12-Volt Module Battery Testing

Application Note BT9911

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INTRODUCTION

Twelve-volt module batteries are presently being used in large numbers and have become popular for the following standby applications:

- Substations
- Telecommunications (outside plants)
- Cellular Sites
- UPS

The primary reason the 12-volt module battery has become popular is cost. Unfortunately, most users do not realize they are trading low cost for quality and are sacrificing system reliability. Twelve-volt VRLA modules do not have a good performance record; in fact, the expected life of these modules is less than five years, and some experts believe the reliable life is only two years. Flooded 12-volt modules are typically used in cycling applications only and are not generally found in standby applications.

TESTING - GENERAL

Twelve-volt module test and maintenance requirements are the same as for 2-volt cell testing, and a conscientious maintenance program should be patterned after IEEE Standard 1188.

Testing 12-volt modules represents a special challenge, since there is no access to individual 2-volt cells. This means that the performance of the module is only as good as its worst cell. Detecting the problem of one single cell in a group of six is possible, but with reduced resolution. Early detection of problems is much more difficult in battery strings that utilize 12-volt modules.

INTERNAL RESISTANCE MEASUREMENTS

Today, the general consensus is that internal resistance measurements are very useful in detecting internal cell problems. In 12-volt module testing, these measurements are useful, but they do not offer the same early warning that can be achieved with single 2-volt cells. This is because all six internal resistances and their associated intercell connection resistances are in series, and the module resistance measurement is the algebraic sum of all these resistances. Thus, if one cell deteriorates to 50% of capacity before the rest, it will not have a major impact on the total module resistance.

The following example illustrates the problem:

- Assume a typical 12-volt module, where the individual cell resistance plus its associated intercell have a value of 500 microhms for known good 100% capacity cells. The total resistance for a good or baseline module is, therefore, 3000 microhms.

- If one of the cells deteriorates to approximately 50% of capacity, its resistance will increase to approximately 750 microhms. This then makes the total module resistance 3250 microhms.

- The total module resistance increase is 250/3000 = 8.3%.

- The present criteria for detecting 2-volt cells below 80% of nameplate rated capacity is: a resistance increase of 25%. If this is applied to the 12-volt module used in this example, the module resistance would be 3000 x 1.25 = 3750 microhms.

- If the entire increase was due to one faulty cell, that cell resistance would have increased to 1250 microhms. This 2.5 times increase in a single cell means the cell has practically zero capacity and would go into polarity reversal as soon as a load was applied to the module.

It is this author's opinion that 12-volt module resistance testing should use a 10% to 15% increase as a criteria for either replacement or further testing, with the only logical testing choice being load testing. The 10-15% criteria will only work well if good baseline information is available for all modules being tested. In some instances, modules of greater than 80% capacity may be replaced prematurely, but this is better than leaving a faulty module in service.

The 10-15% criteria is necessary for VRLA batteries because the cells within the module do not normally deteriorate uniformly. The increase in module resistance is typically due to just one bad cell, and the safest practice is to assume this is always the case.

As a point of information, some battery manufacturers record cell/module resistances at production testing. The typical resistance spread for all new known-good cells/modules (the difference between the highest reading and lowest) is 9% to 10%. Present production methods cannot match the cells any closer than this, and it is necessary to define baseline value as the highest resistance in the production spread.

Many users today rely on Albércorp to supply baseline readings, and we are constantly adding new values to our database. The best way to obtain baseline data is to record readings from different strings that use the same model cells/modules, and then capacity test some of the higher resistance reading cells/modules along with some of the lower reading ones. Take the resistance of the higher reading units that test for capacity at 98% or better and use this resistance value as baseline.

CAPACITY OR LOAD TESTING

Capacity testing 12-volt VRLA battery modules is as uncertain as resistance testing, in that it is difficult to know when a module is going to fail. Resistance testing should be performed before capacity testing, and the results should be used as an indicator of possible problems. Since it is very likely only one of the six cells in the module is defective or low in capacity, it is impossible to know when that cell is going to fail during a load test. When the cell fails, it will most likely go into reversal without warning, and that module will have to be replaced.

Capacity testing is necessary to maintain a reliable system and should be performed regularly. (According to IEEE Std. 1188, it should be performed annually.) How a problem cell/module behaves during a capacity test is a function of the failure mode. If the problem is a high metallic resistance due to a negative lug rot problem or other conduction path problem, then the terminal voltage of the cell/module immediately drops below that of the normal cell/module as soon as the load is applied. In this case, there is early warning that this module will fail. Of course, how badly it fails depends on the test current: the higher the current flowing through a high resistance, the more obvious the problem.

If the problem is electrochemical in nature, such as dryout, then the terminal voltage will appear normal up to just before the failing cell goes into reversal. The reversal process is impossible to detect ahead of time, and it occurs with little or no warning because a moderate dryout failure (cell capacity of 50-70%) has very little impact on cell/module resistance. The terminal voltage of the module, therefore, does not have an unusual depression when the load is first applied.

Albércorp therefore recommends the following:

- Capacity test all critical 12-volt module systems per IEEE Std. 1188.
- Stop the test after the system and all modules have passed with a result of 80% capacity. This proves the system will perform its intended mission and will not expose any good modules to the possibility of a cell reversal.
- If a module fails during the test before the 80% percent point has been proven, replace this module immediately. Replacing the module now reduces the worry of having a module fail due to a single cell going into reversal without warning. Detecting a problem before the 80% point means you were fortunate enough to identify a reliability problem before it could harm the system.

Stopping the test at the 80% point means capacity versus life trending cannot be done. This may be of some concern, since this is an important function used in flooded battery testing to predict end of life. It should be recognized, though, that flooded batteries normally die of positive grid corrosion, a process that takes approximately 20 years for a well maintained lead calcium battery. VRLA batteries do not live long enough to die of normal aging and are, therefore, impossible to trend anyway.

CONCLUSIONS

It is important to recognize that 12-volt module VRLA batteries are inexpensive, low reliability solutions. The only way to achieve any degree of system reliability is to maintain and test these systems per IEEE Std. 1188. That includes periodic resistance and capacity testing.

Knowing that these batteries do not have long life and can fail abruptly, it is a must for the user to have spare batteries available. These spares must be kept in a cool, dry environment and kept on a stable float voltage that meets the manufacturer's recommended value.

RECOMMENDATIONS

- Avoid the use of VRLA batteries in critical applications that cannot tolerate a failure.
- If VRLAs are chosen, then use two or more parallel strings to improve system reliability.
- Use individual 2-volt cells if space permits. This will simplify testing.
- Test any VRLA system per IEEE Std. 1188. If this program is deemed too time intensive, then install a monitor system that automatically performs proactive resistance testing. Internal resistance of VRLA cells/modules can change from the normal range to a failing value in three to four months.