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OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.129

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MAINTENANCE, TESTING, AND REPLACEMENT OF VENTED LEAD-ACID STORAGE BATTERIES FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) developed this regulatory guide to describe a method that the NRC staff considers acceptable for use in complying with the agency's regulations with regard to the maintenance, testing, and replacement of vented lead-acid storage batteries in nuclear power plants. Specifically, the method described in this regulatory guide relates to General Design Criteria (GDCs) 1, 17, and 18, as set forth in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities":

- GDC 1, "Quality Standards and Records," requires that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.
- GDC 17, "Electric Power Systems," requires that an onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety.
- GDC 18, "Inspection and Testing of Electric Power Systems," requires that electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components.

In addition, Criterion XI, "Test Control," in Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 sets forth the following requirements:

- A test program shall be established to ensure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service.
- The test program shall be identified and performed in accordance with written test procedures, which incorporate the requirements and acceptance limits contained in applicable design documents.
- The program shall include, as appropriate, proof tests prior to the installation, preoperational tests, and operational tests during nuclear power plant or fuel reprocessing plant operation, of structures, systems and components.
- Test procedures shall include provisions for ensuring that all prerequisites for the given test have been met, adequate test instrumentation is available and used, and the test is performed under suitable environmental conditions.
- Test results shall be documented and evaluated to ensure that test requirements have been satisfied.

To augment those requirements, Criterion XII, "Control of Measuring and Test Equipment," in Appendix B to 10 CFR Part 50 sets forth the following requirements:

> Measures shall be established to ensure that tools, gages, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated, and adjusted at specified periods to maintain accuracy with necessary limits.

This Revision 2 of Regulatory Guide 1.129 endorses (with certain clarifying regulatory positions described in Section C of this guide) the "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," which the Institute of Electrical and Electronics Engineers (IEEE) published as IEEE Std 450-2002[1]. By contrast, Revision 1 of Regulatory Guide 1.129, dated February 1978, endorsed (with certain clarifying regulatory positions described in Section C) IEEE Std 450-1975, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Lead Batteries for Generating Stations and Substations."

This revised regulatory guide is intended for licensees of new nuclear power plants.[2] Previous revisions of this regulatory guide remain in effect for licensees of current operating reactors,[2] who are unaffected by this revision. However, licensees of current operating reactors may voluntarily convert their battery maintenance, testing, and replacement criteria to the criteria in this revised guide.

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[1] IEEE publications may be purchased from the IEEE Service Center, which is located at 445 Hoes Lane, Piscataway, NJ 08855 [http://www.ieee.org, phone (800) 678-4333].

[2] The terms "new nuclear power plant" and "new plant" refer to any nuclear power plant for which the licensee obtained an operating license after the NRC issued Revision 2 of Regulatory Guide 1.129. The terms "current operating reactor" and "current plant" refer to any nuclear power plant for which the licensee obtained an operating license before the NRC issued Revision 2 of Regulatory Guide 1.129.

This regulatory guide contains information collections, covered by the requirements of 10 CFR Part 50, that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

IEEE Std 450-2002, was developed by the IEEE Standard 450 Working Group, Maintenance and Testing Subcommittee of the Power Engineering Society Stationary Battery Committee (Standards Coordinating Committee 29), and was approved by the IEEE-SA Standards Board on December 9, 2002. IEEE Std 450-2002 provides the recommended maintenance, test schedules, and testing procedures that can be used to optimize the life and performance of permanently installed, vented lead-acid storage batteries used for standby power applications. It also provides guidance to determine when batteries should be replaced. This recommended practice applies to full-float stationary applications, where a battery charger normally maintains the battery fully charged and provides the direct current (dc) loads. However, specific applications, such as emergency lighting units, semiportable equipment, and alternate energy applications, may have other appropriate practices that are beyond the scope of the recommended practice. This recommended practice does not include any other components of the dc system, or inspection and testing of the dc system, even though the battery is part of that system, and does not specifically address Class 1E batteries in nuclear generating stations.

