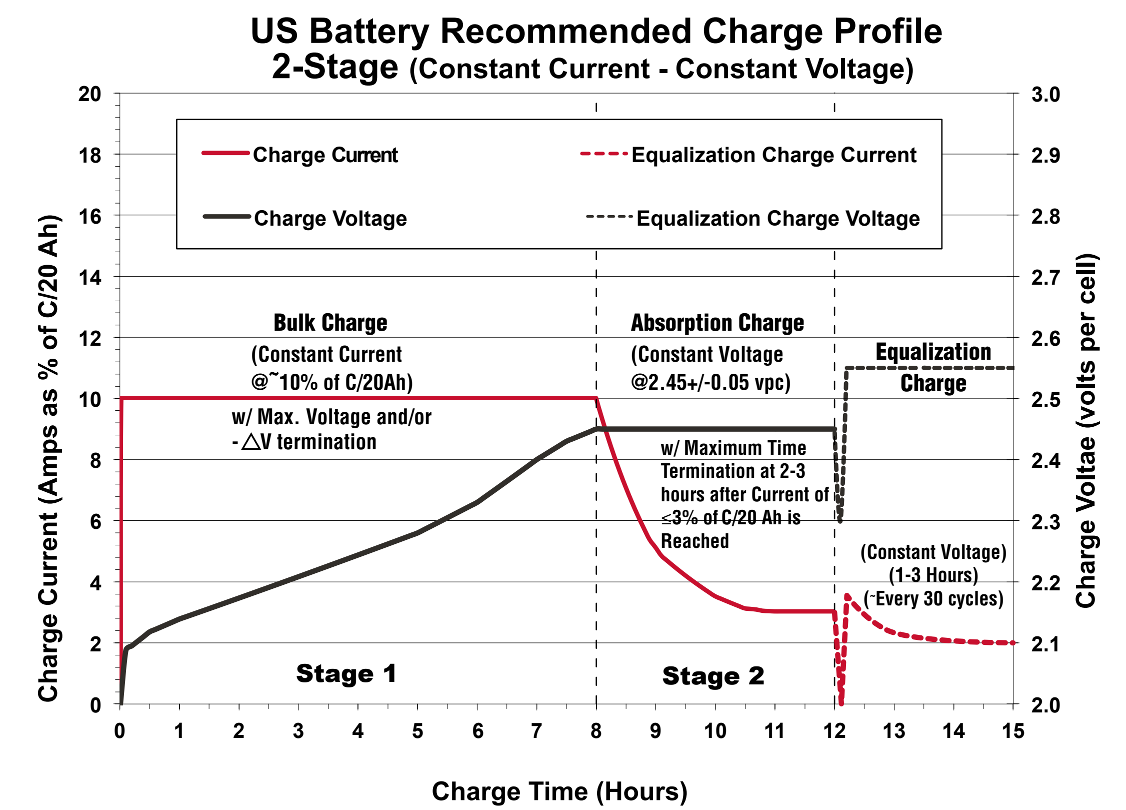


TABLE 4:
Example of voltage settings for deep-cycle flooded lead acid batteries using a 2-stage charger

2-Stage Charger Settings for Deep-Cycle Flooded/Wet Batteries						
System Voltage*	6 Volt	8 Volt	12 Volt	24 Volt	36 Volt	48 Volt
Bulk Charge Voltage	7.05 - 7.5	9.4 - 10	14.1 - 15	28.2 - 30	42.3 - 45	56.4 - 60
Absorption Charge Voltage	7.05 - 7.5	9.4 - 10	14.1 - 15	28.2 - 30	42.3 - 45	56.4 - 60
Absorption Time	2-4 hours					
Float Voltage	6.51	8.68	13.02	26.04	39.06	52.08
Equalization Voltage	7.5 - 7.8	10.0 - 10.4	15.0 - 15.6	30.0 - 31.2	45.0 - 46.8	60.0 - 62.4
Equalization Time	2-4 hours					
Equalization Frequency	At least once a month; Every two weeks if cycled daily.					

*** Battery pack voltage may be lower than the set-points shown at the start of charging. Most automatic chargers require a pack voltage of at least 1 volt per cell for the charger to initiate charging. If pack voltage is less than 1 vpc, a separate manual charger may be needed to bring battery voltages up to the required voltage for charging.**

- **AGM CHARGING RECOMMENDATIONS**

Three-Stage Charger (Constant Current-Constant Voltage-Constant/Pulse Current)*

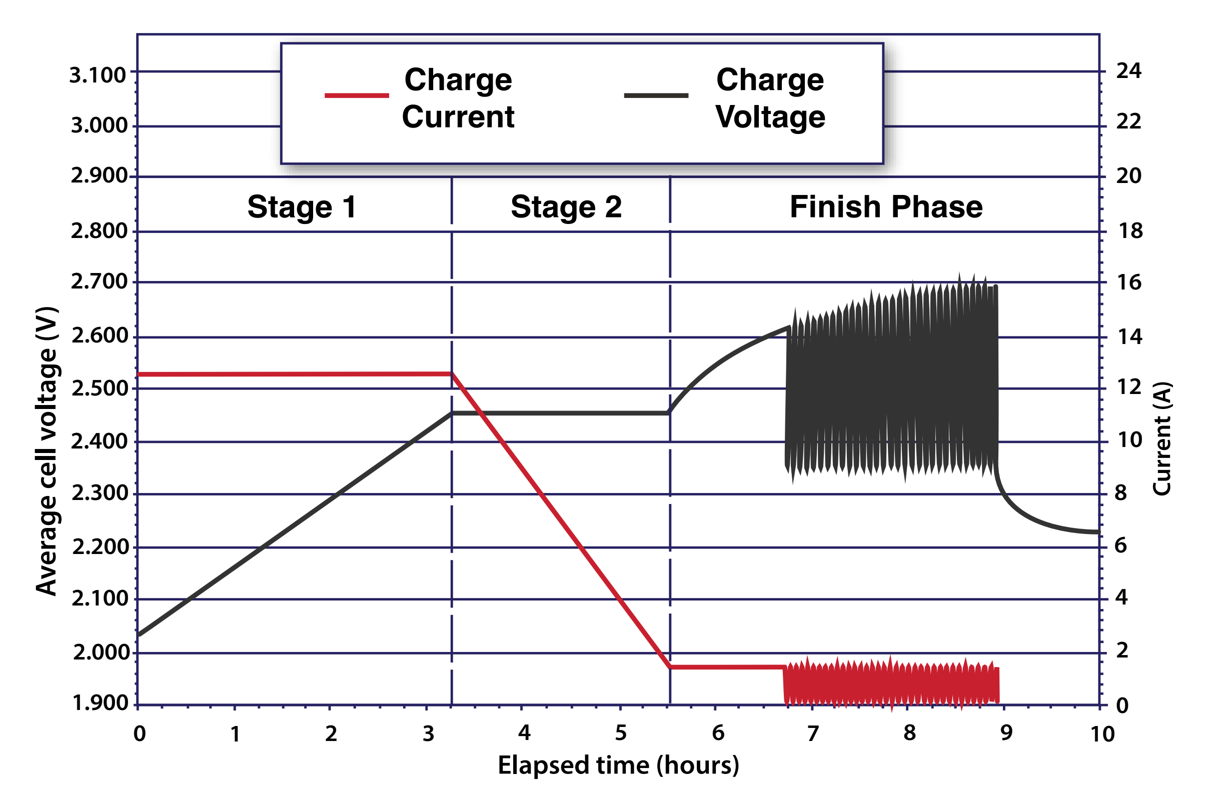
Following is the chargeing recommendations and charging profile using 3 stage* chargers for US AGM deep cycle products.
**Equalization and float charge modes are not considered to be one of the stages in a charge profile.*

1. Bulk Charge	Constant current @ maximum bulk charge to 2.40+/-0.05 volts per cell (e.g. 7.20 volts +/-0.15 volts per 6 volt battery)
2. Absorption Charge	Constant voltage (2.40+/-0.05 vpc) to minimum absorption charge then hold for 2-3 hours and terminate charge.
3. Finish Charge	Constant curent at 3% of C/20 Ah to 2.45+/-0.05 volts per cell then terminate charge (e.g. 7.35 volts +/-0.15 volts per 6 volt battery) Pulse finish: Periodic short current pulses at ~2% of C/20. Voltage rises to 2.7vpc, current turns off, voltage drops to 2.35vpc, current turns on and repeats. Termination is determined by % overcharge or max time.
• (Optional Float Charge)	Constant voltage 2.23+/-0.03 vpc (6.70 volts per 6 volt battery) for unlimited time
• Equalization Charge	Constant voltage (2.45+/-0.05 vpc) extended for 1-3 hours after normal charge cycle (repeat every 30 days)

Notes: Charge time from full discharge is 9-12 hours.
Absorption charge time is determined by the battery but will usually be ~3 hours at 2.40 volts per cell.
Finish charge time is typically 2-4 hours.
Float time is unlimited at 2.23 volts per cell.

DIAGRAM 7

AGM 3-STAGE CHARGING WITH PULSE FINISH



Two-Stage Charger (Constant Current-Constant Voltage)*

Following is the chargeing recommendations and charging profile using 2 stage* chargers for US AGM deep cycle products.

**Equalization and float charge modes are not considered to be one of the stages in a charge profile.*

1. Bulk Charge — Constant current @ maximum bulk charge to 2.45+/-0.05 volts per cell (e.g. 7.35 volts +/-0.15 volts per 6 volt battery)
2. Absorption Charge — Constant voltage (2.45+/-0.05 vpc) to minimum absorption charge then hold for 2-3 hours and terminate charge.

- (Optional Float Charge) — Constant voltage 2.23+/-0.03 vpc (6.70 volts per 6 volt battery) for unlimited time
- Equalization Charge — Constant voltage (2.45+/-0.05 vpc) extended for 1-3 hours after normal charge cycle (repeat every 30 days)

Notes: Charge time from full discharge is 9-12 hours.
Absorption charge time is determined by the battery but will usually be ˜3 hours at 2.45 volts per cell.
Finish charge time is typically 2-4 hours.
Float time is unlimited at 2.23 volts per cell.

