U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE RG 1.158, REVISION 1

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QUALIFICATION OF SAFETY-RELATED VENTED LEAD-ACID STORAGE BATTERIES FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes methods and procedures the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in complying with NRC regulations regarding the qualification method of safety-related lead-acid storage batteries for nuclear power plants. This revision of RG 1.158 endorses, with clarifications, the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 535-2013, "IEEE Standard for Qualification of Class 1E Vented Lead Acid Storage Batteries for Nuclear Power Generating Stations" (Ref. 1).

Applicability

This RG applies to applicants and licensees subject to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50), Appendix A, "General Design Criteria for Nuclear Power Plants" (Ref. 2), and applicants and licensees under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 3).

Applicable Regulations

- 10 CFR 50.55a, "Codes and Standards," lists documents approved for incorporation by reference.
- 10 CFR 50.63, "Loss of all alternating current power," requires, in part, that the reactor core and associated coolant, control, and protection systems, including station batteries and other necessary support systems, must provide sufficient capacity and capability to ensure that the core is cooled and appropriate containment integrity is maintained in the event of a station blackout for the specified duration.
- General Design Criteria (GDC) 1, "Quality standards and records," in Appendix A to 10 CFR Part 50 requires, in part, that structures, systems, and components important to safety be

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Electronic copies of this RG, previous versions of RGs, and other recently issued guides are also available through the NRC's public Web site in the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/, under Document Collections, in Regulatory Guides. This RG is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under ADAMS Accession Number (No.) ML17256A104. The regulatory analysis may be found in ADAMS under Accession No. ML16340A112. The associated draft guide DG-1338 may be found in ADAMS under Accession No. ML16337A005, and the staff responses to the public comments on DG-1338 may be found under ADAMS Accession No. ML17256A103.

designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- GDC 17, "Electric power systems," in Appendix A to 10 CFR Part 50 requires, in part, that an onsite electric power system and an offsite electric power system be provided to permit functioning of structures, systems, and components important to safety.

Related Guidance

- RG 1.32, "Criteria for Power Systems for Nuclear Power Plants" (Ref. 4), endorses, with clarifications, IEEE Std. 308, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations" (Ref. 5). This RG provides guidance for meeting the GDC for the safety-related portions of systems and equipment in the alternating current power systems, direct current (dc) power systems, and instrumentation and control power systems.

- RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants" (Ref. 6), endorses, with clarifications, IEEE Std. 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Ref. 7). This RG provides guidance for complying with 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," with regard to qualification of electric equipment important to safety for service in nuclear power plants to ensure that the equipment can perform its safety function during and after a design basis event.

- RG 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants" (Ref. 8), endorses, with clarifications, IEEE Std. 344, "IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations" (Ref. 9). This RG describes methods the staff of the NRC considers acceptable for use in the seismic qualification and functional qualification of electrical and active mechanical equipment in new nuclear power plants and new or replacement electrical equipment in operating plants.

- RG 1.212, "Sizing of Large Lead-Acid Storage Batteries" (Ref. 10), endorses, with clarifications, IEEE Std. 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." (Ref. 11). This RG provides guidance for defining the dc load and size of vented lead-acid batteries needed to supply the defined load for applications to support nuclear power plants operations.

- RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants" (Ref. 12), endorses, with clarifications, IEEE Std. 484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 13). This RG describes a method that the NRC staff considers acceptable for complying with the agency's regulations with regard to criteria for the installation design and installation of vented lead-acid storage batteries in nuclear power plants.

- RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," (Ref. 14), endorses, with clarifications, IEEE Std. 450, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 15). This RG describes methods the NRC staff considers acceptable for use in complying with the agency's regulations on maintenance, testing, and replacement of vented lead-acid storage batteries in nuclear power plants.

- RG 1.210, “Qualification of Safety-Related Battery Chargers and Inverters for Nuclear Power Plants” (Ref. 16), endorses, with clarifications, IEEE Std. 650, “IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations” (Ref. 17). This RG describes a method that the NRC staff considers acceptable for complying with regulations for the qualification of safety-related battery chargers and inverters for nuclear power plants.

