EAGLE EYE TECHNICAL NOTE

Title	**Stationary Battery Monitoring Vs. Maintenance: Must They Go Hand-In-Hand?**
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Revision History

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Introduction

Battery monitoring has been around for a while. This author first got interested in the subject in the early 1990s when Albér came out with a device that measured the internal dc resistance of a battery cell/unit. To me, this was a giant step forward in battery maintenance. Afterall, with the advent of Valve-Regulated Lead-Acid (VRLA) batteries, it had become difficult to determine the state-of-health (SOH) of a battery because of the inability to see inside the cell/unit and determine the condition of the plates and electrolyte level. Since then, battery monitoring has evolved, with new players and technologies coming into play that included various ohmic measurements.

The Role of IEEE

In the early days of monitoring, the Institute of Electrical and Electronics Engineers (IEEE) took an interest. And, in 1996, it opened a Project Authorization Request (PAR) to initiate the development of a guide to battery monitoring. This document was eventually approved and released in 2005 as IEEE Std 1491™ – *Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.* There was a lot of input from all segments of the industry, and the IEEE working group came up with 17 parameters that could be monitored. The 2012 revision of the document added an additional parameter.[1] IEEE 1491 covered Vented Lead-Acid (VLA), Valve-Regulated Lead-Acid (VRLA), and Nickel-Cadmium (Ni-Cd) batteries, and consequently, all the monitoring parameters could not be applied to all types. The story behind the making of IEEE 1491 and the measurement parameters was presented at Battcon, the international battery conference, in 2007, in a paper titled, *The IEEE 1491 Battery Monitoring Standard and Revision Activities.*[2]

Already in existence was IEEE Std 450™, the *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.*[3] In Section 5 of this document under Monthly Inspections, it called for the inspection of the battery on a regularly scheduled basis (at least once per month), and this should include the following:

Note: The requirements marked with an asterisk cannot be checked by a traditional monitor.

- Float voltage measured at the battery terminals
- General appearance and cleanliness of the battery, battery rack or battery cabinet, and the battery area*
- Charger output current and voltage
- Electrolyte levels
- Cracks in cells or evidence of electrolyte leakage*
- Any evidence of corrosion at terminals, connectors, racks, or cabinets*
- Ambient temperature and ventilation
- Pilot cells' (if used) voltage and electrolyte temperature
- Battery float charging current or pilot cell specific gravity (for lead-antimony cells, specific gravity is preferred)*
- Unintentional battery grounds
- That all battery monitoring systems are operational (if installed)

For a quarterly inspection, the following is also required. Similarly, those marked with an asterisk cannot be checked with a monitor.

- Voltage of each cell
- For lead-antimony batteries, specific gravity of 10% of the cells of the battery* and float charging current
- For technologies other than lead-antimony, if battery float charging current is not used to monitor
- State of charge, specific gravity of 10% of the cells of the battery
- Temperature of a representative sample of 10% of the battery cells

Similarly, IEEE Std 450™, the *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*[4] has the following requirements that cannot be met using a monitor:

- The condition of ventilation and monitoring equipment*
- Cell/unit integrity for evidence of corrosion at terminals, connections, racks, or cabinet*
- General appearance and cleanliness of the battery, the battery rack or cabinet, and battery area, including accessibility*
- Cover integrity and check for cracks in cell/unit or leakage of electrolyte*
- Excessive jar/cover distortion*

NERC PRC-005
Looking at another requirement that the electric utilities might require to adhere to and that is Standard PRC-005-2 *Protection System Maintenance,* currently at issue 6.[5] This document is promulgated by the North American Electric Reliability Council (NERC) with the purpose of documenting and implementing programs for the maintenance of all Protection Systems affecting the reliability of the Bulk Electric System (BES) so that these Protection Systems are kept in working order. Tables 1-4(a) through 1-4(f) pertain to stationary battery maintenance and monitoring.

