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QUALIFICATION TESTS FOR SAFETY-RELATED ACTUATORS IN NUCLEAR POWER PLANTS

A. INTRODUCTION

Purpose

This regulatory guide (RG) endorses, with clarifications and exceptions, the methods described in the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 382-2006, "Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations" (Ref. 1), as an acceptable process for demonstrating compliance with the applicable U.S. Nuclear Regulatory Commission (NRC) regulations for the environmental qualification of safety-related power-operated valve actuators in nuclear power plants.

Applicable Rules and Regulations

The regulations established by the NRC in Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50) (Ref. 2), require that structures, systems, and components (SSCs) important to safety in a nuclear power plant be designed to accommodate the effects of environmental conditions (i.e., they must remain functional under postulated design-basis events (DBE)).

General Design Criterion (GDC) 1, "Quality Standards and Records," GDC 2, "Design Bases for Protection against Natural Phenomena," GDC 4, "Environmental and Dynamic Effects Design Bases," and GDC 23, "Protection System Failure Modes," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, contain general requirements to provide reasonable assurance that SSCs are designed to accommodate the effects of environmental conditions. Augmenting the above mentioned general requirements are specific requirements pertaining to qualification of certain electrical equipment important to safety described in 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants." In addition, Criterion III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, requires that, when a test program is used to verify the adequacy of a specific design feature, the test program must include suitable qualification testing of a prototype unit under the most adverse design conditions. Additionally, in accordance with 10 CFR 52.48, "Standards for Review of Applications," and 10 CFR 52.81, "Standards for Review of Applications," these GDC and quality

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Electronic copies of this regulatory guide, previous versions of this guide, and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/. The regulatory guide 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 No. ML13210A463. The regulatory analysis may be found under ADAMS Accession No. ML12219A400 and the staff responses to the public comments on DG-1235 may be found under ADAMS Accession No. ML13210A462.

assurance criteria also apply to nuclear power reactor licenses issued under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 3).

Related Guidance

In revision 1 of RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," (Ref. 4) the NRC staff endorsed, in part, Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 5) which is generally used by the nuclear industry to qualify safety-related (Class 1E) electric equipment located in an environment resulting from a postulated DBE (termed a harsh environment in IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 6)), non-safety related equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of certain safety functions, and certain post-accident monitoring equipment needed to satisfy the requirements in 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants."

In RG 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," (Ref. 7) the NRC staff describes methods considered acceptable for the seismic qualification of electrical and active mechanical equipment and the functional qualification of active mechanical equipment for nuclear power plants. In revision 3 of RG 1.100, the NRC staff endorses the use of IEEE Std. 344-2004, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 8) and the American Society of Mechanical Engineers (ASME) Standard QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plant," (Ref. 9) with specific conditions.

ASME Standard QME-1-2007 incorporates lessons learned from valve operating experience and research programs for the qualification of power-operated valves used in nuclear power plants. For example, ASME QME-1-2007 includes more stringent provisions for the functional qualification of power-operated valves than specified in IEEE Std. 382-2006, including acceptable qualification methods, actuator grouping, actuator output capability testing, and extrapolation of actuator qualification. ASME QME-1-2007 specifies the seismic qualification of valve assemblies in accordance with IEEE Std. 344-2004 as addressed in RG 1.100 or as described in the ASME standard.

ASME QME-1-2007 specifies, in part, that valve actuators should be environmentally qualified in accordance with IEEE Std. 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 10) and IEEE Std. 382-1985, "Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants" (Ref. 11). The NRC staff however, does not endorse the use of IEEE Std. 323-1983 or IEEE Std. 382-1985, and only accepts the use of IEEE Std. 382-2006 for the environmental qualification of safety related actuators in nuclear power plants subject to the provisions of this RG. In this RG, environmental qualification includes such activities as aging (e.g., thermal, cycling, radiation, and vibration), pressurization cycle testing, radiation exposure testing, and ambient condition testing (e.g., temperature, pressure, moisture, and spray environment). The users of IEEE Std. 382-2006 will need to address the other aspects of the qualification process (such as seismic and functional qualification) for power-operated valves using the guidance in RG 1.100.

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 NRC regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to licensees and 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 NRC.

Paperwork Reduction Act

This RG contains information collection requirements covered by 10 CFR Part 50 and Part 52 that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0011 and 3150-151 respectively. 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

Reason for Revision

Revision 0 of RG 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants," was issued in January 1974 to endorse IEEE Std. 382-1972, "IEEE Trial-Use Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Stations" (Ref. 12). The IEEE standard was revised in 1985, 1996, and again in 2006. However, RG 1.73 has not been updated since its original issue. This revision updates the RG to endorse the current version of IEEE Std. 382-2006, with certain exceptions and modifications.

