U.S. NUCLEAR REGULATORY COMMISSION

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Proposed Revision 4 to Regulatory Guide 1.32

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CRITERIA FOR POWER SYSTEMS FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes a method acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) to meet regulatory requirements for the design, operation, and testing of electric power systems in nuclear power plants. Specifically, it provides guidance for meeting the general design criteria (GDC) for the safety-related portions of systems and equipment in the alternating current (AC) power systems, direct current (DC) power systems, and instrumentation and control power systems. This RG revision endorses, with exceptions and clarifications, Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 308-2020, "IEEE Standard Criteria for Class 1E Power Systems 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" (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 applicants for and holders of licenses, as defined in 10 CFR 50.2, "Definitions." Under 10 CFR Part 52, this RG applies to applicants for and holders of combined licenses, standard design approvals and manufacturing licenses, and applicants for standard design certifications for nuclear power plants.

Applicable Regulations

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," establishes the minimum requirements for principal design criteria for water-cooled nuclear power plants,[1] which include the following:

[1] The GDC in 10 CFR 50 Appendix A are considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units.

- General Design Criteria (GDC) 1, "Quality Standards and Records," requires, in part, that structures, systems, and components important to safety be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed.

- GDC 5, "Sharing of structures, systems, and components," requires that structures, systems, and components important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

- GDC 17, "Electric power systems," requires, in part, an onsite and an offsite electric power system to permit functioning of certain structures, systems, and components.

- GDC 18, "Inspection and testing of electric power systems," requires, in part, that electric power systems important to safety be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the systems and the condition of their components.

- 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Criterion XI, "Test Control," requires, in part, that a test program be established to assure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed.

- 10 CFR 50.55a, "Codes and standards," requires, in part, that structures, systems, and components (SSCs) be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed. Furthermore, 10 CFR 50.55a(h) provides requirements for protection and safety systems and incorporates by reference IEEE Std. 279-1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems" (Ref. 4), IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (Ref. 5), and IEEE Std. 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations" (including the correction sheet dated January 30, 1995) (Ref. 6). The applicability of each of these standards to a given nuclear power plant depends on the plant's licensing date and other criteria.

- 10 CFR Part 52 governs the issuance of early site permits, standard design certifications, combined licenses, standard design approvals, and manufacturing licenses. It specifies, among other things, that contents of certain applications must satisfy the requirements of 10 CFR Part 50, Appendix A, Appendix B and 10 CFR 50.55a.

Related Guidance

- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (Ref. 7), Chapter 8, "Electric Power," provides guidance to the NRC staff for performing safety reviews under 10 CFR Part 50 and 10 CFR Part 52. Specifically, Section 8.2, "Offsite Power Systems"; Section 8.3.1, "AC Power Systems (Onsite)"; and Section 8.3.2, "DC Power Systems (Onsite)," provide guidance for reviewing site electrical systems and compliance with GDCs 5, 17, and 18.

- RG 1.6, “Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6)” (Ref. 8), provides examples of acceptable independence between redundant standby power sources and redundant distribution systems, to comply with GDC 17.

- RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants” (Ref. 9), addresses the application of GDC 5. This RG permits sharing of some AC systems under certain conditions and subject to limitations but does not allow sharing of DC systems among units.

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. Regulatory guides 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, 50.55a 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, 3150-0264, 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 Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0011, 3150-0264, and 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

The NRC issued Revision 3 of RG 1.32, "Criteria for Power Systems for Nuclear Power Plants," in March 2004 (Ref. 10). Revision 3 of RG 1.32 endorsed (with exception) IEEE Std. 308–2001, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations." This revision of the guide (Revision 4) endorses, with exceptions and clarifications, IEEE Std. 308-2020, issued March 16, 2020, and incorporates the NRC's implementation of risk-informed, performance-based approach to licensing. In addition, this RG also includes provisions of RG 1.41, "Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments," issued March 1973 (Ref. 11). RG 1.41 describes methods acceptable to the NRC for independence among redundant, onsite power sources and their load groups as part of the initial preoperational testing program and after major modifications or repairs. Because the provisions of RG 1.41 are being consolidated in this RG, RG 1.41 will be withdrawn with the issuance of RG 1.32 Revision 4.

Background

This RG describes a method acceptable to the NRC staff for complying with the agency's regulations for the design, operation, and testing of electric power systems in nuclear power plants. Specifically, it provides guidance for meeting the GDC for the portions of systems and equipment in the AC power systems, DC power systems, and instrumentation and control power systems that are important to safety. For onsite emergency power systems designed in accordance with RG 1.6 and RG 1.32 (Safety Guides 6 and 32), this guide describes an acceptable method of complying with the Commission's regulations with respect to verifying the proper assignments of redundant load groups to the related onsite power sources.

