Battery Monitoring: Doing it Right

Application Note

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INTRODUCTION

Battery monitoring has finally started to attract some attention, twenty years after the concept was originally introduced. It sure took a long time to convince all those people that believed that a bulb hydrometer was all they needed to determine a battery's state of health!

Once a concept has been introduced and is proven popular, it does not take long for new products to follow. Today, we are seeing an influx of monitors that range from a full function, sophisticated, computer-driven monitor to devices that only monitor one single parameter. This leaves the user with the dilemma of choosing the right one from all those clever ads that proclaim the best product on the market.

SELECTION PROCESS

Selecting the right product is actually quite simple. First, list the main objectives that must be achieved by the monitor system, then look at the available offerings and see if they meet the requirements.

WHY MONITOR?

The main reasons for monitoring are:

1. Increasing system reliability.
2. Effecting cost savings by reducing maintenance hours and optimizing battery life.

INCREASING SYSTEM RELIABILITY

Remember, the reason the battery was installed in the first place was to increase system reliability. Also remember that the battery is the weakest link in the backup system chain and, therefore, requires a substantial amount of maintenance. Refer to IEEE 450-1995 and IEEE 1188-1997 for recommended maintenance and testing of large storage batteries.

HOW IS A BATTERY'S RELIABILITY INCREASED?

The reliability of a battery is increased by detecting developing cell or module problems before they cause a system failure.

HOW IS EARLY DETECTION ACCOMPLISHED?

Early detection is accomplished by monitoring all the important parameters on a continuous basis and performing periodic proactive tests.

A few problems that develop slowly, such as float charge problems and internal shorts, can be detected by voltage measurements alone. However, the main problems that lead to abrupt interruption of power or a serious loss of reserve time can only be detected by proactive testing. The only viable tests recommended by the IEEE Standards are capacity tests or an internal ohmic measurement of each cell/module.

Both of the above tests/measurements have been field proven for many years and require no further justification. However, it should be pointed out that the expense of building a complete battery capacity test system into each monitor site is probably cost prohibitive.

The answer, then, is to select a monitor that performs periodic internal ohmic tests and supports a capacity test using system load or portable load banks.

EARLY DETECTION

The only proven way to detect a developing problem in the early stages is to perform a periodic test that measures both the internal resistance of the individual cells and the resistance of the intercell connections.

Problem detection should be at a point where the cell is just below the capacity level required to perform its intended mission. The closer to 80% of nameplate rated capacity this can be done, the better. Remember that batteries are sized to fulfill their mission at 80% capacity. A realistic early warning level for a failing cell is somewhere between 60 to 80% of rated capacity. This level will yield a high degree of reliability.

EFFECTING COST SAVINGS

LABOR SAVINGS

The industry expert's (IEEE Standard's Battery Working Group) recommended practices for maintaining and testing batteries require monthly, quarterly and annual visits to perform certain tests and measurements.

The estimated hours spent to perform these maintenance routines in a typical substation or four-string central telephone office environment are as follows:

Quantity and Type of Inspections	Substation Hours	TELCO Hours
8 – Monthly	16	20
3 – Quarterly	12	16
1 – Annual	5	7
Total Time (Hours)	33	43

UPS installations require considerably more time than this. The above estimates include a one hour drive time round trip to each installation.

A full function monitor will relieve the user of all the work except (annual) watering and the annual visual inspection. Even if the maintenance program only spent 60% of the above hours, considerable savings could be realized with an installed monitor.

At a hourly rate (including overhead) of $50 per hour, cost savings of anywhere from $1,000 to $1,300 can potentially be realized.

OPTIMIZED BATTERY LIFE

A good quality flooded battery should realistically last 20 years when properly cared for, and a good quality VRLA will realistically last 7 to 8 years. A lot of users are realizing only 60% to 70% of this life because of improper charging and lack of proper ambient temperature controls.

Savings of several hundred dollars per year per string can be realized by maintaining proper charging and temperature controls.

BATTERY TESTING

No one that is concerned about system reliability would ever install a new or replacement battery without acceptance testing it before placing it into service. This type of test can cost from $800 to $4,000, depending on the size of the battery and the test service company that performs the test.

In addition to acceptance testing, the IEEE Standards (450 and 1188) also recommend at least five or more capacity tests during the life of a battery.

Although a monitor does not normally include a load bank, it can still save at least half the cost of the typical test by providing the data logging function during the test.

COST SAVING SUMMARY

All of the above savings equate to at least $1,500 per year per flooded battery at substation and central office TELCO installations. Cost savings are even greater for VRLA strings and large UPS systems, regardless of battery type.

LOOKING AT THE OPTIONS

To keep this discussion relatively brief, the various monitors available today will be grouped into the following four categories: single parameter monitoring, voltage monitors, voltage monitors with voltage management, and full function monitors.

SINGLE PARAMETER MONITORING

The monitors in this category include the following:

- Midpoint voltage monitors
- Midpoint conductance monitors
- AC ripple current monitors

All of the above monitors are basically open circuit detectors that detect problems at a point just before one or more cells are outright failures. These monitors would at best detect a string problem somewhere between 0 to 40 percent of capacity. Is this really when you want to know that you have a problem? What if power fails a day or two before the monitor alarms? Can you afford to take this chance?

In addition to not increasing system reliability by a significant amount, none of these monitors provides any of the cost savings mentioned previously. The user must still perform all the normal monthly, quarterly, and annual maintenance functions.

