U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE 1.212, REVISION 2

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SIZING OF LARGE LEAD-ACID STORAGE BATTERIES

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes an approach that is acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) to meet regulatory requirements for sizing large lead-acid storage batteries for production and utilization facilities. It endorses, with some limitations and a clarification, Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 485-2020, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications" (Ref. 1).

Applicability

This RG applies to licensees and applicants subject to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2), and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 3). Under 10 CFR Part 50, this RG applies to licensees of or applicants for production and utilization facilities. Under 10 CFR Part 52, this RG applies to applicants and holders of combined licenses, standard design certifications, standard design approvals, and manufacturing licenses.

Applicable Regulations

- 10 CFR Part 50 provides regulations for licensing production and utilization facilities.
    - 10 CFR 50.55a, "Codes and standards," requires, in part, that structures, systems, and components be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed.
    - 10 CFR 50.63(a)(2) requires, in part, that the reactor core and associated coolant, control, and protection systems, including station batteries and any other necessary support systems, 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.

Written suggestions regarding this guide may be submitted through the NRC's public Web site in the NRC Library at https://www.nrc.gov/reading-rm/doc-collections/reg-guides/index.html, under Document Collections, in Regulatory Guides, at https://www.nrc.gov/reading-rm/doc-collections/reg-guides/contactus.html, and will be considered in future updates and enhancements to the "Regulatory Guide" series. During the development process of new guides suggestions should be submitted within the comment period for immediate consideration. Suggestions received outside of the comment period will be considered if practical to do so or may be considered for future updates.

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 https://www.nrc.gov/reading-rm/doc-collections/reg-guides/index.html/ 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.) ML23118A344. The regulatory analysis may be found in ADAMS under Accession No. ML22307A144. The associated draft guide DG-1418 may be found in ADAMS under Accession No. ML22307A132, and the staff responses to the public comments on DG-1418 may be found under ADAMS Accession No. ML23118A345.

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 1, "Quality Standards and Records," requires, in part, that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems," 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.

- 10 CFR Part 52 governs the issuance of early site permits, standard design certifications, combined licenses, standard design approvals, and manufacturing licenses for nuclear power facilities. Part 52 specifies, among other things, that contents of some applications must satisfy the requirements of 10 CFR Part 50, Appendix A; 10 CFR 50.55a; and 10 CFR 50.63, "Loss of all alternating current power."

Related Guidance

- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: Light-Water Reactor (LWR Edition)" (Ref. 4), provides guidance to the NRC staff in performing safety reviews under 10 CFR Part 50 and 10 CFR Part 52. Specifically, Section 8.3.2, "DC Power Systems (Onsite)," contains review guidance related to direct current (dc) systems, including batteries.

- RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants and Utilization Facilities" (Ref. 5), endorses, with clarifications, IEEE Std. 450, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 6), as an acceptable method to meet the regulations concerning the maintenance, testing, and replacement of vented lead-acid storage batteries in nuclear power plants.

- RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants" (Ref. 7), endorses, with clarifications, IEEE Std. 484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 8), as an acceptable method to meet the regulations concerning the installation design and installation of vented lead-acid storage batteries in nuclear power plants.

- NUREG-1537, Parts 1 and 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," issued February 1996 (Ref. 9), contains format and content guidance for non-power reactor applicants and licensees, as well as a standard review plan and acceptance criteria for the NRC staff.

- "Final Interim Staff Guidance Augmenting NUREG-1537, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors,' Parts 1 and 2, for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," issued October 2012 (Ref. 10), provides format and content guidance for non-power aqueous homogeneous reactor and radioisotope production facility applicants and licensees, as well as a standard review plan and acceptance criteria for the NRC staff.

- "Endorsement of Appendix A to Oak Ridge National Laboratory Report, 'Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application,' as Guidance for

Preparing Applications for the Licensing of Non-Power Liquid Fueled Molten Salt Reactors," dated November 18, 2020 (Ref. 11), endorses, with clarifications, Appendix A to ORNL/TM-2020/1478, "Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application," issued July 2020 (Ref. 12), to support the review of non-power molten salt reactors.

Purpose of Regulatory Guides

The NRC issues RGs to describe methods that are acceptable to the staff for implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific issues or postulated events, and to describe information that the staff needs in its review of applications for permits and licenses. RGs are not NRC regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs are acceptable if supported by a basis for the issuance or continuance of a permit or license by the Commission.

Paperwork Reduction Act

This RG provides voluntary 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, respectively. Send comments regarding this information collection to the FOIA, Library, and Information Collections Branch (T6-A10M), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the OMB reviewer at: OMB Office of Information and Regulatory Affairs, (3150-0011 and 3150-0151), Attn: Desk Officer for the Nuclear Regulatory Commission, 725 17th Street, NW, Washington, DC, 20503; e-mail: oira_submissions@omb.eop.gov.

