IEEE Stationary Battery Committee

NERC Task Force Report

Part of IEEE Power & Energy Society

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At the most recent meeting of the IEEE Battery Standards Committee Meeting in January of this year concerns were registered over statements contained in the proposed NERC Document PRC-005-2 Protection System Maintenance.

As a result of these concerns, a special task force (herein referred to as ***the task force***) was formed to study the details of PRC-005-2 as it relates to stationary batteries. This task force is composed of a number of members who are recognized representatives of battery manufacturers, battery charger manufacturers, ohmic measurement and battery monitoring equipment manufacturers, battery testing companies and functional entities (nuclear, power generation and substation).

We recognize that the document is intended to address reliability issues for protection and control circuits for the Bulk Electric System [BES], but because of the integral role played by the stationary batteries, they have been included under the expanded scope of the DC power supply section.

If we understand the objective of the PRC document, it is to lay out a baseline standard that ensures that all components identified within the scope of the standard are capable of performing as expected in a worst case condition and verified by periodic maintenance that includes testing and/or measurements as defined for batteries in Tables 1-4(a) through 1-4(f).

A common thread is that the functional entity employing this Protection System Maintenance Program (PSMP) "verifies" that the functional components (in this case, the battery) "can perform as designed." This is confirmed by the wording at the end of the section describing maintenance activities for the VLA wet cell in Table 1-4(a), the VRLA "sealed" cell in Table 1-4(b) and the Nickel Cadmium cell in Table 1-4(c).

If we read the document correctly, there seems to be an implication that ohmic measurements can act as an alternative to capacity testing to determine that the battery will "perform as designed." It appears that support for this position is confirmed in the *Supplementary Reference and FAQ* where on pages 80 and 81 discussion is made with respect to "two acceptable methods for proving that a station lead acid battery can perform as designed."

Reference is made to EPRI technical reports and application guides and certain IEEE battery standards. The IEEE Battery Standard Committee Guidelines of 450 (VLA), 1188 (VRLA) and 1106 (Ni-Cd) are referenced specifically. The specific EPRI technical reports are not referenced in Section 15.4; however, one of the most widely referenced EPRI documents is 1002925 for "Stationary Battery Monitoring by Internal Ohmic Measurements." It is the foundational basis for a paper given by Eddie Davis and Dan Funk of the Edan Engineering Corporation and Wayne Johnson of EPRI at the Battcon 2002 conference.

In the EPRI document under Section 13.4 on page 13-6 the conclusion is given: *"Internal ohmic measurements have the ability to identify degradation in individual cells. Although the internal ohmic measurements can identify low capacity cells (which is certainly valuable), the technology does not precisely predict overall battery capacity. Important backup power applications should still be confirmed by periodic battery capacity tests."*

In the concluding remarks of the 2002 Battcon paper, the statement is fortified: *"This does not really imply a shortcoming of internal ohmic measurement technology, but it does mean that we will likely be limited to identifying good or bad cells rather than making claims that a certain internal resistance indicates a particular cell capacity."*

In addition to the EPRI report and the Battcon paper there are several other papers that have been written on ohmic measurement testing. All draw the same conclusion. Several leading US and European battery manufacturers have weighed in on the subject through white papers and/or operating instructions. Four examples are given below:

> *"Ohmic measurements are not a substitute for capacity testing and should not be used to predict absolute capacity values"* – EnerSys white paper entitled "Ohmic Measurements as a Maintenance Tool for Lead Acid Stationary Cells."
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> *"In summary, internal ohmic testing can be a valuable tool to assist in diagnosing batteries, but it is important to understand what the measurement value represents and know the limitations. . . . . The only surefire way to tell the battery's true health and whether or not the batteries will provide sufficient capacity to fully support the system load is through a measured capacity discharge test."* – C&D Technologies white paper entitled *"Impedance (Conductance) Readings," 2009.*
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> *"Responsible ohmic device manufacturers acknowledge that there is no direct relationship between percent ohmic change from baseline and battery capacity"* – GNB Installation and Operating Instructions for ABSOLYTE GP Batteries, 2010.

Right now the current state of technology of ohmic testing has significant value in monitoring the trend of changes within individual cells or continuity in a battery string. But if performance or capacity has to be verified, the only true methodology at this point in time is a capacity or performance test." – Hoppecke in a paper entitled "Ohmic Measurements as a Tool for Determining Capacity of a Stationary Lead-Acid Battery," 2012.

In conclusion, ***the task force*** wishes to make the following points and recommendations:

1. ***The task force*** in no way wants to instruct the NERC PRC 005 Standard Drafting Team (SDT) on how it should write its standard. It would welcome the opportunity of assigning a representative from our membership to participate with the SDT going forward as it relates to appropriate battery testing and maintenance.