In comparison to IEEE Std 450-1975, IEEE Std 450-2002 is an updated national consensus standard that adds new recommendations and requirements, as well as informative annexes that reflect the current state of technology for vented lead-acid batteries. It is important to recognize that IEEE Std 450-2002 states that it shall be used in conjunction with IEEE Std 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." Consequently, some of the criteria in IEEE Std 450-2002 (such as the test acceptance criteria) depend on having sized the batteries in accordance with IEEE Std 485-1997. For example, the battery replacement criteria in IEEE Std 450-2002 are based on IEEE Std 485-1997, which recommends that the batteries be replaced when their actual performance drops below 80 percent of their rated performance. Consequently, IEEE Std 485-1997 recommends that to ensure the batteries are capable of meeting their design loads throughout their service life, the batteries' rated capacity should be 125 percent (1.25 aging factor) of the load expected at the end of their service life.

IEEE Std 450-2002 also introduces the use of stabilized charging current to determine a fully charged condition. The information in IEEE Std 450-2002 indicates that after battery discharge, the recharge current is initially high (typically for a few hours), but rapidly decreases to a relatively constant value as the battery voltage approaches the charger voltage. When the charging current stabilizes at the charging voltage for three consecutive hourly measurements, the battery is near full charge. IEEE Std 450-2002 also states that some methods to determine the state of charge are better suited than others for some battery cell plate metallurgies. Specifically, using stabilized charging current to determine a fully charged condition is the recommended practice for lead-calcium batteries, and using electrolyte-specific gravity and battery float voltage measurement readings is the recommended practice for lead-antimony batteries. The manufacturer should be consulted for the recommended charging method, as well as for the charging current and voltage parameters.

IEEE Std 450-2002 also introduces the use of a modified performance test in lieu of a service test and/or a performance test. A service test is a periodic test of the as-found condition of a battery to meet its duty cycle, and its results reflect the effectiveness of maintenance practices. A performance test is a periodic test of the battery capacity, and its results are used to trend battery aging and to determine when the battery needs to be replaced. By contrast, a modified performance test is a test of the battery capacity with the discharge rate modified according to the rules in an informative annex of IEEE Std 450-2002. These rules ensure that the modified performance testing is of sufficient magnitude and duration to envelop every portion of the battery duty cycle, the service test, and the performance test. For best trending results, the same test methods should be used throughout the battery life. Notably, the regulatory position in Revision 1 of Regulatory Guide 1.129 stated that both the performance and service tests should be performed, and the service test should be performed with a typically expected refueling cycle.

In addition, IEEE Std 450-2002 discusses the practice of allowing users to correct for temperature before or after conducting the discharge tests. The staff endorses IEEE's position to adjust temperature before conducting the test.

The NRC has developed this Revision 2 of Regulatory Guide 1.129 to (1) carry forward the regulatory position from Revision 1, and (2) develop regulatory positions based on the review of the differences between IEEE Std 450-1975 and IEEE Std 450-2002, with consideration of Class 1E batteries used in nuclear power generating stations.

C. REGULATORY POSITION

Conformance with IEEE Std 450-2002 requirements (indicated by the verb "shall") for maintenance, testing, and replacement of vented lead-acid storage batteries for stationary applications provides an adequate basis for complying with the requirements set forth in GDCs 1, 17, and 18 of Appendix A to 10 CFR Part 50, as well as Criterion III of Appendix B to 10 CFR Part 50, as they relate to testing the operability and functional performance of the components of large lead storage battery systems, subject to the following regulatory positions:

1. Subsection 2, "References," which stipulates that this standard should be used in conjunction with other IEEE standards, should be supplemented as follows:

   "This recommended practice shall be used in conjunction with the following publications:

   - IEEE Std 308, 'Criteria for Class 1E Power Systems for Nuclear Power Generating Stations,' as endorsed by Regulatory Guide 1.32
   - IEEE Std 484, 'IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications,' as endorsed by Regulatory Guide 1.128
   - IEEE Std 485-1997, 'IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications'"

2. Subsection 5.2, "Inspections," should be supplemented with the following:

   "For nuclear power generating station Class 1E batteries, battery float current and voltage should be measured and recorded weekly. Where reference is made to the pilot cell, pilot cell selection shall be based on finding an average cell that is representative of the entire battery's individual cell voltage and specific gravity readings. If the temperature differential across the battery exceeds 5 °F, it is appropriate to include average cell temperature in the selection criteria."

