SAFETY EVALUATION
GE-HITACHI NUCLEAR ENERGY
TOPICAL REPORT NEDE-33516P
QUALIFICATION PLAN REQUIREMENTS
FOR 72-HOUR DUTY CYCLE BATTERIES
FOR THE ECONOMIC SIMPLIFIED BOILING-WATER REACTOR DESIGN

1.0 Introduction

In a letter dated April 17, 2009 (Reference 1), supplemented by letters dated July 27, 2009, September 15, 2009, and December 12, 2009 (References 2-4), GE-Hitachi Nuclear Energy (GEH) submitted its plan for qualifying 72-hour duty cycle batteries, detailed in NEDE-33516P, "ESBWR Qualification Plan Requirements for a 72-hour Duty Cycle Battery," (Reference 5) for review by the U.S. Nuclear Regulatory Commission (NRC) staff. NEDE-33516P is a proprietary report that provides GEH's process for qualifying long duty cycle batteries for the economic simplified boiling-water reactor (ESBWR) passive design. It will serve as the basis for the battery vendor to develop the equipment qualification data package in accordance with the GEH equipment qualification specification, which calls for two 250-volt direct current batteries per division; two parallel strings of 120 lead acid cells per string and 240 cells per battery; and 6,000 amp-hours per battery (8-hour rate to 1.75 volts per cell (vpc) at 77 degrees Fahrenheit and qualified to a 72-hour duty cycle).

2.0 Regulatory Criteria

The applicable regulatory requirements, guidelines, and related acceptance criteria for the qualification of long duty cycle Class 1E batteries are General Design Criterion (GDC) 2, "*Design Bases for Protection against Natural Phenomena," and* GDC 4, "*Environmental and Dynamic Effects Design Bases," in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."*

At present, no regulatory guides (RGs) or industry standards are available that provide procedures or assessment methods to qualify a battery for the 72-hour duty cycle duration. However, in reviewing this report, the staff considered applicable sections of guidance related to the qualification of batteries for 8-hour duty cycles. The staff used the following related RGs:

- RG 1.89, Revision 1, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," issued June 1984, endorses the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," dated February 28, 1974 (References 6-7).

- RG 1.100, Revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," issued June 1988, endorses IEEE Std 344, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," dated August 3, 1987 (References 8-9).

Enclosure 1

- RG 1.129, Revision 2, “Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” issued February 2007, endorses IEEE Std 450, “IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead Acid Batteries for Stationary Applications,” dated April 3, 2003 (References 10-11).

- RG 1.158, Revision 0, “Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants,” issued February 1989, endorses IEEE Std 535, “IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations,” dated June 25, 1986. IEEE reaffirmed IEEE Std 535 in 1994 with no changes (References 12-13).

- RG 1.212, Revision 0, “Sizing of Large Lead-Acid Storage Batteries,” issued November 2008, endorses IEEE Std 485, “IEEE Recommended Practice for Sizing of Lead-Acid Batteries for Stationary Applications,” dated September 3, 1997 (References 14-15).

Since ESBWR design duty cycles are significantly longer than 8-hour duty cycles, and IEEE Std 535 was written under the assumption of an 8-hour duty cycle, it was not clear how the standard would apply. Therefore, the IEEE Std 535 Stationary Battery Subcommittee working group proposed a test plan to include the qualification of vented lead-acid batteries for extended duty cycles (i.e., those that go beyond 8 hours). The test plan outlines the qualification process for 72- hour duty cycle batteries. The qualification process incorporates the proposed test plan specification for passive plant design developed by several industry members in various meetings sponsored by the Electric Power Research Institute (EPRI), which calls for the testing to meet the provisions of IEEE Std 535, which states that “[t]he 3-hour rate shall be used because it provides a uniform basis for qualification by all manufacturers for all types.” Additional testing using an 8-hour performance test as a standard rating is more indicative of a deeper discharge and will be used to allow for comparison to the IEEE Std 535 performance test requirements. The proposed test plan requires type testing to generally follow IEEE Std 535. Testing should be performed that is equivalent to one test each year for the desired qualification duration plus 10 percent, with an additional discharge test after seismic testing. Testing should follow the IEEE Std 450 schedule for performance testing at 2 years and every 5 years thereafter.

