

3.11 Environmental Qualification of Safety-Related Mechanical and Electrical Equipment

This section defines the environmental conditions with respect to limiting design conditions for all the safety-related mechanical and electrical equipment, and documents the qualification methods and procedures employed to demonstrate the capability of this equipment to perform safety-related functions when exposed to the environmental conditions in their respective locations. The safety-related equipment within the scope of this section are defined in Subsection 3.11.1. Dynamic qualification is addressed in Sections 3.9 and 3.10 for Seismic Category I mechanical and electrical equipment, respectively.

Limiting design conditions include the following:

- (1) Normal Operating Conditions—planned, purposeful, unrestricted reactor operating modes including startup, power range, hot standby (condenser available), shutdown, and refueling modes.
- (2) Abnormal Operating Conditions—any deviation from normal conditions anticipated to occur often enough that the design should include a capability to withstand the conditions without operational impairment.
- (3) Test Conditions—planned testing including pre-operational tests.
- (4) Accident Conditions—a single event not reasonably expected during the course of plant operation that has been hypothesized for analysis purposes or postulated from unlikely but possible situations or that has the potential to cause a release of radioactive material (a RCPB rupture may qualify as an accident; a fuel cladding defect does not).
- (5) Post-Accident Conditions—during the length of time the equipment must perform its safety-related function and must remain in a safe mode after the safety-related function is performed.

3.11.1 Equipment Identification and Environmental Conditions

Safety-related electrical equipment within the scope of this section includes all three categories of 10CFR50.49(b) (Reference 3.11-1). Safety-related mechanical equipment (e.g., pumps, MOVs, SRVs, and check valves) are as defined and identified in Section 3.2. Electrical and mechanical equipment safety classifications are further defined on the system design drawings.

Safety-related equipment must perform its proper safety function during normal, abnormal, test, design basis accident and post-accident environments as applicable. A list of all safety-related electrical and mechanical equipment that is located in a harsh environment area will be included in the Environmental Qualification Document (EQD) to be prepared as mentioned in Subsection 3.11.6.1. The COL applicant will provide a list of impacted non-safety-related

control systems and the design features for preventing the potential adverse consequences identified in IE Information Notice 79-22, Qualification of Control Systems. The COL applicant will also address issues related to equipment wetting and flooding above the flood level identified in IE Information Notice 89-63, Possible Submergence of Electrical Circuits Located Above the Flood Level Because of Water Intrusion and Lack of Drainage, as required in Subsection 3.11.6.

Environmental conditions for the zones where safety-related equipment is located are calculated for normal, abnormal, test, accident and post-accident conditions and are documented in Appendix 3I, Equipment Qualification Environmental Design Criteria (EQEDC). Environmental conditions are tabulated by zones, contained in the referenced building arrangements. Typical equipment in the noted zones are shown in the referenced system P&ID and IED design drawings.

Environmental parameters include temperature, pressure, relative humidity, and neutron dose rate and integrated dose. Where applicable, these parameters are given in terms of a time-based profile.

Occurrences of anticipated abnormal operating conditions are similar to test conditions and their significant environments are comparable. Equipment significant deviations (magnitude and 60 year frequency) from normal environments have minimal effects on equipment total normal or accident thermal aging. Cumulative abnormal conditions are much less than the bounding accident conditions in the Appendix 3I tables.

Margin is defined as the difference between the most severe specified service conditions of the plant and the conditions used for qualification. Margins shall be included in the qualification parameters to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance. The environmental conditions shown in the Appendix 3I tables do not include margins.

Some mechanical and electrical equipment may be required by the design to perform an intended safety function within minutes of the occurrence of the event but less than 10 hours into the event. Such equipment shall be shown to remain functional in the accident environment for a period of at least 1 hour in excess of the time assumed in the accident analysis unless a time margin of less than 1 hour can be justified. Such justification will include for each piece of equipment:

- (1) Consideration of a spectrum of breaks,
- (2) The potential need for the equipment later in the event or during recovery operations,
- (3) Determination that failure of the equipment after performance of its safety function will not be detrimental to plant safety or mislead the operator, and

- (4) Determination that the margin applied to the minimum operability time, when combined with other test margins, will account for the uncertainties associated with the use of analytical techniques in the derivation of environmental parameters, the number of units tested, production tolerances, and test equipment inaccuracies.

The environmental conditions shown in the Appendix 3I tables are upper-bound envelopes used to establish the environmental design and qualification bases of safety-related equipment. The upper bound envelopes indicate that the zone data reflect the worst case expected environment produced by a compendium of accident conditions. Estimated chemical environmental conditions are also reported in Appendix 3I.

3.11.2 Qualification Tests and Analyses

Safety-related mechanical and electrical equipment is qualified by type testing, operating experience analysis, or any combination thereof as described in IEEE-323 and permitted by 10CFR50.49(f)(Reference 3.11-1). Equipment type test is the preferred method of qualification. Equipment in a harsh environment is designed and qualified to survive the combined effects of temperature, pressure, humidity, radiation, and other conditions related to LOCA or other design-bases accident environment as a portion of their qualified and/or design life.