3. Subsection 5.4.1, "State of Charge Indicator," should be supplemented with the following:

   "(c) For nuclear power generating stations, the manufacturer should be consulted for the proper voltage and charging current ranges and durations."

   "(d) For nuclear power generating station Class 1E batteries, the use of stabilized charging current to determine a fully charged condition should (1) be limited to lead-calcium batteries and (2) verified by measurements during charging. When it has been recorded that the charging current has stabilized at the charging voltage for three consecutive hourly measurements, the battery is near full charge. These measurements shall be made after the initially high charging current decreases sharply and the battery voltage rises to approach the charger output voltage. As there is wide variation in the initial and end charging currents, the instrumentation used to measure charging currents should have the appropriate range and sensitivity."

4. Subsection 6, "Test Schedule," should be supplemented with the following:

   "For nuclear power generating station Class 1E batteries, the battery service test discussed in Subsection 6.3, 'Service,' and described in Subsection 7.5, 'Service Test,' should be performed in addition to the battery performance test described in Subsection 6.2, 'Performance.' The battery service test should be performed with intervals not to exceed 24 months."

5. In Subsection 6.4, "Modified performance test," the last paragraph states that a modified performance test can be used in lieu of a service test and/or a performance test at any time, and if the battery has been sized in accordance with IEEE Std 485-1997, it is acceptable if it delivers a tested capacity of 80 percent. This statement should be replaced with the following:

   "For nuclear power generating station Class 1E batteries, a modified performance test can be used in lieu of a service test and/or a performance test at any time. However, it is preferred that the same test method be used throughout the battery life. The modified performance test should follow the 'Rules for Modified Performance Tests' in Annex I, 'Modified Performance Testing Methods and Examples,' of IEEE Std 450-2002. If the battery has been sized in accordance IEEE Std 485-1997, the battery is acceptable if (1) it delivers a tested capacity of greater than 80 percent, and (2) there is no indication of degradation as indicated in Subsection 6.2(c) of IEEE Std 450-2002. The modified performance test should be performed with intervals not to exceed 24 months. However, when modified performance test results show that the battery has degraded, or has reached 85% of the expected life with a capacity lower than 100% of the manufacturer's rating, modified performance testing should be performed on an annual basis."

6. Subsection 7.1, "Initial conditions", item (c), should be revised to read as follows:

   "Record the specific gravity and float voltage of each cell just prior to the test."

7. Subsection 7.6, "Restoration", should be supplemented with the following:

   "Following the test, record the specific gravity and float voltage of each cell of the string."

8. Annexes A, B, C, D, G, H, J, K, L, and M are informative and provide optional test methods. Unless otherwise stated in a regulatory position, endorsement of IEEE Std 450-2002 does not include these annexes.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide. Because some areas of IEEE Std 450-2002 do not meet the NRC's regulatory requirements, this Revision 2 of Regulatory Guide 1.129 (1) carries forward the regulatory position from Revision 1, and (2) sets forth regulatory positions based on the staff's review of the differences between IEEE Std 450-1975 and IEEE Std 450-2002, with consideration of vented lead-acid batteries used in nuclear power generating stations. No backfitting is intended or approved in connection with the issuance of this revision.

Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide to evaluate (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate changes involving the maintenance, testing, and replacement of vented lead-acid batteries in nuclear power plants.

REGULATORY ANALYSIS / BACKFIT ANALYSIS

The regulatory analysis and backfit analysis for this regulatory guide are available in Draft Regulatory Guide DG-1155, "Maintenance, Testing and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants."[3] The NRC issued DG-1155 in October 2006 to solicit public comment on the draft of this Revision 2 of Regulatory Guide 1.129.

[3] Draft Regulatory Guide DG-1155 is available electronically under Accession #ML062540343 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4205, by fax at (301) 415-3548, and by email to PDR@nrc.gov.