DIAGRAM 8

AGM 2-STAGE CHARGING

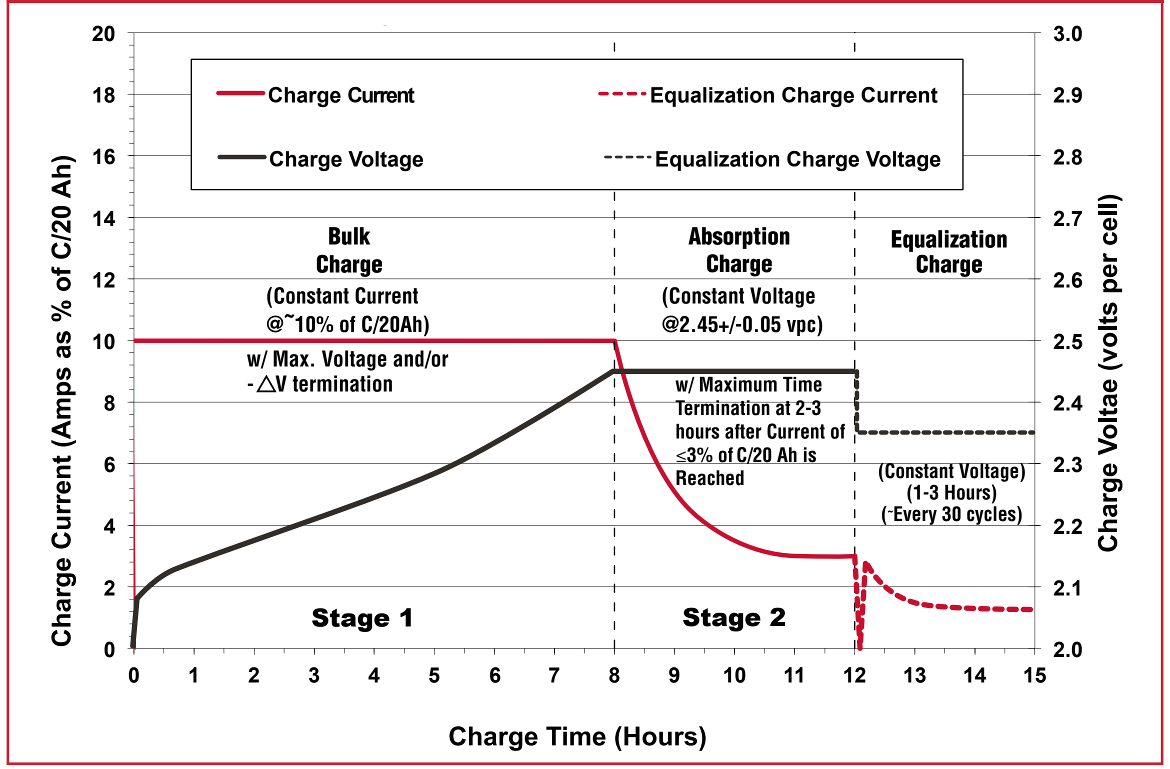


TABLE 5
Example of voltage settings for deep-cycle AGM lead acid batteries using a 2-stage charger

2-Stage Charger Settings for Deep-Cycle AGM Batteries

System Voltage*	6 Volt	8 Volt	12 Volt	24 Volt	36 Volt	48 Volt
Bulk Charge Voltage	7.2 - 7.35	9.6 - 9.8	14.4 - 14.7	28.8 - 29.4	43.2 - 44.1	57.6 - 58.8
Absorption Charge Voltage	7.2 - 7.35	9.6 - 9.8	14.4 - 14.7	28.8 - 29.4	43.2 - 44.1	57.6 - 58.8
Absorption Time	2-3 hours					
Float Voltage	6.7	9	13.5	27	40.5	54
Equalization Voltage	7.35	9.8	14.7	29.4	44.1	58.8
Equalization Time	5-6 hours					
Equalization Frequency	At least once a month; Every two weeks if cycled daily.					

*** Battery pack voltage may be lower than the set-points shown at the start of charging. Most automatic chargers require a pack voltage of at least 1 volt per cell for the charger to initiate charging. If pack voltage is less than 1 vpc, a separate manual charger may be needed to bring battery voltages up to the required voltage for charging.**

4.3 EQUALIZATION CHARGING RECOMMENDATIONS

As deep cycle battery packs are discharged and recharged over multiple cycles, the individual cells within the batteries can become imbalanced due to small differences among the cells. This can result in differences in specific gravity between cells over time. If left uncorrected, the lower cells can become progressively undercharged resulting in capacity loss, sulfation and premature battery failure. To correct for this effect, equalization charging should be used to rebalance the cells. Equalization charging is a fixed overcharge performed after the charger has completed a normal full charge. Equalization charging also assures that all the cells are gassing enough to fully mix the electrolyte to prevent electrolyte stratification. US Battery recommends an equalization charge of 2-4 hours every 30 days or 30 cycles or whenever a specific gravity difference of over 15 points is noted among all the cells of the battery.

Some chargers have an equalization charge programmed into their charge algorithm but manual equalization can be initiated as follows:

- **Fully charge batteries.**
- **Unplug charger until it completely turns off.**
- **Plug the charger back in.** The charger should perform a shortened charge cycle and go through the initial charge stages very quickly. It should then remain in the last charge stage until the charge termination criteria are met. This normally takes 2-4 hours and results in an extended overcharge that balances the cells. This should be confirmed by checking specific gravities.
- **Measure the specific gravity.** If the specific gravity is <1.265 or there is >0.015 points of variance between the cells, then repeat the equalization steps until those two conditions are met.

4.4 FLOAT CHARGE

- **A float charge** is given to the batteries in order to overcome the self-discharge rate. This should be applied to the batteries when stored and after given a full charge. The float voltage for flooded lead acid US Batteries is 2.17 volts per cell and 2.23 volts per cell for US AGM Batteries.

4.5 RENEWABLE ENERGY LINE

Deep cycle batteries used in Renewable Energy applications are subjected to a different kind of service compared to deep cycle batteries used in vehicular applications. Renewable Energy applications are considered ‘stationary’ applications and do not have the movement that occurs in vehicles. As a result, renewable energy batteries experience failure modes that are not prevalent in vehicular applications. To offset these effects, US Battery has designed Renewable Energy batteries with specific design features to address failure modes such as mossing and sulfation. US Battery uses ‘moss shields’ to prevent moss shorts that can form when positive active material dislodges from the positive plates and collects under the plate connectors. US Battery also uses an ‘Outside Positive Plate’ design that minimizes the effects of ‘Partial State of Charge’ or PSOC operation often found in renewable energy applications using solar and wind as the source for charging that often results in incomplete charging.

Since many of the charge controllers for solar applications are two stage chargers the best way to ensure your batteries get a full charge is to increase the absorption stage in 30 minute increments until a full charge is verified with specific gravity readings.

4.6 TEMPERATURE COMPENSATION

Temperature compensation is critical for charging and maintaining batteries in environments with ambient temperatures significantly higher or lower than 80ºF (27ºC) where overcharging or undercharging may occur. **Temperature compensation allows the use of higher charge currents; 20% of the 20 hour rating compared to 10% when charging FLA batteries. AGMs can accept 25% of the 20 hour rating compared to 15%.** Also, temperature compensation is required for warranty claims with AGMs due to their sensitivity to overcharging. Many chargers today come with temperature probes making temperature compensation easy.

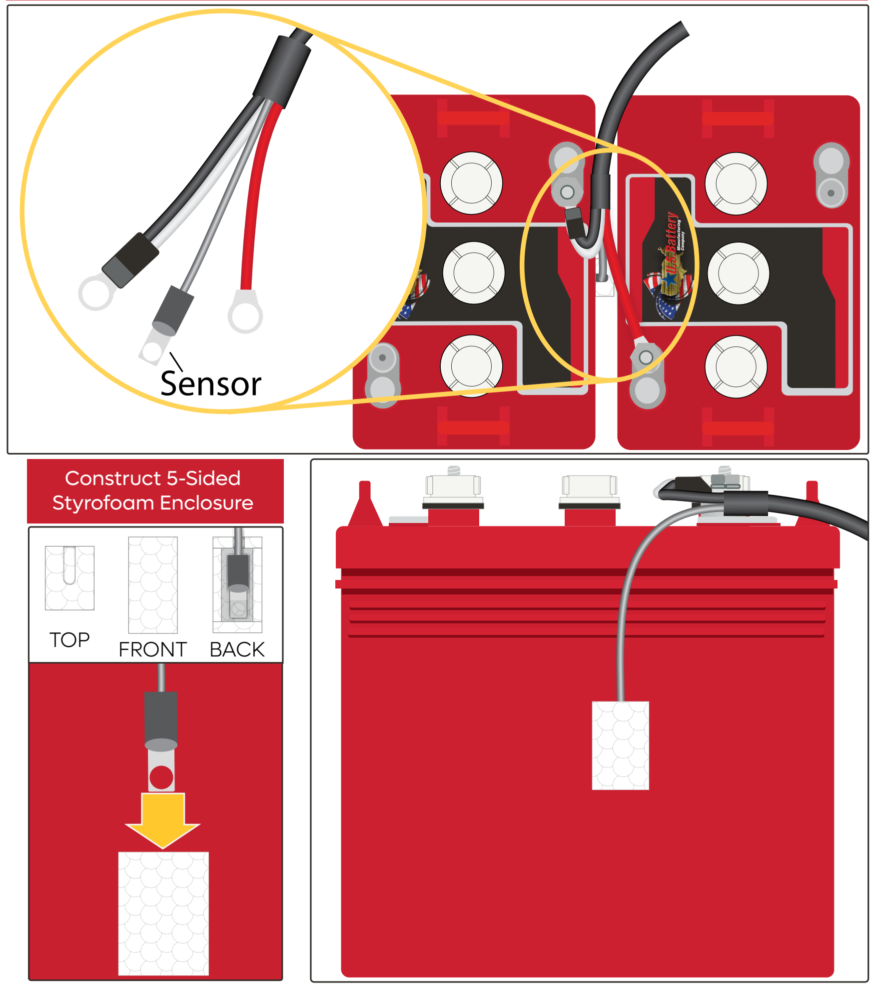
- **The temperature compensation formula is as follows:**
  - Fahrenheit
    - Subtract 0.0028 volts per cell per degrees F above 80ºF
    - Add 0.0028 volts per cell per degrees F below 80ºF
  - Celsius
    - Subtract 0.005 volts per cell per degrees C above 27ºC
    - Add 0.005 volts per cell per degrees C below 27ºC
  - Example
    - Two 6Vs wired in series for 12Vs. 100ºF sunny day in California.
    - Typically the bulk charge voltage would be ~ 14.1V at 80ºF.
    - At 100ºF, subtract (0.0028 * 6 cells * 20ºF) 0.336v from all voltages.
    - The bulk charge voltage would then be ~13.8V.