The qualification methodology is described in detail in the NRC approved licensing Topical Report on GE's environmental qualification program (Reference 3.11-2). This report also addresses compliance with the applicable portions of the General Design Criteria of 10CFR50, Appendix A, and the Quality Assurance Criteria of 10CFR50, Appendix B. Additionally, the report describes conformance to NUREG-0588 (Reference 3.11-3), and Regulatory Guides (i.e., RG 1.89) and IEEE Standards referenced in Section 3.11 of NUREG-0800 (Standard Review Plan).

A mild environment is that which, during or after a design basis event (DBE, as defined in Reference 3.11-2), would at no time be significantly more severe than that which exists during normal, test and abnormal events.

Safety-related mechanical equipment that is located in a harsh environment is qualified by analysis of materials data which are generally based on test and operating experience.

For equipment located in a mild environment, certificate of compliance shall be submitted certifying that the equipment has been qualified to assure its required safety-related function in its applicable environment. This equipment is qualified for dynamic loads as addressed in Sections 3.9 and 3.10. Further, a surveillance and maintenance program will be developed to ensure equipment operability during its designed life (Subsection 3.11.6).

The information described in this section is also documented in the Toshiba ABWR Equipment Qualification Program (EQP) document (Reference 3.11-4). The requirements in the Toshiba

ABWR EQP meet or exceed the requirements in Reference 3.11-2, as documented in the Equivalency Evaluation Report (Reference 3.11-5).

3.11.3 Qualification Test Results

The results of qualification tests for safety-related equipment will be documented, maintained, and reported as mentioned in Subsection 3.11.6.

3.11.4 Loss of Heating, Ventilating, and Air Conditioning

To ensure that loss of heating, ventilating, and air conditioning (HVAC) system does not adversely affect the operability of safety-related controls and electrical equipment in buildings and areas served by safety-related HVAC systems, the HVAC systems serving these areas meet the single-failure criterion. Section 9.4 describes the safety-related HVAC systems, including the detailed safety evaluations. The loss of ventilation calculations are based on maximum heat loads and consider operation of all operable equipment regardless of safety classification.

3.11.5 Estimated Chemical and Radiation Environment

3.11.5.1 Chemical Environment

Equipment located in the containment drywell and wetwell is potentially subject to water spray modes of the RHR System. In addition, equipment in the lower portions of the containment is potentially subject to submergence. The chemical composition and resulting pH to which safety-related equipment is exposed during normal operation and design basis accident conditions are reported in Appendix 3I.

Sampling stations are provided for periodic analysis of reactor water, refueling and fuel storage pool water, and suppression pool water to assure compliance with operational limits of the plant technical specifications.

3.11.5.2 Radiation Environment

Safety-related systems and components are designed to perform their safety-related function when exposed to the normal operational radiation levels and accident radiation levels.

Electronic equipment subject to radiation exposure in excess of 10 Gy and other electrical and electrically driven mechanical equipment in excess of 100 Gy will be qualified in accordance with Reference 3.11-1. The normal operational exposure is based on the radiation source terms provided in Section 11.1 and inventories for components provided in Section 12.2. Radiation sources associated with the DBA and developed in accordance with NUREG-0588 (Reference 3.11-3) are evaluated using source terms derived from TID-14844. The DBA source defined for the maximum condition are given in each table. For example Table 3I-18 uses the LOCA analysis (Subsection 15.6.5) for evaluation of dose rates and integrated doses for six months. For Table 3I-17 various components use different DB accidents and integration times as indicated. For the LOCA case, the source term is defined as 100% noble gases and 50% halogens for airborne species (Regulatory Guide 1.3) and 50% halogens and 1% all others for

water borne species (Regulatory Guide 1.7). Integrated doses associated with normal plant operation and the DBA condition for various plant compartments are described in Appendix 3I.

3.11.6 COL License Information

3.11.6.1 Environmental Qualification Document (EQD)

The EQD shall be prepared summarizing the qualification results for all safety-related equipment located in harsh environments (Subsection 3.11.3). The EQD shall include the following:

- (1) The test environmental parameters and the methodology used to qualify the equipment located in mild and harsh environments shall be identified.
- (2) A summary of environmental conditions and qualified conditions for the safety-related equipment located in a harsh environment zone shall be presented in the system component evaluation work (SCEW) sheets.

3.11.6.2 Environmental Qualification Records

The results of the qualification tests shall be recorded and maintained in accordance with the requirements of Reference 3.11-1 (Subsection 3.11.1).

3.11.6.3 Surveillance, Maintenance and Experience Information

The COL applicant will require equipment certificates of qualification compliance and will develop a surveillance and maintenance program in accordance with Subsection 3.11.2.

Non-safety-related control systems subjected to adverse environments will be evaluated for safety implications to safety-related protective functions, and equipment wetting and flooding above the flood level will be addressed in accordance with Subsection 3.11.1

3.11.7 References

- 3.11-1 Code of Federal Regulations, Title 10, Chapter I, Part 50, Paragraph 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plant.
- 3.11-2 [*“General Electric Environmental Qualification Program”, NEDE-24326-1-P, Proprietary Document, January 1983.*]*
- 3.11-3 Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment, NUREG-0588.
- 3.11-4 U7-PROJ-K-PRD-0025, "Project Requirements Document: Equipment Qualification Program," Latest Revision.

* See Section 3.10 and Appendix 3K. This reference is same as Reference 3.9-6 (Subsection 3.9.8).

- 3.11-5 U7-PROJ-L-EVAL-LIC-0001, "Equivalency Evaluation Report for Equipment Qualification Program," Revision 5.