ELECTROLYTE MIXING PROCEDURES

Read instructions carefully and completely before proceeding. Please call with any questions- Steve at (406) 579-7777, or Hank at (406) 596-1022.

Things that will be needed:

1. A new, unused battery hydrometer
2. Distilled water
3. Mineral oil
4. Two plastic mixing buckets
5. Plastic PVC pipe for use as a stirring stick

Use only high-purity potassium hydroxide, containing less than the following:

Wt%	CO2	carbon dioxide	.12
Wt%	CL	chlorine	.002
Wt%	SO4	sulfate	.02
Wt%	CaO	calcium oxide	.003
Wt%	K2CO3	potassium carbonate	.50
PPM	KCI	potassium chloride	90 ppm

Always use consumable grade mineral oil of high purity (99% pure) to prevent carbon from passing through to the KOH and thus creating carbonate in the electrolyte. (Our potassium hydroxide is made with a non-mercury cell process.) High levels of these ingredients can lead to inefficiencies and carbonate formation.

Cautions:

1. Always wear protective gear for hands, face, and eyes. Wash completely for 15 minutes and contact a health-care professional if chemicals come in contact with eyes or skin.

2. Never add water to potassium hydroxide- it gets hot and splatters.

3. Always mix chemicals in a well-ventilated area.

4. Use plastic buckets, and use PVC pipe for stirring the electrolyte mix. EXAMPLE: Use a 5-gallon bucket and fill it with three gallons of distilled water. That bucket is placed inside a larger bucket, also filled with water to match the water level of the inside bucket. This is for cooling the potassium-hydroxide reaction.

5. If potassium hydroxide is not to be used immediately after receiving, it is important to store the chemical in air-tight containers to prevent carbon from reducing the electrolyte efficiency. Make sure the containers are clearly labeled with chemical name, date, and sufficient warnings.

Procedure:

1. You will need a 5-gallon bucket to use as the chemical mixing bucket, and a slightly larger bucket to act as the coolant tank.
2. Fill the chemical mixing bucket approximately 2/3 full with distilled water. Be sure to leave room for stirring and mixing.
3. Fill outside bucket with tap water for cooling to the same level as the mixing bucket. Do not allow the tap water to come in contact with the distilled water.
4. For temperatures between 70 and 140 degrees Fahrenheit, add potassium hydroxide to distilled water, stirring as potassium is being added. At this point, the electrolyte will warm. Specific gravity will be at 1225.
5. If temperature is 40 to 60 degrees Fahrenheit, mix to 1300 specific gravity.

Filling:

1. Connect all cells, positive to negative. Cells are 1.2 volts each in series for the desired voltage, and parallel in some cases. For example, ten cells in series is a 12-volt cell. We recommend using our copper connectors. If you make your own, be sure they have sufficient conductivity.
2. When all connections are made, remove the red plug and use a funnel to fill the jar 4 inches from the top. This will allow room for testing the system voltage, prevent leaks caused by overfilling, and allow room for mineral oil. (Note: extra electrolyte can be added to bring the level to 2 inches from the top after all system adjustments have been made as specified below.)
3. Add 1/4-1/2 inch of mineral oil. Mineral oil is very important to maintain the electrolyte efficiency by preventing carbonate absorption from the air that would reduce the battery capacity. A ZappStar 250 battery will take a minimum of 1/2 cup per jar, and a ZappStar 500 battery will take a minimum of 1 cup per jar.

NOTE: Sometimes it is hard to visualize the electrolyte level through the side of the battery jar. If this is the case, look in through the hole and fill the jar just to the top of the battery plates. When you can see the top of the plates, the electrolyte level is 2 inches higher than the level that will expose the active material on the plates.

NOTE: Batteries have plugs that pop off. DO NOT INSTALL TIGHT-FITTING PLUGS, as there is hydrogen present. The plugs/ watering caps that are provided are designed to pop out in the event of an explosion, preventing damage to the container. THE BATTERY JARS ARE NOT SEALED, as they are intended to be cleaned and are designed for stationary applications.

Charging:

For the 12-volt cell, the low charge is 15.5 volts, and the high charge is 17+ volts. Charging at the lower voltage will reduce the need for watering. The batteries will charge faster at the higher rate.

24-volt cell = 31V low, 34V high

36-volt cell = 46.5V low, 51V high

48-volt cell = 62V low, 68V high

With a charge controller, bulk can be set to the highest setting- 1.7V or higher per cell for a time, with floating at 1.6V per cell. Charging at the highest voltage is a huge advantage, but too long at a high voltage will cause foaming of the mineral oil. So, the length of time at these high voltages needs to be limited on bulk charge to prevent overflow leaking from the battery case. Normally, float at 1.6V per cell or lower.

Every system is a little different due to the vast varieties of equipment. The problem is voltage parameters. On any system with 1.65Vdc or higher, the following two steps apply:

Step 1- Determine the highest bulk voltage your equipment can produce. Charge at the highest voltage possible, watching the mineral oil level. It will foam as hydrogen and oxygen are formed. Determine the length of time and voltage it takes for the mineral oil to reach 1 inch from lid. This is the bulk voltage and time. Set your charging time to 20% less than this measurement. This will allow maximum absorption of power.

Step 2- If the outside temperature is colder, the batteries can be charged longer at higher voltages, as it will take longer for the mineral oil to start foaming. This can be noted for adjusting the system for the temperature change from summer to winter.

The fastest way to get started is to set the charge controller to 1.6V per cell bulk and float. Then adjust for fine tuning to maximize the potential of the batteries to your system. Call and we will be happy to help you in the fine-tuning of your system.

Overcharging or running batteries completely dead will not damage the batteries. Do not allow the water levels to drop below five inches from the top of the battery jar. A water level lower than five inches will expose the plates, reduce the battery capacity, and possibly allow carbonate to form in the electrolyte and on the plates.

