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MFN 09-701, Revision 2

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U.S. Nuclear Regulatory Commission
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Subject: **Revised Response to Nuclear Regulatory Commission Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application - DCD Tier 2 Section 3.11 - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-39**

The purpose of this letter is to submit a revised GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 378 sent by NRC letter dated October 8, 2009 (Reference 1) and subsequent NRC staff comments. RAI Number 3.11-39 was addressed in References 2 and 3. For completeness Enclosure 1 contains the revision previously transmitted. Enclosure 2 contains the final response. Enclosure 3 contains the DCD changes as a result of GEH's final response.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-641, Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No. 378 Related to ESBWR Design Certification* Application dated October 8, 2009
2. MFN 09-701, *Response to NRC RAI Letter No. 378 Related to ESBWR Design Certification Application - – DCD Tier 2 Section 3.11 - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-39* dated November 17, 2009
3. MFN 09-701, Revision 1, *Revised Response to NRC RAI Letter No. 378 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.11 - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-39* dated February 4, 2010

Enclosures:

1. Revised Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-39

2. Final Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-39.

3. Final Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application - Environmental Qualification of Mechanical and Electrical Equipment; DCD Markups for RAI Number 3.11-39

cc:	AE Cubbage	USNRC (with enclosures)
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	DH Hinds	GEH/Wilmington (with enclosures)
	PM Yandow	GEH/Wilmington (with enclosures)
	eDRF Section	0000-0109-2638 Revs 2 and 3

MFN 09-701, Revision 2

Enclosure 1

Revised Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application

Environmental Qualification of Mechanical and Electrical Equipment

RAI Number 3.11-39

NRC RAI 3.11-39, Revision 1

1. DCD Tier 2 Table 1.9-22 references Electric Power Research Institute (EPRI) TR-102323 Revision 3, 2004, which has not been reviewed or accepted by the NRC. The NRC has reviewed and accepted TR-102323 Revision 0, 1994 as discussed in RG 1.180-2003, "The NRC staff accepted the Electric Power Research Institute (EPRI) topical report TR-102323, "Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants," in a Safety Evaluation Report (SER) by letter dated April 17, 1996, as one method of addressing issues of electromagnetic compatibility (EMC) for safety-related digital I&C systems in nuclear power plants. The original Regulatory Guide 1.180 (January 2000) and this revision complement the position set forth in the SER." The staff notes that TR-102323 Revision 2 was reviewed by the NRC and not accepted.

Revise the reference for TR-102323 to the approved 1994 version (noting the 1996 SER) or submit TR-102323 Revision 3, 2004 for staff review.

2. In DCD Tier 2 Section 3.11 and 7.1, GEH committed to comply with RG 1.180 and RG 1.209.

RG 1.180 Section A states in part,

> *"Methods for addressing electromagnetic compatibility (EMC) constitute Tier 2* information under the 10 CFR Part 52 requirements." (Last sentence in top paragraph on page 2)*

DCD Tier 2 Section 3.11.4.4 references NEDE-24326-1-P, "General Electric Environmental Qualification Program," January 1983 as part of the environmental qualification licensing basis. However, NEDE-24326-1-P does not address conformance to RG 1.180 and RG 1.209 and neither NEDE-24326-1-P nor the DCD provide methods for Q-DCIS electromagnetic and radio-frequency interference (EMI/RFI) qualification. Provide methods for Q-DCIS EMI/RFI qualification.

3. DCD Tier 1, Table 3.8-1, Item 3 provides ITAAC for the equipment qualification safety-related digital I&C equipment.

Inspection, Test, Analyses 3.ii. states,

> *"Type tests, analyses, or a combination of type tests and analyses will be performed on the equipment qualification program's digital I&C equipment located in a mild environment."*

The DCD identifies conformance to RG 1.180 and IEEE STD 323-2003. However the DCD statement above is inconsistent IEEE STD 323-2003, Section 5.1.3, "Analysis," which states in part,

> *"However, analysis alone cannot be used to demonstrate qualification."*

Revise DCD Tier 1, Table 3.8-1, Item 3 to remove the option of demonstrating qualification by analysis alone and revise DCD Tier 2 Section 3.11.4.3 to state that analysis alone cannot be used to demonstrate qualification.

