3.11 Environmental Qualification of Mechanical and Electrical Equipment

Introduction

This section describes the implementation of the US-APWR environmental qualifications (EQ) program. The US-APWR EQ Program demonstrates and documents compliance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 4, “Environmental and Dynamic Effects Design Bases,” (Reference 3.11-1) which requires:

> 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 accidents.

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Mechanical, electrical, and I&C equipment associated with systems described in this paragraph are included within the scope of this environmental qualification program:

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.

In this section the term "environmental qualification" means verification of design, limited to demonstrating that mechanical, electrical 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. Additionally, environmental design requirements apply to all equipment listed above (i.e., both mild and harsh environments).

For active mechanical equipment meeting the equipment scope described above 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 active mechanical devices located in mild environments, compliance with the environmental design provisions of GDC 4 are generally achieved and

demonstrated by proper incorporation of relevant environmental conditions into the design process, including the equipment specification. DCD_03.11-63

The general requirements 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/or 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. Environmental design and qualification requirements are described in MHI Technical Report MUAP-08015, "US-APWR Equipment Qualification Program," issued as a separate report (Reference 3.11-3). ~~Electrical, mechanical, and I&C (both analog and digital) equipment designated as safety-related or important to safetywithin scope of the EQ Program includes:~~ DCD_03.11-41

- ~~Safety-related electrical and I&C equipment (i.e., Class 1E equipment),~~
- ~~Nonsafety-related electrical equipment, located in a harsh environment, whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions by the safety-related equipment,~~
- ~~Certain post-accident monitoring equipment described in Section 7.5, and~~
- ~~Safety-related mechanical equipment that includes non-metallic components.~~

This equipment is addressed in the EQ Program to verify it is capable of performing its design function(s) under all anticipated service conditions. These service conditions are defined in 10 CFR 50.49(b)(1)(ii), (Reference 3.11-2) and are listed below. There is no nonsafety-related electrical equipment, located in a harsh environment, whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions by the safety-related equipment. The equipment addressed by the EQ Program is identified in ~~Appendix 3D~~Table 3D-2. DCD_03.11-41

The typical design basis events include the following:

1. Normal operating conditions (e.g., refueling, shutdown, startup, operating)
2. AOO (e.g., plant trips, testing)
3. DBAs (e.g., LOCA, HELB)
4. External events (e.g., loss of offsite power)
5. Natural phenomena (e.g., earthquake, tornado, hurricane) DCD_02-03 S01

Technical report MUAP-08015 addresses the relevant environmental design and qualification 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, DCD_03.11-66

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 report also addresses seismic qualification as described in Section 3.10, and functional qualification of active mechanical components described in Section 3.9, as an integrated US-APWR equipment qualification program as described in Appendix 3D. Implementation of the EQ Program is addressed as part of this integrated equipment qualification program. DCD_03.11-66 DCD_03.11-64

~~The implementation of the US-APWR EQ Program is described in MHI Technical Report MUAP-08015 titled, US-APWR Equipment Qualification Program issued as a separate report (Reference 3.11-3). This Technical Report addresses the environmental qualification required by 10 CFR 50.49 (Reference 3.11-2) as well as seismic qualification described in Section 3.10, and functional qualification of active mechanical components described in Section 3.9, as an integrated US-APWR equipment qualification program as described in Appendix 3D. Implementation of the EQ Program is addressed as part of this integrated equipment qualification program.~~ DCD_03.11-41

The Technical Report describes the EQ Program applicable to each licensed US-APWR. The Report describes the EQ process and its implementation during the design, procurement, construction, startup, and turnover phases of a US-APWR plant project. It identifies the various qualification programs, procedures, and policies that MHI and the applicable Architect/Engineer/Constructor implements in conjunction with the delivery of a US-APWR plant. The Report discusses the application of the EQ Program to both domestic and international suppliers, of the electrical and mechanical equipment ~~described in Appendix 3D~~listed in Table 3D-2. The EQ Program, quality assurance, record keeping, and associated programmatic interfaces is described to facilitate implementation of the post-turnover EQ Program by the licensee. The COL Applicant is to provide a schedule showing the EQ Program proposed implementation milestones. DCD_03.11-41

The COL Applicant is responsible for assembling and maintaining the environmental qualification document, which summarizes the qualification results for all equipment identified in Appendix 3D, for the life of the plant. The environmental qualification document is to address the following information:

- Identification of the equipment and applicable plant, system, and equipment selection basis, particularly with respect to normal environmental conditions, AOOs, accident, post-accident, and test environmental conditions.