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

This revision of the RG (Revision 2) endorses, with some limitations and a clarification, IEEE Std. 485-2020 and applies to production and utilization facilities licensed under 10 CFR Part 50 and 10 CFR Part 52 within the scope of this RG. The previous version of this RG endorsed, with certain clarifications, IEEE Std. 485-2010. In 2020, the IEEE revised IEEE Std. 485 to refine the methods for defining dc load guidance and sizing large lead-acid batteries to ensure consistent performance. The revised IEEE standard provides a succinct document for the sizing of batteries with informative annexes. The NRC staff determined that, based on the revised IEEE standard, a revision to this RG is needed to support applications for new reactor licenses, design certifications, and license amendments.

Background

This RG provides guidance to applicants and licensees for defining the dc load and sizing lead-acid batteries to supply the defined load for full-float stationary battery applications. IEEE Std. 485-2020 describes the recommended methods for defining the dc load and for sizing lead-acid batteries to supply dc power to applications during the full range of operating and emergency conditions.

IEEE Std. 485-2020 is an updated national consensus standard that adds new recommendations and guidance, as well as informative annexes, for both vented and valve-regulated lead-acid batteries for stationary applications. The standard was developed by the IEEE Power Engineering Society Stationary Batteries Committee and approved by the IEEE Standards Association Standards Board on May 6, 2020. The standard is applicable to vented and valve-regulated lead-acid batteries and also describes some factors relating to cell selection. However, consideration of battery types other than lead acid is beyond the scope of this RG. Additionally, installation, maintenance, qualification, testing procedures, and design of the dc system and sizing of the battery charger(s) are beyond the scope of the IEEE standard and this RG.

It is important to recognize that IEEE Std. 485-2020 states it can be used as a standalone document. However, the NRC staff has found that using IEEE Std. 485-2020 in conjunction with IEEE Std. 450 and IEEE Std. 484 provides the user with a general guide to the design, installation, and maintenance of vented lead-acid batteries. In addition, the staff notes that IEEE/American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 1635-2022, "Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications," (Ref. 13) provides helpful ventilation calculations that are associated with IEEE Standard 484. For the design, installation, and maintenance of valve-regulated lead-acid (VRLA) batteries, the NRC staff reviewed IEEE Std. 1187, "IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications" (Ref. 14), and IEEE Std. 1188, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications" (Ref. 15), and found that the standards provide additional information and criteria for VRLA battery users.

The sizing methodology in IEEE Std. 485-2020 is very similar to that in IEEE Std. 485-2010. The approach consists of defining the load that the batteries will be required to support and using the guidance in the IEEE standard to determine the best battery for the application. To this end, IEEE Std. 485-2020 provides guidance on general considerations that should be included in defining the duty cycle; load classifications, including continuous, noncontinuous, and momentary loads; and the construction of a duty cycle diagram. In calculating the number of cells and minimum voltage section, IEEE Std. 485-2020

cautions the user that the charging voltage needs to be recalculated and verified for adequacy if the numbers of cells are rounded off. It also discusses how to ensure all voltage drops are considered when calculating the allowable minimum voltage.

IEEE Std. 485-2020 discusses defining loads and other considerations but notes that for sizing purposes the loads can be treated as constant power or constant current. The updated annexes A, B, C, D, E, F, G, and H are informative, and applicants and licensees should review them to assist with the battery design.

IEEE Std. 485-2020, section 4.2.5, "Duty Cycle Diagram," states that the total time span of the duty cycle is determined by the requirements of the installation. This duty cycle time depends on the type of production and utilization facility design and is typically discussed in a plant safety analysis report. This guidance does not apply to the emergency diesel generators (EDGs) or onsite emergency power source's own battery if provided separately (which is exclusively sized based on the starting requirement of the EDG or onsite emergency power source, such as field flash).

Consideration of International Standards

The International Atomic Energy Agency (IAEA) works with member states and other partners to promote the safe, secure, and peaceful use of nuclear technologies. The IAEA develops safety requirements and safety guides for protecting people and the environment from harmful effects of ionizing radiation. This system of safety fundamentals, safety requirements, safety guides, and other relevant reports reflects an international perspective on what constitutes a high level of safety. Pursuant to the Commission's International Policy Statement (Ref. 16) and Management Directive 6.6, "Regulatory Guides" (Ref. 17), the NRC considered the following IAEA safety guide and safety requirement in the development of the RG:

- IAEA Safety Guide NS-G-1.8, "Design of Emergency Power Systems for Nuclear Power Plants," (Ref. 18)

- IAEA Safety Standards Series No. SSG-34, "Design of Electrical Power Systems for Nuclear Power Plants," (Ref. 19)

Although the NRC has an interest in facilitating the harmonization of standards used domestically and internationally, the agency does not specifically endorse the IAEA documents listed above and is only acknowledging that such documents may be a useful reference for general information.

Documents Discussed in Staff Regulatory Guidance

This RG endorses, in part, 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 has itself been 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 has been 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 has neither been 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, consistent with current regulatory practice, and consistent with applicable NRC requirements.