Background

IEEE Std. 382-2006, was published on March 15, 2007. It was developed by the Subcommittee on Qualification of Actuators (SC 2.3) of the IEEE Nuclear Power Engineering Committee and approved by the IEEE Standards Association (IEEE-SA) Standards Board on December 6, 2006. This standard establishes criteria for the qualification of safety-related actuators and actuator components, in nuclear power generating stations. The primary objective is to demonstrate with reasonable assurance that safety-related actuators for which a qualified life or condition has been established can perform their safety function(s) without common-cause failures before, during, and after applicable DBE. Safety-related actuators and their interfaces must meet or exceed the equipment specification requirements. The IEEE standard specifies procedures for testing under conditions that simulate (1) the postulated DBE conditions including specified high-energy line break, loss of coolant accident, main steam line break, and safe shutdown seismic earthquake events, and (2) those occurring during normal operating conditions.

The standard specifies procedures for accomplishing aging of components to simulate the effects of long-term operation under normal and abnormal operating conditions. These effects include exposure to thermodynamic environment (temperature, pressure, relative humidity), fluid jet or spray environment, seismic and non-seismic vibration environment, radiation environment, anticipated variations in input power source (electrical and mechanical), and electrical and mechanical characteristics. The standard provides guidance for how to incorporate manufacturers' recommended maintenance intervals into the qualification process.

Harmonization with International Standards

The International Atomic Energy Agency (IAEA) has established a series of safety guides and standards constituting a high level of safety for protecting people and the environment. IAEA safety guides are international standards to help users striving to achieve high levels of safety. Pertinent to this RG, IAEA Safety Reports Series No. 3, "Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving, and Reviewing," issued April 1998, (Ref. 13) addresses environmental qualification of equipment important to safety in nuclear power plants. This RG incorporates similar environmental qualification recommendations and is consistent with the basic safety principles provided in IAEA Safety Report Series No. 3.

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 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 an 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 an 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 guidance in IEEE Std. 382-2006 provides an acceptable approach to the NRC staff for meeting the agency's regulatory requirements for environmental qualification of safety-related power-operated valve actuators in nuclear power plants with the exceptions and additions listed in this section. The guidance also provides an adequate basis for complying with the qualification testing requirements of Criterion III, "Design Control" of Appendix B to 10 CFR Part 50 to verify adequacy of design for service under DBE conditions subject to the following modifications.

1. Section 1.2 of IEEE Std. 382-2006 references IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Ref. 14) which provides guidance on demonstrating the qualification of safety-related equipment including components of any interface whose failure could adversely affect the performance of safety-related systems and electric equipment. As of the date of this RG, the NRC staff does not endorse IEEE Std. 323-2003 or IEEE Std. 323-1983 as acceptable means of meeting regulatory requirements for qualifying equipment for operations in harsh environments.

2. To the extent practical, auxiliary equipment (e.g., limit switches) that are not integral with the actuator mechanism but will be part of the installed actuator assembly should be tested in accordance with guidance in IEEE Std. 382-2006.

3. The applicants and licensees should perform environmental qualification of safety-related actuators using the guidance in RG 1.89. This testing includes a combination of type testing,

operating experience, and analysis rather than just type testing and operating experience, ongoing qualification, or a combination thereof. Type testing is the preferred method of equipment qualification because other methods may be based on older or dissimilar equipment that may not be comparable to the equipment being qualified.

4. The radiological source term for qualification tests in a nuclear radiation environment should be based on the source term methodology used in RG 1.89 or RG 1.183. The containment size should be taken into account in each case. For exposed organic materials, calculations should take into account both beta and gamma radiation.

5. Section 2, "Normative References," of IEEE Std. 382-2006, lists additional applicable IEEE standards. The specific applicability or acceptability of these referenced standards is discussed in the paragraph titled “Documents Discussed in Staff Regulatory Guidance” in Section B of this RG.

6. The environmental qualification criteria described in Section 6, "Qualification Testing of Selected Actuators in Generic Actuator Group," and Section 7, "Qualification of Actuator for Specific Application," of IEEE Std. 382-2006 should be used to qualify actuators in generic and specific applications, respectively, unless the anticipated actual service operating sequence for the actuator is expected to create a more severe impact than described in Section 6.3.2, "Test Sequence and Requirements." In such case, the actual service sequence should be used in the test.