IEEE Std. 308-2020 was prepared by IEEE Nuclear Power Engineering Committee Working Group 4.1, "Class 1E Power Systems Working Group," and was approved by the IEEE Standards Board on March 6, 2020. IEEE Std. 308-2020 provides (1) the principal design criteria and the design features for the safety-related power systems that enable the systems to meet their functional requirements under the conditions produced by the postulated design-basis events, (2) methods for tests and surveillance of the safety-related power systems, (3) criteria for sharing safety-related power systems in multi-unit nuclear power plants, and (4) provisions for documenting the safety-related power systems.

Regarding harmonics and harmonic distortion, IEEE Std. 519, "IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems," (Ref. 12) provides guidance in the design of power systems with nonlinear loads. IEEE Std. 1159, "IEEE Recommended Practice for Monitoring Electric Power Quality," (Ref. 13) and IEEE Std. 1531, "IEEE Guide for the Application and Specification of Harmonic Filters," (Ref. 14) provide additional information on monitoring power quality and harmonic filters, respectively. The NRC staff reviewed IEEE Standards 519, 1159, and 1531 and found that these documents contain information on power quality, harmonics, and harmonic filters; however, this revision of RG 1.32 does not endorse IEEE Std. 519, 1159, or 1531. Additionally, the NRC published Research Information Letter 2023-09, "An Assessment of the Harmonics Effects on Undervoltage Relays in Nuclear Power Plants" (Ref. 15) that contains information on the effects of harmonic distortion on electrical protection relay operation.

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. To inform its development of this RG, the NRC considered IAEA Safety Requirements and Safety Guides pursuant to the Commission's International Policy Statement (Ref. 16) and Management Directive and Handbook 6.6, "Regulatory Guides" (Ref. 17).

The following IAEA Specific Safety Guide was considered in the update of the Regulatory Guide:

- IAEA Specific Safety Guide No. SSG-34, "Design of Electrical Power Systems for Nuclear Power Plants," issued March 2016 (Ref. 18)

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 NRC staff finds that IEEE Std. 308-2020 provides methods acceptable for complying with the design, operation, and testing requirements for electric power systems, subject to the following exceptions and clarifications.

1. This RG does not endorse Section 2, "Normative References," of IEEE Std. 308-2020. The following RGs contain additional information for the design, operation, and testing requirements for electric power systems.

    - RG 1.28, "Quality Assurance Program Criteria (Design and Construction)," (Ref. 19) which endorses ASME NQA-1, with clarifications.

    - RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," (Ref. 20) which endorses IEC/IEEE 60780-323, with clarifications.

    - RG 1.152, "Criteria for Use of Computers in Safety Systems of Nuclear Power Plants," (Ref. 21) which endorses IEEE 7-4.3.2, with clarifications.

    - RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants," (Ref. 22) which endorses IEEE Std. 317, with clarifications.

    - RG 1.118, "Periodic Testing of Electric Power and Protection Systems," (Ref. 23) which endorses IEEE Std. 338, with clarifications.

    - RG 1.75, "Criteria for Independence of Electrical Safety Systems," (Ref. 24) which endorses IEEE Std. 384, with clarifications.

    - RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," (Ref. 25) which endorses IEEE Std. 387, with clarifications.

    - RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Production and Utilization Facilities," (Ref. 26) which endorses IEEE Std. 450, with clarifications.

    - RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants," (Ref. 27) which endorses IEEE Std. 484, with clarifications.

    - RG 1.212, Sizing of Large Lead-Acid Storage Batteries," (Ref. 28) which endorses IEEE Std. 485, with clarifications.

    - RG 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants," (Ref. 29) which endorses IEEE Std. 535, with clarifications.

    - RG 1.238, "Criteria for the Protection of Class 1E Power Systems and Equipment for Nuclear Power Plants," (Ref. 30) which endorses IEEE Std. 741, with clarifications.

2. This RG does not endorse Section 7.3 of IEEE Std. 308-2020, which states, "Class 1E dc systems shall not be shared in multi-unit stations unless it can be shown that such sharing will not impair

their ability to perform their safety function." Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," states that dc power systems in multi-unit nuclear power plants should not be shared. Consistent with RG 1.81, the NRC does not endorse the IEEE Std. 308-2020 criteria for sharing safety-related dc power systems in multi-unit or multi-module nuclear power plants.