The good news is, if capacity is reduced from exposure to carbonate, it can be remedied. First, pour out the electrolyte. Then fill the cell with distilled water and let it sit for 20 minutes. Dump out the water, and fill the cell with distilled water for a second time. Dump out the water again, and refill with new electrolyte.

It is important to stress temperature. The optimum temperature range for ZappStar batteries is 70 degrees to 120 degrees Fahrenheit. At colder temperatures the amperage will drop, reaching 50% of their rating at 40 degrees. Keep the batteries in a warm environment for best results. For an outside temperature of 60 degrees or less, a higher rate of potassium hydroxide is needed- mix to 1300 specific gravity.

We send the batteries to each customer with the dry plates exposed. In order to be shipped, the battery plates must be completely rinsed to remove all the potassium hydroxide. They can be left in this state in a dry environment without problems, as it is the electrolyte that deposits carbonate from the air onto the plates. Once electrolyte and mineral oil is added, it will be important to maintain the fluid levels.

The purpose of mineral oil is to form a barrier between the potassium hydroxide and the air. This prevents carbon build-up and formation of salt crystals, caused by potassium hydroxide combining with carbon molecules in the air, reducing the electrolytic nature of the potassium hydroxide. If mineral oil is not used, the electrolyte will need to be changed every 10 to 15 years. With mineral oil used in a stationary application, the electrolyte should not need to be changed in an average person's lifetime. In less technical terms, the mineral oil prevents contact with the air.

In times when the batteries are not being used (charged and discharged), disconnect power to the batteries. This will prevent water loss. If the batteries go dead, it will not hurt them. In an application when a continual charge is supplied to the batteries, such as hydro, a lower battery voltage could be used to reduce the need for watering. Each cell produces 1.38 to 1.40 volts. Any voltage above 1.40 volts per cell will start to charge the batteries. A higher voltage will charge faster.

When setting up a system on wind or solar, set the voltage as high as necessary to charge the system without using much water.
The following are key differences in our approach compared to lead acid systems:

1. Overcharging and/or charging too quickly can cause damage to lead acid cells. This does not happen with nickel iron batteries.

2. A 12V lead acid battery will read 13.0V when fully charged and over time the voltage will drop. With no load, the nickel iron 12V batteries will read 13.8V to 14.0V in either a charged state or nearly dead state. Under load the voltage drops to 12Vdc and slowly drops to 10Vdc. This drop in voltage determines when the batteries ought to be charged. For Hank's 12V system, he sets the back-up generator to turn on at 9.8Vdc and run for 5-10 minutes until the auto system turns off the generator at 16V. NOTE: The manufacture's charge and shut-down voltages are listed in the owner's manual. The batteries are capable of going lower than 10V. But because the typical inverter shuts off in the 10V range, the generator is set to turn on at just above the shut-off voltage. For example, if your inverter shuts off at a lower voltage, set the auto-start to turn on at 0.3-0.4V above

that. If your inverter shuts down at 9.5Vdc, set the auto-start at 9.8-9.9Vdc. This will allow for loads above the C5 rating to be picked up by the generator, and charge the batteries at the same time.

NOTE: Generators should have their own starting battery. Otherwise, the voltage drop on the main battery caused by the generator start-up will turn off the inverter. This will happen with any battery bank system that is not set up properly.

3. Lead acid batteries get weaker with use. Nickel iron batteries gain up to 30% more capacity with use.

Rating of batteries from the major suppliers is a shell game with the intent to make the user feel confident, while not knowing the issues. Three variables are necessary to have an accurate rating of the battery: (1) load, (2) length of time, and (3) voltage drop or cut-off voltage. It is common knowledge in the battery world that batteries are typically overrated. Zapp Works, on the other hand, provides accurate ratings based upon the battery pack and usage revealing how they are rated. Testing as a battery pack is more accurate than testing single cells. Single cells test higher individually than they do in a battery pack, because of internal losses. For example, a 750 amp-hour single cell would be equal to a 500 amp-hour battery pack. Zapp Works batteries produce ten times what they are rated, as explained in the 100-hour rate description below.

The Zapp Star 12V 500 amp-hour battery is tested at 5-hour rating. The question is, how much actual power does this provide? The Zapp Star battery pack (volts x amps = watts) is rated in kilowatts (kW). Zapp Works rates the batteries to be cut off at the 10V level, since most inverters cut off at 10V. A 20-hour rating will show much more than 500 amp hours. To figure a 100-hour rate, take the discharge of 60 watts run for 100 hours, equaling 6,000 watts or 6kW. However, discharge will continue past that length of time until the 10V cut-off is reached, yielding 60,000 watts or 60kW.

EXAMPLE: A 1.2kW discharge for 5 hours equals 6kW or 6,000 watts. The energy density at the 100-hour rate is 10 times that rating, equaling 60kW or 60,000 watts. (Most lead acid batteries rate at the 100-hour rate.) The 50-hour rate is similar in energy density to the 100-hour rate.

NOTE: The C5 rating is the max discharge rating of the batteries. Any discharges greater are limited to voltage drop below 1.0V per cell. This measure is used in system design and generator automatic back-up systems, for when heavy loads are placed on the batteries, keeping the inverter from shutting off due to low voltage.

NOTE: The perfect inverter system will have the following characteristics:

System	Cut-off Voltage	High-Charge Voltage
12Vdc	9Vdc	18Vdc
24Vdc	18Vdc	36Vdc
48Vdc	36Vdc	72Vdc

These voltages are not possible with all inverters. However, these numbers will provide the best results with ZappStar batteries. Please consult with us, as we have inverters, charge controllers, wind turbines, and much more to match your system and your needs.