



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

3.11 ENVIRONMENTAL QUALIFICATION OF MECHANICAL AND ELECTRICAL EQUIPMENT

REVIEW RESPONSIBILITIES

- Primary** - Organization responsible for the review of environmental qualification of electrical equipment
- Secondary** - Organization responsible for the review of instrumentation and control systems
- Organization responsible for the review of environmental qualification of mechanical equipment

I. AREAS OF REVIEW

The information presented in Section 3.11 of the applicant's safety analysis report (SAR) should be sufficient to support the conclusion that all items of equipment that are important to safety (mechanical, electrical, and instrumentation and control (I&C), including digital I&C) are capable of performing their design safety functions under all normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions. The "normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions" include all environmental conditions that may result from any normal mode of plant operation, anticipated operational occurrences, design basis events (as defined in 10 CFR 50.49(b)(1)(ii)), post-design basis events, and containment tests.

The review will be performed to assure conformance with the environmental design basis requirements of 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 4 which states, in part, that "Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant

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USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

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accidents." The review will assure conformance with the applicable portions of other relevant regulations, including 10 CFR Part 50, Appendix A, General Design Criteria (GDCs) 1, 2, and 23; and 10 CFR Part 50, Appendix B, Quality Assurance Criteria III, XI, and XVII. The review also assures conformance to 10 CFR 50.49, which contains specific requirements regarding the environmental qualification of electrical equipment important to safety that is located in a harsh environment. In addition, an application to use an alternative source term pursuant to 10 CFR 50.67 may need to include evaluations showing compliance with 10 CFR 50.49.

For mechanical equipment located in a harsh environment, compliance with the environmental design provisions of GDC 4 are generally achieved by demonstrating that the non-metallic parts/components are suitable for the postulated design basis environmental conditions.

For electrical and mechanical devices located in mild environments, compliance with the environmental design provisions of GDC 4 are generally achieved and demonstrated by proper incorporation of all relevant environmental conditions into the design process, including the equipment specification.

Reviews to determine compliance with related requirements for (1) dynamic and seismic qualification of electrical and mechanical equipment, (2) protection of electric and mechanical equipment against other natural phenomena and external events, (3) functional qualification of mechanical equipment, (4) equipment survivability for beyond design basis hydrogen burns, and (5) qualification of I&C equipment located in mild environments are described in other SRP sections.

The specific areas of review are as follows:

1. Mechanical, electrical, and I&C equipment associated with systems described in this paragraph are reviewed to determine whether they are designed to meet the requirements described under the acceptance criteria of this SRP section. Mechanical, electrical, and I&C equipment covered by this SRP section include the following:
 - A. Equipment associated with systems that are essential for emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or otherwise are essential in preventing significant release of radioactive material to the environment,
 - B. Equipment that initiates the above functions automatically,
 - C. Equipment that is used by the operators to initiate the above functions manually,
 - D. Equipment whose failure can prevent the satisfactory accomplishment of one or more of the above safety functions,
 - E. Other electrical equipment important to safety, as described in 10 CFR 50.49(b)(1) and (2), and
 - F. Certain post-accident monitoring equipment, as described in 10 CFR 50.49(b)(3) and Regulatory Guide 1.97.
2. Section 3.11 of the SAR is reviewed to determine whether the required environmental design and qualification of all equipment important to safety will be, or has been adequately demonstrated. The term "environmental qualification" means verification of

design, limited to demonstrating that electrical or mechanical or I&C equipment are capable of performing their safety function under significant environmental stresses (i.e., harsh environments) resulting from design basis events in order to avoid common-cause failure. Environmental design requirements apply to all equipment important to safety (i.e., both mild and harsh environments).