- Designated functional requirements, the definition of the applicable environmental parameters, and the documentation of the qualification process employed to demonstrate that the required environmental compliance is achieved.

- Identification of the test environmental parameters and the methodology used to qualify the equipment located in harsh environments.

- A summary of environmental conditions and qualified conditions for the equipment located in a harsh environment zone are presented in the system component evaluation work sheets or packages and are compiled in the environmental qualification document.

instructions, and qualifications packages consistent with the requirements of 10 CFR 50, Appendix B, Section III (Reference 3.11-7), 10 CFR 50.49(f) and 10 CFR 50.49(j) ~~for safety-related equipment and augmented quality assurance requirements for non-safety-related equipment~~. DCD_03.11-64 DCD_03.11-69 DCD_03.11-41

The specific normal and transient service conditions are identified in the design process for equipment located both inside and outside of the plant. These service conditions may include temperature extremes, including freezing, as part of the environmental requirements. Special considerations (which include heat tracing, insulation, wind shields, etc.) are addressed in the design process for maintaining system operability for outdoor components including instrument sensing lines (Reference 3.11-9).

3.11.2 Qualification Tests and Analyses

ITAAC is also known as the plant operational program review. An applicant or licensee who references the US-APWR Design Certification rule performs and demonstrates conformance with the ITAAC in conjunction with the licensing process. A number of tests and design verifications are performed in conjunction with the US-APWR EQ Program are summarized in Table 3.11-1. Verification of conformance to the EQ Program objectives includes performance of various construction and startup tests and then after turnover to the licensee, periodic surveillances and inspections. Routine maintenance and calibrations performed by the licensee are intended to detect degradations in SSCs in time to allow repairs or replacement of these items. Licensee ISI programs as well as replacement of plant components within the plant's 60-year lifetime assure compliance with EQ Program requirements. These licensee programs minimize the possibility of unknown effects, including common mode failures going undetected. The need for additional plant specific tests is developed as identified and included during the application process.

Aging: The equipment is qualified for aging by test or analysis, which considers natural or artificial (accelerated) aging to its end-of-installed life condition. Consideration is given to all significant types of degradation, which can have an effect on the functional capability of the equipment. Since the effects of aging are sometimes difficult to quantify, a rigorous, periodic inspection, test, and calibration program is implemented during the life of the plant to verify that systems and components remain operational.

Synergistic Effects: The US-APWR EQ process involves detailed testing during the procurement, construction, and startup phases. As equipment is installed and tested, synergistic effects are evaluated to verify that these effects do not adversely impact the qualification of the electrical equipment. An example of this testing is the onsite testing for electromagnetic and radio frequency interference. Testing is performed that complies with the guidance provided in RG 1.180, Guidelines for Evaluating Electromagnetic and Radio Frequency Interference in Safety-Related Instrument and Control Systems (Reference 3.11-10). Other tests are conducted to verify satisfactory performance of mechanical and electrical systems in their installed environments. Examples of these tests include thermal expansion tests, vibration tests, and process interaction tests (usually performed in conjunction with hot functional testing). These various tests augment the EQ process and assist in meeting the intent of evaluating synergistic effects that could have an adverse impact on ~~safety and important to safety~~ equipment included in Table 3D-2. DCD_03.11-41

qualified as part of the US-APWR EQ Program. Active mechanical equipment qualification is discussed in Subsection 3.9.3 and in Appendix 3D. The EQ program provides for qualification of non-metallic components such as gaskets, O-rings, seals, and lubricants for ~~safety-related and important to safety~~ mechanical equipment included in Table 3D-2. Non-active mechanical equipment that is equipment whose primary safety function is structural integrity (support or pressure boundary), is qualified pursuant to the requirements of ASME Boiler and Pressure Vessel Code, Section III. In addition, certain mechanical structures are qualified in conjunction with plant startup testing (e.g., the reactor containment structure is qualified, in part, by the performance of various construction tests [e.g., weld certifications] and the performance of the containment ILRT). DCD_03.11-41