3. With the withdrawal of RG 1.41, its provisions for preoperational testing of load groups and proper redundant source independence are herein consolidated with the following supplement to Section 6.3, "Preoperational system test," of IEEE Std. 308-2020:

> As part of the initial preoperational testing program and after major modifications or repairs to a nuclear facility, those onsite electric power systems designed in accordance with RG 1.6 (Safety Guide 6) and RG 1.32 should be tested as follows to verify the existence of independence among redundant onsite power sources and their load groups.
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> I. The plant electric power distribution system, not necessarily including the switchyard and the startup and auxiliary transformers, should be isolated from the offsite transmission network. Preferably, this isolation should be initiated by direct actuation of the undervoltage-sensing relays within the onsite system.
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> II. Under the conditions of I above, the onsite electric power system should be functionally tested successively in the various possible combinations of power sources and load groups with all DC and onsite AC power sources for one load group at a time completely disconnected. Each test should include injection of simulated accident signals, startup of the onsite power source(s) and load group(s) under test, sequencing of loads, and the functional performance of the loads. Each test should be of sufficient duration to achieve stable operating conditions and thus permit the onset and detection of adverse conditions that could result from improper assignment of loads (e.g., the lack of forced cooling of a vital device).
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> III. During each test, the DC and onsite AC buses and related loads not under test should be monitored to verify absence of voltage at these buses and loads.

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 regulatory guide 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. 31), 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 [2]

These references indicate the versions of the documents available at the time of issuance of this regulatory guide (RG). Licensees or applicants using this RG should check all referenced documents to verify that no change has occurred since the issuance of the RG.

1. Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 308-2020, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations," Piscataway, New Jersey, March 2020.[3]

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. IEEE, Std. 279-1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems," Piscataway, New Jersey, 1968.

5. IEEE, Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Piscataway, New Jersey, 1971.

6. IEEE, Std. 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations" (including the correction sheet dated January 30, 1995), Piscataway, New Jersey, 1995.

7. U.S. Nuclear Regulatory Commission (NRC), NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Washington, DC.

8. NRC, Regulatory Guide (RG) 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6)," Washington, DC.

9. NRC, RG 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants," Washington, DC.

10. NRC, RG 1.32, "Criteria for Power Systems for Nuclear Power Plants," Revision 3, Washington, DC.

11. NRC, RG 1.41, "Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments," Washington, DC.

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[2] 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.

[3] 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, P.O. Box 1331, Piscataway, New Jersey 08855 or through the IEEE's public website at http://www.ieee.org/publications_standards/index.html.

12. IEEE Std. 519, "IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems," Piscataway, New Jersey, August 2022.

13. IEEE Std. 1159, "IEEE Recommended Practice for Monitoring Electric Power Quality," Piscataway, New Jersey, August 2019.

14. IEEE Std. 1531, "IEEE Guide for the Application and Specification of Harmonic Filters," Piscataway, New Jersey, January 2021.

15. NRC, Research Information Letter 2023-09, "An Assessment of the Harmonics Effects on Undervoltage Relays in Nuclear Power Plants," Washington, DC, January 2024, (ADAMS Accession No. ML23352A256).

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) Specific Safety Guide No. SSG 34, "Design of Electrical Power Systems for Nuclear Power Plants," Vienna, Austria, March 2016.[4]

19. NRC. RG 1.28, "Quality Assurance Program Criteria (Design and Construction)," Washington, DC.

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

21. NRC, RG 1.152, "Criteria for Programmable Digital Devices in Safety-Related Systems of Nuclear Power Plants," Washington, DC.

22. NRC, RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants," Washington, DC.

23. NRC, RG 1.118, "Periodic Testing of Electric Power and Protection Systems," Washington, DC.

24. NRC, RG 1.75, "Criteria for Independence of Electrical Safety Systems," Washington, DC.

25. NRC, RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," Washington, DC.

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

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

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

[4] Copies of International Atomic Energy Agency (IAEA) documents may be obtained through their website: www.iaea.org or by writing the International Atomic Energy Agency, P.O. Box 100, Wagramer Strasse 5, A-1400 Vienna, Austria.

29. NRC, RG 1.158, “Qualification of Safety-Related Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” Washington, DC.

30. NRC, RG 1.238 “Criteria for The Protection of Safety-Related (Class 1E) Power Systems and Equipment for Production and Utilization Facilities,” Washington, DC (currently identified as draft regulatory guide DG-1354 ML24158A041).

31. NRC, Management Directive 8.4, “Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests,” Washington, DC.