This standard is much more lenient with respect to visual maintenance of the battery system, only requiring the following:

- Every 18 months, inspect the physical condition of the battery rack.
- Cell condition of all individual battery cells where cells are visible – or measure battery cell/unit internal ohmic values where the cells are not visible (VLA only)
  Author's Note: It is assumed that this means where the edges of the plates are visible.
- Cell condition of all individual battery cells (Ni-Cd only)

But the big difference between the IEEE maintenance requirements and those of PRC-005 is that if a monitor is connected to the battery system, all the visual and periodic maintenance requirements of PRC-005 are unnecessary if the monitor measures:
- Any station dc supply with high and low voltage monitoring and alarming of the battery charger voltage to detect charger overvoltage and charger failure
- Any battery-based station dc supply with electrolyte level monitoring and alarming in every cell
- Any station dc supply with unintentional dc ground monitoring and alarming
- Any station dc supply with charger float voltage monitoring and alarming to ensure correct float voltage is being applied on the station dc supply
- Any battery-based station dc supply with monitoring and alarming of battery string continuity

- Any battery-based station dc supply with monitoring and alarming of the intercell and/or terminal connection detail resistance of the entire battery
- Any VRLA or VLA station battery with internal ohmic value or float current monitoring and alarming and evaluating present values relative to baseline internal ohmic values for every cell/unit
- Any VRLA or VLA station battery with monitoring and alarming of each cell/unit internal ohmic value

As stated previously, PRC-005 is much more lenient with respect to physical inspections. However, it also has drawbacks, and it is this author's opinion - along with many other seasoned battery professionals - that unless some more stringent requirements are inserted into the maintenance plan, the reliability of the battery system will be degraded.

It could also be argued that the IEEE time-based maintenance requirements are overkill and often ignored, especially for VRLA batteries, for both economic and practical purposes. The cost of providing and installing a permanent monitor will often be considered alongside the cost and criticality of the battery. The general location of the battery plant, from climate-controlled and manned locations to unmanned and often remote sites, has been a catalyst in the development and monitoring capabilities of battery monitoring devices.

There are several excellent monitors on the market that employ dc resistance, impedance, admittance (the reciprocal of impedance), and conductance. Still, none of these methods, which are often indicative of battery state-of-health, can determine battery capacity. Only a load test will do that. One direction that some recent battery monitors are heading in is the ability to incorporate machine learning and artificial intelligence. This will aid greatly in trending and predictability.

Conclusion
So, to answer the question posed in the title of this article, Stationary Battery Maintenance and Monitoring: Must They Go Hand-in-Hand? The conclusion, based upon the above, is that they certainly do. Any maintenance plan, to be meaningful and successful, and if the battery importance and location requires it, should include elements of both visual inspection, adequate monitoring attributes and load testing. One factor that is often overlooked is that the measurements and data produced by the monitor should be analyzed for trending and aberrations. It is also important for the alarm point limits to be realistic and not so stringent as to cause nuisance alarming.

References.

1. IEEE Std 1491-2012™ *IEEE Guide for Selection and Selection and Use of Battery Monitoring Equipment in Stationary Applications.* IEEE publication are available from IEEE, 501 Hoes Ln, Piscataway, NJ 08854. Tel +1-800-702-4333. (USA and Canada). +1-732-981-0600 (Worldwide). Or online onlinesupport@ieee.org.

2. Cotton, Bart, Lambert, Dan, and Byrne J. Allen. *The IEEE 1491 Battery Monitoring Standard and Revision Activities.* The proceedings of Battcon 2007

3. IEEE Std 450™, the *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.* See 1 above.

4. IEEE Std 450™-2020, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.* See 1 above.

5. NERC Standard PRC-005-6 *Protection System Maintenance* NERC, 3353 Peachtree Road NE Suite 600, North Tower Atlanta, GA 30326 Tel. 404-446-2560. www.nerc.com

Additional Reading.

- *Vented Lead-Acid (VLA) Batteries. The Differing Maintenance Requirements of IEEE 450 and PRC-005*. Eagle Eye Technical Note 1/28/18.
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- Pedersen, George and Gomes, Steve. *Battery Maintenance, Battery Monitoring, Battery Management. What's in a name.* Proceedings of Battcon 2008,

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- DeMar, Peter. *How The Current Draft Standard of NERC PRC-005-2 Maintenance Requirements Will Reduce Battery System Reliability.* Proceedings of Battcon 2012.

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