IEEE Standards Interpretations for IEEE Std 535™-2006 IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations

January 2009

Interpretation Request #1
Topic: Length of duty cycle for which a vented lead-acid battery is qualified, limitations on the length of duty cycle, and technical bases **Classification:** Unambigious

Please identify the length of the duty cycle for which a vented lead-acid battery is qualified per IEEE Std 535-2006. Also, discuss if there are any limitation(s) on the length of the duty cycle for a vented lead-acid battery, and please specify the technical bases (i.e., methodology, assumptions, and prerequisites) used to establish this.

Interpretation Response
The length of duty cycle is not specifically addressed within IEEE Std 535-2006 and no specific clauses are referenced in your request. Therefore, a formal interpretation cannot be given.

The following explanation is provided to address consideration of the duty cycle length with respect to qualification as described in IEEE Std 535-2006. This information is being referred to the sponsor for possible action at the next revision.

Explanation on Battery Duty Cycles
IEEE Std 535-2006 4 references IEEE Std 450-2002. This standard has a temperature correction table (Annex L, Table L1) which has a note that states "This table is based on nominal 1.215 specific gravity cells. For cells with other specific gravities, refer to the manufacturer. The manufacturer's recommend that battery testing be performed between 18.3°C (65°F) and 32.2°C (90°F). These values are the average for all time rates between 1 hour and 8 hours." This statement implies that the information is val-

id for duty cycles up to 8 hours. For discharge durations longer than 8 hours, the user will need to obtain validated appropriate correction factors from the manufacturer. Note, preliminary data from one vendor indicated that the electrolyte temperature during a 72 hour discharge decreased by a couple of degrees F. It appears that at the low discharge rate, the I2R heating was less than the heat needed by the slightly endothermic chemical reaction during the discharge to maintain temperature. The temperature correction factors for duty cycle durations may need to be modified for duty cycle durations significantly longer than 8 hours. IEEE Std 535-2006 8.2 states, "This procedure will age the entire cell to the predominant aging failure mode, which is based on the failure of the positive plates."

The basis of IEEE Std 535-2006 8.2 was the destructive examination of cell plates that were tested at the 8 hour rate. The documentation of the results of destructive examination is available for viewing at the vendors who have previously qualified cells per IEEE Std 535-2006. The available vendor data available indicates that the ampere hours discharged at the 72 hour rate to 1.75 vpc is in the range of 115% of the ampere-hours discharged at the 8 hour rate to 1.75 vpc. For discharge durations greater than 8 hours where the ampere-hours discharged is greater than the rated 8 hour ampere hours, the cell manufacturer will need to demonstrate that there are no other significant failure modes or reduced life due to higher sensitivity due to known failure modes. IEEE Std 535-2006 8.2.2(h) states "Life expectancy of batteries is not affected by two deep discharges per year. Therefore, the above procedure will qualify the battery for the equivalent of two performance discharge tests per year, average, over the qualified life of the battery." In order to meet the requirements of IEEE Std 535-2006, applications with duty cycles durations over 8 hours that discharge more than the rated 8 hour ampere-hours will need to demonstrate that the battery cells can meet the basis statement in 8.2.2(h).

Clause 5 of IEEE Std 535-2006 is reproduced below for reference.
"5. Principles and methods of qualification The capability of Class 1E vented lead acid batteries and racks, including interfaces, to perform their required functions shall be demonstrated. Principles and methods for demonstrating the qualification of Class 1E equipment shall include:

a) Assurance that the severity of the qualification parameters are equal to the maximum anticipated service requirements and conditions with appropriate design margin (see 6.3.1.6 of IEEE Std 323-2003)
b) Assurance that any extrapolation or inference be justified by allowances for known potential failure modes and the mechanism leading to them (i.e., multiple posts, different jar sizes, plate size and thickness)
c) Documentation files that provide the basis for qualification
d) Qualification of any interface utilized in demonstrating the adequacy of the battery and rack, including, but not limited to, rack attachments and plant wiring"

According to 5.a), the severity of the qualification parameters must be equal to the maximum anticipated service requirements and conditions. Duty cycle length and am-

pere-hours discharged for the discharge tests performed as a part of qualification testing is a part of the anticipated service requirements. According to 7.5 of IEEE Std 450-2002, the service test must meet the duty cycle which means the test duration must be equal to or greater than the duty cycle duration.

Based on these factors, for duty cycles greater than 8 hours in duration that discharge amperehours greater than the 8 hour rating, IEEE Std 535-2006, 8.2.2h is not satisfied without further documentation to justify any extrapolation or inferences made for applications using the longer durations. Particular attention would be needed to demonstrate that no additional failure modes are introduced due to the additional energy delivered due to the longer durations.

In summary, in order to meet the requirements of IEEE Std 535-2006, applications with duty cycles over 8 hours will need to demonstrate that the cells fully comply with the qualification principles in Clause 5 and meet the basis requirements in 8.2.