3. At the construction permit (CP) stage, the staff review considers the conceptual approach for meeting the environmental design and qualification requirements addressing the following areas:
 - A. Identification of all mechanical, electrical, and I&C systems required to perform the functions defined in Subsection I, Item 1, above.
 - B. Identification of the environmental design bases for the equipment identified, including the definition of anticipated operational occurrences and normal, accident, and post-accident environments.
 - C. Requirements for documentation of the qualification tests and analyses that have been, or will be performed on the equipment to meet the design bases.
 - D. Demonstration of the adequacy of the environmental design and qualification.
4. At the operating license (OL) stage, the staff's review includes the following:
 - A. A review of the applicant's environmental qualification program and the submitted results of its implementation.
 - B. An audit of the applicant's records, including a review of the documentation provided in the file to permit verification of environmental design and qualification for all mechanical, electrical, and I&C equipment covered by this SRP section. The staff's review is performed to determine (1) proper implementation of criteria established in the CP review, and (2) adequate environmental design and qualification for all electrical, mechanical, and I&C equipment covered by this SRP section.
5. The staff's review for design certification (DC) consists of an evaluation of the applicant's approach for selecting and identifying equipment required to be environmentally designed and qualified for the standard design.
6. Operational Program Description and Implementation. For a COL application, the staff reviews the Environmental Qualification program description and the proposed implementation milestones. The staff also reviews final safety analysis report (FSAR) Table 13.4.x to ensure that the Environmental Qualification Program and associated milestones are included.
7. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the

ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

8. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Review of the adequacy of the design, installation, inspection, and testing of containment systems is performed under SRP Sections 6.2.1 through 6.2.6.
2. Review of the adequacy of the design, installation, inspection, and testing of the Reactor Core Isolation Cooling system, the Residual Heat Removal system, and the Emergency Core Cooling System, and the accident analysis is performed under SRP Sections 5.4.6, 5.4.7, 6.3, and applicable sections of Chapter 15, respectively.
3. Review of the adequacy of the design, installation, inspection, and testing of I&C, including the functional design and qualification of digital I&C equipment located in a mild environment and the post-accident monitoring (PAM) equipment identified in 10 CFR 50.49(b)(3), is performed under SRP Chapter 7. Qualification guidance of digital I&C equipment located in a mild environment is also addressed in Regulatory Guide 1.209.
4. Review of the adequacy of the design, installation, inspection, and testing of electric power systems is performed under SRP Chapter 8.
5. Review of the adequacy of the design, installation, inspection, and testing of the containment spray system is performed under SRP Section 6.5.2.
6. Review of the adequacy of the design of all ventilation systems utilized to maintain a controlled environment in areas containing safety-related equipment is performed under SRP Section 9.4.5.
7. Review of the applicant's quality assurance (QA) program to verify that it satisfies the requirements of 10 CFR Part 50, Appendix B, Criteria III, XI, and XVII is performed under SRP Chapter 17.
8. Review of design basis radiological consequence analyses associated with design basis accidents is performed under SRP Section 15.0.3.
9. Review of the adequacy of chemical conditions for qualification to accident and post-accident environments, as well as anticipated operational occurrences is performed under SRP Section 6.5.2.

10. The functional design and qualification of mechanical, electrical, and I&C equipment are addressed in several sections of SRP Chapter 3. For example:
 - A. SRP 3.9.5 includes evaluation of potential adverse flow effects on mechanical and electrical equipment (such as electromatic relief valves in BWR steam systems) from pressure fluctuations and vibration caused by acoustic resonances and hydrodynamic forces.
 - B. SRP 3.9.6 includes functional design and qualification of pumps, valves, and dynamic restraints at a nuclear power plant. The review includes the potential impact of adverse environmental conditions on active mechanical and electrical equipment. For example, electric motors might produce less torque under high temperature conditions than under ambient conditions, which could impact their capability to operate their individual pumps or valves.
 - C. The design bases for protection of mechanical and electrical equipment against natural phenomena and external events, are reviewed under appropriate sections of SRP Chapter 3 (e.g., 3.3.1, 3.3.2, 3.4.1, 3.5.1.1, 3.5.1.4, 3.5.1.5, and 3.5.2). SRP Section 3.10 includes seismic and dynamic qualification of mechanical and electrical equipment.
11. Review of the adequacy of equipment functional performance during and after being exposed to the environmental conditions resulting from the release of hydrogen generated by the equivalent of a 100% fuel-clad metal-water reaction, as stated in 10 CFR 50.44(c), is performed under SRP Section 6.2.5.
12. For COL reviews of operational programs, the review of the applicant's implementation plan is performed under SRP Section 13.4, "Operational Programs."

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants."
2. 10 CFR 50.67, "Accident Source Term."
3. 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 1, "Quality Standards and Records."
4. GDC 2, "Design Bases for Protection Against Natural Phenomena."
5. GDC 4, "Environmental and Dynamic Effects Design Bases."
6. GDC 23, "Protection System Failure Modes."

7. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Section III, "Design Control."
8. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Section XI, "Test Control."
9. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Section XVII, "Quality Assurance Records."
10. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;
11. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

The general requirement for environmental design and qualification can be summarized as follows: (1) the equipment shall be designed to have the capability of performing its design safety functions under all anticipated operational occurrences and normal, accident, and post accident environment, and for the length of time for which its function is required; (2) the environmental qualification of equipment located in harsh environment shall be demonstrated by appropriate testing and analyses; and (3) a QA program meeting 10 CFR 50, Appendix B, shall be established and implemented to provide the assurance that all requirements have been satisfactorily accomplished. The environmental design and qualification of mechanical, electrical, and I&C equipment is acceptable when it can be ascertained that all three requirements have been met.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

If the NRC staff has endorsed a referenced standard in a regulatory guide, that standard constitutes an acceptable method for use in meeting the related regulatory requirement as described in the regulatory guide. If a referenced standard has not been endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard, if appropriately justified, consistent with current regulatory practice.

1. NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment," Revision 1, July 1981 provides staff positions applicable to existing plants for assessing the compliance of an environmental qualification program with 10 CFR 50.49. For future plants, Regulatory Guide 1.89 provides the principal guidance for implementing the requirements and criteria of 10 CFR 50.49 for environmental qualification of electrical equipment that is important to safety and located in a harsh environment. However, certain NUREG-0588 Category I guidance may be used if relevant guidance is not provided in Regulatory Guide 1.89. NUREG-0588 includes two sets of qualification criteria, Category I and Category II. Category I refers to IEEE Std 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." Category I applies to plants whose CP SERs were dated after July 1, 1974. Category II refers to IEEE Std 323-1971, and is not applicable to any future plants.
2. IEEE Std 323 contains the principles and criteria that are generic to the environmental qualification process. The following clarification related to the criteria in IEEE Std 323 should be considered. IEEE Std 323 requires that the service environment, including the installed configuration of the equipment, be considered as part of the qualification process. In meeting this requirement, the potential for flooding of electrical equipment that are installed above the flood level, but are subject to water and moisture intrusion, should be considered as part of environmental qualification. Operating experience (e.g., Information Notice 89-63) shows that electrical enclosures that are located above the flood level and are subject to water and moisture intrusion could result in submergence of electrical components inside the enclosures, if the enclosures do not have drainage holes. The reviewer should confirm that equipment in such locations, whose design is such that water accumulation is possible, should have measures to preclude such accumulation (e.g., enclosure drain holes) or the affected equipment should be qualified for the anticipated submergence.
3. Regulatory Guide 1.40, "Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants," endorses IEEE Std 334, "IEEE Trial Use Guide for Type Tests of Continuous-Duty Class 1 Motors Installed Inside the Containment of Nuclear Power Generating Stations." These documents contain guidance acceptable to the staff for the environmental design and qualification of Class 1E motors, and should be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental design and qualification of Continuous-Duty Class 1E Motors.
4. Regulatory Guide 1.63, "Electrical Penetration Assemblies in Containment Structures for Nuclear Power Plants," endorses IEEE Std 317, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations." These documents contain general guidance that is acceptable to the staff for the environmental design and qualification of electrical penetration assemblies, and should be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental design and qualification of electrical penetration assemblies.
5. Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants," endorses IEEE Std 382, "IEEE Trial Use Guide for Type Test of Class 1E Electric Valve Operators for Nuclear Power Generating Stations." These documents contain guidance acceptable to the staff for the environmental design and qualification of Class 1E electric valve operators, and should

be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental design and qualification of Class 1E electric valve operators.

6. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety in Nuclear Power Plants," provides guidance for implementing the requirements and criteria of 10 CFR 50.49 for environmental qualification of electrical equipment that is important to safety and located in a harsh environment. Regulatory Guide 1.89 endorses the provisions of IEEE Std 323 as being acceptable to the staff, and provides supplementary guidance for satisfying the Commission's regulations regarding the environmental qualification of electrical equipment located in a harsh environment.
7. Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident," provides guidance acceptable to the staff for the environmental qualification of the post-accident monitoring equipment described in Subsection I, Item 1(f), of this SRP section, as well as instruments and controls for the equipment described in Subsection I, Items 1(a) to 1(e), of this SRP section. These criteria, as supplemented by those of Regulatory Guide 1.89, should be used to evaluate the environmental qualification of the I&C equipment.
8. Draft Regulatory Guide 1.131, "Qualification Tests of Electric Cables and Field Splices for Light-Water-Cooled Nuclear Power Plants," endorses IEEE Std 383, "Standard for Type Test of Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations." These documents contain guidance acceptable to the staff for the environmental qualification of Class 1E electric cables and field splices, and should be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental qualification of Class 1E electric cables and field splices. Pending issuance of the "Final" version, the Draft version of RG 1.131 may be used as guidance.
9. Regulatory Guide 1.156, "Environmental Qualification of Connection Assemblies for Nuclear Power Plants," endorses IEEE Std 572, "IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations." These documents contain guidance acceptable to the staff for the environmental qualification of Class 1E connection assemblies, and should be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental qualification of Class 1E connection assemblies.
10. Regulatory Guide 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants," endorses IEEE Std 535, "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations." These documents contain guidance acceptable to the staff for the environmental qualification of Class 1E lead storage batteries, and should be used in conjunction with NUREG-0588 and Regulatory Guide 1.89, as appropriate, for evaluating the environmental qualification of lead storage batteries.
11. Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," provides guidance acceptable to the staff for determining electromagnetic compatibility for I&C equipment during service. These criteria, as supplemented by those of

Regulatory Guide 1.89, should be used to evaluate the environmental design and qualification of safety-related I&C equipment. New digital systems and new advanced analog systems may require susceptibility testing for electromagnetic interference/radio-frequency interference (EMI/RFI) and power surges, if the environments are significant to the equipment being qualified. The functional descriptions of I&C equipment are provided in SRP Chapter 7.

12. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," provides guidance acceptable to the staff for determining the radiation dose and dose rate for equipment during postulated accident conditions. These criteria, as supplemented by those of Regulatory Guide 1.89, should be used to evaluate the accident source term used in the environmental design and qualification of equipment important to safety.

10 CFR 50.67, "Accident Source Term," provides the requirements for licensees to revise the accident source term used in design basis radiological analyses for plants licensed prior to January 10, 1997.

Radiation dose and dose rate used to determine the radiation environment for qualification of electrical and mechanical equipment must be based on an NRC staff-approved source term and methodology, as discussed in NUREG-0588 and as supplemented by Section II.B.2 of NUREG-0737, "Clarification of TMI Action Plan Requirements," and NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License," or as discussed in NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants." The radiation environment must be based on the integrated effects of the normally expected radiation environment over the equipment's installed life, plus the effects associated with the most severe design basis event during or following which the equipment is required to remain functional. The effects of beta radiation must also be considered in the qualification process. The effects of radiation exposure due to recirculatory fluid must be considered for equipment located outside the containment.

The staff's definition of what constitutes a mild radiation environment for electronic components, such as semiconductors or electronic components containing organic material, differs from that for other equipment. The staff's position, as stated in NUREG-1503, "Final SER ABWR, Chapter 3, Design of Structures, Components, Equipment, and Systems," and NUREG-1793, "Final SER AP1000, Chapter 3, Design of Structures, Components, Equipment, and Systems," is that a mild radiation environment for electronic equipment is a total integrated dose less than 10 Gy (1E3 rad), and a mild radiation environment for other equipment is less than 100 Gy (1E4 rad).

Environmental qualification for electrical equipment located in a "Radiation harsh" environment (i.e., locations where radiation is the only harsh environmental condition) can be accomplished in accordance with 10 CFR 50.49(f)(4) using analysis of test data (from identical materials) combined with radiation test information (i.e., partial test data), and appropriate consideration of margin and aging effects for nonmetallic components/materials when sufficient documentation is available to preclude the need for a type test.

13. The effects of chemical exposure must be addressed in the environmental qualification process. The concentration of chemicals used for qualification must be equivalent to, or more severe than that resulting from the most limiting mode of plant operation

(e.g., containment spray, emergency core cooling system initiation, or recirculation phase). If the chemical composition of the chemical spray can be affected by equipment malfunctions, the most severe chemical environment that results from a single failure in the spray system must be assumed. If only demineralized water spray is used, then the effect of the demineralized water spray must be included in the equipment qualification.

