DRAFT REGULATORY GUIDE DG-1155

(Proposed Revision 2 of Regulatory Guide 1.129, dated February 1978)

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":

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- 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.

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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 proposed 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 450-20021. By contrast, Revision 1 of Regulatory Guide 1.129, dated February 1978, currently endorses (with certain clarifying regulatory positions described in Section C) IEEE 450-1975, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Lead Batteries for Generating Stations and Substations."

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

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. The NRC issues regulatory guides in draft form to solicit public comment and involve the public in developing the agency's regulatory positions. Draft regulatory guides have not received complete staff review and, therefore, they do not represent official NRC staff positions.

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 450-2002, was developed by the 450 Working Group, of the IEEE Power Engineering Society Stationary Battery Committee (previously IEEE Standards Coordinating Committee 29), and was approved by the IEEE-Standards Association Standards Board on December 9, 2002. IEEE 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, semi-portable 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.

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In comparison to IEEE 450-1975, IEEE 450-2002 **COMMENT: IEEE 450 is a recommended practice. It is incorrect to refer to it as a standard. For consistency, the abbreviation Std should be removed from all locations.** 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 450-2002 states that it shall be used in conjunction with IEEE 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." Consequently, some of the criteria in IEEE 450-2002 (such as the test acceptance criteria) depend on having sized the batteries in accordance with IEEE 485-1997. For example, the battery replacement criteria in IEEE 450-2002 are based on IEEE 485-1997, which recommends that the batteries be replaced when their actual performance drops below 80 percent of their rated performance. Consequently, IEEE 485-1997 recommends that to ensure that 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.

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IEEE 450-2002 also introduces the use of stabilized charging current to determine a fully charged condition. The information in IEEE 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 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.

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IEEE 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 normative Annex I of IEEE 450-2002. **COMMENT: Normative Annexes are part of the document and endorsement of the document includes this annex.** 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.

COMMENT: This statement is incorrect. 450-1975 adjusted for temperature after the test. It is a change from IEEE 450-1980 through 1995 which were never endorsed by the NRC. The change back to post test temperature correction was driven by the adoption of the modified performance test. Applying a temperature correction to the discharge rates prior to performing a service or modified performance test can result in discharge rates less than the battery load profile and is therefore not allowed in Annex I. There is also significant industry experience to show that many errors in testing have been made by incorrect application of the correction factor prior to testing. For these reasons, the working group made the decision to return to post test temperature correction and applied it to all tests for consistency. Since this was a return to the original test methodology, no technical justification was required.

The NRC has developed this proposed 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 450-1975 and IEEE 450-2002, with consideration of Class 1E batteries used in nuclear power generating stations.

C. REGULATORY POSITION

Conformance with the requirements denoted by the verb shall and recommendations denoted by the verb should of IEEE 450-2002 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: **COMMENT: The wording change was done for consistency with 1154.**

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

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

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

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

"For nuclear power generating station Class 1E batteries, battery float current and voltage shall be measured and recorded weekly." **COMMENT: This requirement exists in TSTF-360 and the text needs to be clear it is a requirement.**

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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. See Annex A.2 and A.4 for additional information."

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 6.1, "Acceptance test," a second sentence should be added to state as follows:

"However, a test of the battery's capability (Service Test or Modified Performance Test) (see 7.5) shall be made upon initial installation."

COMMENTS:

1. This statement is not based on IEEE 450 recommendations or requirements and does not belong in Reg. Guide 1.129. It is based on IEEE 336 pre-operational test requirements and IEEE 484-6.3.4 acceptance test requirements. Please select one of the following options: remove the requirement, re-locate the requirement to the IEEE 336 Reg. Guide, relocate the requirement to Reg. Guide 1.128 or provide bases information in this section identifying the source document(s) and requirement. The recommendation is to relocate the requirement to Reg. Guide 1.128 which describes the other installation test requirements.

2. More importantly, this statement assumes a factory acceptance test was performed. If a factory acceptance test was not performed then a modified performance test or both a service and performance test is/are required at installation to meet the requirements of IEEE 336 for pre-operational testing and IEEE 484-6.3.4 for post installation testing.

6. 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 450-2002. If the battery has been sized in accordance IEEE 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 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."

COMMENT: You cannot adjust for temperature prior to a modified performance test because doing so could result in test rates below the battery load profile. In addition, NORMATIVE Annex I 'Rules for Modified Performance Tests' specifically states to not adjust for temperature prior to the test. Therefore, this statement is technically incorrect and in conflict with Item 6 above must be removed.

7. 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 450-2002 does not include these annexes.

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Deleted: <#>In Subsection 7.2.2, "Discharge Rate," the last paragraph allows users to transition from correcting for temperature *before* conducting the discharge test to correcting for temperature *after* conducting the discharge test. This statement should be supplemented with the following:
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"For nuclear power generating station Class 1E batteries, the preferred method is to adjust the discharge rate for the time-adjusted method for temperature before conducting the test."
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8. Informative Annexes E and F provide visual inspection and intercell connection resistance inspection and test methods and are specifically endorsed as part of IEEE 450-2002.
COMMENT: These annexes are required to support the periodic inspections and tests of Clause 5 and must be endorsed.

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D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this draft regulatory guide. Because some areas of IEEE 450-2002 do not meet the NRC's regulatory requirements, this proposed 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 450-1975 and IEEE 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 proposed revision.

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The NRC has issued this draft guide to encourage public participation in its development. 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 methods to be described in the active guide will reflect public comments and will be used in evaluating (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.