Purpose of Regulatory Guides

The NRC issues RGs 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 events, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

Paperwork Reduction Act

This RG provides guidance for implementing the mandatory information collections in 10 CFR Parts 50 and 52 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), under control numbers 3150-0011 and 3150-0151. Send comments regarding this information collection to the Information Services Branch, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0011, 3150-0151), Office of Management and Budget, Washington, DC 20503.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless the document requesting or requiring the collection displays a currently valid OMB control number.

B. DISCUSSION

Reason for Revision

Revision 1 of RG 1.158 endorses, with clarifications, IEEE Std. 535-2013, which was updated to include more up-to-date methods, tests and qualifying documentation related to lead storage batteries. The NRC staff determined that RG 1.158 should be revised to endorse, with clarifications, the 2013 version of IEEE Std. 535 to support new reactor license applications, design certifications, and applications for license amendments.

Background

Revision 0 of RG 1.158 (Ref.18), endorsed with clarifications, IEEE Std. 535-1979, "IEEE Standard for Qualification of Class IE Lead Storage Batteries for Nuclear Power Generating Stations" (Ref. 19).

IEEE Std. 535-2013 was developed by the IEEE Power and Energy Society Stationary Batteries Committee and approved by the IEEE Standards Association Standards Board on October 31, 2013. The 2013 revision of IEEE Std. 535 refines the qualification methods and type-test procedures for two different battery applications. One application is for duty cycles equal to or less than 8 hours and the other application is for duty cycles greater than 8 hours. The 2013 revision of IEEE Std. 535 demonstrates and outlines the qualifying process for both applications to ensure battery performance. The standard also includes a normative annex that reflects the 10-to 20-year qualification testing programs for batteries with 24-hour and 72-hour duty cycles. The standard is only applicable to vented lead-acid batteries. The installation, maintenance, and design of the dc system and the sizing of batteries and battery charger(s) are beyond the scope of the IEEE standard and this RG.

Safety related batteries and battery racks undergo a qualification program for the verification that each battery meets or exceeds its design specification throughout the period for which the battery is installed to its removal (installed life). The term installed life is also discussed in the endorsed guidance IEEE Std. 450 and IEEE Std. 485. This RG provides guidance on the qualification methods for vented lead-acid batteries and their racks to ensure that the equipment meets or exceeds its design specifications throughout its installed life. Further discussion on the seismic qualification of battery racks is provided in IEEE Std. 344, which is endorsed in RG 1.100. According to IEEE Std. 535-2013, vented lead-acid batteries to be qualified must be aged (by natural or accelerated means) to their end-of-installed-life condition and the user must demonstrate that the predominant failure mechanism for the batteries is addressed. This RG also addresses the changes from a typical dc system duty cycle of 8 hours or less to extended duty cycles of longer than 8 hours in specific applications.

The qualification of Class 1E vented-lead acid storage batteries, as described in IEEE Std. 535-2013, may be conducted by various methods which includes type testing. The type testing method provides qualification guidance for batteries to demonstrate each battery's capacity and capability to perform its design function. It requires the user to demonstrate that, for full float service, (1) the predominant failure mechanism is positive plate grid corrosion and (2) the accelerated aging factors are addressed in accordance with the standard. The standard provides accelerating thermal aging factors (temperature and duration) based on activation energy values for three specific positive plate types.

Harmonization with International Standards

The International Atomic Energy Agency (IAEA) has established a series of safety guides and standards that present good practices, and that increasingly reflect best practices, to help users achieve high levels of safety. Pertinent to this RG is IAEA Safety Guide No. 34, "Design of Electrical Power Systems for Nuclear Power Plants" (issued 2016) (Ref. 20). IAEA Safety Guide No. 34 addresses the management, verification, testing, and documentation of the electrical power systems design and components. More specifically, section 9.15 (v) references the documentation of the equipment qualification plans, analyses and test reports. There are additional applicable sections (5.154 - 5.165 and 5.169 - 5.179) that are relevant to equipment qualification that are applicable to this RG. This RG incorporates similar design and qualification testing guidelines and is consistent with the basic safety principles provided in IAEA Specific Safety Guide No. 34.