14. Mechanical components must be designed to be compatible with postulated environmental conditions, including those associated with loss-of-coolant accidents (LOCAs). A process must be established to determine the suitability of materials, parts, and equipment needed for safety-related functions, and to verify that the design of such materials, parts, and equipment is adequate. Also, equipment records must be maintained, and these records must include the results of tests and material analyses used as part of the environmental design and qualification process for each component.

For mechanical equipment, the staff concentrates its review on materials that are sensitive to environmental effects (e.g., seals, gaskets, lubricants, fluids for hydraulic systems, and diaphragms). The reviewer confirms that the applicant has (1) identified safety-related mechanical equipment located in harsh environment areas, including its required operating time; (2) identified nonmetallic subcomponents of such equipment; (3) identified the environmental conditions and process parameters for which this equipment must be qualified; (4) identified nonmetallic material capabilities; and (5) evaluated environmental effects.

15. For electrical and mechanical equipment located in a mild environment, acceptable environmental design can be demonstrated by the "design/purchase" specifications for the equipment. The specifications must contain a description of the functional requirements for a specific environmental zone during normal environmental conditions and anticipated operational occurrences.

A well-supported maintenance/surveillance program, in conjunction with a good preventive maintenance program, is sufficient to ensure that equipment that meets the design/purchase specifications is qualified for the designed life. Compliance with 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants," and associated guidance in Regulatory Guide 1.160 are sufficient to provide reasonable assurance that environmental considerations established during design are reviewed every refueling outage and maintained on a continuing basis to ensure that the qualified design life has not been reduced by thermal, radiation, and/or cyclic degradation resulting from unanticipated operational occurrences or service conditions. Modification to the replacement program and/or replacement of equipment should be based on the review of maintenance/surveillance data.

16. For COL reviews, the description of the operational program and proposed implementation milestone(s) for the environmental qualification program are reviewed in accordance with 10 CFR 50.49. The implementation milestone for the environmental qualification program is to have all qualification requirements met prior to the loading of fuel. Implementation is required by a license condition.

Technical Rationale

The technical rationale for application of these acceptance criteria to reviewing this SRP section are discussed in the following paragraphs:

1. Compliance with 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," requires that the applicant establish a program, as described therein, for qualifying electrical equipment important to safety located in a harsh environment.

10 CFR 50.49 applies to this Section since it provides the regulations related to the environmental qualification of electrical and I&C equipment located in a harsh environment. The environmental qualification process described by this regulation provides requirements to ensure that equipment will be able to perform acceptably during all anticipated operating conditions, even after being degraded due to exposure to service conditions during its qualified life.

Meeting the requirements of 10 CFR 50.49 provides assurance that electrical and I&C equipment important to safety that are located in a harsh environment are environmentally qualified and are capable of performing their intended safety function.

2. Compliance with 10 CFR 50.67, "Accident Source Term," requires that licensees of plants licensed prior to January 10, 1997 seeking to revise the accident source term used in design basis radiological analyses apply for a license amendment, and provide an analysis of the consequences of applicable design basis accidents previously analyzed in the plant's safety analysis report.

10 CFR 50.67 applies to this section since it provides licensees with an option as to the source term used in design basis radiological analyses. This applies to environmental qualification, for which the radiological environment associated with a design basis event is used as the basis for qualification. The accident conditions under which the equipment must operate, and for which the equipment is qualified, will be impacted by the accident source term used in the postulated design basis event.

Meeting 10 CFR 50.67 provides assurance that a revision to the accident source term will include an analysis of the consequences of such a change, including impacts to the environmental qualification of equipment important to safety.

3. Compliance with GDC 1, "Quality Standards and Records," requires that components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

GDC 1 is applicable to this Section since it includes requirements for quality standards that must be met, and records that must be kept concerning the quality standards for design, fabrication, erection, and testing of components important to safety. Components in the scope of this SRP Section that are subject to environmental design and qualification must have auditable records to document that environmental design and qualification requirements have been met.

Meeting GDC 1 provides assurance that the equipment is of sufficiently high quality to be capable of performing their design safety functions acceptably during all anticipated operating conditions and that appropriate records are maintained to document meeting these requirements.

4. GDC 2, "Design Bases for Protection Against Natural Phenomena," requires that components important to safety be designed to withstand the effects of natural

phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety function.