Additionally, the proposed test plan requires that a simulated service test should be conducted any year that a performance test is not undertaken. The simulated service test should be discharged at 80 percent of the cell rating. The simulated service test is based on a battery sized in accordance with IEEE Std 485, which recommends an aging factor of 1.25. The test just before seismic testing will always be a performance test. Post-seismic testing involves two tests. The first test will be an 8-hour rate performance test that includes the service test’s depth of discharge. The second test will be a 4-hour rate performance test for the cells. The test should include at least three cells or three multiple cell units with the electrical connections of middle and end or row connections simulated. The acceptance criteria call for no failures during seismic testing, and the batteries need to deliver at least 80 percent rated capacity in the post-seismic capacity discharge test.

The NRC staff will use the proposed plan recommended by the IEEE Std 535 working group members as guidance for evaluating the qualification of extended duty cycle batteries for passive designs.

3.0 Summary of Technical Information

NEDE-33516P provides the test plan for qualifying 72-hour duty cycle batteries for ESBWR plants. The objective of this qualification plan is to demonstrate that the Class 1E batteries and racks used in the ESBWR design, as installed, will perform their required safety function throughout their qualified life. The batteries are sized in accordance with the aging factor of 1.25 recommended by IEEE Std 485, which corresponds to 80 percent of the manufacturer's rating at the end of life. [[

]]

4.0 Staff Evaluation

The GEH qualification test plan is based on the recommendations in IEEE Std 323, IEEE Std 344, IEEE Std 450, IEEE Std 485, and IEEE Std 535 (with the exception that the duty cycle is 72 hours). The 72-hour duty cycle batteries are sized in accordance with IEEE Std 485, which is consistent with the guidance in RG 1.212. The qualified life of the batteries will be based on 20 years. Qualification of the batteries will be performed by type testing. The objective of the qualification plan is to demonstrate that the batteries and racks used in the ESBWR design, as installed, will perform their required safety-related Class 1E function throughout their 20-year qualified life. This demonstration includes the evaluation for potential failure mechanisms stemming from radiation exposure, time-temperature aging, and cycle aging. GEH stated that the ESBWR safety-related battery qualification meets IEEE Std 535, [[

]]

The NRC staff has compared the test plan provided in NEDE-33516P for ESBWR battery qualification against the EPRI-sponsored proposed test plan and finds that the test plan in NEDE-33516P is more conservative than the battery working group's proposed test plan in the following areas:

- The battery working group's proposed test plan recommends that testing should follow the IEEE Std 450 schedule for performance testing at 2 years and every 5 years. A simulated service test will be conducted any year that a performance test is not undertaken. [[

]]

- The battery working group's proposed test plan recommends that the testing performed after seismic testing should include an 8-hour rate performance test that envelops the service test's depth of discharge and a 4-hour rate performance test for the cells. [[

]]

[[

]]

The 20-year battery cells are then mounted in the ESBWR battery rack and seismically tested in accordance with IEEE Std 344 and IEEE Std 535 to the required response spectra plus margin. [[ ]] tests are performed after seismic testing to ensure that before reaching 1.75 vpc the battery delivers at least 80-percent rated capacity. This satisfies the requirements of GDC 2 and the guidance of RGs 1.100 and 1.129.

