RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**527-8686**
SRP Section:	**03.11 - Environmental Qualification of Mechanical and Electrical Equipment**
Application Section:	**3.11**
Date of RAI Issue :	**10/21/2016**

Question No. 03.11-18

Background

10 CFR 50.49, “Environmental qualification for electric equipment important to safety for nuclear power plants,” provides specific requirements pertaining to qualification of certain electric equipment important to safety. Section 50.49 requires that three categories of electric equipment important to safety be qualified for their application and specified performance and provides requirements for establishing environmental qualification methods. These three categories are: (1) safety-related electric equipment (Class 1E), (2) non-safety-related electric equipment (non-Class 1E) whose failure under postulated environment conditions could prevent satisfactory accomplishment of safety functions by safety-related equipment, and 3) certain post-accident monitoring equipment. Regulatory Guide (RG) 1.89, Revision 1, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants,” describes a method acceptable to the NRC staff for complying with § 50.49. RG 1.89 endorses IEEE Std. 323-1974, “IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations.” The procedures described by IEEE Std. 323-1974 are acceptable to meet the requirements in 10 CFR 50.49 to ensure that the Class 1E equipment can perform its safety functions in harsh environments.

Federal Register (FR) 2729, Vol. 48, No. 15 of January 21, 1983 provides the statements of consideration for the issuance of 10 CFR 50.49. The FR states in part that, 10 CFR 50.49 rule is based on "Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors," November 1979 (DOR Guidelines) and NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment." NUREG-0588 contains two sets of criteria: the first for plants originally reviewed in accordance with IEEE Std. 323-1971 and the second for plants reviewed in accordance with IEEE Std. 323-1974. Thus, 10 CFR 50.49 is based only on IEEE Std. 323-1971 and IEEE Std. 323-1974.

Issue

By letter dated June 15, 2015, NRC issued RAI-7944, Question 03.11-1 regarding the applicant's use of IEEE Std. 323-2003 for environmental qualification of Class 1E electrical equipment located in harsh environments. The NRC staff has not endorsed IEEE Std. 323-2003 for environmental qualification of Class 1E electrical equipment located in a harsh environment. However, NRC approved IEEE Std. 323-2003 only for environmental qualification of safety elated computer-based I&C systems located in a mild environment as addressed in RG 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants," (March 2007). Since IEEE Std. 323-1974 remains the current standard of record and is endorsed by RG 1.89 for environmental qualification, the staff asked the applicant to provide the justification why IEEE Std. 323-2003 is acceptable for qualification of Class 1E electrical equipment located in harsh environment or, otherwise, revise Section 3.11 of the DCD Tier 2 to reflect the change from IEEE Std. 323-2003 to IEEE Std. 323-1974.

By letter dated July 17. 2015 (ADAMS Accession No. ML15198A260), the applicant responded to RAI-7944, Question 03.11-1, stating that Standard Review Plan (SRP) 3.11 allows the use of information of other standards not endorsed by regulatory guides if appropriately justified. The applicant provided a justification for the use of IEEE Std. 323-2003, stating that it conforms with 10 CFR 50.49, that there are no technical differences between the 2003 and 1974 versions of the IEEE Std. 323, and that IEEE Std. 323-2003 reflects current practices for environmental qualifications. In addition, the applicant provided a basic table comparing the guidance contained in IEEE Std. 323-1974 and IEEE Std. 323-2003.

The staff evaluated the response from the applicant and recognizes that the applicant can use the other standards not endorsed by the NRC in regulatory guidance. However, the staff has identified issues discussed in the following questions with regards to the definitions and content of IEEE Std. 323-2003, and therefore requests that the applicant address them.

Regulatory Basis:

10 CFR 50.49(b)(1)(i) states, in part, that "[Safety-related electric equipment] is that relied upon to remain functional during and following design basis events."

Questions:

a) Definition 3.4, "Condition-based qualification," in IEEE Std. 323-2003 is defined as "Qualification based on measurement of one or more condition indicators of equipment, its components, or materials for which an acceptance criterion can be correlated to the equipment's ability to function as specified during an applicable design basis event" (emphasis added).

   The staff finds that the definition of condition-based qualification does not address that the equipment should remain functional following a design basis event (DBE), consistent with 10 CFR 50.49(b)(1)(i). Therefore, the staff requests that the applicant clarify its definition of condition-based qualification to include the verification that SSCs can perform their safety function during and following DBEs.

b) IEEE Std. 323-2003 Section 4.4, “Qualification Documentation,” states that “the results of a qualification program shall be documented to demonstrate the equipment’s ability to perform its safety function(s) during its qualified life and applicable design events.”