Temperature sensors

Most chargers that utilize temperature compensation in their charge algorithms provide a temperature sensor to measure battery temperature at a battery. These temperature sensors are usually designed to be attached to a battery terminal and utilize an internal program to correlate battery terminal temperature to actual internal battery temperature. One common method is to attach the temperature sensor to the negative battery terminal along with the negative lead. However, it is important to follow the charger manufacturer's instructions for installation of the temperature sensor since various charger manufacturers use different methods. For example, another method is to attach the temperature sensor to the side of a battery in the pack. It is usually recommended to attach the temperature sensor to the middle of the long side of a battery in the center of the battery pack. It may also be necessary to insulate the sensor following the charger manufacturer's instructions.

DIAGRAM 8

Mounting Temperature Sensor



4.7 DELTA-Q CHARGING ALGORITHMS

The following link will take you to a US Battery Technical Service Bulletin regarding the appropriate Delta-Q charging algorithms for each battery: Delta-Q Charging Algorithms

The following tips will help ensure that your batteries remain in good condition during storage:

- **Fully charge batteries** before placing in storage.
- **Store in a cool, dry location**, protected from the elements.
- **Disconnect from equipment** to eliminate potential parasitic loads that may discharge the battery.
- **Batteries gradually self-discharge** during storage. Monitor the specific gravity or voltage every 4-6 weeks. Stored batteries should be given a boost charge when they are at 80% state of charge (SOC) or less. Refer to Diagrams 9 and 10 for specific gravity and voltage measurements for flooded/wet and AGM batteries respectively.
- **When batteries are taken out of storage**, recharge before use.
- **If put on float voltage** there is no need for periodic boost.

DIAGRAM 9

U.S. BATTERY FLOODED-LEAD ACID BATTERY SELF-DISCHARGE RATE AT 20°F TO 120°F

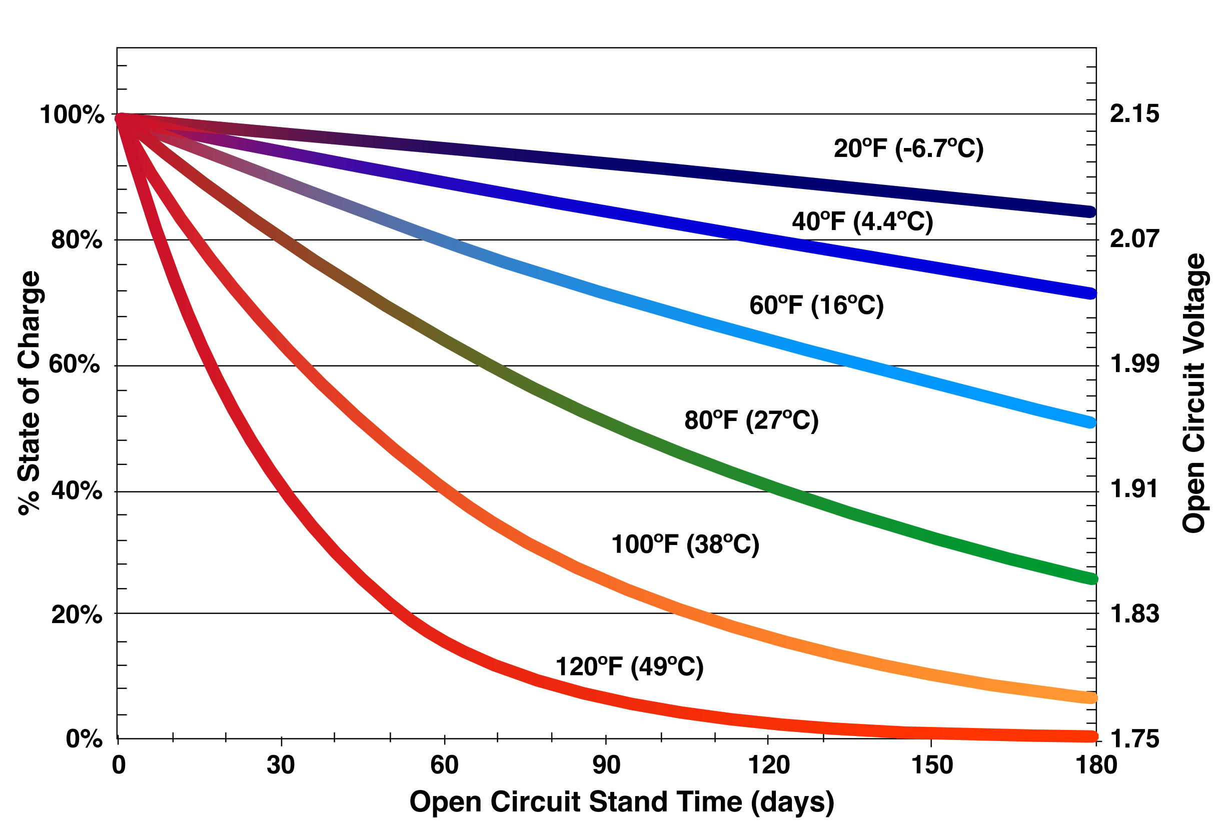
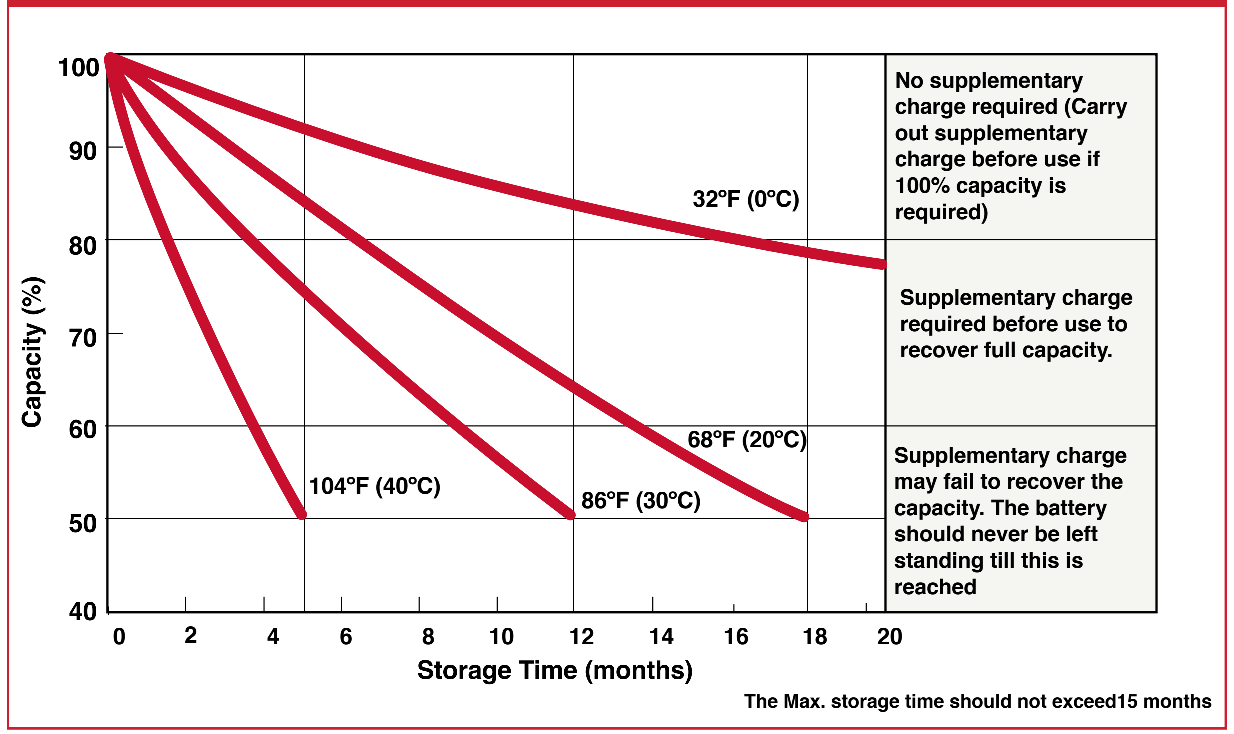


DIAGRAM 10

U.S. BATTERY AGM BATTERY SELF-DISCHARGE RATE AT 32°F TO 104°F



5.1 STORAGE IN HOT ENVIRONMENTS (GREATER THAN 90°F OR 32°C)

Avoid direct exposure to heat sources, if possible, during storage. Batteries self-discharge faster in high temperatures. If batteries are stored during hot, summer months, monitor the specific gravity or voltage more frequently (approximately every 2-4 weeks). Refer to the self-discharge graph above and the freezing point graphs on the next page for more info.

5.2 STORAGE IN COLD ENVIRONMENTS (LESS THAN 32°F OR 0°C)

Avoid locations where freezing temperatures are expected, if possible, during storage. Batteries can freeze in cold temperatures if they are not fully charged. If batteries are stored during cold, winter months, it is critical that they are kept fully charged. Refer to the self-discharge graph above and the freezing point graphs below for more info.