2. ***The task force*** recognizes that many functional entities are looking for a way to reduce costs through reduced manual maintenance and testing equipment related expenses. However, economic or risk-management decisions should be based upon just that, i.e. the economic or risk factors; and not justified by the use of unproven or misleading interpretation of data.

3. ***The task force*** believes strongly, and is supported by the vast majority of battery manufacturers and ohmic measurement testers, as well as from papers and the study of the closest correlation testing published to date, that ohmic measurement testing cannot serve as a substitute for capacity testing if the true reliability of the battery is to be measured against the statement that the battery "can perform as designed." Capacity testing is the only way to confirm that the battery will perform as designed.

4. Therefore, to ensure the highest reliability of a stationary battery system, load testing per IEEE guidelines is recommended. We appreciate that there are installations where the economics are such that load testing may not be a viable option. However, the functional entity must recognize that some level of reliability will be sacrificed if other analytical techniques such as ohmic testing are used in lieu of load testing.

5. It is the opinion of ***the task force*** that ohmic testing alone is not sufficient to achieve the required reliability of the BES.

6. We recommend that language to that effect be clearly established in the revised draft of PRC-005-2.

Respectfully,

Bill Cantor
Bill Cantor
Chair of IEEE Stationary Battery Committee
TPI Engineering

Chris Searles
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Other Task Force Members:

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Stationary Battery Committee

http://www.ewh.ieee.org/cmte/PES-SBC/

March 27, 2012

Dear Mr. McMeekin,

As chair of the IEEE Stationary Battery Committee, I was approached by several committee members concerning the battery testing and maintenance recommendations in the proposed NERC Document PRC-005-2. There was a consensus in the committee that the aforementioned recommendations did not reflect the best practices in the industry.

In the January Stationary Battery Committee meeting, a task force was formed and approved to review the NERC proposed recommendations. The report from this task force is attached to this letter.

Please note that this task force included some of the committee's most knowledgeable members, including present and past committee chairs, working group chairs, battery and ohmic measurement equipment manufacturers, and an EPRI battery expert who was a principal on the EPRI study regarding ohmic measurements and capacity, as well as many long-time contributors to our standards. The report represents the unanimous agreement of the Task Force.

We trust that this communication will receive the important consideration by you and the NERC SDT that we feel it deserves. We plan to have a few representatives attend your upcoming meeting in Ft. Worth in April. Please feel free to contact me in the meantime if I can provide any additional insight or assistance.

Sincerely,

William P. Cantor

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Dear Mr. Cantor:

The NERC Protection System Maintenance and Testing Standard Drafting Team (PSMTSDT) for NERC Project 2007-17 (PRC-005-2) appreciates your remarks and the comments of the IEEE Stationary Battery Committee Task Force regarding its review of the battery maintenance activities described in the latest versions of PRC-005-2 and its supporting Supplementary Reference and FAQ document.

Your comments and those of the IEEE Task Force reflect the valid concerns of industry experts relative to language in the Supplementary Reference and FAQ document that, in their opinion, seems to imply that periodically reviewing and trending the results of inter cell/unit ohmic tests is equivalent to periodic performance of capacity tests. Based on this valuable feedback, the PSMTDT has modified the Supplementary Reference document to eliminate this misconception by stating that capacity testing is the only industry approved method of determining the true capacity of lead acid and nickel–cadmium station batteries. In the revised language, the Supplementary Reference further expresses that, while it has been stated in the EPRI reports (EPRI TR-108826 and 1002925) cited by the IEEE task force's report that there is a definite relationship between internal ohmic measurements and cell capacity of lead acid batteries, the PSMTSDT believes that an accurate determination of a battery's exact capacity cannot be attained by measuring its cell's internal ohmic values alone.

However, the PSMTSDT feels that both Maintenance Activities listed in tables 1-4(a) and 1-4(b) for lead acid batteries are appropriate for verifying "that the station battery can perform as designed." The PSMTSDT defines this as the process of determining when the station battery must be replaced or when an individual cell or battery unit must be removed or replaced.

In the mid 1990's, several large and small utilities began developing maintenance and testing programs for Protection System station batteries using a condition based maintenance approach of trending internal ohmic measurements to each station battery cell's baseline value. Battery owners use the data collected from this maintenance activity to determine (1) when a station battery requires a capacity test (instead of performing a capacity test on a predetermined, prescribed interval), (2) when an individual cell or battery unit should be replaced, or (3) based on the analysis of the trended data, if the station battery should be replaced without performing a capacity test.

As noted by a major manufacturer of lead acid batteries that conducted aging tests on various, similar battery products, some of the trending of ohmic readings from testing conducted on some manufacturers batteries "clearly would have resulted in the rejection/replacement of cells well before the end of their useful life…" This battery manufacturer sums up the methodology most experienced users of periodic trending of ohmic measurements apply when determining that the station battery can perform as designed by saying, "users and manufacturers need to use judgment and experience to analyze the data, and then supplement the data with additional measurements – including capacity testing – when deciding whether to replace product in the field."