The staff finds that the IEEE Std. 323-2003 requirement for Qualification Documentation does not verify that the equipment can perform its safety function during and following a design basis event as applicable, consistent with 10 CFR 50.49(b)(1)(i). Therefore, the staff requests that the applicant clarify that the qualification documentation will provide auditable records that show that equipment can perform its safety function during and following a DBE, as applicable.

Response

a) KHNP agrees that for the equipment needed to perform its safety function(s) during and after an accident, the qualification must demonstrate that the equipment can function during and after the applicable design basis event. Though the definition of condition-based qualification specified in IEEE Std. 323-2003 may not explicitly state following a DBE, the standard does, however, adequately ensure that the qualification will be demonstrated during and after the applicable design basis event, and therefore is acceptable to use.

As addressed in IEEE Std. 323-2003 Section 6.3.6, condition-based qualification is an adjunct to type testing.

Condition-based qualification is applied as follows:

1. Perform type test and monitor condition indicators to determine whether they have linear characteristics.
2. Establish end conditions of the condition indicator(s) at the conclusion of age conditioning, prior to DBA testing, (if the test is completed successfully, including DBA testing).
3. Install the equipment and monitor the condition indicators.
4. Use the equipment until the condition indicators reach the end condition.

Type testing shall be performed as specified in IEEE Std.323-2003 Section 6.3.1.7 “Test Sequence.” Furthermore, Section 6.3.1.7 g) states that “The test sample shall perform its required safety function(s) while exposed to simulated accident conditions, including conditions following the accident for the period of required equipment operability, as applicable” (emphasis added). As a result, operability of the equipment during and following accident condition is evaluated at the stage of type testing.

Also, IEEE Std. 323-2003 Section 4.1, “Qualification objective,” states that “The primary objective of qualification is to demonstrate with reasonable assurance that Class 1E equipment for which a qualified life or condition has been established can perform its safety function(s) without experiencing common-cause failures before, during, and after applicable design basis events” (emphasis added).

Therefore, stating that condition-based qualification is to be performed in accordance with 323-2003 will require that qualification verification be demonstrated to show that SSCs can perform their safety function during and following DBEs.

b) IEEE Std. 323-2003 Section 6.1.5.2, “Design basis event condition,” states that “The postulated design basis event conditions including specified high-energy line break, loss-of-coolant accident, main steam line break, and/or safe shutdown seismic events, during or after which the equipment is required to perform its safety function(s), shall be specified. Equipment shall be qualified for the duration of its operational performance requirement for each applicable design basis event condition, including any required post design basis event operability period.” (emphasis added) The “applicable design events” that are mentioned in Section 4.4, “Qualification Documentation,” include post DBA period during and/or after which the equipment is required to operate.

A requirement will be added in TeR APR1400-E-X-NR-14001-P/NP Section 6.1.5, “Qualification Test Report” to ensure that the results of the qualification program shall be documented that demonstrate the equipment will perform its safety function during and following a DBE.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical Report APR1400-E-14001-P/NP will be revised as indicated in the Attachment.

6.1.5 Qualification Test Report

Upon completion of qualification testing, an equipment-specific test report will be prepared summarizing the test results, conclusions, and recommendations. The following types of information will be addressed and included, as appropriate:

a. Identification of the equipment qualified

b. Equipment specification

c. Qualification program

d. Identification of any scheduled surveillance/maintenance, periodic testing, and any parts replacement required to maintain qualification

e. Identification of safety function(s) to be demonstrated by test data

f. Test plan

g. The report of test results shall include:

1) Test objective

2) Detailed description of test sample

3) Description of test setup, instrumentation and calibration data

4) Test procedure

5) Summary of test data, accuracy, and anomalies

6) The result of a qualification program to demonstrate that the equipment remains functional during and following a DBE as applicable.

h. Summary and conclusions, including limitations and qualified life or periodic surveillance/ maintenance interval determination

i. Approval signature and date

6.1.6 Operating Experience Data

a. Identification of equipment qualified

b. Equipment specification

c. Qualification program

d. Identification of any scheduled surveillance/maintenance, periodic testing, and any parts replacement required to maintain qualification

e. Identification of the safety function(s) to be demonstrated by operating experience

f. Specification of the equipment for which operating experience is available

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SRP Section:	**03.11 - Environmental Qualification of Mechanical and Electrical Equipment**
Application Section:	**3.11**
Date of RAI Issue :	**10/21/2016**

Question No. 03.11-19

Regulatory Basis:

10 CFR 50.49(b)(1)(ii) states, in part, that DBEs are defined as conditions of normal operation, including anticipated operational occurrences, design basis accidents, external events, and natural phenomena for which the plant must be designed to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures.