DIAGRAM 11

Electrolyte Freezing Point vs State of Charge of FLA Batteries

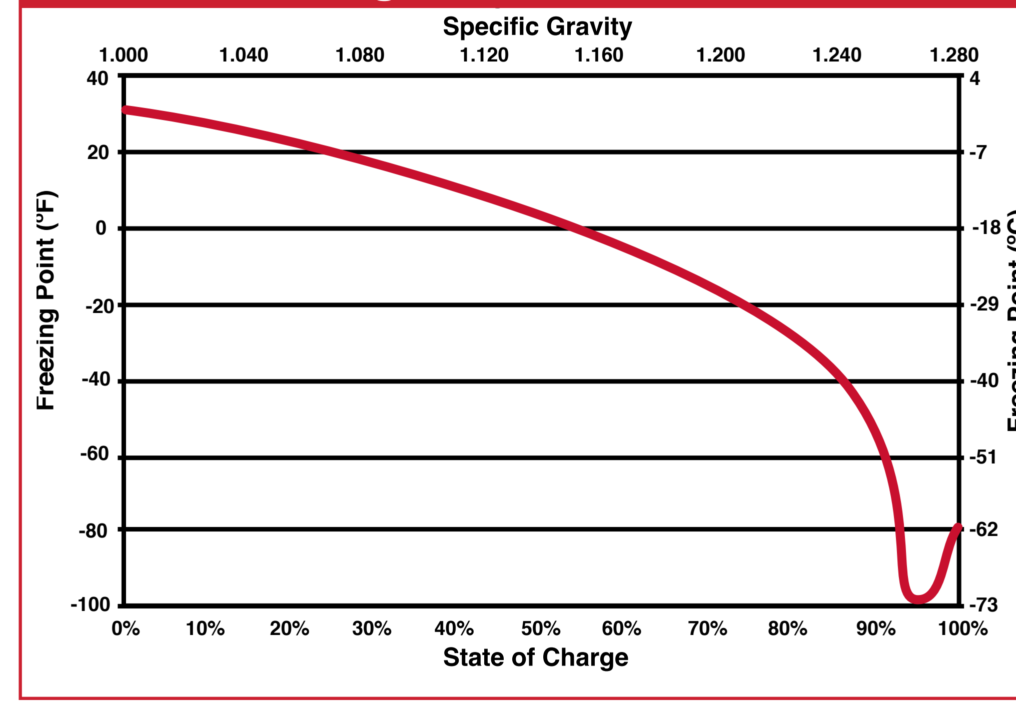
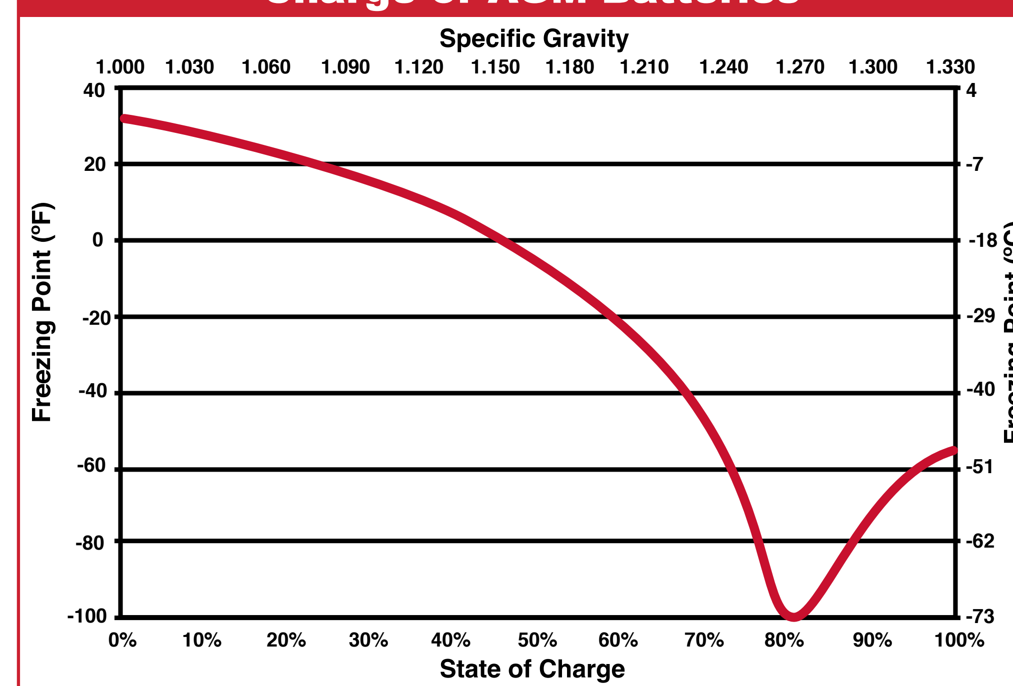


DIAGRAM 12

Electrolyte Freezing Point vs State of Charge of AGM Batteries



- **Read and understand the information** provided here regarding proper installation, care and maintenance, and storage.
- **US Battery recommends** that you limit the depth of discharge to 50% of the 20hr capacity in order to optimize cycle life vs runtime.
- **Avoid discharging to >80% DOD to prevent** over-discharging which causes irreversible damage to the battery.
- **If you have any questions or concerns** about the proper care and maintenance, please contact US Battery or your local battery dealer before a problem develops.

6.1 OPPORTUNITY CHARGING

Opportunity charging is a charge given to the battery pack outside of the normal charge cycle, but in between usages. Examples may include plugging a machine in while on lunch, charging a golf cart in-between rounds, or simply plugging a machine in when there is a known break in work. US Battery **recommends** opportunity charging for our flooded and AGM batteries in all applications. Following this recommendation will assure that batteries are always at the highest possible State of Charge (SOC) to maximize performance and range and to minimize the battery's Depth of Discharge (DOD) to optimize performance and life.

Opportunity charging can extend the life of the battery by limiting the depth of discharge the battery regularly experiences. Depth of discharge (DOD) is the level at which a battery is discharged as a percentage of the overall capacity. Batteries that are limited to shallower depths of discharge exhibit much greater cycle life than batteries that are deeply discharged. By limiting the discharges to shallower levels, you can increase the energy delivered over the entire life of the battery. **Refer to the expected cycle life chart in the next section for more info.**

EXAMPLE:

Take the following scenario for example: An operator routinely draws a battery to a 30% DOD, an hour lunch is taken, and then the battery is drawn to a 60% DOD. If the pack is opportunity charged for the hour while the operator is on lunch, the pack can regain 10%, and thus be only 50% discharged at the end of the shift. While this 10% may seem insignificant, it can result in longer life of the battery pack and shorter charge times in between uses.

6.2 CYCLE LIFE

The number of cycles a US Battery will deliver depends highly upon its depth of discharge (DOD). In other words, if you discharge the battery at a lesser extent, you will get more cycles out of the battery. The relationship isn't linear however. As shown in the following graph, if you discharge the battery to 80% of its 20hr rated capacity, you will get 675 cycles out of it. If you were to discharge the battery to 40% of its 20hr rated capacity you can expect to get 1475 cycles out of the battery. That's more than double the cycle life.

DIAGRAM 13

Expected Life Cycles vs. DOD (XC, XC2, & AGM)

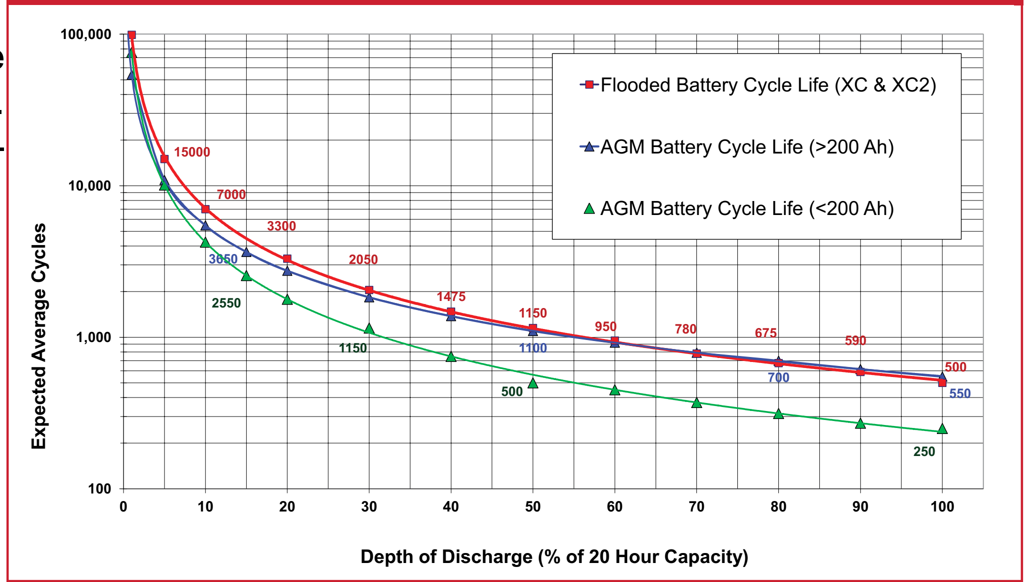
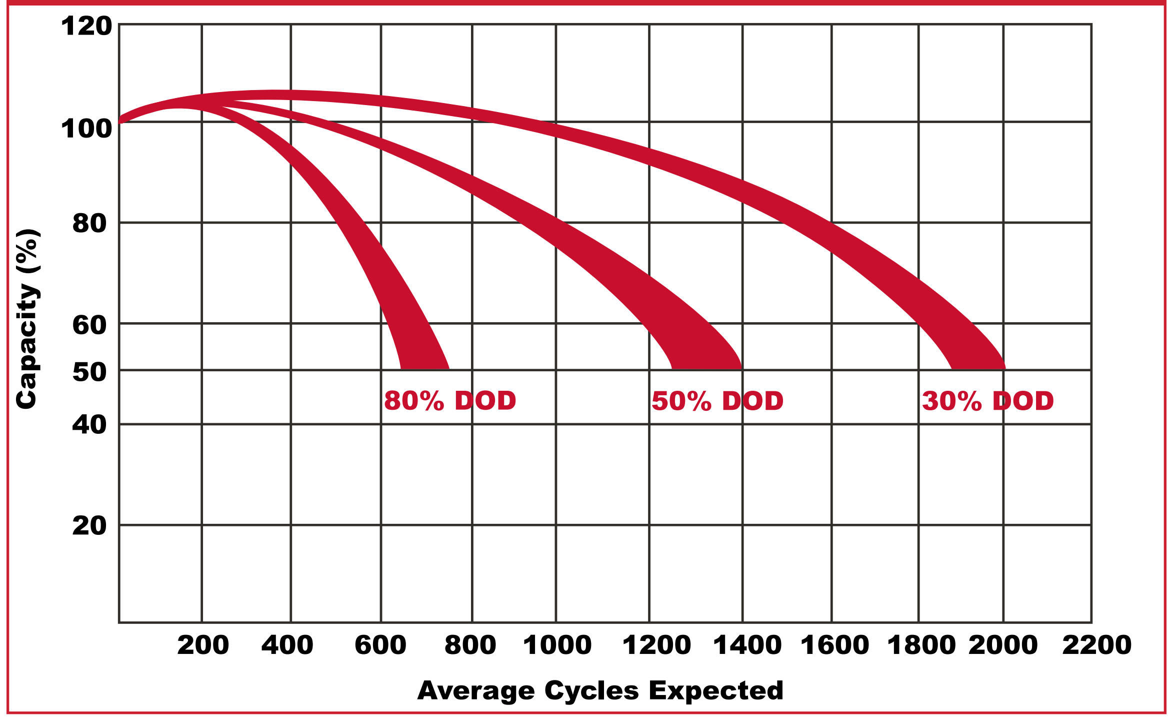