7. Section 12.3, "Test Conduct," of IEEE Std. 382-2006 for Cycle Aging Tests, provides a representative number of cycles for the valve application. The applicant or licensee will be responsible for qualifying the actuator for its qualified life including its design cycles, as specified in the design requirements for new nuclear power plants or plants receiving license renewal for plant life extension.

8. Section 14, “Vibration Aging Test,” of IEEE Std. 382-2006 states that the vibration aging test is intended to provide a vibratory environment that is representative of normal plant induced vibration including system operating transients and other dynamic vibratory environments. The environmental qualification for power-operated valves should also address flow-induced vibration caused by acoustic resonance and hydraulic loading in the reactor, steam, and feed-water systems.

9. The NRC staff considers the guidance in IEEE Std. 382-2006 section 15 as an acceptable method for the environmental qualification of valve actuators as part of the qualification process for power-operated valves described in RG 1.100 subject to the following provisions:

    9.1 Section 15.3(b) of IEEE Std. 382-2006 states, “Each sweep shall be from 2 Hz to 35 Hz to 2 Hz, or other enveloping frequency range specified by the user." This requirement should be replaced with the following… “Each sweep shall be from 2Hz to 64Hz to 2Hz or, if the Required Response Spectra (RRS) has a frequency range exceeding 64Hz, then the frequency sweep should be consistent with the RRS of the specific plant equipment.”

    9.2 Section 15.3(c), of IEEE Std. 382-2006 states, for HRHF site plants, “...at one-third octave interval test frequencies indicated on Figure 1.” This should be replaced with the following: “…the frequency interval should be one-sixth octave to adequately identify resonance frequencies.” The users of IEEE Std. 382-2006 need to address the other

aspects of the qualification process (such as seismic and functional qualification) for power-operated valves as described in RG 1.100.

10. To ensure that the actuator is tested under an environment of sufficient severity, the magnitude of the environmental conditions (e.g., temperature, pressure, radiation, humidity) that simulate the conditions to which the actuator is expected to be exposed during and following a DBE (Section 17, "DBE environment test" of IEEE Std. 382-2006) should be based on conservative calculations. The equipment needs to be qualified for the duration of its operational performance requirement for each applicable DBE condition, including any required post DBE operability period.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] may use this guide and information regarding NRC 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[2] 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 the applicant or licensee provides 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 regulatory guide 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 that 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.

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1 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52, and "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.

2 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.

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 new or 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 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 NUREG-1409, "Backfitting Guidelines," (Ref. 15) and the NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 16).

REFERENCES[3]

1. Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 382-2006, "Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations," Piscataway, NJ.[4]

2. *U.S. Code of Federal Regulations* (CFR) "Domestic Licensing of Production and Utilization Facilities, Part 50, Chapter 1, Title 10, "Energy."

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

4. U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," revision 1, June 1984, Washington, DC. (ADAMS Accession No. ML003740271)

5. IEEE Std. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ. (ADAMS Accession No. ML032200206)

6. IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ, 2004.

7. NRC, RG 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Revision 3, September 2009, Washington, DC. (ADAMS Accession No. ML091320468)

8. IEEE Std. 344-2004, "Recommended Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ, 2004.

9. American Society of Mechanical Engineers (ASME) Standard QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plant," New York, NY.[5]

10. IEEE Std. 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ. 1983.

11. IEEE Std. 382-1985, "Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants," Piscataway, NJ. 1985.

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3 Publicly available NRC published documents can be accessed 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 also can 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 by e-mail pdr.resource@nrc.gov.

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

5 Copies of American Society of Mechanical Engineers (ASME) standards may be purchased from ASME, Three Park Avenue, New York, New York 10016-5990; Telephone 800-843-2763. Purchase information is available through the ASME Web site store at http://www.asme.org/Codes/Publications/.

12. IEEE Std. 382-1972, "IEEE Trial-Use Guide for Type Test of Class I Electric Valve Operators for Nuclear Power Generating Stations," Piscataway, NJ, 1972. (ADAMS Accession No. ML032200228)

13. International Atomic Energy Agency (IAEA) Safety Reports Series No. 3, "Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving, and Reviewing," April 1998, Vienna, Austria. [6]

14. IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" Piscataway, NJ, 2004.

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

16. NRC, Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection," Washington DC.

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 (+431) 2600-0, Fax (+431) 2600-7, or E-Mail at Official.Mail@IAEA.Org