Questions:

a) Definition 3.11, “Harsh environment,” in IEEE Std. 323-2003 is defined as “an environment resulting from a design basis event, i.e. loss-of-coolant accident (LOCA), high-energy line break (HELB), and main steam line break (MSLB).” IEEE Std. 323-2003, Definition 3.6, defines DBEs as “Postulated events used in the design to establish the acceptable performance requirements for the structures, systems, and components.”

   However, 10 CFR 50.49 defines DBEs more broadly to include anticipated operating occurrences (AOOs) and would include a small-break LOCA (SBLOCA), for example. The staff requests that the applicant address SBLOCA and discuss postulated AOOs that may create harsh environments, consistent with the definition of DBE in 10 CFR 50.49.

b) Definition 3.16, “Qualified Life,” is defined in IEEE Std. 323-2003 as “the period of time, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service condition.” IEEE Std. 323-2003 Section 5.3, “Condition monitoring,” states that “condition monitoring may be used with or independently from the concept of qualified life. As the qualified equipment approaches the end of its theoretical qualified life, periodic condition monitoring may be implemented to determine if actual aging is occurring at a slower rate, and if further qualified service is possible based on the condition monitoring results."

The definition of qualified life in IEEE Std. 323-2003 does not include a DBE. Therefore, the staff determines that DBE capability must be addressed in order to use condition monitoring as a method to determine if further qualified service is possible, as the plant must be designed to ensure functions during DBE. Staff requests the applicant to explain how condition monitoring addresses DBEs.

c) IEEE Std. 323-2003 Section 6.1.2, "Interfaces" states that "material incompatibilities at interfaces shall be considered and evaluated."

The staff requests that the applicant confirm that material incompatibilities at interfaces are demonstrated under the worst case environmental conditions that it will be exposed, such as DBE as defined in 10 CFR 50.49(b)(ii).

d) Section 6.1.5.2, "Design basis event conditions," of IEEE Std. 323-2003 states that "the postulated design basis event conditions including specified high-energy line break, loss-of-coolant accident, main steam line break, and/or safe shutdown seismic events, during or after which the equipment required to perform its safety function(s), shall be specified."

The staff requests the applicant to discuss the other applicable DBE conditions and how the design is demonstrated to conform to 10 CFR 50.49.

Response

a) IEEE Std.323-1974 Section 1 "Scope" states that "These qualification requirements, when met, will confirm the adequacy of the equipment design under normal, abnormal, design basis event, post design basis event, and containment test conditions for the performance of Class 1E function."

Based on the statement above, both IEEE Std.323-2003 and IEEE Std.323-1974 use the DBE concept to mean accidents (not including AOOs and normal operation). However, KHNP introduced the concept of DBA (Design Basis Accident) which is included in DBE in order to meet the requirements of 10CFR50.49. DCD Tier 2 Section 3.11.1.1.a "Harsh environment," defines a harsh environment as "An environment where a significant increase in pressure, temperature, relative humidity, or chemical environment occurs as a result of a design basis accident or where a total integrated dose of greater than 100 Gy is predicted" (emphasis added).

In environmental qualification, equipment is demonstrated under the worst case environmental conditions to which it is exposed. Therefore, the most limiting conditions that the equipment is exposed to shall be specified. Since other accident conditions, including SBLOCA, result in a less severe environment than a LOCA, MSLB and HELB, they are not specified in the APR1400 environmental qualification.

AOOs shall be included as a service condition as defined in IEEE Std.323-2003 Section 3.17 "Service conditions," which states that "Environmental, loading, power, and signal conditions expected as a result of normal operating requirements, expected extremes (abnormal) in operating requirements, and postulated conditions appropriate for the design basis events of the station" (emphasis added). In order to meet the requirements of 10CFR50.49, KHNP specified service conditions in the purchase specification as a range of environmental parameters as a result of analysis of normal operation and AOOs.

b) IEEE Std.323-2003 Section 4.2, "Qualified life and qualified condition," states that "The qualified life determination must consider degradation of equipment capability prior to and during service. Inherent in establishing a qualified life is that a qualified condition is also established. This qualified condition is the state of degradation for which successful performance during a subsequent design basis event was demonstrated." That is, to establish qualified life, it shall be demonstrated that the equipment can perform its safety function during a subsequent DBE.