C. STAFF REGULATORY GUIDANCE

The staff finds that IEEE Std. 485-2020 provides methods acceptable to the NRC staff for complying with the design requirements for stationary battery applications in full-float operation for production and utilization facilities, subject to the following limitations and a clarification:

1. Annex A to IEEE Std. 485-2020 is informative and provides sample sizing demonstrations. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

2. Annex B to IEEE Std. 485-2020 is informative and provides a method for estimating battery terminal voltage at various points in the battery duty cycle using the manufacturer's typical discharge characteristics. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

3. Annex C to IEEE Std. 485-2020 is informative and provides a method for considering other cell types when selecting a battery for its intended application. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

4. Annex D to IEEE Std. 485-2020 is informative and provides a method for sizing a battery properly for a constant power application and for converting from either constant power loads or constant resistance loads to constant current. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

5. Annex E to IEEE Std. 485-2020 is informative and provides a method for describing the construction and use of the battery discharge characteristics curve. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

6. Annex F to IEEE Std. 485-2020 is informative and provides a method for addressing random loads and their application in the battery sizing process. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

7. Annex G to IEEE Std. 485-2020 is a full-size worksheet, "Sizing Lead-Acid Batteries for Stationary Applications," and is endorsed as an accepted method for sizing lead-acid batteries.

8. Annex H to IEEE Std. 485-2020 is informative and provides the bibliography. Unless otherwise stated in a separate regulatory position, endorsement of IEEE Std. 485-2020 does not include endorsement of this annex.

9. The safety analysis report should discuss the battery duty cycle span. For active designs, the battery duty cycle should cover both DBA and SBO scenarios (with a permitted load shedding scheme). The minimum duty cycle for active designs for DBAs should be 2 hours.

D. IMPLEMENTATION

The NRC staff may use this regulatory guide as a reference in its regulatory processes, such as licensing, inspection, or enforcement. However, the NRC staff does not intend to use the guidance in this RG to support NRC staff actions in a manner that would constitute backfitting as that term is defined in 10 CFR 50.109, "Backfitting," and as described in NRC Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests," (Ref. 20), nor does the NRC staff intend to use the guidance to affect the issue finality of an approval under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The staff also does not intend to use the guidance to support NRC staff actions in a manner that constitutes forward fitting as that term is defined and described in Management Directive 8.4. If a licensee believes that the NRC is using this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfitting or forward fitting appeal with the NRC in accordance with the process in Management Directive 8.4.

REFERENCES [1]

1. Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 485-2020, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," Piscataway, New Jersey.[2]

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

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

4. U.S. NRC, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 8.3.2, "DC Power Systems (Onsite)," Washington, DC. (ADAMS Accession No. ML100740391)

5. NRC, RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Production and Utilization Facilities," Washington, DC.

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

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

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

9. NRC, NUREG-1537, Parts 1 and 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," Washington, DC, February 1996. (ML12156A069 and ML12156A075, respectively)

10. NRC, "Final Interim Staff Guidance Augmenting NUREG-1537, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors,' Parts 1 and 2, for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," Washington, DC, October 17, 2012. (ML12156A053)

11. NRC, "Endorsement of Appendix A to Oak Ridge National Laboratory Report, 'Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application,' as

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1 Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public website 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. For problems with ADAMS, contact the Public Document Room staff at 301-415-4737 or (800) 397-4209, or email pdr.resource@nrc.gov. The NRC Public Document Room (PDR), where you may also examine and order copies of publicly available documents, is open by appointment. To make an appointment to visit the PDR, please send an email to PDR.Resource@nrc.gov or call 1-800-397-4209 or 301-415-4737, between 8 a.m. and 4 p.m. eastern time (ET), Monday through Friday, except Federal holidays.

2 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/index.html.

Guidance for Preparing Applications for the Licensing of Non-Power Liquid Fueled Molten Salt Reactors," Washington, DC, November 18, 2020. (ML20251A008)

12. Oak Ridge National Laboratory, ORNL/TM-2020/1478, "Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application," Oak Ridge, Tennessee, July 2020. (ML20219A771)

13. IEEE/American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), IEEE/ASHRAE 1635-2022, "Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications," Piscataway, New Jersey.

14. IEEE Std. 1187, "IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications," Piscataway, New Jersey.

15. IEEE Std. 1188, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications," Piscataway, New Jersey.

16. NRC, "Nuclear Regulatory Commission International Policy Statement," *Federal Register*, Vol. 79, No. 132, July 10, 2014, pp. 39415–39418.

17. NRC, Management Directive 6.6, "Regulatory Guides," Washington, DC.

18. International Atomic Energy Agency (IAEA) Safety Guide NS-G-1.8, "Design of Emergency Power Systems for Nuclear Power Plants," IAEA, Vienna, Austria, 2004.[3]

19. IAEA, Safety Standards Series No. SSG-34, "Design of Electrical Power Systems for Nuclear Power Plants," IAEA, Vienna, Austria, 2016.

20. NRC, Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests," Washington, DC.

3 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.