Battery System Maintenance and Repair

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Good design and installation practices are essential to a well-functioning inverter–battery system, but that is only a start. This article will review the ongoing battery maintenance that is crucial to a system's longevity.

Adding Water

For flooded lead-acid (FLA) batteries, it is critical to check the electrolyte level on a regular basis. As batteries charge, some water in the electrolyte is converted to hydrogen and oxygen gas, and released through the vent caps. The electrolyte needs to be replenished to the proper level by adding distilled water.

In cool climates such as Washington State, a system with a moderate C/10 charge rate should be checked every one to two months. In hot climates like Haiti, the electrolyte level needs to be checked at least twice a month.

Recording the date and the amount of water added to the battery allows you to identify usage trends and spot potential problems. Batteries in hotter climates will use more water than ones in cooler climates, as will systems with heavy discharging and higher charging rates. When a battery starts requiring more water, it is typically a sign that it is failing—or that something has dramatically changed in the charging or load profile. Keeping track of the changes in water consumption will help determine when it's time to replace the battery or investigate other problems.

The correct electrolyte level is usually about 1/4 inch below the vent tube. Adding water to a battery cell should be done only after charging the battery to 100% or after an equalization charge has been completed. However, if the plates inside the battery are close to being exposed (which can cause permanent damage to the battery), add enough water to keep them covered before recharging. However, be careful not to overfill during recharging or equalization. Otherwise, the electrolyte can overflow, making a hazardous mess. Losing electrolyte and replacing it with distilled water results in dilution, effectively reducing the battery's capacity and, therefore, its performance. Automatic watering systems and recombination caps can reduce the time required for refilling batteries. However, most of them require removal before doing an equalization charge on the batteries.

Cleaning Battery Terminals

Corrosion can occur on and between the cable lugs and the battery terminals, creating higher resistance that impedes the flow of current when charging or discharging. Corrosion can also occur between battery terminals and the metal casing of the battery rack, potentially resulting in ground faults and creating a shock hazard.

If even only one terminal has corrosion, the high resistance on that series-connected string of batteries will result in less charging and discharging. Specifically, the other battery strings will compensate for the loss of total capacity, and be charged and discharged at higher rates. This will create imbalances within the battery bank, reduce system performance, and decrease the life and performance of the entire battery bank.

During the monthly inspection, check all battery connections for corrosion. If there's a metal rack or enclosure, also check for corrosion between the terminals and the metal. If caught early, it can be removed with a wire brush without much effort. If excess corrosion is found covering the terminal and hardware, shut down the system by removing all charging and discharging connections from the battery, disassemble the battery hardware and cables, and thoroughly clean the terminal, hardware, and cable lug. A baking soda and water mixture can be applied to the corroded areas, which can then be scrubbed with a wire brush. However, be extremely careful that none of the baking soda mixture gets into the battery cells, as it will neutralize some of the electrolyte, reducing the battery's performance. Finally, rinse all of the baking soda off with clean water and dry with a clean rag.

Before reconnecting the battery cables, wire-brush the terminals until the lead is shiny, tighten the connection, and then cover the terminal and cable with an anticorrosion coating the best is a spray-on type that dries upon contact.

Common petroleum jelly can also be used, but it can attract dust and dirt, and will be a sticky nuisance to deal with when checking the terminals for tightness.

Checking Connections

The bolt and nut connection needs to be tight enough to fully compress the split-type lock washer (which should always be included, along with two flat washers). The bolt should be tight enough that the cable lug cannot be moved on the terminal when pulled. Battery manufacturers will specify torque values for their terminals. Typical torque levels for 1/4-inch hardware is 6 foot-pounds; for 5/16-inch hardware it's 11 foot-pounds. Be careful when using metal wrenches on the battery as it is very easy to accidentally cause a short circuit to adjacent terminals. Using specially made, insulated tools or, at the very least, wrapping the handle of the wrench with insulating tape, is highly recommended. Some tips for making battery connections are:

- Always use stainless-steel hardware to connect cables to terminals.
- Always clean the terminal posts and cable lugs so that they are shiny prior to installing the connections.
- Always include flat washers to prevent the bolt and nut heads from digging into the soft lead terminals and copper cable lugs (but do not place them between the cable lug and the battery terminal).
- Always include a split-type lock washer to help keep the bolted connection tight.
- Always use an anticorrosion coating over cleaned connections, and reapply the coating after retightening or replacing cables.

Recharging & Equalizing the Batteries

One of the most critical factors in maintaining good battery health is regularly charging the battery to a full state of charge. Ideally, this should be done once a week.

No matter the cause, an undersized PV array, running excessive loads, or not having a secondary energy source for extended cloudy periods—undercharging batteries can permanently harm them over time. When batteries are not fully charged, sulfate crystals form on the lead plates' surfaces. This reduces the contact area between the lead and the electrolyte, decreasing the battery's capacity. Sulfate crystal buildup can become an irreversible condition that will worsen until the battery is unusable.