IEEE Std.323 Section 5.3, "Condition monitoring," states that "Condition monitoring may be used in place of a qualified life to determine if qualified equipment is suitable for further service" (emphasis added). That is, the equipment shall be qualified first to use the condition based qualification method. IEEE Std. 323-2003 Section 4.1, "Qualification objective," states that "The primary objective of qualification is to demonstrate with reasonable assurance that Class 1E equipment for which a qualified life or condition has been established can perform its safety function(s) without experiencing common-cause failures before, during, and after applicable design basis events." Therefore, the DBE capability is addressed at the initial stage of qualification. Response to Question 3.11-18a) provides additional information related to this question.

c) For equipment qualification, type testing is performed by applying the actual installation configuration. Since the basic concept of qualification is simulating the worst case condition that the equipment is exposed, the interfaces of equipment are demonstrated under the worst case scenario.

A statement will be added in DCD Section 3.11.2.2, "Environmental Qualification during and after a Design Basis Accident" to ensure that material compatibilities at interfaces are demonstrated under the worst case environmental conditions.

d) The APR1400 General Design Criteria Section 2.1 "Design Basis Conditions, Events, and Load Combination," classifies design basis conditions into two categories: normal operation and anticipated operational occurrences and postulated accidents.

- Normal operation and anticipated operational occurrences
  - Normal operation: Normal operation includes plant heat-up and cool-down, power level increases, and load decreases.
  - Anticipated operational occurrences (AOOs): Events in which the reactor plant conditions exceed the normal operational conditions.
- Postulated accidents
  - Postulated accidents are unanticipated events or transients that are not expected to occur over the life of the plant, but which could cause the release of radioactive materials from the plant. Postulated accidents include feedwater system pipe

break, reactor coolant pump shaft break, steam generator tube rupture, loss of coolant accident, major steam system piping failure and design basis fuel handling accident.

Environmental qualification is performed under the most limiting condition to which the equipment is exposed. LOCA (Loss of Coolant Accident), MSLB (Main Steam Line Break) and HELB (High Energy Line Break) are the most limiting design basis events which are used to establish the acceptable performance requirements for the design of safety-related structures, systems or components as well as providing the basis for limiting conditions for operation. Other accidents (e.g., design basis fuel handling accident and feedwater system pipe break) do not result in limiting conditions for safe shutdown consideration; therefore, these are not considered in the environmental qualification.

Impact on DCD

DCD Section 3.11.2.2 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

k. Regulatory Guide 1.209, Guidelines for Environmental Qualifications of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants

l. Regulatory Guide 1.210, Qualification of Safety-Related Battery Chargers and Inverters for Nuclear Power Plants

m. Regulatory Guide 1.211, Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants

n. Regulatory Guide 1.213, Qualification of Safety-Related Motor Control Centers for Nuclear Power Plants

o. General Design Criteria 1, 2, 4, and 23 of 10 CFR Part 50, Appendix A

p. Quality assurance in accordance with 10 CFR Part 50, Appendix B

The COL applicant is to address operational aspects for maintaining the environmental qualification status of components after initial qualification.

Passive pressure boundary components inside the containment are designed for the appropriate temperature and pressure environment in accordance with the applicable code to which the component is constructed. The environmental qualification testing is not necessary for such components.

The materials used in the fabrication of mechanical and structural components inside the containment are selected to minimize corrosion and hydrogen generation resulting from contact with spray solutions. The use of aluminum and zinc is minimized in these components.

Material incompatibilities at interfaces are demonstrated under the worst case environmental conditions that it will be exposed to.

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Date of RAI Issue :	**10/21/2016**

Question No. 03.11-20

Regulatory Basis:

10 CFR 50.49(e)(8) states in part that "margins must be applied to account for unquantified uncertainty, such as the effects of production variations and inaccuracies in test instruments. These margins are in addition to any conservatisms applied during the derivation of local environmental conditions of the equipment unless these conservatisms can be quantified and shown to contain appropriate margins."

Questions:

a) Definition 3.13, "Margin," in IEEE Std. 323-2003 is defined as "The difference between service conditions and the conditions used for equipment qualification." Section 6.3.1.5, "Margin," in IEEE Std. 323-1974 defines margin as, "the difference between the most severe specified service conditions of the plant and the conditions used in type testing to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance."

   The staff requests that the applicant confirm that margin is applied on the most severe service condition as specified for temperature, pressure, chemical spray and radiation condition during and following design basis accident in 10 CFR 50.49(e).

b) IEEE Std. 323-2003, Section 6.3.1.6, "Margin" states that lesser values of margin may be adequate based on factors such as product design control, test sample size and test measurement accuracy.

