

Using Conductance Technology to ensure Battery System Reliability

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When Facility or Maintenance Engineers, Operations Managers or Power Provision Operators consider back-up power options that include battery systems, it is quite typically as a “last line of defense” for their power application. Stationary (or standby power) batteries have been installed in ever increasing numbers by a wide variety of organizations in varying industries in recent years. Included among these firms are communications and data related companies worldwide who view these systems as an insurance policy against the risks, and ultimately losses associated with disruptions or temporary loss of the power supplied from the commercial power grid.

However, with the introduction of a wide number of variables, including environmental fluctuations, application variations, and design inconsistencies, continued reliability from stationary batteries is not a guaranteed result from the time of installation. Most organizations that rely on stationary batteries for back-up power recognize that proper consistent, and effective testing or monitoring of the stationary batteries within the systems (including detailed testing to the individual battery cell level) is essential for effective system cost management, power assurance and peace of mind.

Battery testing and monitoring has become a critical element of a complete power maintenance regime. Historically, this regime has included regular discharge (also known as load) testing. This testing, while quite conclusive in terms of evaluating the battery systems’ ability to deliver its designed power *at that given moment*, can be somewhat impractical for modern operations given the logistics, time and resources required, not to mention the expertise. To address these weaknesses electronic test technology has emerged since the 1970s, offering an alternative to the burdensome qualities of battery discharge testing. A leader among this electronic technology has been the use of electrical conductance within the battery.

Conductance Technology as an established alternative

Conductance measurement is classified as an Ohmic technique; a broad term used to describe any of several common electrical measurement methods. These tests can be used to identify the electrical or Ohmic “signature” of a lead acid battery or cell, which can be associated with a battery’s state of health condition when at its maximum. Ohmic test results are obtained by performing a calculation of the relationship between electrical resistance with combinations of either AC or DC current and voltage measurements on the subject battery.¹

As a member of this Ohmic “family,” Conductance is a measurement of a battery’s ability to produce current or its electrical efficiency. It is calculated and measured, producing a result in a value that has been designated as either Siemens or Mhos (the reverse of Ohms). The value in Conductance or other Ohmic measurement can be more directly described as: *An increased internal resistance or reduced measured conductance of a cell results in a reduction of the expected capacity or discharge performance from the cell.*² Applying this conclusion, evidence of battery state-of-health can be identified when comparing conductance measurements from similar cells in a battery system. The higher the conductance value (or lower internal resistance), the better the expected performance potential from the battery. In order to perform a Conductance or other Ohmic measurement, a low frequency AC signal is sent through the battery and a portion of the AC current response is then captured and from this output a Conductance measurement is calculated. Conductance can be also described as the equivalent measurement of the plate surface available within the battery for chemical reaction and exchange, a known determinant of the limits of supplied power from the battery. During the normal aging and use process, the battery’s plate surface can sulfate, shed active material, and change chemically; conversions that adversely affect the battery’s ability to perform. This normal process forces battery conductance to decrease gradually as the cell service life is consumed.

Conductance testing, among the other Ohmic techniques, has been investigated extensively in independent laboratory research.³ The data that follows can illustrate that the Conductance technique has a dependable capability to identify the suspect cells most likely to have lowered capacities:

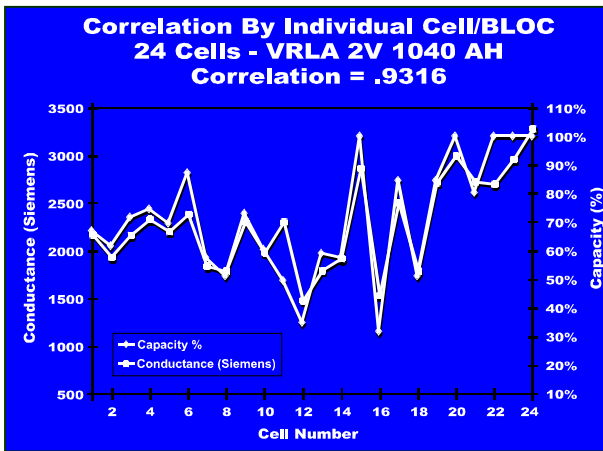


Figure A.

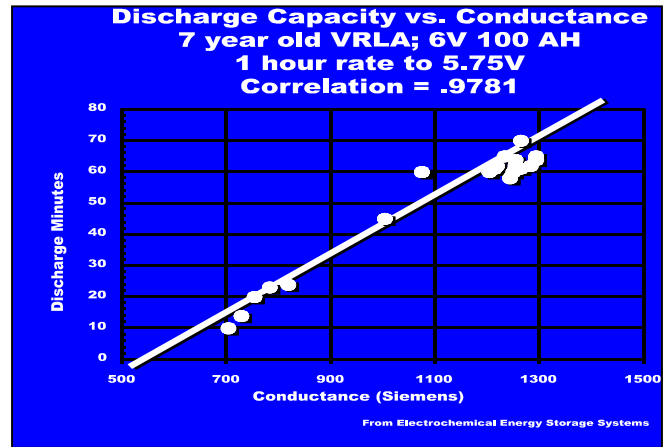


Figure B.

In terms of power provisions, this suggests that conductance can be used to detect cell defects, shorts and open circuits that can reduce the ability of the battery to deliver current. Conductance test measurements can, therefore, become an equivalent of a battery's true state-of-health diagnosis.

