Quick Primer on Battery Bank testing re: NERC for US power utilities Rev 1

For ProgUSA technical sales force use to understand battery bank testing basics and history thereof, and NOT to be used as an official document. A reader should download the latest doc from NERC to be fully aware. http://www.nerc.com/files/PRC-005-2.pdf

NERC guideline PRC-005-2 came into being an official guideline about April 2015, and NERC will be ensuring US generating utilities follow it. -2 version covers station batteries and relays which is our main interest here. -3 adds automatic reclosers, -4 adds sudden pressure relays, -5 deals with Distribution generation and those versions are being adopted later in 2015-16.

There are 3 different battery types used in power utilities in the USA.

1. Flooded lead acid , FLA, (aka VLA, for vented lead acid, usually lead calcium although some lead antimony exist). These cells can have life of 30+ years and are widely used. Tried and true but do need maintenance with minimum or visual check for electrolyte levels and leaks.
2. VRLA (valve regulated lead acid). These cells have a life of about 12 years max. and were the latest thing about 10 years ago and are slowly being obsoleted today with the traditional lead acid cells. They have an advantage of less maintenance and better temp tolerance but lifetime is now a show stopper for new buys.
3. NiCad (sealed with liquid electrolyte inside). Some utilities have used these in warmer climates in certain geographic areas due to better resistance to heat. But other Nicad advantages of ruggedized for mobile application and high short term current haven't been so strong an advantage, so these are losing popularity in new utility buys. Their life is shorter and testing is not as simple as noted below.

Cell and block notes: In FLA and VRLA a cell is always 2.1V nominal and in Nicad is 1.35V. Larger FLA have one cell per block (plastic container) and one + and one – terminal. Some configs can have 3 cells per block with either one + and one – or actually 3 + and 3- terminal. A 12V automotive battery as you all recognize, has 6 cells and only 1 + and one – terminal. A string of 10 x 12V auto batteries can be used as a decent portable back up battery in a truck or trailer, or 2 of these 10 block strings paralleled for more Ampere Hours. The trailer with these batts plus a charger, can be used as a temporary replacement bank as a discharge test (mentioned below) is done.

FLA and VRLA have a 'float' voltage of about 2.2V per cell and this is continuously 24/7/365 applied via a charger as long as the charger has AC power in. So 60 cells sit at 60*2.2 all day long = 132V, but when energy is needed 60*2.1V is the design rated bank supply of 126V. There is also an "Equalize" voltage which is about 2.35V per cell and is applied as selected on the charger about once per 6 months or once per year. The theory is that equalize can 'burn off' some deposits on the plates and re-juvenate an aging cell. Most chargers will have setting to equalize for certain time and then auto step back to float mode. Battery strings (aka banks, aka plants) should **never** be left on continuous equalize!

TESTING according to NERC of above 3 types is as follows:

1. **FLA (VLA)** must be ohmic (intercell, i.e. cell strap resistance of few micro-ohms) tested every 18 months or either ohmic (internal) every 18 months or discharge tested (aka load tested, aka capacity tested) every 6 years.

If this is a new battery the 18 months impedance (better nomenclature as ohmic testing, as PRC-005 is not specific (yet) if DC resistance test, AC impedance test or AC+DC resistance/impedance test, and all 3 test modes can be different values of ohms) can be a test to satisfy NERC. BUT consistency of testing types and trending is the key here. Also the current at which ohmic tests are done is also not specified or how long that current is taken from the battery bank. Most use between 20 and 60 Amps, from 100 msec to 500 msec to 2 minutes. Hence the sales and application arguments begin amongst different ohmic test set vendors. Trending over months of life is the key with ohmic testing. Ohms tend to rise during aging, although a significant drop in ohms implies internal shorts in the cell. A typical number here may be 5 milli-ohms per cell. And battery manufacturers have trouble making consistent ohmic values per cells, hence the reason for trending.

If this is an aged battery, say 7 years old, a baseline ohmic vales per cell, needs to be established and this is not clear in PRC 005. So a recommendation is to do a discharge test to ensure all cells are healthy and deliver rated A-H power and then do the first ohmic test when charged back up. Time for discharge test is another variable and an obvious A-H test would be 8 hours since most battery ratings or model numbers are based on an 8 hour discharge rate. So now practically a 3 to 5 hour test makes sense to fit in an 8 hour work day, and some do only 1 hour. Each battery has a spec sheet and a discharge chart that shows how many amps need to be pulled via a load unit for a certain number of hours. Adjusting the AMPS draw rate and time can help one select the best load unit to buy and use. For example if a 3 hour test needs to pull 150A, and the main load unit has a limit of 130A at 125V (DV Power BLU200A), then a slave load unit (BXL) can be added to the main BLU 200A to absorb the extra 20A to get to 150A.