Since 2006, when NERC standard PRC-005-1 was adopted by the NERC Board of Trustees, those large and small utilities who put into practice the ohmic measurement condition based maintenance and testing programs for Protection System station batteries, have become NERC-registered Transmission Owners, Generation Owners and Distribution Providers subject to the requirements of PRC-005-1. This mandatory and enforceable standard requires those owners to have "a Protection System maintenance and testing program" that "shall include maintenance and testing intervals and their basis" along with "a summary of their maintenance and testing procedures." Through the successful performance of ohmic trending that began in the mid 1990's and over 6 years of applying this method in their maintenance programs required by PRC-005-1, the PSMSDT believes Protection System equipment owners have, effectively, established an acceptable maintenance practice (supported by EPRI technical references) and maximum maintenance interval, for verifying that a station battery can perform as designed.

Historically, Transmission Owners, Generator Owners, and Distribution Providers have not considered the insignificant power requirements of their Protection Systems (several hundred amperes for duration of less than 0.5 seconds and for not more than 10 amperes of continuous protective relay load when the station battery charger is out of service) when sizing batteries used for station dc supply. Instead, these entities have sized their station batteries for other significantly larger dc loads and duty cycles such as those for inverters, heaters, telecommunication equipment, emergency lighting, load profile of emergency bearing oil and seal oil pumps etc. Considering this factor, it would take a loss of battery capacity of well below 50% (which can be easily detected by ohmic trending) for a battery emergency to significantly affect the functioning of Protection System equipment powered from the station battery.

If the primary purpose of the station battery is to provide the instantaneous stored energy of several hundred amperes for extremely short durations (close to the short circuit duration for a station battery) and provide the minimal protective relay power supply load of not greater than 10 amperes whenever the dc station charger is out of service (which is the case for many Transmission Owners), then the minimum activity of evaluating the measured cell/unit internal ohmic values to station battery baseline to verify that the station battery can perform as designed will achieve the reliability purpose of PRC-005-2 and satisfy the risk-management requirements of the Protection System owner.

In contrast to the Transmission Owner battery design function, a Generator Owner's battery likely feeds other critical loads such as DC powered oil pumps, seal oil pumps, and other DC control power loads necessary to safely shutdown a power plant following a loss of AC power. In the case of nuclear plants, these DC loads could include motor operated valves and other loads related to nuclear safety. For the Generator Owner, the design load profile for the battery is a long duration, deep discharge of the battery. While a cell ohmic value trending program might be adequate to prove that the Generator Owners battery could fulfill its Protection System function, the Generator Owner might want to validate the deep discharge capability of the battery by routine periodic capacity testing to prove the battery's adequacy at providing power to those long duration loads critical for plant shutdown. The PSMTSDT believes that this deep discharge battery capacity test approach will prove the battery can meet its function relative to the plant Protection System without also having a trending program for cell ohmic values.

It is the intent of the PSMTSDT to provide Transmission Owners, Generator Owners, and Distribution Providers flexibility to employ testing methods already utilized in their program, and as appropriate for

their facility type, in order to prove their battery's "ability to function as designed." The PSMTSDT agrees with the task force suggestion that entities should implement this flexibility with due consideration of the economic or risk-management decisions associated with choosing which minimum maintenance activity is appropriate for battery systems at their facilities. However, the PSMTSDT also believes entities can achieve the reliability purpose of PRC-005-2 ("to document and implement programs for the maintenance of all Protection Systems affecting the reliability of the BES so that these Protection Systems are kept in working order.") and thereby enhance the reliability of the BES, by using an ohmic value trending program, as described in Tables 1-4(a) and 1-4(b) of the standard, to provide an adequate indicator of battery health.

Again, the PSMTSDT is grateful to the IEEE Stationary Battery Committee's task force for its review of the draft of the NERC standard PRC-005-2 and the accompanying draft Supplementary Reference and FAQ document. The insights of the task force's experts have assisted the Drafting Team in revising statements in the Supplementary Reference. Furthermore, please accept the team's apology for our oversight of leaving the IEEE Stationary Battery Committee off the list of references in our supplemental document. Our goal is to have the proper references attributed within the document that will go to the NERC Board of Trustees for approval.

Please bear in mind that PSMTSDT meetings, as all NERC Drafting Team meetings, are posted on the NERC web site and are always open to guests and observers. The PSMTSDT solicits the active participation of its guests in its meetings. In fact, significant contributions to the development of PRC-005-2 have been made by those who have attended the Drafting Team meetings as guests and observers. In that regard, should you or someone from your membership be interested in coming to any of the PSMTSDT meetings, we would welcome your attendance and participation.

Sincerely

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April 13, 2012