[[

]]

In the course of its review of the GEH test plan, the NRC staff found that some definitions needed clarification in terms of the type of test to be performed, as well as the frequency with which each test will be performed. In Request for Additional Information (RAI) 8.3-64 S02 (Reference 16), the NRC staff asked the following:

> In regards to the Topical Report NEDE-33516P, please clarify test definitions and frequencies as follows:
>
> [[

]]

In a letter dated December 12, 2009 (Reference 4), GEH responded to the RAI and [[

]]

This submission clarified the testing to be performed and enabled comparison with the EPRI-sponsored proposed test plan. These changes were incorporated into NEDE-33516P Revision 2. Based on the applicant's response, RAI 8.3-64 S02 was resolved.

5.0 Conclusion

The staff finds that the test plan provided in NEDE-33516P to qualify 72-hour duty cycle batteries satisfies the requirements of GDC 2 and GDC 4 and the applicable guidance of RGs 1.89, 1.100, 1.129, 1.158, and 1.212. Therefore, the staff concludes that the GEH qualification test plan provides reasonable assurance that qualified ESBWR batteries and racks will perform their required safety function throughout their qualified life.

6.0 References

1. Letter from R.E. Kingston (GEH) to NRC, MFN 09-187, "Supplemental Response to Portion of NRC Request for Additional Information Letter No. 296 Related to ESBWR Design Certification Application - Qualification of batteries for 24 and 72 hour duty cycles - RAI 8.3-64," April 17, 2009 (ADAMS Accession No. ML091110418)

2. Letter from R.E. Kingston (GEH) to NRC, MFN 09-503, "Response to NRC Request for Additional Information Letter No. 349 Related to ESBWR Design Certification Application - Qualification of Batteries- RAI 8.3-64 S01," July 27, 2009 (ADAMS Accession No. ML092100216)

3. Letter from R.E. Kingston (GEH) to NRC, MFN 09-531, "Response to NRC Request for Revision of Licensing Topical Report NEDE-33516P, "ESBWR Qualification Plan Requirements for a 72-Hour Duty Cycle Battery," September 15, 2009 (ADAMS Accession No. ML092590284)

4. Letter from R.E. Kingston (GEH) to NRC, MFN 09-785, "Response to a Portion of NRC Request for Additional Information Letter No. 399 Related to ESBWR Design Certification Application - Qualification of Batteries- RAI 8.3-64 S02," December 12, 2009 (ADAMS Accession No. ML093491006)

5. NEDE-33516P, Revision 2, "ESBWR Qualification Plan Requirements for a 72-hour Duty Cycle Battery," December 2009 (ADAMS Accession No. ML093491007)

6. Regulatory Guide 1.89 "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 1984 (ADAMS Accession No. ML003740271)
7. Institute of Electrical and Electronics Engineers (IEEE) Standard 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," New York, February 28, 1974.
8. Regulatory Guide 1.100, Revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 1988 (ADAMS Accession No. ML003740293)
9. Institute of Electrical and Electronics Engineers Standard 344, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," New York, August 3, 1987.

10. Regulatory Guide 1.129, Revision 2, “Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, February 2007 (ADAMS Accession No. ML063490110)

11. Institute of Electrical and Electronics Engineers Standard 450, “IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead Acid Batteries for Stationary Applications,” New York, April 3, 2003.

12. Regulatory Guide 1.158, Revision 0, “Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, February 1989 (ADAMS Accession No. ML003740047)

13. Institute of Electrical and Electronics Engineers Standard 535, “IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations,” New York, June 25, 1986.

14. Regulatory Guide 1.212, Revision 0, “Sizing of Large Lead-Acid Storage Batteries,” U.S. Nuclear Regulatory Commission, November 2008 (ADAMS Accession No. ML082740047)

15. Institute of Electrical and Electronics Engineers Standard 485, “IEEE Recommended Practice for Sizing of Lead-Acid Batteries for Stationary Applications,” New York, September 3, 1997.

16. Letter from D.J. Galvin (NRC) to J.G. Head (GEH), “Request for Additional Information Letter No. 399 related to Design Certification Document Revision 6,” December 7, 2009 (ADAMS Accession No. ML093370504)