3.11.3 Qualification Test Results

Environmental qualification of the equipment listed in ~~Appendix 3D~~Table 3D-2 may rely on testing in conjunction with the verification process. Where the qualification process involves testing, the various tests are conducted following written test procedures in compliance with the requirements of 10 CFR 50, Appendix B, Criterion XI, Test Control (Reference 3.11-7) and 10 CFR 50.49(f)~~for safety-related equipment and augmented quality assurance requirements for non-safety-related equipment~~. These tests may apply to aging, seismic, radiation, or environmental qualification parameters. DCD_03.11-41 DCD_03.11-64 DCD_03.11-69 DCD_03.11-41

The tests may be performed by the manufacturers, qualified testing laboratories, or during the construction and startup phases as part of the ITAAC process. Procurement associated testing results are documented prior to installation. The preoperational and operational tests results are recorded and verified against acceptance limits contained in the applicable design documents, and associated environmental parameters determined in support of the formulation of Appendix 3D.

The testing is performed to verify that ~~safety-related SSCs, as well as those important to safety, operate~~equipment included in Table 3D-2 operates satisfactorily in service and in accordance with their design basis. The test results are documented and evaluated to assure that EQ requirements have been satisfied. DCD_03.11-41

Equipment that has been previously qualified by means of tests and analyses may not need to be retested for qualification provided proper documentation of such tests and analyses is available (Reference 3.11-4).

The COL Applicant is to describe how the results of the qualification tests are to be recorded in an auditable file in accordance with requirements of 10 CFR 50.49 (j) (Reference 3.11-2). Such a record is maintained for the entire period during which the related equipment remains installed in the plant, stored for future use, or is held for permit verification.

3.11.4 Loss of Ventilation

HVAC systems provide ventilation, help reduce air infiltration, and maintain pressure relationships between spaces. The design and evaluation of the plant's HVAC systems is described in Section 9.4. Electrical equipment located in conditioned spaces is evaluated for performance during the loss of HVAC type events. Equipment which may be impacted

The radiation sources presented in this DCD are developed from the DBA available data and in accordance with NUREG-1465 (Reference 3.11-20). The radiation (neutron, beta and gamma) dose rates and integrated doses for normal, accident, post-accident, and harsh environmental conditions for various plant locations are presented in Technical Report, MUAP-08015, US-APWR Equipment Qualification Program (Reference 3.11-3). The values presented in the Technical Report are used as the basis for electrical and mechanical equipment dose exposures presented in Appendix 3D. Their parameters are presented in time-based units, where appropriate.

The expected levels of radiation exposure factored into the design process are based on the type of radiation, the total dose expected during normal operation over the installed life of the equipment, and the radiation environment associated with the most severe DBA during or following an accident in which the equipment is required to remain functional, including the radiation resulting from re-circulating fluids for equipment located near the re-circulating lines and including dose-rate effects. Equipment that will not be exposed to total integrated doses of 10^4 Rads as a result of a DBA is not qualified for radiation exposure in most cases. In all cases, each piece of equipment in a potential harsh environment is evaluated for the need for qualification due to radiation exposure.

Electrical and mechanical equipment subject to radiation exposure is qualified for use in the US-APWR pursuant to the implementation of the US-APWR EQ Program. For equipment that is only located in areas considered harsh by the potential presence of radiation, this equipment is qualified by analysis and partial test data with the appropriate considerations for margins and aging effects.

3.11.6 Qualification of Mechanical Equipment

The qualification of mechanical equipment is included in Subsection 3.11.2.1.