GDC 2 is applicable to this section since the design bases for components important to safety must consider the effects of the most severe natural phenomena anticipated for the site, together with normal and accident plant operating conditions and the importance of the safety function to be performed. Components in the scope of this section that are subject to environmental design and qualification must consider environmental conditions/stressors resulting from natural phenomena as part of the environmental conditions evaluated.

Meeting GDC 2 provides assurance that appropriate combinations of the effects of normal and accident conditions resulting from the effects of the natural phenomena are considered in meeting the environmental design and qualification requirements.

5. Compliance with GDC 4, "Environmental and Dynamic Effects Design Bases," requires that components important to safety be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs. Components must be protected against dynamic effects, including those of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

GDC 4 is applicable to this section since it provides the requirement for components important to safety to be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs.

Meeting GDC 4 ensures that equipment important to safety are environmentally designed and qualified, and provides assurance that the equipment will be able to accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs.

6. Compliance with GDC 23, "Protection System Failure Modes," requires that protection systems be designed to fail in a safe state, or in a state demonstrated to be acceptable on some other defined basis, if conditions such as postulated adverse environments (e.g., extreme heat or cold, pressure, steam, water, or radiation) are experienced.

GDC 23 is applicable to this section since the environmental design and qualification of protection systems must ensure that the protection systems will fail in a safe state, or in a state demonstrated to be acceptable on some other defined basis, if they are subjected to harsh conditions such as postulated adverse environments. Components in the scope of this section that are subject to environmental design and qualification requirements must consider the failure mode of the equipment.

Meeting GDC 23 provides assurance that the failure mode of protection system components is considered in the environmental design and qualification process.

7. Compliance with 10 CFR Part 50, Appendix B, Criterion III, "Design Control," requires that measures be established to ensure that applicable regulatory requirements and the associated design bases are correctly translated into specifications, drawings,

procedures, and instructions. These measures should include provisions to ensure that appropriate quality standards are included in design documents and that deviations from established standards are controlled. A process should also be established to determine the suitability of equipment that is essential to safety-related functions and to identify, control, and coordinate design interfaces between participating design organizations. Where a test program is used to verify the adequacy of a specific design feature, it shall include suitable qualification testing of a prototype unit under the most adverse design conditions.

10 CFR 50, Appendix B, Criterion III is applicable to this Section since it includes requirements for test programs that are used to verify the adequacy of a specific design feature. Such test programs must include suitable qualification testing of a prototype unit under the most adverse design conditions. For components in the scope of this section that are subject to environmental qualification testing, the test program must address these requirements.

Meeting 10 CFR Part 50, Appendix B, Criterion III provides assurance that the environmental qualification process includes suitable qualification testing of a prototype unit under the most adverse design conditions.

8. Compliance with 10 CFR Part 50, Appendix B, Criterion XI, "Test Control," requires that a test control plan be established to ensure that all tests needed to demonstrate a component's capability to perform satisfactorily in service be identified and performed in accordance with written procedures that incorporate the requirements and acceptance limits contained in applicable design documents.

10 CFR 50, Appendix B, Criterion XI is applicable to this Section since it includes requirements for developing a test control plan to ensure that all tests needed to demonstrate a component's capability to perform satisfactorily in service be identified and performed in accordance with written procedures that incorporate the requirements and acceptance limits contained in applicable design documents. Components in the scope of this SRP Section that are subject to testing to verify conformance to environmental design and qualification requirements must consider these requirements for a test control plan.

Meeting 10 CFR Part 50, Appendix B, Criterion XI provides assurance that a test control plan is established for components subject to testing for environmental design and qualification to ensure that all tests needed to demonstrate a component's capability to perform satisfactorily in service are identified and performed in accordance with written procedures that incorporate the requirements and acceptance limits contained in applicable design documents.

9. Compliance with 10 CFR Part 50, Appendix B, Criterion XVII, "Quality Assurance Records," requires that sufficient records be maintained to furnish evidence of activities affecting quality. The records must include inspections, tests, audits, monitoring of work performance, and materials analysis. Records must be identifiable and retrievable.

10 CFR 50, Appendix B, Criterion XVII is applicable to this Section since it includes requirements for records that must be maintained to furnish evidence of activities affecting quality. Environmental design and qualification are activities that can affect quality, therefore, components in the scope of this section that are subject to

environmental design and qualification must have identifiable and retrievable records that document the fact that they meet these requirements.