Documents Discussed in Staff Regulatory Guidance

This RG endorses the use of one or more codes or standards developed by external organizations and other third party guidance documents. These codes, standards, and third party guidance documents may contain references to other codes, standards or third party guidance documents ("secondary references"). If a secondary reference is incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference is endorsed in a RG as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific RG. If the secondary reference is neither incorporated by reference into NRC regulations nor endorsed in a RG, then the secondary reference is neither a legally-binding requirement nor a "generic" NRC-approved acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified and consistent with applicable NRC requirements and current regulatory practice.

C. STAFF REGULATORY GUIDANCE

The NRC staff endorses IEEE Std. 535-2013 and finds that it provides acceptable methods for complying with the qualification requirements for stationary battery applications for nuclear power plants, subject to the following regulatory positions:

1. Section 2, "Normative references," of IEEE Std. 535-2013 stipulates that this standard is to be used in conjunction with other IEEE standards. It should be supplemented as follows:

   For nuclear power generating stations, the recommended practice should also be used in conjunction with other pertinent publications and applicable NRC guidance. The most recent revision of the pertinent publications should be used. The pertinent publications include the following IEEE standards (with associated applicable NRC guidance):

   - IEEE Std. 308, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations" (as endorsed, with clarification, by RG 1.32);
   - IEEE Std. 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (as endorsed, with clarification, by RG 1.89);
   - IEEE Std. 344, "IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations" (as endorsed, with clarification, by RG 1.100);
   - IEEE Std. 450, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications" (as endorsed, with clarification, by RG 1.129);
   - IEEE Std. 484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications" (as endorsed, with clarification, by RG 1.128); and
   - IEEE Std. 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications" (as endorsed, with clarification, by RG 1.212).

2. Section 4, "Qualification requirements," of IEEE Std. 535-2013 states that the qualification may be accomplished by type testing, operating experience, or analysis, and any of these may be used individually or in combination. This statement is inconsistent with IEEE Std. 323, Section 5.1.3, "Analysis," which states that analysis alone cannot be used to demonstrate qualification. Therefore, Section 4 of IEEE Std. 535-2013 should be supplemented with the below clarifications.

   - For nuclear power generating station's Class 1E batteries, the qualification of the batteries can be accomplished by type testing, or type testing in combination with operating experience or analysis, or type testing in combination with both operating experience and analysis.
   - For nuclear power generating station's Class 1E batteries, the qualification of the batteries can be accomplished by operating experience alone, or in combination with analysis, provided that the following elements (which are derived from IEEE Std. 323, Section 5.1.2 "Operating Experience") are evaluated and documented.

- Performance data from equipment of similar design that has successfully operated under known service conditions may be used in qualifying other equipment to equal or less severe conditions.

- Adequate data and documentation that establishes past service conditions, equipment performance, and similarity against the equipment to be qualified and upon which operating experience exists.

- A demonstration of required operability during applicable design basis event(s) shall be included in equipment qualification programs based on operating experience, when design basis event qualification is required.

3. Section 8.3.2, "Accelerated Aging Conditions," of IEEE Std. 535-2013 provides accelerated aging factors based on accelerated thermal (time-temperature) aging factors, however the standard does not provide the methodology used to develop the aging factors. The use of aging factors in the standard or the use of any alternatives should be based on the Arrhenius method[1]. The use of the Arrhenius method should be documented in the test record.