The COL Applicant is to provide the site-specific mechanical equipment requirements. This equipment is to be qualified using a qualification process that is equivalent to that delineated for the US-APWR Standard Plant, as described in Technical Report MUAP-08015~~(R1)~~ (Reference 3.11-3). DCD_03.11-63

3.11-3 US-APWR Equipment Qualification Program, MUAP-08015, Rev. ~~1, October 2009~~2, August 2013. DCD_03.11-63

3.11-4 Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants, Regulatory Guide 1.89, U.S. Nuclear Regulatory Commission, Washington, DC, 1984.

3.11-5 Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment. NUREG-0588, U.S. Nuclear Regulatory Commission, Washington, DC.

3.11-6 Emergency Planning and Preparedness for Production and Utilization Facilities, Domestic Licensing of Production and Utilization Facilities, Energy. Title 10, Code of Federal Regulations, Part 50, Appendix E, U.S. Nuclear Regulatory Commission, Washington, DC.

3.11-7 Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, Domestic Licensing of Production and Utilization Facilities, Energy. Title 10, Code of Federal Regulations, Appendix B, III, XVII, XI, U.S. Nuclear Regulatory Commission, Washington, DC.

3.11-8 IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations, IEEE Std 323-1974, Institute of Electrical and Electronics Engineers (endorsed by Regulatory Guide 1.89 and NUREG-0588).

3.11-9 Instrument Sensing Lines, Regulatory Guide 1.151, U.S. Nuclear Regulatory Commission, Washington, DC, July 1983.

3.11-10 Guidelines for Evaluating Electromagnetic and Radio Frequency Interference in Safety-Related Instrumentation and Control Systems. Regulatory Guide 1.180, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, October, 2003.

3.11-11 Qualification of Continuous-Duty Safety-Related Motors for Nuclear Power Plants. Regulatory Guide 1.40, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, February 2010.

3.11-12 Electric Penetration Assemblies in Containment Structures for Light Water-Cooled Nuclear Power Plants. Regulatory Guide 1.63, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, February 1987.

3.11-13 Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants. Regulatory Guide 1.73, U.S. Nuclear Regulatory Commission, Washington, DC, January 1974.

3.11-14 Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants. Regulatory Guide 1.97, Rev. 4, U.S. Nuclear Regulatory Commission, Washington, DC, June 2006.

3.11-15 Deleted

3D Equipment Qualification ~~List Safety and Important to Safety~~of Electrical and Mechanical Equipment

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3D.1 Introduction

This Appendix ~~lists safety and important to safety~~describes the mechanical and electrical equipment that is qualified for service in the US-APWR in accordance with the requirements delineated in the US-APWR equipment qualification ~~(EQ) Program (see Table 3D-2)~~program that includes the Environmental Qualification (EQ) Program as described in Section 3.11.

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3D.1.1 Equipment Identification

Equipment addressed by the equipment qualification program includes:

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- Equipment qualified by the EQ Program described in Section 3.11 ~~(i.e., Class 1E equipment, certain post accident monitoring equipment and safety related mechanical equipment that includes non-metallic components)~~

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- Active mechanical components required to be functionally qualified as described in Sections 3.9.3 and 3.9.6
- Mechanical and electrical equipment with special seismic qualification requirements such as seismic categories I and II described in Section 3.10.

Table 3D-2 lists the equipment required to be qualified under the EQ Program. Active mechanical components including snubbers are identified in Section 3.9.6 and Tables 3.9-13 and 3.9-14. Equipment with special seismic qualification requirements are identified in Table 3.2-~~1~~2 for mechanical equipment and Tables 3D-2 and 3D-4 for electrical equipment.

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Equipment is identified by system code and component type. Safety-related systems are described in Section 3.2. Safety-related components and systems are relied upon to mitigate the consequences of a design basis accident (DBA). A safety-related function is an action relied upon during and following a design basis event to provide for:

- Integrity of the reactor coolant system
- The capability to shut down and maintain the reactor in a safe-shutdown conditions
- The capability to prevent or mitigate the consequences of an accident that could result in the potential for offsite exposure pursuant to the requirements delineated in 10 Code of Federal Regulations (CFR) 100.

Safety-related components and systems are selected in accordance with the above definition.