Reduce Potential Failures

Because of these defined characteristics, it is then obvious that conductance can provide significant assistance in preventing catastrophic system failures. Through a regular program of testing of an entire string of batteries in a stationary power system, gross deviations among batteries are easily spotted and corrective actions can be taken prior to the system being called into service.

For example, if a particular battery (monobloc or cell) offers a conductance measurement of 400 Siemens, while the remainder of the batteries within the string measure at an average of 1500 Siemens, the technician can be certain that a significant loss of capacity has occurred in that particular cell. The battery, and therefore the system, cannot be expected to perform to its designed level, providing the power for which it was designed. Perhaps more significant, this type of deviation from the remainder of the units suggests that there does exist a potential for danger should the system be called into service and a sizeable load placed on it. Through the introduction of regular Conductance testing, this type of battery fault can be identified prior to a failure, without a discharge or disruption in power, and without removing the equipment from service. Corrective actions can be scheduled under non-emergency conditions, significantly reducing costs.

Diagnose Battery Health and Develop Replacement Strategy

A related benefit is simply to promote increased service life, and ensure full use of this service life. By monitoring and testing a battery site through the deployment of Conductance enabled devices, warning signs of unacceptable operating conditions can be detected and rectified prior to a catastrophic loss. By making necessary corrections to the power system, battery life can be extended and replacement costs reduced or avoided entirely.

Another benefit of Conductance monitoring and testing is the ability to predict end-of-life for battery cells and strings. Rather than just identifying degraded cells, Conductance testing can be used to measure battery health over time. By regularly measuring conductance from the time of installation, changes in measured conductance and the related loss of capacity can be observed and trended. The rate of degradation can be estimated from this practice, allowing effective management of time for replacement and procurement of the consumable element of the power system.

To further support these suggestions, it is also prudent to mention that the current battery maintenance practices developed and endorsed by the IEEE advise Ohmic testing of all Valve-regulated, lead acid batteries once per quarter. It is suggested that this testing will allow for effective maintenance and assurance of the performance of the system. However, this concept is based on understanding the capacity, or conductance, for a new, healthy battery. By using the measured conductance value of an "optimized" cell or the average conductance signature of a battery type sampling as a benchmark, an operator can easily develop a replacement strategy as conductance degrades over time and apply the maintenance methodology adopted by many organizations who have successfully reduced battery related failures and unnecessary costs.

Simplified Battery Management

Of the benefits offered by the use of Ohmic testing technology, and specifically Conductance testing, simplified battery management is perhaps the most significant. Through the application of conductance technology into a battery management product offering, user friendliness, portability and functionality can become uniquely available in the form of menu configuration, datalogging, portable printing, PC transfer, and trending software reducing documentation and administration requirements. Battery suppliers and high-tech companies are working to develop a system of benchmark reference values for common batteries to further help streamline the overall maintenance complexity. As a result, there is a reduction in the “guesswork” of battery management, and ability for companies to reduce their battery replacement costs by scheduled replacement of only necessary batteries.

To further understand the proliferation in the implementation of Ohmic, and more accurately conductance, testing programs it is important to analyze its attributes compared to discharge testing:

- * **Fast:** The most observable attribute of a conductance test as compared to a discharge test (or, in fact, some other Ohmic tests) is speed. Conductance tests produce measurements in a matter of seconds rather than the hours of time required for discharge testing. With some equipment, test results can be available in *just seconds*, rather than after several hours of battery discharge. Conductance technology also enables battery monitoring that is full time, on-line, and automated -- eliminating costly labor and travel to remote locations.
- * **On-Line Testing:** Discharge testing typically involves several hours of power system down time. Furthermore, the apparatus being supported can be unavailable while it is offline. The battery system could be unavailable for over 24 hours depending on certain factors including safety issues, load equipment, re-cabling, and battery discharge and recharge time. The latest conductance technology monitors or tests battery power systems on-line; further, these tests are passive and do not alter or cycle the battery to cause premature aging.
- * **Accurate:** At the same time, Conductance testing has proven accurate to the level that a few global telecom companies have discontinued discharge testing, except to completely analyze a questionable battery cell with a low conductance value. (See *Figures A & B* for correlation statistics.)
- * **Safe:** The passive nature of the latest Conductance technology makes it substantially safer than discharge testing. A discharge test produces heat and often sparks, which can be dangerous to both operator and the overall site. In comparison, testers and monitors utilizing conductance technology eliminate the hazardous potentials posed by heat and arcing when load testing cells.
- * **Repeatable:** One coincidental benefit of passive conductance testing is repeatability, where cells can be tested at any time without waiting for a recharge and with no safety risk. This can be done to verify any questionable test results or for site validation requirements including testing inter-cell connection resistance values.
- * **Simple:** In addition to being quick, Ohmic testing can also be very simple. Removing the guesswork of battery interpretation is only the start. The newest conductance testers are menu-driven, require only pinpoint connection to two battery posts or straps, and provide absolute measurements with no further mathematical calculations needed.

Finally, one of the best aspects associated with Ohmic/Conductance technology advances is that the equipment is relatively inexpensive when compared to older technologies. The savings in resources and improved safety aspects alone make this technology an affordable and desirable service option positioned to become a standard tool of technicians in the rapidly growing cable television/broadband industry worldwide, expanding the benefits of Ohmic testing even further.

References

¹⁻³ Cox, Daniel C., *Establishing VRLA Battery Maintenance Programs Using Ohmic Reference Values and Historical Test Data*