[1] The Arrhenius method is an accelerated aging technique based on the use of elevated temperature to accelerate the rate of aging of components. The method is based on the Arrhenius equation for the thermal energy addition to increase rate of reaction.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[2] may use this RG and information regarding the NRC's plans for using this RG. In addition, it describes how the NRC staff complies with 10 CFR 50.109, "Backfitting" and any applicable finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

Use by Applicants and Licensees

Applicants and licensees may voluntarily[3] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this RG may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged**.**

Licensees may use the information in this RG for actions that do not require NRC review and approval, such as changes to a facility design under 10 CFR 50.59, "Changes, Tests, and Experiments." Licensees may use the information in this RG or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this RG. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this RG, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this RG to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this RG. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the RG, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this RG, generic communication, or promulgation of a rule requiring the use of this RG without further backfit consideration.

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this RG, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this RG are part of the licensing basis of the facility. However, unless this RG is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this RG constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this revised RG and (2) the specific subject matter of this RG is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the

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2 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; and the term "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

3 In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

guidance in this RG or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Additionally, an existing applicant may be required to comply with new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

If a licensee believes that the NRC is either using this RG or requesting or requiring the licensee to implement the methods or processes in this RG in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 21), and NUREG-1409, "Backfitting Guidelines" (Ref. 22).

REFERENCES[4]

1. Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 535-2013, "IEEE Standard for Qualification of Class 1E Vented Lead Acid Storage Batteries for Nuclear Power Generating Stations," Piscataway, NJ, 2013[5].

2. *U.S. Code of Federal Regulations* (CFR), "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter I, Title 10, "Energy" (10 CFR Part 50).

3. CFR, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy" (10 CFR Part 52).

4. U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 1.32, "Criteria for Power Systems for Nuclear Power Plants," Washington, DC.

5. IEEE Std. 308, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations" Piscataway, NJ.

6. NRC RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Washington, DC.

7. IEEE Std. 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ.

8. NRC RG 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," Washington, DC.

9. IEEE Std. 344, "IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations," Piscataway, NJ.

10. NRC RG 1.212, "Sizing of Large Lead-Acid Storage Batteries," Washington, DC.

11. IEEE Std. 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," Piscataway, NJ.

12. NRC RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," Washington, DC.

13. IEEE Std. 484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," Piscataway, NJ.

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4 Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/ and through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. The documents can also be viewed online or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD. For problems with ADAMS, contact the PDR staff at 301-415-4737 or (800) 397-4209; fax (301) 415-3548; or e-mail pdr.resource@nrc.gov.

5 Copies of Institute of Electrical and Electronics Engineers (IEEE) documents may be purchased from the Institute of Electrical and Electronics Engineers Service Center, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855 or through the IEEE's public Web site at http://www.ieee.org/publications_standards/index.html.

14. NRC RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," Washington, DC.

15. IEEE Std. 450, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," Piscataway, NJ.

16. NRC RG 1.210, "Qualification of Safety-Related Battery Chargers and Inverters for Nuclear Power Plants," Washington, DC.

17. IEEE Std. 650, "IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations," Piscataway, NJ.

18. NRC RG 1.158, "Qualifications of Safety-Related Leads Storage Batteries for Nuclear Power Plants," (Revision 0), February 1989, Washington, DC.

19. IEEE Std. 535-1979, "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations," Piscataway, NJ, 1986.

20. International Atomic Energy Agency (IAEA), Specific Safety Guide No. 34, "Design of Electrical Power Systems for Nuclear Power Plants," Vienna, Austria, 2016[6].

21. NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection," dated October 9, 2013, Washington, DC.

22. NRC NUREG-1409, "Backfitting Guidelines," July 1990, Washington, DC. (ADAMS Accession No. ML032230247).

6 Copies of International Atomic Energy Agency (IAEA) documents may be obtained through their Web site: WWW.IAEA.Org/ or by writing the International Atomic Energy Agency P.O. Box 100 Wagramer Strasse 5, A-1400 Vienna, Austria. Telephone (+43-1) 2600-0, Fax (+43-1) 2600-7, or E-Mail at Official.Mail@IAEA.Org