DIAGRAM 14

Cycle Life in Relation to Depth of Discharge



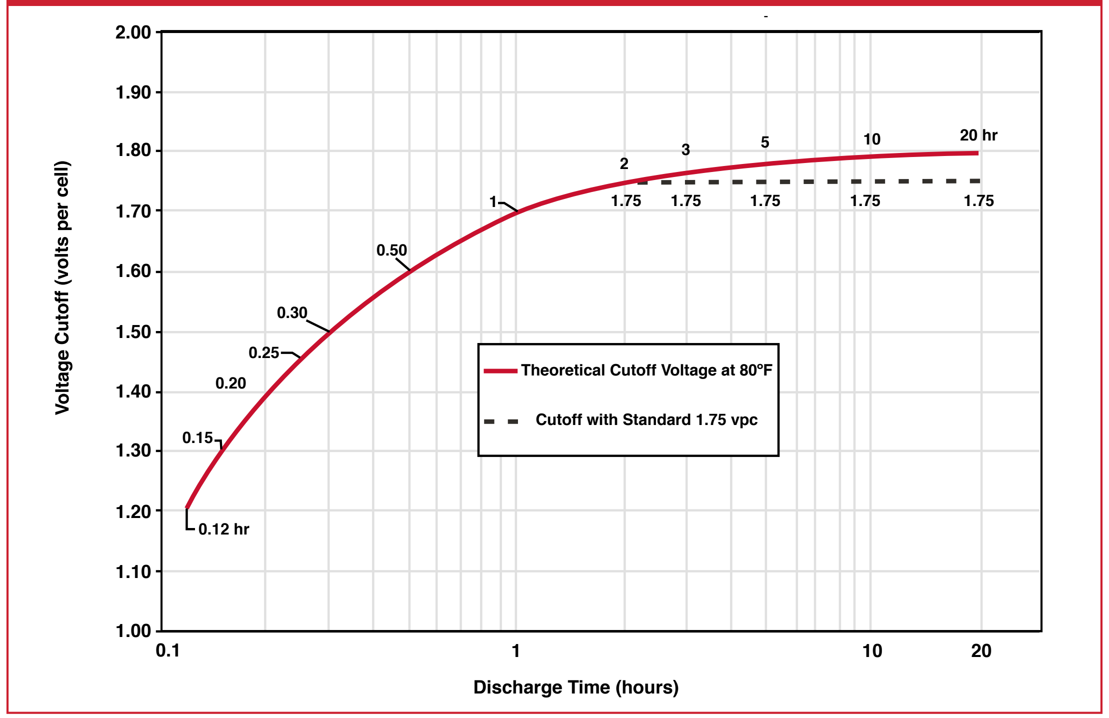
6.3 DISCHARGE VOLTAGE CUTOFF

A convenient method for optimizing runtime vs DOD is to adjust the discharge cutoff voltage.

Diagram 15 shows the discharge cutoff voltage vs discharge rate to achieve ~80% DOD at that rate. To limit the DOD to less than 80% DOD, use a cutoff voltage that is higher than the values shown.

DIAGRAM 15

LEAD ACID BATTERY DISCHARGE CUTOFF VOLTAGE VS DISCHARGE TIME THEORETICAL AND STANDARD 1.75 VPC



Discharge times between the 2 hour and 20 hour should use the 1.75vpc cutoff voltage. Discharge times less than 2 hours should use the specified voltage cutoff. The voltage cutoffs were determined at the standard temperature; 80ºF. Temperature compensation must be applied for battery temperatures significantly deviating from the standard temperature.

6.4 CHARGER OPTIMIZATION/DIAGNOSIS

Undercharging is one of the most common reasons for reduced operating time and overall poor performance of golf cars and other types of electric vehicles that use deep cycle flooded lead-acid batteries. While many golf car operators blame the batteries, the problem can also result from a poorly performing charging system. Keep in mind that battery chargers are subjected to temperature extremes and corrosive environments that can affect their performance over time. So before you replace another set of batteries, try these diagnostic procedures to ensure your charger and charging methods are working properly:

1. **Connect the charger and make sure it is on and charging.** Test the voltage at the battery pack positive and negative terminals. On-charge voltage will normally continue to increase until the charger terminates the charge automatically. It is important to determine the maximum on-charge voltage and charge current (on the charge meter if available) observed near the end of the charge cycle just before the charge terminates.
2. **Once the charger has completed a charge cycle** and has automatically turned off, unplug the power to the charger. Wait one to two minutes and reconnect it. The charger should resume charging normally. Note the charge current and the time at the beginning of charge. This is usually described as an ‘equalization charge’ and should continue for at least 30 minutes before checking the charger’s performance. With many chargers, this step can also be performed by unplugging the DC power cord from the charger to the battery pack. If this method is used, confirm that the charger restarts and continues to charge for at least 30 minutes.
3. **It’s at this point that you can begin to check the charger’s performance** Check the on-charge voltage at the battery pack’s positive and negative termi nals. The voltage will normally continue to increase to the range of 2.50-2.60 volts per cell, until the charge terminates automatically. See Table 6 to determine the minimum and maximum on-charge voltages for the battery pack based on nominal pack voltage. If the voltage does not increase or initially increases and then decreases, record the following information.
   a) The maximum and final on-charge voltages.
   b) Charge current (if available).
   c) The charging time from the start until it terminates automatically.
4. **The next step** is to check the on-charge voltage of each battery and compare it to Table 7 to determine the acceptable Charge Voltage Variation for each battery’s nominal voltage. If the voltage varies beyond the values stated in Table II (either variation from pack average or variation from highest to lowest), replace the lowest voltage battery and repeat the diagnostic test. Test the failed battery separately to determine mode of failure.

Armed with this information, you may be able to determine that the charger is not working properly if:

a) Either the on-charge voltage for the battery pack or on-charge voltage for each battery fail to reach the equivalent of 2.5 volts per cell times the number of cells connected in series.
b) The on-charge voltage increases and then decreases (with charger still charging), and if the on-charge voltage of each battery does not vary by more than the values shown in Table 6 for 6, 8, or 12 volt batteries; either variation from pack average or variation from highest to lowest.
c) If the battery pack on-charge voltage reaches the equivalent of 2.60 volts per cell (the maximum in Table 7), and the charger does not terminate the charge after 1-3 hours. If you found that your charger is not working properly, keep in mind that your batteries may still be good. Flooded lead-acid batteries can be brought back to full capacity with a full charge.

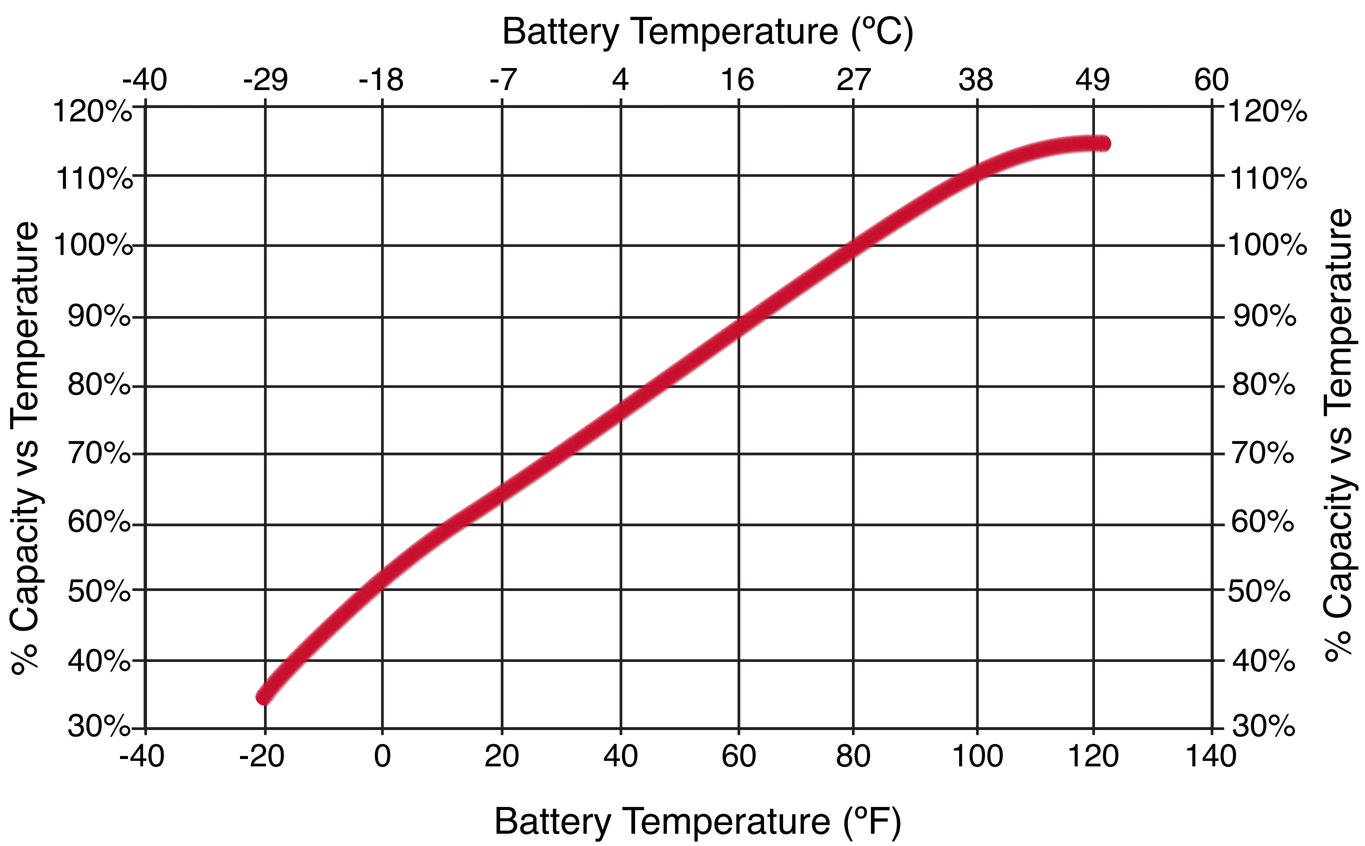
If you decide to purchase a new charger, look for a programmable charger with a selection of multiple charge algorithms. Deep cycle batteries from various battery manufacturers require different charge characteristics to deliver optimum performance and life. Most charger manufacturers provide programmable chargers with selectable charge algorithms designed for each battery manufacturer's products. Using the battery manufacturer's recommended charging procedure will optimize battery performance and life of your battery pack.