   The staff requests that the applicant confirm that the margins will meet the requirement in 10CFR 50.49(e)(8) and, if seeking to use lesser values of margin, discuss how product design control, test sample size, and test measurement accuracy are addressed.

Response

a) Although the definition of margin has changed slightly in the IEEE 323 versions, IEEE Std.323-2003 still applies margin only to accident conditions (the most severe specified conditions of the plant). Section 6.3.1.6 “Margin,” of IEEE Std.323-2003 states that “The following suggested margins apply to design basis event service conditions and do not apply to age conditioning.” Therefore, the application of margin according to IEEE Std.323-2003 is not different from IEEE Std.323-1974 and will be applied on the most severe service condition as specified for temperature, pressure, chemical spray and radiation condition during design basis accident in accordance with the requirement of 10CFR50.49.

b) As stated in 10CFR50.49(e)(8), “Margin must be applied to account for un-quantified uncertainty, such as the effects of production variations and inaccuracies in test instruments” (emphasis added). To lessen certain values of margin, it is essential to quantify the uncertainty. However, it is impossible to quantify certain values of margin. Although IEEE Std.323-2003 opens the possibility to lessen the values of margin based on factors such as product design control, test sample size, and test measurement accuracy, it has not been used in the qualification process on the APR1400 and is not part of the APR1400 qualification program.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

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Question No. 03.11-21

Regulatory Basis:

10 CFR 50.49(e)(7) states in part that “synergistic effects must be considered when these effects [temperature, pressure, humidity, chemical effects, radiation, aging, and submergence] are believed to have a significant effect on equipment performance.”

Questions:

a) IEEE Std. 323-1974, Section 5.1, “Type Testing,” states that ”type test qualifications must consider synergistic effects during the testing in order to address the worst effects in accordance with 10 CFR 50.49 (e)(7). In contrast, IEEE Std. 323-2003 Section 5.1.1, “Type Testing,” does not address synergistic effects during the type tests. Although DCD Tier 2 section 3.11.2.3(a) states that synergistic effects are considered in the aging program, the use of IEEE Std. 323-2003 does not address synergistic effects. RG 1.89 position C.5.a states that if synergistic effects have been identified prior to the initiation of qualification, they should be accounted for in the qualification program.

   The staff requests that the applicant clarify the discrepancy and explain how synergistic effects are considered for type test qualification.

b) RG 1.89 Position C.5.a states that if synergistic effects have been identified prior to the initiation of qualification, they should be accounted for in the qualification program. The RG also states: “The procedures described by IEEE Std. 323-1974, "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations," are acceptable to the NRC staff for satisfying the Commission's regulations pertaining to the qualification of electric equipment for service in nuclear power plants.” IEEE Std. 323-1974, Section 4, “Introduction” states that “Qualification by analysis must include justification of methods, theories, and assumptions used. In general, electric equipment is too complex to be qualified by analysis alone.

The staff finds that qualification by analysis will not address the combined effects of the operating environment. If qualification by the method of analysis is used, the staff requests information on 1) how synergistic effects are addressed, and 2) add justification of methods, theories, and assumptions would be included.

Response

a) IEEE Std.323-2003 Section 6.3.1.8.2, "Age conditioning," refers to synergistic effects by stating "The sequence of age conditioning should consider sequential, simultaneous, and synergistic effects in order to achieve the worst state of degradation" (emphasis added). It is appropriate to mention in Section 6.3.1.8.2, "Age conditioning," (a required part of type testing), because synergistic effects must be considered at the stage of age conditioning.

b) Because there is no applicable analysis model to simulate more than one environmental stress, it is not possible to address the combined effects solely by analysis. Furthermore, IEEE Std.323-2003 Section 5.1.3 states that "Analysis alone cannot be used to demonstrate qualification," and 10CFR50.49 does not specify a method to use analysis alone. Therefore, test data or operating experience shall be combined with analysis. If synergistic effects exist, they shall be addressed during type testing or plant operation.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

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Question No. 03.11-22

Regulatory Basis:

10 CFR 50.49(e)(5) states that "Equipment qualified by test must be preconditioned by natural or artificial (accelerated) aging to its end-of-installed life condition. Consideration must be given to all significant types of degradation which can have an effect on the functional capability of the equipment. If preconditioning to an end-of-installed life condition is not practicable, the equipment may be preconditioned to a shorter designated life. The equipment must be replaced or refurbished at the end of this designated life unless ongoing qualification demonstrates that the item has additional life."