An intentional overcharging, called equalization, helps remove the sulfation from the battery's plates. Equalization charging is a process where the battery is intentionally overcharged to bring weaker cells up to parity with stronger cells and should only be done with FLA-type batteries (NOT AGM BATTERIES). During equalization, the battery's cells will gas vigorously, mixing up the electrolyte and eliminating stratification. Most sophisticated inverter/chargers and PV charge controllers have an equalization function, which allows the charging source to charge the battery for a timed period and achieve a preset, high-voltage set point. During equalization, closely monitor the electrolyte's level and temperature, and be prepared to shut down the charging when the equalization is finished or if the temperature exceeds 125°F (52°C).

During the monthly or quarterly maintenance checks, measure and record the battery's voltage and each cell's specific gravity. A SG difference of 0.025 or higher between cells indicates an equalization charge is needed. To perform an equalization charge on an FLA battery:

- Draw a diagram or label each battery cell with a reference number.
- Charge the batteries through the bulk and absorb stages before starting the equalization process.
- Measure and record the voltage and SG of each battery and cell.
- Choose the cell on each battery string with the lowest SG reading as a pilot cell—these will be the cells tested to determine when equalization is complete.
- Check the electrolyte level in each cell to make sure the battery plates are covered.

- Initiate the equalization charge.
- Check and record SG readings of the pilot cells every half hour.
- Check electrolyte levels to ensure that they never fall below the top of the plates.
- Check temperatures of the batteries' electrolyte every 30 minutes to make sure it never exceeds 125°F (52°C). Stop equalization if this temperature is exceeded.
- Stop equalization when the SG reading in the pilot cells stays constant for three readings.
- Water each cell to 1/4 inch below the vent tube and replace the caps.

Not all users will want or be able to check the electrolyte's SG on a monthly or quarterly basis. A more general method is to set predetermined routine equalization maintenance on a monthly, quarterly, or biannual basis without checking either voltage or SG. To keep it simple once the equalization process has started, charge time can be set depending on the battery bank and charger's size, and how often the batteries are charged to 100%. The amount of time typically will range from two to five hours.

Daily Monitoring

If it's your first time dealing with a battery-inverter system, it will take some time to understand the ebbs and flows of the system's readings in a "normal" day of charging and discharging, and recognize if something is wrong. Checking the battery's voltage and state of charge every day can provide a valuable orientation to the system, you'll begin to understand what is (and isn't) normal.

Monthly Maintenance Checklist

Using a monthly battery-inverter maintenance checklist can help you stay organized and help you pinpoint recurring issues with your battery system.

- Battery/Inverter:
- Clean corrosion from battery terminals and cable ends.
- Clean tops of batteries.
- Clean the inverter fan filter.
- Check electrolyte levels, and add water if necessary.
- Keep track of water additions—an increased need for water may indicate increased cycling or a failing battery.
- Check to see if surge (lightning) protectors are intact.
- Check inverter(s) for error and event indicators.

Battery Temperature Sensor — Each month, visually inspect the battery temperature sensor (BTS), its cable, and its connection to the inverter:

- Check the adhesion of the sensor on the battery case.
- Verify that the sensor is in the proper place on the battery's side.
- Verify that the sensor is in an interior location in the pack or enclosure.
- Check for breaks, nicks, or tears in the cable from the BTS to the point of connection at the inverter or charge controller.
- Make sure the BTS cable's inverter connection is not damaged or corroded, and that its protective insulation is still intact.

- Verify that there's no dust, dirt, corrosion, or insects in the BTS's connector at the inverter.
- Verify that the BTS is connected to the correct inverter.
- Verify a reasonable battery temperature is displayed, based on ambient or battery temperature.

Common Battery Problems & Solutions

The battery bank has a mixture of strong and weak individual batteries, and is close to the end of its life. Group the strong batteries in one string and group the weak batteries in another string. This will ensure a more even charging and will allow the strong batteries to contribute more when the system is discharging.

One cell or battery has a low voltage and a low specific gravity. Remove that cell or battery and charge it separately using a power supply or battery charger. Another option is to equalize the entire bank, but this may require too much time and can put a lot of stress on the good cells in the battery.

A battery is requiring frequent watering. When there is a failing battery or cell, the "good" cells in the battery string will become overcharged and will often require more frequent watering compared to the rest of the battery. The damaged cells cause the other good cells in the battery to be overcharged. Investigate the entire battery bank to identify which cells are having problems.

One failed cell. If the battery bank is in good overall condition (verified with voltage, specific gravity, and load testing) and is less than two years old, replacing just the failed cell or battery can be a viable option. Be sure to fully charge the new cell or battery before adding it, and check all of the cells frequently to ensure that there is not a problem with the new cell or battery becoming out of balance with the others. In an older battery, a failed cell or battery indicates that the entire battery is at the end of its life and needs to be completely replaced.

Poor crimps on cable lugs or loose connections on battery terminals. Loose connections or poor crimps on cable lugs will cause high resistance. This causes the battery's voltage to appear higher when recharging, resulting in the charger shutting off before the battery is at a 100% full level. It will also cause the voltage to appear lower when the battery is discharging; resulting in the inverter shutting off earlier than it should when running loads. Check that all the cable lugs are properly crimped and that all the connections are tight.

Access

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