After you fully charge the batteries with your new charger, you can always take specific gravity readings for each battery with a hydrometer to determine if the battery is at a full state of charge. Several cycles of charging and discharging with the new charger may be required to return the battery pack to peak capacity. For a more detailed version of this charger diagnostic procedure or more information on flooded lead acid batteries or specific gravity readings for batteries, visit www.usbattery.com

- **A brand new deep-cycle battery** will deliver less than the rated capacity. This is normal as it takes cycling and use for a deep-cycle battery to reach maximum capacity.
- **US Battery's batteries take 30 to 80 cycles to cycle up to peak capacity.**
- **When operating batteries at temperatures below 80°F (27°C)** they will deliver **less** than the rated capacity. When operating batteries at temperatures **above 80°F (27°C)** they will deliver more than the rated capacity but the battery life will be reduced. **Refer to the "Battery % Capacity vs Temperature" graph below.**
- **Just like the expected lifespan of anything else**, the life of a battery is difficult to predict, as it is a function of many variables: charging algorithms, application and use, maintenance, temperature, and purity of water used, to name a few.

DIAGRAM 16

BATTERY % CAPACITY VS TEMPERATURE



8 TROUBLESHOOTING

The following troubleshooting tips are for general diagnosis of battery issues only. There may be issues that occur within the batteries that aren't addressed in this section. For help with this section and interpreting the results, contact our technical support group by filling out the support form.

- **Internal Resistance** (i.e. C.C.A testers) and carbon pile discharge testers are not suitable testing methods for deep-cycle batteries.

8.1 TEST PREPARATION

- **Check that all vent caps are securely installed on the battery**
- **Properly clean the top of the battery**, terminals, and connections with a cloth and/or wire brush. Electrolyte should be cleaned with a baking soda and water solution in order to neutralize the acid.
- **Check the battery cables and connection integrity.** Ensure all connections are tightened to the correct torque per the torque Table 1.
- **For flooded lead acid batteries**, check that the electrolyte is at the correct level per the fill Diagram 4.
- **Fully charge the batteries** before testing in order to obtain meaningful results.

8.2 SPECIFIC GRAVITY TESTING

- **Use a hydrometer to test the specific gravity.**
    - A hydrometer is a tool that extracts the electrolyte into a vessel that contains a calibrated float. The float is measuring the specific gravity or the density ratio of acid to water.

- **Hydrometers must be corrected for temperature**
    - Add 0.004 points for every 10ºF(5ºC) above 80ºF(27ºC)
    - Subtract 0.004 for every 10ºF below 80ºF(27ºC)
    - If every cell within the battery is below 1.250 then the battery may be undercharged. If so, recharge batteries.
    - If any battery has a specific gravity variation of more than 0.015 between cells you should equalize the set.
    - If the specific gravities still vary then you may have a bad battery.
    - If a single cell within a battery is more than 0.050 points off from the others it is safe to assume it is a bad cell.

8.3 DISCHARGE TESTING

- **Ensure that all charging sources and loads** are disconnected from the battery.
- **Connect and start the discharger** at the desired discharge rate.
- **Record the runtime when the discharger is finished.**
- **The runtime has to be corrected for temperature** since the ratings that will be used for comparison were determined at 80ºF. Temperatures above and below 80ºF will affect the overall runtime.
- **Temperature Compensation**
    - Fahrenheit
        - Tc = Tr[1 – 0.005(F-80)]
    - Celsius
        - Tc = Tr[1 – 0.009(C-27)]
    - Where,
        - Tc = Corrected discharge time.(Corrected to 80ºF(27ºC))
        - Tr = Recorded discharge time.
        - F/C = Battery Temperature at the end of discharge(Fahrenheit, Celsius)

- **If the corrected discharge time is greater than 50%** of the rated capacity at that rate then the pack is still usable.
- **Restart the discharger** to observe the individual battery voltages while under a load.
- **If a battery voltage within a pack** is more than 0.5V lower than the highest voltage battery then it may be a bad battery.

8.4 ON-CHARGE VOLTAGE TESTING

- **Disconnect and reconnect DC plug to restart charger.**
- **While the batteries are on-charge** record the current in the last half hour of charge and measure the battery pack voltage.
- **If the measured current is below 5 amps** compare the measured pack voltage to the table below. If the measured voltage exceeds the "End-of-Charge Threshold Voltage," proceed to the next steps.

TABLE 6

On-Charge Test Voltage						
System/Battery Voltage	6V	8V	12V	24V	36V	48V
End-of Charge Threshold Voltage	7V	9.3V	14V	28V	42V	56V

- **If the end-of-charge voltage** does not exceed the values above, check the charger to ensure the proper output is being maintained. Recharge the batteries and measure again. If the pack voltage is still low, you may have a bad battery.
- **While the pack is on charge**, measure the individual battery voltages and compare to the table below. If the minimum voltage is not attained and/or the variance between the batteries is greater than the allowable variation, the low battery may be failing.

TABLE 7

On-charge Test Threshold		
Nominal Battery Voltage	Minimum Voltage Threshold	Allowable Variation within a Set
6V	7V	0.5V
8V	9.3V	0.7V
12V	14V	1.0V

8.5 OPEN CIRCUIT VOLTAGE TESTING

This is the least preferred method of evaluating the condition of your battery due to the misleading nature of open circuit voltages.

- **For accurate voltage readings, flooded lead acid batteries should remain idle for at least 4-6 hours. AGMs should remain idle for at least 24 hours.**
- **Measure the individual battery voltages.**
- **If any recorded voltage** differs from another battery within the set by more than 0.3V, you may have a failing battery.

QUICK TIP

SINGLE POINT WATERING KITS: ARE A GREAT WAY TO REDUCE THE AMOUNT OF TIME IT TAKES TO MAINTAIN YOUR FLOODED BATTERIES. ALL BATTERIES CAN BE WATERED FROM ONE SOURCE. THE VALVES ENSURE THAT ELECTROLYTE LEVELS ARE PROPERLY MAINTAINED. FOR MORE INFORMATION VISIT WWW.USBATTERY.COM

TABLE 8

Flooded Lead Acid Battery State of charge vs Specific Gravity and Open Circuit Voltage									
Depth of Discharge	State of Charge	Specific Gravity Corrected to 80ºF	Open-Circuit Voltage						
			6V	8V	12V	24V	36V	48V	108V
0%	100%	1.270	6.37	8.49	12.73	25.46	38.20	50.93	114.7
10%	90%	1.246	6.31	8.41	12.62	25.24	37.85	50.47	113.6
20%	80%	1.221	6.25	8.33	12.50	25.00	37.49	49.99	112.5
30%	70%	1.197	6.19	8.25	12.37	24.74	37.12	49.49	111.4
40%	60%	1.172	6.12	8.16	12.24	24.48	36.72	48.96	110.2
50%	50%	1.148	6.05	8.07	12.10	24.20	36.31	48.41	108.9
60%	40%	1.123	5.98	7.97	11.96	23.92	35.87	47.83	107.6
70%	30%	1.099	5.91	7.88	11.81	23.63	35.44	47.26	106.4
80%	20%	1.074	5.83	7.77	11.66	23.32	34.97	46.63	104.9
90%	10%	1.050	5.75	7.67	11.51	23.02	34.52	46.03	103.5
100%	0%	1.025	5.68	7.57	11.35	22.70	34.05	45.4	102.2
		#Cells	3	4	6	12	18	24	54

TABLE 9

AGM Battery State of Charge vs Open Circuit Voltage								
Depth of Discharge	State of Charge	AGM Battery Open-Circuit Voltage						
		6V	8V	12V	24V	32V	48V	108V
0%	100%	6.50	8.67	13.00	26.00	39.00	52.00	117.0
10%	90%	6.44	8.58	12.87	25.75	38.62	51.50	115.9
20%	80%	6.37	8.50	12.75	25.50	38.24	50.99	114.7
30%	70%	6.31	8.41	12.62	25.24	37.87	50.49	113.6
40%	60%	6.25	8.33	12.50	24.99	37.49	49.98	112.5
50%	50%	6.19	8.25	12.37	24.74	37.11	49.48	111.3
60%	40%	6.12	8.16	12.24	24.49	36.73	48.98	110.2
70%	30%	6.06	8.08	12.12	24.24	36.35	48.47	109.1
80%	20%	6.00	7.99	11.99	23.98	35.98	47.97	107.9
90%	10%	5.93	7.91	11.87	23.73	35.60	47.46	106.8
100%	0%	5.87	7.83	11.74	23.48	35.22	46.96	105.7
	#Cells	3	4	6	12	18	24	54

9.1 PRODUCT SPECIFICATION SHEETS

TABLE 10

Flooded Deep-Cycle Lead Acid Batteries		
6 VOLT BATTERIES	**8 VOLT BATTERIES**	**12 VOLT BATTERIES**
US1800 XC2	US8VGCE XC2	US12VE XC2
US2000 XC2	US8VGC XC2	US12V XC2
US2200 XC2	US8VGCHC XC2	US12VRX XC2
US125 XC2	US8VHATB XC2	US12VXZ XC2
US145 XC2	US 13-4-1 XC2	US24DC XC2
US RE GC2H XC2	US 15-4-1 XC2	US27DC XC2
US RE L16 XC2	US 17-4-1 XC2	US31DC XC2
US250E XC2	US 19-4-1 XC2	US185E XC2
US 250 XC2		US185 XC2
US250HC XC2	**2 VOLT BATTERIES**	US185HC XC2
US305E XC2	US RE L16 2V XC2	US8DHC XC2
US305 XC2		
US305HC XC2		
USL16E XC2		**12 VOLT SLI**
USL16 XC2		US 6TMF
USL16HC XC2		
US1HC XC2		
US100DIN XC2		
AGM Deep-Cycle Lead Acid Batteries		
6 VOLT BATTERIES	**8 VOLT BATTERIES**	**12 VOLT BATTERIES**
US AGM 2224	US AGM 8V170	US AGM U1
US AGM 2000		US AGM 24
US AGM 6V27		US AGM 27
US AGM 6V260		US AGM 31
US AGM 305		US AGM 12V140
US AGM L16		US AGM 12V150
		US AGM 12V240
		US AGM 8D

9.2 SHORT CIRCUIT CURRENT

Deep-cycle lead acid batteries are capable of delivering large amounts of current when shorted. It is for your own safety and the safety of your equipment that a short circuit breaker should be added to your system. US Battery recommends the following when determining the breaker size:

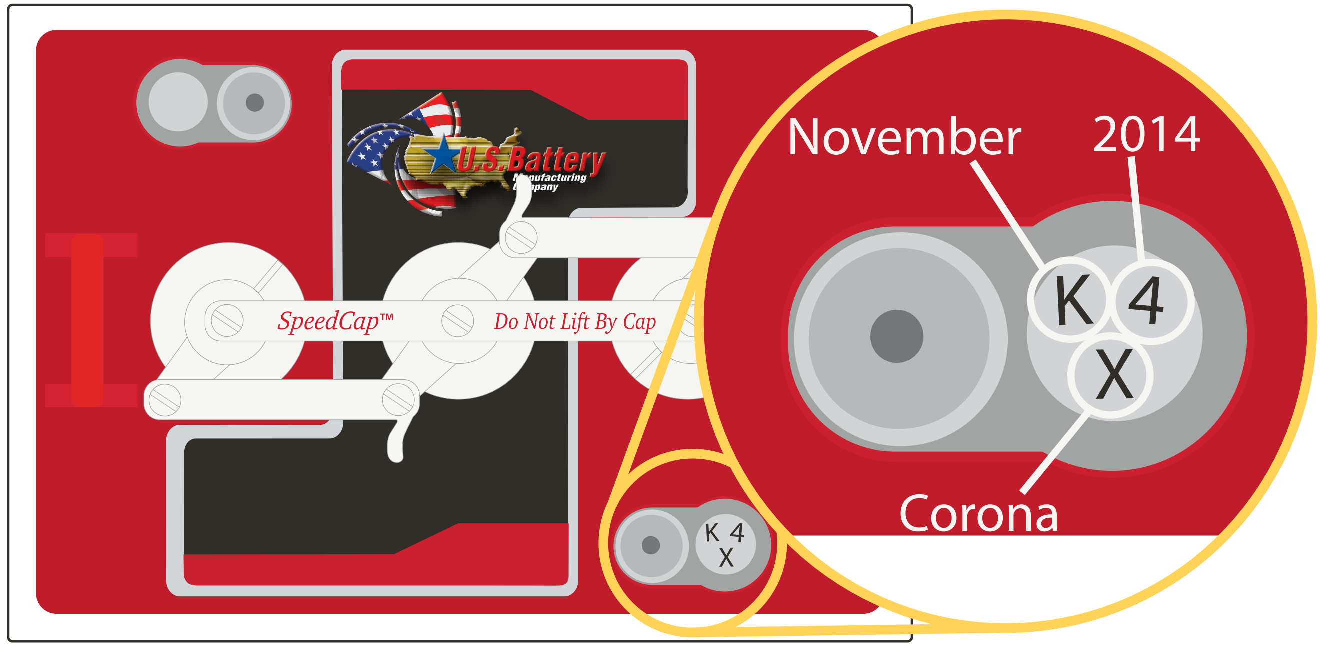
- **Determine your maximum current load.** Turn on all your auxiliary units and any high amperage equipment (Fridges, ACs, etc.)
- **Multiply the current load by 1.5.** The extra 50% will act as a buffer for current spikes or unexpected loads.
- **You now have the appropriate breaker size needed for your system.**

9.3 DATE CODES

Date codes are found on all US Battery products indicating the month, year, and factory that they were manufactured.

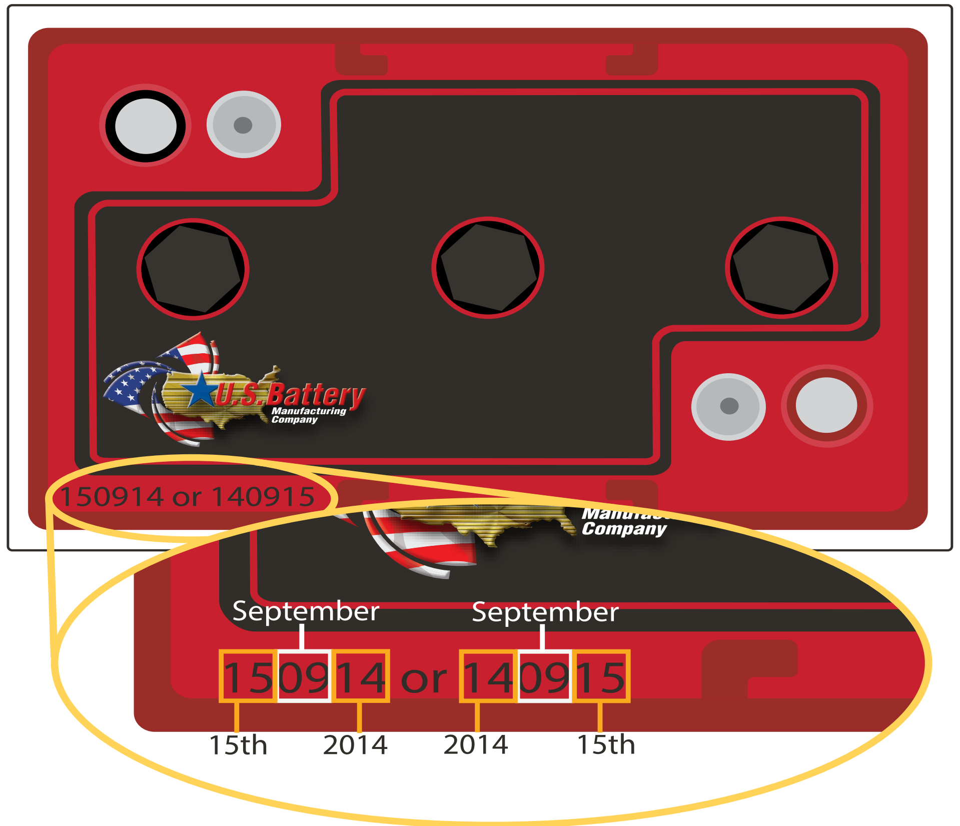
- **Flooded Lead Acid:** For flooded lead acid batteries, the date code is stamped on the positive terminal using two letters and a number. The first letter refers to the month it was manufactured: A-L refers to January – December. The number refers to the year in which the battery was made. For example: 2 would be 2012, 3 would be 2013, 4 would be 2014, etc. The last letter refers to the plant in which the battery was made. For example: X refers to Corona, Y refers to Augusta, and Z refers to Evans.

DIAGRAM 17



- **AGM:** The AGM batteries have a date that is laser etched into the cover of the battery. The date is written either in the format DDMMYY or YYMMDD. If the date code were to be 150914 or 140915, the battery would be manufactured on September 15th, 2014.

DIAGRAM 18



9.4 C-RATES

The capacity in amp-hours and/or runtime of deep cycle batteries varies with the rate of discharge. Battery ratings are often given in runtime at specified discharge currents but are also given in various discharge times usually referred to as 'hourly ratings'. This is often a more convenient method for sizing batteries to a desired length of runtime in an application. Hourly ratings are usually shown as 'C' followed by a number that signifies the number of hours used for the rating. For example, the 20 hour rating can be shown as C/20 or C20 or sometimes as 0.05C where 0.05 = 1/20. The notation with a number preceding 'C' is normally used for ratings that are less than 1 hour, for example the 30 minute (half-hour) rating could be shown as C/0.5 but is more conveniently shown as 2C where 1/0.5 = 2. The most common hourly ratings are shown in Table 11.

Note that hourly ratings are shown in amp-hours and hourly discharge rates are shown in amps. For example, a battery with a 20 hour rating or C/20 of 200 amp-hours would have a discharge rate of 10 amps (200 Ah / 20 hours = 10 amps). Similarly, the same battery might have a 30 minute or C/0.5 rating of only 100 amp-hours at a discharge rate of 200 amps (100 Ah / 0.5 hours = 200 amps). Note that both the runtime and the capacity in amp-hours decrease as the discharge rate increases. The rate of this decrease is often referred to as the Peukert number from the Peukert relationship developed by W.Peukert in 1897. Since the relationship is not linear, the ratings data are often plotted on a log-log chart.

Charging rates can also be given as an hourly rate or as a percentage of an hourly capacity rating. For example, a 200 Ah battery can be charged at two times the C/20 rate of 10 amps (2 x 10 amps = 20 amps) or at 10% of the C/20 Ah rating in amps (10% of 200 Ah = 20 amps).

TABLE 11

C-RATE EXAMPLE - US2200							
Ratings (amp-hours)	30 min	1-hr	2-hr	5-hr	20-hr	72-hr	100-hr
	110	133	152	181	232	252	258
C-rate (V.1)	C/0.5	C/1	C/2	C/5	C/20	C/72	C/100
1/(rating hours)	1/0.5=2	1/1=1	1/2=0.5	1/5=0.2	1/20=0.05	1/72=0.014	1/100=0.01
C-rate (V.2)	C0.5	C1	C2	C5	C20	C72	C100
C-rate (V.3)	2C	1C	0.5C	0.2C	0.05C	0.014C	0.01C

9.5 WARRANTY

U.S. Battery offers a specific limited liability warranty for each of its product lines. Because of differences in product design and use parameters in various applications, each product line has a different warranty policy. These can be found at:

- Flooded/Wet Deep-Cycle Lead Acid Battery Warranty
- Renewable Energy Deep-Cycle Lead Acid Battery Warranty
- AGM Deep-Cycle Lead Acid Battery Warranty

9.6 BATTERY WATERING SYSTEMS

US Battery recommends the following battery watering systems:

- BWT: Battery Watering Technologies
- Flow-Rite Controls

9.7 PRODUCT COMPARE

US Battery manufactures 6V, 8V, & 12V deep-cycle lead acid batteries in a variety of capacities and sizes: Product Compare

9.8 BATTERY DEALERS NEAR YOU

US Battery authorized distributors and dealers are found throughout the United States and around the world. Visit our distributor locator page to find one near you:

- United States & Canada
- The World

10 FREQUENT SCENARIOS

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

WHEN A CHARGE IS INITIATED THE VOLTAGE OF THE BATTERY BANK RISES VERY QUICKLY AND TRANSITIONS INTO THE ABSORPTION CHARGE CYCLE OR SHUTS OFF CHARGE COMPLETELY.

- If the batteries are not already fully charged, this can be an indication of sulfated batteries which may be causing a higher than normal internal resistance. Capacity of the bank will be reduced and can be confirmed by running a load test.
- An increase in bulk charge voltage and/or absorption time may be necessary to de-sulfate the battery bank. Increase bulk/absorption charge voltage in 0.05 volt per cell increments or increase absorption time in 15 – 30 minute increments as necessary.
- If the battery bank is heavily sulfated, an equalization may be necessary. Perform an equalization charge if specific gravity readings are <1.250 or vary by more than 0.015 volts between cells.
- Sulfated batteries may heat up more than usual. Follow the guidelines for controlling maximum charging temperatures.