10 CFR 50.49(b)(1)(ii) states, in part, that DBEs are defined as conditions of normal operation, including anticipated operational occurrences, design basis accidents, external events, and natural phenomena for which the plant must be designed to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures.

Questions:

a) IEEE Std. 323-2003 Section 6.3.1.8.1, "Natural aging," states that natural aging may be supplemented by analysis to account for differences between the specified service and the natural aging conditions to justify the qualified life of the sample.

   Please discuss how natural aging supplemented by analysis addresses the end-of-installed-life condition and demonstrates that the equipment remains functional during and following design basis events, in accordance with 10 CFR 50.49(e)(5)

Response

a) Qualification using natural aging is accomplished as follows:

1. Equipment is aged naturally to end-of-life condition for the plant's operational condition. If it is not practicable to age the equipment to an end-of-life condition, a shorter life may be designated. (Note 1)

2. Analysis is performed to verify that natural aging conditions are at least as severe as the intended service condition. (Note 2, 3)

3. DBA testing is performed on the naturally aged sample. When analysis and DBA testing are successfully completed, the qualified life is determined based on the designated life.

Note 1: When the equipment cannot be aged to the end-of-life condition, the equipment will be replaced at a specified interval.

Note 2: Operating data and maintenance/replacement records will be maintained and made available.

Note 3: It is difficult to increase the designated life (when the equipment is preconditioned to the designated life) even though natural aging condition is more severe than the specified service condition because additional information (activation energy of materials, regression line) is needed to calculate the increased life.

As stated above, analysis and additional DBA testing shall be supplemented to use the natural aging process. First, analysis is performed to verify that the natural aging conditions (including service, loading, and environmental conditions) are at least as severe as the intended service condition. Then, DBA testing is performed on the naturally aged sample to demonstrate that the equipment can remain functional during and/or following the applicable design basis events. The end-of-installed-life condition is established when the analysis can ensure that the natural aging conditions are as severe as or more severe than the intended service condition and the DBA testing demonstrates the DBA capability.

A discussion on natural aging will be added to Section in 3.2.1.2 of APR1400-E-NR-14001-P/NP to more clearly align it with the requirements of 10 CFR 50.49 as shown in Attachment.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical Report APR1400-E-14001-P/NP will be revised as indicated in the Attachment.

This report will address each one of the above areas as it applies to safety-related electrical and active mechanical equipment.

The qualification program is established to meet the requirements of 10 CFR 50.49, and the "Category I" requirements of NUREG-0588, NUREG-0800, NRC RG 1.89, and IEEE Std. 323. The qualification program has two approaches that are based on the equipment's location. Equipment located in a harsh environment is not treated in the same fashion as equipment located in a mild environment. Regardless of equipment location, qualification will be demonstrated based on either type testing, accelerated age conditioning, periodic replacement, surveillance/preventive maintenance (S/PM), and/or any combination thereof. The qualification methods associated with both approaches are as follows:

a. Harsh Environments

Safety-related equipment located in a harsh environment, such as in containment and in some auxiliary building areas, required to be functional during and after the DBAs will undergo an aging analysis and an accelerated aging program. Subsequent to age conditioning, the equipment will undergo type testing for the accident environment as specified in Sections 2.0, 3.0, and 4.0 of NUREG-0588 and Section 6.0 of IEEE Std. 323. Equipment subjected to a postulated harsh environment includes Class 1E transmitters, cables and connectors, some process instrumentation, electrical penetration assemblies, cubicle coolers, ACU, nuclear service valves and auxiliary equipment, radiation and hydrogen monitoring equipment, pump motors and damper.

b. Mild Environments

Safety-related equipment located in a mild environment, such as control areas and some areas in the plant, will be qualified for the normal local environment and a seismic event. An aging analysis will be performed prior to qualification type testing to determine whether or not known significant aging mechanisms exist for that equipment. The aging analysis will focus on the identification of known aging mechanisms that significantly increase the equipment susceptibility to its DBA (seismic only for mild environments). Pending the results of the aging analysis, the equipment will either require an accelerated age conditioning program, periodic part replacement program, surveillance/preventive maintenance program, or any combination thereof to demonstrate and maintain qualification status. Equipment subjected to a mild environment includes Class 1E local control panels, some process instrumentation (indicators, converters, and recorders), load center, SWGR, DC control center, MCC, battery, charger and inverter, AHU, fan and duct heaters, EDG, and miscellaneous electronic modules.

Replace with "A"

3.2.1 Aging

The aging analysis and the accelerated age conditioning program will be conducted in accordance with Section 4.0 of NUREG-0588 and Section 6.0 of IEEE Std. 323.