Meeting 10 CFR Part 50, Appendix B, Criterion XVII provides assurance that identifiable and retrievable records are maintained to furnish evidence of activities affecting quality, which includes environmental design and qualification.

10. In Staff Requirements Memorandum SECY-05-0197, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria," dated February 22, 2006, the Commission approved the use of a license condition for operational program implementation milestones that are fully described or referenced in the final safety analysis report. The 10 CFR 50.49 environmental qualification regulation for electrical and I&C equipment located in a harsh environment was identified as an operational program in that memo.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

For each area of review specified in subsection I of this SRP section, the review procedure is identified below. These review procedures are based on the identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives to the SRP criteria provide an acceptable method of complying with the relevant NRC requirements identified in subsection II.

1. At the CP stage, the staff reviews the program that the applicant has described in the preliminary safety analysis report (PSAR) for the environmental design and qualification of the mechanical, electrical, and I&C equipment. The program is measured against the acceptance criteria listed in Subsection II of this SRP section. Of particular interest to the reviewer is the proper use of test and analytical procedures. Equipment should be tested unless testing of the component is impractical due to size limitations or partial type-test data are provided to support the analytical assumptions and conclusions reached. The environmental design and qualification program is reviewed for the identification of normal, accident, and post-accident environmental conditions; anticipated operational occurrences; required operating time; and chemical, submergence, aging, and margin considerations, including the acceptance criteria of the test results.
2. At the OL stage, the staff reviews the program again, as described by the applicant in the FSAR. In addition, the FSAR is reviewed for documentation of the successful implementation of the environmental design and qualification program, including test and analytical results. The reviewer verifies that the applicant's list of systems, which includes the list of equipment associated with each such system, is consistent with the definition of the systems and equipment described in Subsection I, Item 1, of this SRP section.

At the time of the OL application, the reviewer confirms that complete records are retained at a facility in an auditable and readily accessible form, which describe the environmental design and qualification method used for all mechanical, electrical, and I&C equipment in sufficient detail to document the degree of compliance with the requirements discussed herein. The reviewer also confirms that, thereafter, such

records will be updated and maintained current as equipment is replaced, tested, or otherwise qualified.

To confirm the extent to which the equipment meets the requirements of Subsection II, the staff audits the environmental design and qualification files and records, and conducts a plant site review. For selected equipment, the staff reviews the test procedure and test results, and examines the equipment configuration and mounting, and then determines whether the test or analysis referenced demonstrates compliance with the established criteria. The staff may require that component evaluation worksheets for all equipment be submitted to the staff. After the visit, the applicant may be required to submit certain selected documents and reports for further staff review. If the staff has reviewed an applicant's environmental design and qualification files and records for a previous application, they may elect not to require the applicant to submit all the qualification summary data sheets, but instead elect to audit the environmental design and qualification files and records.

3. For new applications, the 10 CFR 50.49(b)(3) requirement to qualify certain types of post-accident monitoring (PAM) equipment located in a harsh environment applies to those instruments identified as requiring such qualification based on the applicant's submittal and the NRC review thereof, including the review conducted under SRP Chapter 7. The regulatory requirements in 10 CFR 50.49(b)(3) reference the guidance in Revision 2 to Regulatory Guide 1.97. Applicants and licensees may use later revisions of Regulatory Guide 1.97 when appropriate.
4. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

5. For a COL application, the staff reviews the requirements of the 10 CFR 50.49 environmental qualification program for electrical and I&C equipment located in harsh environments and the proposed implementation milestones.
6. The reviewer verifies that the Environmental Qualification Program is fully described and that implementation milestones have been identified. The reviewer verifies that the program and implementation milestones are included in FSAR Table 13.4.x. Implementation is required by a license condition.

Implementation of this program will be inspected in accordance with NRC Inspection Manual Chapter IMC-2504, "Construction Inspection Program - Non-ITAAC Inspections."

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

The staff concludes that the environmental design and qualification of mechanical, electrical and I&C equipment that are important to safety is acceptable and meets the relevant requirements of 10 CFR 50.49; 10 CFR 50.67; 10 CFR Part 50, Appendix A, General Design Criteria 1, 2, 4, and 23; and 10 CFR Part 50, Appendix B, Quality Assurance Criteria III, XI, and XVII; with respect to systems and components being designed to withstand the effects of, and being capable of performing their safety function, in the environmental conditions associated with normal operation, maintenance, testing, and accident conditions.