2. **VRLA** must be either ohmic tested every 18 months for intercell and internal ohmic values, plus every 6 months internal ohmic tests or discharge tested (aka load tested, aka capacity tested) every 3 years.
3. **Ni-Cad** must be only discharge tested every 6 years. Ohmic testing is not accepted for NiCad's

IEEE battery testing guidelines are similar to these NERC guidelines with every 5 years for discharge testing instead of 6, and have been established for the last 5 years or so. IEEE 450, 1188 and 1106 are guides for FLA, VRLA and NiCad.

Wise Diagnostic suggestion: If one wants to only satisfy NERC, do the impedance testing for FLA and VRLA and don't worry about recharging a drained battery caused by discharge testing. BUT if one wants to prove the energy is really in the battery bank then a discharge test is the ONLY way to prove it. Most Battery experts agree with this and many pro-active utilities practice this. And then if one is interested in finding weak cells, use a cell by cell scanner (DV Power BVS) during the discharge test to find the weak cell(s). The combo system of BLU and BVS make a good comprehensive diagnostic tool here.

And since a discharge test will take most of the energy from a battery bank, one should not leave the battery right after test without charging it back to xx% capacity. So what users do is have a portable standby battery bank that is connected as the tested bank is disconnected for discharge, and that way the standby can carry the critical DC load during recharge of the tested battery bank,, or they have dual strings installed permanently where one can carry the critical

load if main AC failure happens,, or they wait on site for a charge up to occur. In the UPS battery world, dual strings are common.
Another discharge test tip is have the utility's battery engineer agree on say a 1 hour test at a 3 hour test rate and if all batteries hold their voltage above the low threshold, usually 1.75V, it's a satisfactory load test. This allows a 'pseudo' discharge to be done and with the practical reasoning that most energy is drawn from a bank in the first 10-20 minutes of discharge (tripping breakers and reclosers and powering relays, etc) and only needs maybe 20% of battery capacity. And in that 1 hour discharge, a defective cell(s) will usually drop and be obvious if seriously defective.
Note: stopping a test when cell reaches the minimum of 1.75V is good practice and NERC gives you 5 minutes to strap out that weak cell and continue the test. If longer than 5 minutes, NERC says to recharge and restart the test. Some will agree that as long as you don't go into a negative voltage on that cell, it doesn't damage the cell or the string. This 'zero V minimum' would be a battery supplier or utility engineer's decision.

<u>Old tales and accessories:</u>

1. Load testing kills a battery string faster than no testing. FALSE. FACTS are: This is from the days when discharge test persons using older simple resistive load banks, would try to drain the bank down to zero and some cells may even go –ve V. –V certainly damages the cells and possibly the adjacent cells in the string.
   Modern load test sets have string voltage minimum setting, to STOP discharge, and by adding the cell by cell monitor, a discharge can be stopped when a weak cell gets down to a serious low value. Batteries are designed for multiple discharges and usually the number of discharge cycles is specified in the few 000's, mostly depending on temperature. Thus the ideal battery test system is a modern load test set with a cell by cell scanner system sync'd.
2. A note on specific gravity. This number can vary for different batteries for different end voltages. A very common number here is S.G of 2.15 for an end voltage of 1.75V. When batteries first started to be tested many years ago there was only discharge testing and specific gravity testing. S.G is a chemical test of the electrolyte where a sample is extracted and run through an electronic measuring device. Anton Paar is a popular manufacturer of these measurement devices. Certain ohmic test sets today still interface with this accessory (about $4500) to capture Ss.G. numbers. Specific gravity use has faded in recent years giving way to the easier ohmic testing. NERC does not specify s.g numbers or test regularity of it.
3. Thermal imaging is an accessory test that is becoming popular but a static battery on float may not show a problem thermally, but when under load test of heavy discharge, the possibility of finding a heat problem improves, such as loose intercell strap, with this tool.

   A. Source notes: Original primer doc from K. Etherington and engineer in sales support of ProgUSA LLC based in Orlando FL., from notes taken during attending multiple Battcon conferences held annually in FL in May, and speaking with various US utility battery maintenance personnel and demonstrating various ProgUSA battery test equipment over the past 10 years.