REGULATORY ANALYSIS

1. Statement of the Problem

Revision 1 of Regulatory Guide 1.129, dated February 1978, currently endorses (with certain clarifying regulatory positions) IEEE 450-1975. By contrast, IEEE 450-2002, which the IEEE-Standards Association Standards Board approved on December 9, 2002, is an updated national consensus document that reflects the current state of technology. There is an immediate need to revise Regulatory Guide 1.129, as IEEE 450-2002 introduces several new technologies that could result in greater efficiencies for both new and currently operating reactors. IEEE 450-2002 introduces the application of stabilized charging current, rather than specific gravity, to determine a lead-calcium battery's state-of-charge. It also introduces a modified performance test that has been designed to envelop the traditional performance and service tests. Accordingly, the NRC's Office of Nuclear Reactor Regulation (NRR) has requested that the agency update the current regulatory guidance in Revision 1 of Regulatory Guide 1.129 based on the latest available information to support the licensing of new and currently operating reactors.

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2. Technical Approach

In developing Revision 2 of Regulatory Guide 1.129, the NRC staff considered the following two alternative approaches:

(1) **Take no action.** IEEE 450-2002 has been updated to reflect the current state of technology, and it is already being used voluntarily by licensees of current operating reactors. Taking no action adds no value, as it leaves in place a regulatory guide that is based on a 31-year-old IEEE recommended practice that does not reflect current technology. Moreover, without revised regulatory guidance, NRR will most likely require additional resources to evaluate the differences when applications for new reactors or licensing amendments for current operating reactors use the more recent revision. As a result, the staff did not select this approach.

(2) **Revise Regulatory Guide 1.129 to incorporate previous regulatory positions pertaining to this subject and endorse IEEE 450-2002 with clarifying exceptions as appropriate.** Revision 2 of Regulatory Guide 1.129 is intended for new plants. However, it is likely that new reactors and current operating reactors will voluntarily adopt this standard because of the effectiveness and efficiencies of the new technologies.

The NRC staff compared IEEE 450-2002 to IEEE 450-1975 to identify the changes to be evaluated with regard to their impact on safety and the regulatory positions in Revision 1 of Regulatory Guide 1.129.

3. Values and Impacts

In the following summary of values and impacts, an impact represents a "cost" in terms of schedule, budget, staffing, or an undesirable attribute that would accrue from taking the proposed approach.

3.1 Alternative 1: Take No Action

This alternative has a perceived cost benefit, in that IEEE 450-1975, as endorsed by Revision 1 of Regulatory Guide 1.129, has been in use for many years and is familiar to the industry. However, applicants for new reactors are not using IEEE 450-1975, and the industry has indicated a general interest in using IEEE 450-2002 for current operating reactors.

Value: None. Although the industry is familiar with Revision 1 of Regulatory Guide 1.129, which endorses IEEE 450-1975, new plants are using, and current operating reactors are likely to voluntarily adopt, IEEE 450-2002 because of the resulting efficiencies.

Impact: This alternative would incur schedule and staff costs to the NRC and applicants associated with evaluating case-by-case differences between IEEE 450-1975 (as endorsed by Revision 1 of Regulatory Guide 1.129) and, when used, IEEE 450-2002.

3.2 Alternative 2: Revise Regulatory Guide 1.129 to Incorporate the Previous Regulatory Positions Pertaining to This Subject and Endorse IEEE 450-2002 with Clarifying Exceptions as Appropriate

Value: IEEE 450-2002 reflects the current state of technology, which, if adopted for new or current operating reactors, will help to ensure compliance of battery maintenance,

testing, and replacement with GDC 1, 17, and 18 (as set forth in Appendix A to 10 CFR Part 50) and Criteria III and XII (as set forth in Appendix B to 10 CFR Part 50).

Battery charging current, in accordance with clarifying regulatory positions, may be a more reliable indicator of the state-of-charge for lead-calcium batteries than specific gravity. The use of a modified performance test in lieu of performance and/or service tests neither adds nor detracts in value, as it envelops both tests and demonstrates the high rate capability of the battery to meet its duty cycle.

Impact: The regulatory position to add weekly measurements should generally have no impact, as it is consistent with typical nuclear generating station Technical Specification Surveillance Requirements.

The use of battery charging current and modified performance testing, in accordance with clarifying regulatory positions, should have a favorable impact. The use of stabilized charging current to determine the state of charge is expected to lead to remote battery monitoring and be significantly more efficient than the use of specific gravity. A single test takes less time and is more efficient than two tests.

Another benefit of utilizing the modified performance test in lieu of the service test is that it would provide more data points for trending the capacity of the battery.

Adjusting the discharge rate for the time-adjustment method for temperature before conducting the test is the current method and should have no impact.

The use of IEEE 485-1997 in conjunction with IEEE 450-2002 is implicit, and this should have no impact as IEEE 485-1997 is the general battery sizing criterion that has been used by the industry.

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4. Conclusion

The staff recommends that the NRC issue Revision 2 of Regulatory Guide 1.129 to endorse IEEE 450-2002 as the recommended practice for the maintenance, testing, and replacement of vented lead-acid storage batteries for stationary applications. This action will enhance the licensing process for new nuclear power plants, while providing the flexibility for current operating reactors to adopt this guidance without cost impact.

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BACKFIT ANALYSIS

This regulatory guide does not require a backfit analysis, as described in 10 CFR 50.109, "Backfitting," because it is intended for new nuclear power plants. The use of this revision by current operating licensees is entirely voluntary.

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