This conclusion is based on the finding that the applicant has implemented an environmental design and qualification program that provides adequate assurance that mechanical, electrical, and I&C equipment that are important to safety will function as intended in the event of anticipated operational occurrences, as well as in the normal, accident, and post-accident environmental conditions. The applicant's environmental design and qualification program is in accordance with the requirements and guidance described in the regulations, regulatory guides and industry standards identified in Subsection II of SRP Section 3.11.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

The applicant described the Environmental Qualification Program and its implementation in conformance with the relevant requirements of 10 CFR 50.49; 10 CFR Part 50, Appendix A, General Design Criteria 1, 2, 4, and 23; and 10 CFR Part 50, Appendix B, Quality Assurance Criteria III, XI, and XVII. Implementation milestones are contained in FSAR Table 13.4-x and will be addressed in a license condition.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

This section is intended to provide guidance to applicants and licensees regarding the NRC staff's plan for using this SRP section.

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superceded by a later revision.

Each plant is required to have complete environmental design and qualification records, including an environmental qualification file for 10 CFR 50.49 equipment, that demonstrate compliance with this review plan (or uses established bases for alternate requirements) before submittal of an OL application.

For COL applicants referencing a certified design, the staff will review specific details of the plant's environmental design and qualification program using the acceptance criteria and review procedures described in this SRP section.

VI. REFERENCES

1. 10 CFR 50.44, "Combustible Gas Control for Nuclear Power Reactors."
2. 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants."
3. 10 CFR 50.67, "Accident Source Term."
4. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records;" General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena;" General Design Criterion 4, "Environmental and Dynamic Effects Design Bases;" and General Design Criterion 23, "Protection System Failure Modes."
5. 10 CFR Part 50, Appendix B, Criterion III, "Design Control"; Criterion XI, "Test Control"; and Criterion XVII, "Quality Assurance Records."
6. 10 CFR 52.47, "Contents of Applications; Technical Information."
7. 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants."
8. 10 CFR 52.80, "Contents of Applications; Additional Technical Information."
9. IEEE Std 317-1983 , "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generation Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.63).
10. IEEE Std 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.89 and NUREG-0588).
11. IEEE Std 334-1971, "IEEE Trial-Use Guide for Type Tests of Continuous-Duty Class 1 Motors Installed Inside the Containment of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.40).
12. IEEE Std 382-1972, "IEEE Trial-Use Guide for Type Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.73).

13. IEEE Std 383-1974, "IEEE Standard for Type Test of Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Draft Regulatory Guide 1.131).
14. IEEE Std 535-1986, "IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.158).
15. IEEE Std 572-1985, "IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.156).
16. NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment."
17. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."
18. NUREG-0737, "Clarification of TMI Action Plan Requirements."
19. NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants."
20. NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design."
21. NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design."
22. Regulatory Guide 1.40, "Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants" (this guide endorses IEEE Std. 334-1971).
23. Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Light Water-Cooled Nuclear Power Plants" (this guide endorses IEEE Std 317-1983).
24. Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants" (this guide endorses IEEE Std 382-1972).
25. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants" (this guide endorses IEEE Std 323-1974).
26. Regulatory Guide 1.97, "Instrumentation For Light-Water-Cooled Nuclear Power Plants To Assess Plant and Environs Conditions During and Following an Accident."
27. Draft Regulatory Guide 1.131, "Qualification Tests of Electric Cables and Field Splices for Light-Water-Cooled Nuclear Power Plants." (This draft guide is used for guidance pending issuance of the "Final" version).
28. Regulatory Guide 1.156, "Environmental Qualification of Connection Assemblies for Nuclear Power Plants" (endorses IEEE Std 572-1985).

29. Regulatory Guide 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants" (endorses IEEE Std 535-1986).
30. NRC Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 2, March 1997. (Revision 2, ML003761662)
31. Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems."
32. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors."
33. Regulatory Guide 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants."
34. SECY-05-0197, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria."
35. NRC Inspection Manual Chapter IMC-2504, "Construction Inspection Program - Non-ITAAC Inspections," issued April 25, 2006.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

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