BATTERY TERMINAL HAS MELTED

- This is most commonly caused by loose connections resulting in a high resistance connection. This resistance has caused heat buildup and melted the terminal connection.
  - Loose connections
  - Over-tightened connections
  - Improperly sized cables (too small) or cable/terminal connections not properly made.
  - Corroded connections
  - Improper use of washers/lock washers.
  - Too many connections on the same terminal
  - Discharge rates higher than recommended

BATTERY(S) TEMPERATURES ARE VERY HIGH.

- If at or near 50˚C (120˚F) shut off charge and allow batteries to cool to 32˚C (90˚F).
- If a single battery or cell in a string is hot, this may indicate a cell failure or short. Verify specific gravity for all cells and take voltage readings from each battery. Perform a load test to identify any cell failures and verify proper cell operation.
- Check for any loose terminal connections that may be causing excess heat.

SPECIFIC GRAVITY READINGS AT FULL CHARGE VARY SIGNIFICANTLY, (>0.015)

- This may be caused by multiple parallel strings of batteries in a bank, which often result in charge imbalance. U.S. Battery does not recommended that a system exceed 3 strings of batteries connected in parallel.
- Charge voltage may be too low. Verify they meet US Battery recommended charging parameters for Flooded batteries.
- An increase in Absorption charge time may be necessary. Increase in 15 to 30 minute increments as necessary.
- If specific gravity readings vary by >0.050 points then it is safe to assume the battery has a bad cell.

BATTERY CASES ARE BULGING ON THE SIDES.

- As batteries age, some bulging of the side and end walls caused by growth of internal components is normal.
- Due to the weight of electrolyte, some case bulging is normal with new batteries.
- Excessive bulging may be the result of operation at higher than recommended temperatures (>120ºF or 49ºC) or from prolonged undercharge causing excessive sulfation. This can cause permanent loss of capacity and shorten battery life.
- Severe bulging may be an indication that the batteries have been frozen. Freezing can do permanent damage to the internal components in batteries and could result in an exploded battery. Batteries that are frozen or have been frozen should not be used. See Section 5.2 for recommendations on how to prevent batteries from freezing.

CAPACITY(RUNTIME) OF THE BATTERY BANK HAS DECREASED.

- Capacity loss may be due to:
  - Sulfation of the cells. Equalize batteries until all cells have a specific gravity >1.265.
  - Overheating the batteries. Verify that temperature sensors are properly mounted and verify cell temperatures remain below 50°C (120°F) during charging.
  - Over-discharging the battery bank. Capacity of the battery bank may no longer support an increase in load.
  - Aging batteries. Towards end of life, batteries will slowly drop in capacity until only 50% of the capacity is usable. At this point U.S. Battery recommends battery replacement.
  - Consistent undercharging. Verify that your batteries are receiving a full charge using specific gravity readings.

SPECIFIC GRAVITY READINGS ARE CONSISTENTLY HIGHER THAN RECOMMENDED. (>1.300)

- Charging voltages may be too high and/or Absorption time should be decreased to prevent overcharge. Usage may have decreased, reducing depth of discharge (DOD and the time required to recharge, causing the batteries to overcharge.
  - Decrease bulk/absorption voltage in 0.05 volts per cell increments as necessary.
  - Decrease absorption time in 15 – 30 minute increments as necessary.

SPECIFIC GRAVITY READINGS OF ALL CELLS IN THE BATTERY BANK INDICATE LOW STATE OF CHARGE. READINGS VARY BY CELL, BUT <0.015 BETWEEN THE CELLS.

- Charging voltages may be too low and/or Absorption time may need to be increased to prevent undercharging. Usage may have increased, resulting in increased depth of discharge (DOD) and sulfation.
  - Increase Bulk/Absorption/Boost Voltage iin 0.05 volts per cell increments as necessary.
  - Increase Absorption Time in 15 – 30 minute increments as necessary.

MY BATTERIES ARE BOILING.

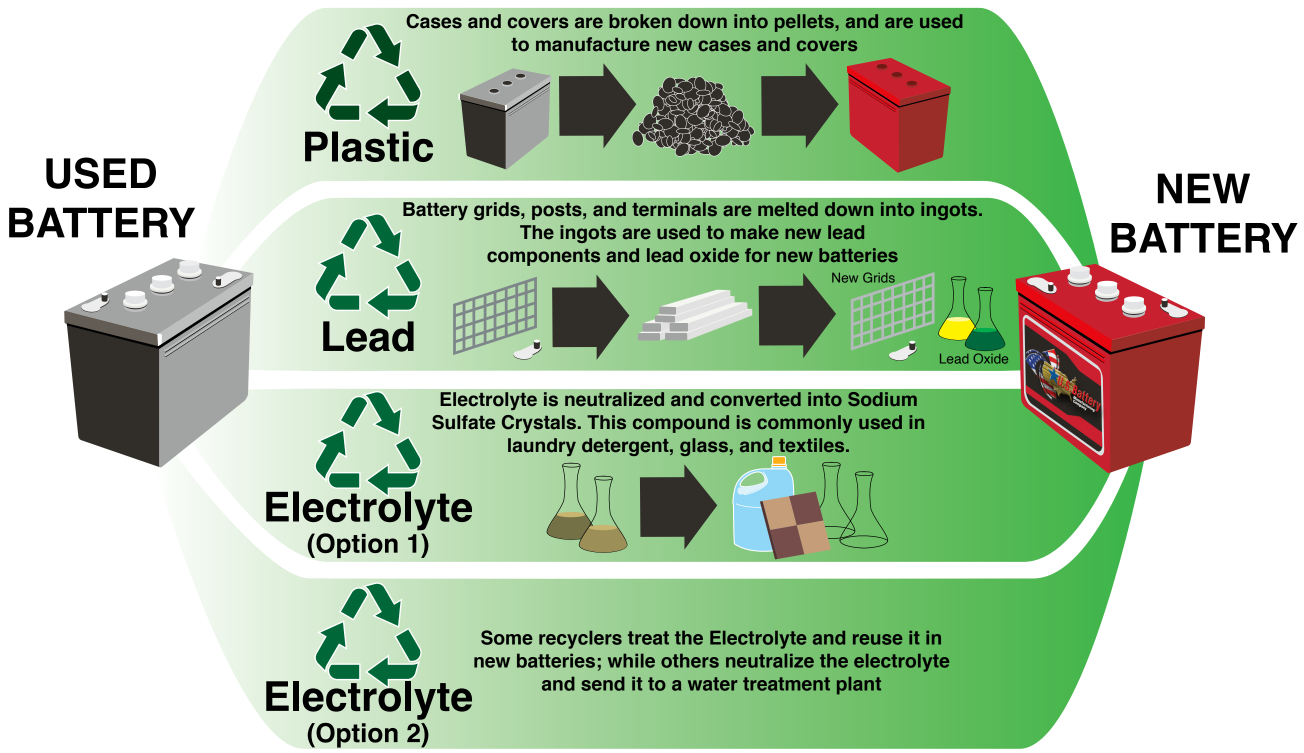
- This is called gassing and is a normal process when properly charging your batteries. As lead acid batteries recharge, the voltage increases to the point that electrolysis begins. Electrolysis is the separation of water molecules into its constituent parts, hydrogen and oxygen. The gasses travel through the electrolyte to the top of the battery cell where they vent to atmosphere. The movement of the gasses through the electrolyte gives the appearance of boiling. Gassing mixes the electrolyte achieving a homogenous acid solution. Proper electrolyte mixing is essential to the continued performance of your batteries.
- In severe overcharge, excessive gassing and water loss will occur. This will shorten battery life.
  - Decrease bulk/absorption charge voltage in 0.05 volts per cell increments as necessary.
  - Decrease absorption time in 15 – 30 minute increments as necessary.
  - Gassing can cause leaking to occur if the cells were overfilled. This will result in permanent capacity loss.

MY BATTERIES ARE LEAKING.

- Leaking is not normal and is typically due to overfilling the cells, but can also be caused by excessive overcharging. Both causes will result in permanent capacity loss if not rectified. Refer to the watering and charging sections for guidelines.

11 BATTERY RECYCLING

DIAGRAM 19



https://usgreentechnology.com/recycling-reusing-electric-car-batteries/

The following terms and abbreviations are used in this document as well as the battery industry:

AC – Alternating Current

AGM – Absorbed Glass Mat, a type of lead acid battery in which the liquid electrolyte is absorbed within a glass mat separator

AMP – Ampere, a measure of battery electrical current

Ah – Ampere-Hour, a measure of battery electrical capacity (calculated by multiplying amps x time)

CCA – Cold Cranking Amps, a measure of a battery's engine start capability at 0ºF

DC – Deep Cycle or Direct Current (depending on context)

DOD – Depth of Discharge, the amount a battery is discharged in % of capacity

dI/dt – The change in current over a given amount of time

dV/dt – The change in voltage over a given amount of time

FLA – Flooded Lead Acid, the most common type of lead acid battery

GEL – Gelled Electrolyte, a type of valve regulated lead acid battery in which the electrolyte is gelled

MCA – Marine Cranking Amps, a measure of a battery's engine start capability at 32ºF

OCV – Open Circuit Voltage

SG – Specific Gravity, a measurement of density with respect to water

SLI – Starting Lighting Ignition, a type of battery used for starting and lighting

SOC – State Of Charge

T – Temperature

UT – Universal Terminal

UTL – Universal Terminal Low

V – Volt, a measure of electromotive force

VPC – Volts per Cell, Number of volts for each cell (6 volt battery has 3 cells, 8 volt has 4 cells, etc.)

VRLA – Valve Regulated Lead Acid battery, a type of sealed lead battery using a pressure relief valve to control internal gas pressure

W – Watt, a measure of battery electrical power (calculated by multiplying volts x amps)

W-Hr – Watt-hour, a measure of battery electrical energy (calculated by multiplying volts x amps x time)

Watt-Hr per kilogram – Gravimetric Energy Density, a measure of a battery's energy per unit weight

Watt-Hr per liter – Volumetric Energy Density, a measure of a battery's energy per unit volume

XC2 – Xtreme Capacity 2, US Battery's proprietary paste formula

NOTES

NOTES

Data references within this publication are nominal and should not be considered or construed as maximum or minimum values for specifications or for final design. Data for these product types and models may vary from what is shown in this publication, and U.S. Battery Mfg., Co. makes No warranties, expressed or implied based on the data within this publication.

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