Examples of why the single parameter monitors mentioned above cannot be relied on:

- A midpoint monitor or a ripple current detector will not detect float voltage problems until they are way out of line. A VRLA battery that develops a cell or two with an internal short will cause an increase in voltage across other cells that may then start gassing faster than recombination can take place. This of course leads to the failure of previously good cells, leading to a complete string replacement by the time the monitor finally alerts the user to the problem.
- A substantial increase in the internal resistance of one or two cells in a telephone office string could easily go undetected with the above monitors. When a power outage occurs, the resulting voltage drops within these cells, coupled with the coup-de-fouet phenomena, would take the office down within the first minute of operation.

VOLTAGE MONITORS

Voltage monitors capable of reading individual cell voltages will provide a reasonable amount of cost savings. However, internal ohmic measurements, which are time consuming, still have to be performed manually.

The voltage monitor does not increase system reliability, since cell voltages are not a reliable indicator of whether a cell will perform under load.

VOLTAGE MONITORS WITH VOLTAGE MANAGEMENT

Voltage monitors that include voltage management may, at first glance, sound pretty good, but a good quality battery ought to not require equalization or voltage management more than once a year. Excessive equalization of a cell will accelerate the deterioration of that cell, due to corrosion.

If the voltage management is not implemented correctly, it could artificially hold up the voltage of a failing cell, thereby masking a real problem. The battery manufacturers have not been supportive of individual cell equalization, since they do not believe that it is necessary and may indeed mask certain cell problems.

A voltage management capability may include a charge response test that consists of step changing the charge voltage and measuring the charge current response of the cell. This test not only does not produce any valid values that can be used for trending, it does not repeat from one test to another unless the cell temperature and float voltage are exactly the same each time. The current flow is also more dependent on the length of the test leads than it is on the internal resistance of the cells.

FULL FUNCTION MONITORS

Full function monitors continuously read all battery voltages, currents, and pilot temperatures and perform periodic internal resistance or impedance tests of each cell or module. If an out-of-tolerance condition is detected, the monitor alarms and stores a time-stamped record of the event.

A full function monitor also detects any discharge condition of the battery and initiates a high-speed data logging function that displays and stores all pertinent data during the event. Data is later printed out by the user to evaluate the performance of the battery during the load condition. The auto discharge detect function is used to capture data during both scheduled and unscheduled discharges.

A time-stamped periodic snapshot of all battery parameters is stored at user programmed intervals and is used to verify and trend battery performance.

A full function monitor should be IEEE 450 and IEEE 1188 compliant and should eliminate all maintenance time except for annual visual inspections and watering of flooded cells, leading to significant cost savings.

The monitor also alerts the user of any charging or temperature problems, thus allowing control of these parameters to values that optimize battery life.

For the monitor to be effective in scheduled load testing, as well as capturing data during unscheduled power outages, the monitor must be capable of capturing and displaying data in real time. Real time data on all parameters should be updated at least once every five seconds. This gives the monitor the capability of capturing even short duration outages. It also provides safety during capacity testing by identifying high resistance connections before they become hot spots that could lead to potential explosions or fires.

It is also desirable that the monitor be capable of estimating reserve time remaining during a power outage. However, it should be noted that the reserve time algorithms used today, including the Bellcore one, are pretty crude, not very accurate, and are based on the battery voltage decaying at a gradual rate throughout the discharge. Basically, the algorithms will work on good or slightly deteriorated batteries and may work reasonably well for flooded batteries, but will fail miserably for VRLA batteries that suffer from dry out or loss of fuel supply.

VRLA batteries that fail during a discharge appear to behave like normal cells in the beginning of a discharge, but when they run out of fuel, their terminal voltages fall off very abruptly. (Refer to Figure 1 below.) This means that the user will get a false sense of security from the time-to-go indicator and may not have much time to react when one or more cells fails abruptly.

A good example of where this would be a problem is a cellular or telecom office. In the communications industry, the normal battery operating voltage is very close to the cutoff voltage of the telephone equipment. In some instances, even a single cell failing could take the office down.

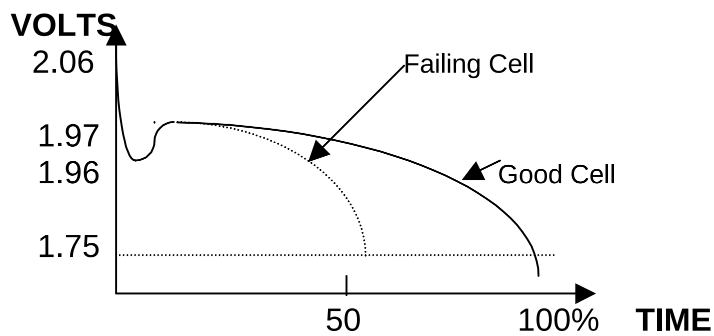

FIG. 1

What this really means, then, is that the monitor must include a proactive resistance test to verify that all cells are in good condition; otherwise, the time-to-go indicator cannot be relied upon.

Overall system reliability is raised to an exceptionally high level by using proactive internal cell resistance testing. Resistance testing has been proven in the field on thousands of battery strings as an effective tool in finding cell or module problems at an early stage.

SUMMARY

- A full function monitor that typically costs $2,500 to $4,500 per string will pay for itself in a short period, while providing the highest possible degree of system reliability.
- The single parameter monitors will not pay for themselves, regardless of cost. They do very little to improve system reliability.
- The voltage monitors do offer some cost savings, but do practically nothing in terms of improving system reliability. They will not pay for themselves in the same period as a full function monitor, while costing almost as much.

CONCLUSIONS

- The selection process is very easy once the monitor objectives are clearly stated.
- There is no advantage in spending money on monitors that do not substantially improve reliability and provide no financial payback.
- For the small initial dollar difference per string and the return on investment provided, even corporate accounting should agree that it makes sense to buy a full function monitor.
- There is no substitute for *doing it right!*