As described in Section 3.2, the qualification program is determined by two approaches based on whether or not equipment is located in a harsh or mild environment. Regardless of equipment location, an aging analysis will be performed on all equipment. Thermal, radiation, humidity, cyclic operation, electromechanical, and synergistic effects will be addressed as appropriate.

The methodology used in the determination and evaluation of the equipment age-related failure modes and mechanisms will include, as appropriate, the following types of information:

a. Arrhenius and/or activation energy data

b. Aging acceleration rate data

c. Failure modes and effects analysis (FMEA) data

d. Thermal stress data

e. Electrical stress data

f. Electromechanical and operational cycling data

g. Normal operating vibration data

h. Radiation component susceptibility data

i. Major industry known synergistic data

Replace with "A"

3.2.2 Seismic

The seismic qualification program for Class 1E equipment will be in accordance with IEEE Std. 344 (Reference 9.10).

Seismic qualification of pump motors, and nuclear service valves and auxiliary equipment, is per IEEE Std. 344.

This report does not describe seismic testing, methods, or results, other than to reference IEEE Std. 344.

The detailed seismic qualification is described in Part 2, Seismic Qualification Program.

3.2.3 Environmental

Equipment will be environmentally qualified to levels at least as severe as the conditions specified in Table 3 of this report for normal and accident conditions. Environmental parameters and qualification profiles for DBAs (LOCA, MSLB, HELB) are provided in Table 3, 4 and Figure 1 to Figure 3-5 of this report.

3.3 ENVIRONMENTAL CONDITIONS AND EFFECTS

The postulated environmental conditions to which safety-related equipment are exposed generally include long time periods at either moderate or low levels of temperature, pressure, humidity, and radiation, followed by, for equipment located in the containment, exposure to high levels of these same parameters for relatively short periods of time. Equipment operation under these high stress levels may be required in order to mitigate or monitor the postulated accident conditions. The level of exposure may also be affected by the location of the particular equipment.

For example, a component located in the reactor containment building may be exposed to moderate temperature, pressure, humidity, and radiation for long periods of time and then would be required to function for safety purposes under possible conditions of high temperature, pressure, humidity, radiation and chemical spray resulting from a LOCA or MSLB /MFLB.

The purpose of the qualification program is to demonstrate that equipment will perform its Class 1E function.

"A"

3.2.1 Aging

The assessment of equipment aging effects is required to determine if significant aging mechanism does exist regardless of equipment location. Thermal, radiation, humidity, cyclic operation, electromechanical, and synergystic effects will be addressed as appropriate. Where significant aging mechanisms are identified, equipment shall be preconditioned by natural or accelerated aging.

3.2.1.1 Accelerated age conditioning

The accelerated age conditioning program will be conducted in accordance with Section 4.0 of NUREG-0588 and Section 6.0 of IEEE Std. 323.

The methodology used in the determination and evaluation of the equipment age-related failure modes and mechanisms will include, as appropriate, the following types of information:

a. Arrhenius and/or activation energy data
b. Aging acceleration rate data
c. Failure modes and effects analysis (FMEA) data
d. Thermal stress data
e. Electrical stress data
f. Electromechanical and operational cycling data
g. Normal operating vibration data
h. Radiation component susceptibility data
i. Major industry known synergistic data

3.2.1.2 Natural aging

The natural aging will be conducted in accordance with 10CFR50.49 and Section 6.3.1.8.1 of IEEE Std. 323-2003. If naturally preconditioning the equipment to end-of-life condition is not practicable, shorter life can be designated. In this case, the equipment shall be replaced at a specified interval. Analysis is performed to verify that natural aging conditions are at least as severe as the intended service condition. In the end, qualified life is determined based on the designated life when analysis and DBA testing are successfully completed.

Natural aging can be used for type testing provided that

a. Operating data of the equipment is available
b. Operating and maintenance/replacement records are available
c. Operating conditions are at least as severe as intended service condition

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**527-8686**
SRP Section:	**03.11 - Environmental Qualification of Mechanical and Electrical Equipment**
Application Section:	**3.11**
Date of RAI Issue :	**10/21/2016**

Question No. 03.11-23

Regulatory Basis:

10 CFR 50.49(d)(3) states that environmental conditions, including humidity, at the location where the equipment must perform should be included in the qualification file. Furthermore, 10 CFR 50.49(e)(5), "Aging" states that "Equipment qualified by test must be preconditioned by natural or artificial (accelerated) aging to its end-of-installed life condition. Consideration must be given to all significant types of degradation which can have an effect on the functional capability of the equipment."

Questions:

a) IEEE Std. 323-2003 Section 6.3.1.8.2, "Age conditioning," states that age conditioning generally involves applying simulated in-service stresses, typically thermal, radiation, wear, and vibration, as appropriate, at magnitudes or rates that are more severe than expected in-service levels, but less severe than levels that cause aging mechanisms not present in normal service. It is the intent of the age conditioning process to put the test sample in the worst state of degradation that it would experience during the qualified life, prior to the design basis event." Thus, during age-conditioning humidity should be considered if it has an effect on the functional capability of the equipment.

   Please demonstrate how humidity is considered during age conditioning, in accordance with 10 CFR 50.49.

Response

a) KHNP realizes that there is no generally accepted model for accelerating aging degradation caused by humidity as was reiterated by the staff in the NRC resolution of comment No. 89 to NUREG-0588 Rev.1 which stated that the staff had not endorsed any one specific method of accelerating humidity. Assurance can be obtained by demonstrating that equipment aging is not susceptible to humidity effects by 1) consideration during the design process, 2) providing a technical justification, and 3) performing humidity conditioning or testing.

1) Design Process (Equipment designed to be resistant to humidity)

   Regulatory Guide 1.89 Section 3.b states that “Electric equipment located in an area where rapid pressure changes are postulated simultaneously with the most adverse relative humidity should be qualified to demonstrate that the equipment seals and vapor barriers will prevent moisture from penetrating into the equipment to the degree necessary to maintain equipment function-ability.” If equipment is designed to prevent moisture from penetrating into the equipment, it can be assured that the equipment has tolerance to humidity. For example, equipment may be designed to have a certain level of water-tightness (such as those types classified by NEMA, UL, CSA or IP) or the interfaces can be sealed with electrical conduit seal assemblies (ECSAs) to prevent moisture intrusion.

2) Technical Justification

   Data exists that analyzes the correlation between equipment and humidity. For example, the aging analysis report, SAND 78-0344 “Aging of Nuclear Power Plant Safety Cable,” provides assurance that humidity effects on cable insulation materials tested is not a significant aging contributor. For qualification of equipment using these previously evaluated materials, the aging effects due to humidity may be omitted. Other vendor and industry data may exist that can be used for specific equipment evaluation.

3) Humidity conditioning or testing

   Resolution of comment No. 89 of NUREG-0588 Rev.1 states that various methods of accelerating humidity effects during the aging portion of the test program or humidity conditioning during a test sequence may be found acceptable. As stated in NUREG-0588, various applicable methods of humidity conditioning can be performed to address tolerance to humidity such as Military Humidity Test (Test Method 507.3) and IEC 60068-2-3 “Environmental Testing – Part 2: Test: Damp heat, steady state” are applicable.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**527-8686**
SRP Section:	**03.11 - Environmental Qualification of Mechanical and Electrical Equipment**
Application Section:	**3.11**
Date of RAI Issue :	**10/21/2016**

Question No. 03.11-24

Regulatory Basis:

10 CFR 50.49(f) states:

"(f) Each item of electric equipment important to safety must be qualified by one of the following methods:

(1) Testing an identical item of equipment under identical conditions or under similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable.

(2) Testing a similar item of equipment with a supporting analysis to show that the equipment to be qualified is acceptable.

(3) Experience with identical or similar equipment under similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable.

(4) Analysis in combination with partial type test data that supports the analytical assumptions and conclusions."

Questions:

a) IEEE Std. 323-2003 Section 6.3.3, "Analysis," states that "analytical techniques are limited for many types of equipment, and analysis supplemented by test data or operating experience is usually needed for a comprehensive qualification program."

Discuss how it is ensured that the qualification requirements of 10 CFR 50.49(f) will be met when using the method allowed under 10 CFR 50.49(f)(4), considering that IEEE Std. 323-2003 only recommends analysis should be supplemented with test data.

Response

a) Section 6.3.3 of IEEE Std.323-2003 states that “Qualification by analysis requires a logical assessment, similarity evaluations, or a valid mathematical model to establish that the equipment to be qualified can perform its safety function(s) when subjected to the specified service conditions.” That is, qualification by analysis shall establish the base of qualification first (logical assessment, similarity evaluations, or valid mathematical model), and the base is supported with test data or operating experience. For example, if a similarity evaluation is selected to qualify the equipment, test data or operating experiences of similar equipment shall be provided. In this manner, qualification is completed in accordance with the method of 10 CFR 50.49(f)(4) using analysis with test data that supports the analytical assumptions and conclusions.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.