GEH Response to RAI 3.11-39

Question 1

1. DCD Tier 2 Table 1.9-22 references Electric Power Research Institute (EPRI) TR-102323 Revision 3, 2004, which has not been reviewed or accepted by the NRC. The NRC has reviewed and accepted TR-102323 Revision 0, 1994 as discussed in RG 1.180-2003, "The NRC staff accepted the Electric Power Research Institute (EPRI) topical report TR-102323, "Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants," in a Safety Evaluation Report (SER) by letter dated April 17, 1996, as one method of addressing issues of electromagnetic compatibility (EMC) for safety-related digital I&C systems in nuclear power plants. The original Regulatory Guide 1.180 (January 2000) and this revision complement the position set forth in the SER." The staff notes that TR-102323 Revision 2 was reviewed by the NRC and not accepted.

Revise the reference for TR-102323 to the approved 1994 version (noting the 1996 SER) or submit TR-102323 Revision 3, 2004 for staff review.

GEH Response

GEH concurs and will revise the DCD.

Table 1.9-22 will be revised to reference TR-102323–1994 *"Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants,"* which is the approved version based upon the 1996 SER.

DCD Impact

DCD Tier 2, Table 1.9-22 will be revised as noted in the attached markup.

Question 2

2. In DCD Tier 2 Section 3.11 and 7.1, GEH committed to comply with RG 1.180 and RG 1.209.

RG 1.180 Section A states in part,

> *"Methods for addressing electromagnetic compatibility (EMC) constitute Tier 2* information under the 10 CFR Part 52 requirements." (Last sentence in top paragraph on page 2)*

DCD Tier 2 Section 3.11.4.4 references NEDE-24326-1-P, "General Electric Environmental Qualification Program," January 1983 as part of the environmental qualification licensing basis. However, NEDE-24326-1-P does not address conformance to RG 1.180 and RG 1.209 and neither NEDE-24326-1-P nor the DCD provide methods for Q-DCIS electromagnetic and radio-frequency interference (EMI/RFI) qualification. Provide methods for Q-DCIS EMI/RFI qualification.

GEH Response

GEH concurs and will revise the DCD.

For Harsh Environments there is no change in the DCD. As stipulated in 3.11.4.1 "Electromagnetic interference (EMI)/radio frequency interference (RFI) and Voltage Surges" for a harsh environment, EMI qualifications follow the requirements defined in MIL-STD 461E and IEC 61000-4. The qualification for EMI/RFI and voltage surges for EQ equipment in harsh and mild environments is by test, consistent with RG 1.180.

For Mild Environments, the following clarifications will be added to section 3.11.4.2.

> "Safety-related equipment located in a mild environment will be qualified per guidelines of Regulatory Guide 1.209-2007 and IEEE 323-2003 for qualification of Safety Related or Important to Safety digital I&C to be installed in a mild environment."

For EMI/RFI, qualification methodology shall be in compliance with EPRI TR-102323-1994 (as approved in 1996 NRC SER), Mil Std 461E or IEC 61000 Series (as endorsed in RG 1.180, Rev 1.)

In the original RAI response the last paragraph of section 3.11.4.4 was deleted. Following discussion with the NRC, this statement is being reinserted into section 3.11.4.4 of the DCD per Rev 1.

DCD Impact

DCD Tier 2, Sections 3.11.4.2 and 3.11.4.4 will be revised as noted in the attached markup.

Question 3

3. DCD Tier 1, Table 3.8-1, Item 3 provides ITAAC for the equipment qualification safety-related digital I&C equipment.

Inspection, Test, Analyses 3.ii. states,

> *"Type tests, analyses, or a combination of type tests and analyses will be performed on the equipment qualification program's digital I&C equipment located in a mild environment."*

The DCD identifies conformance to RG 1.180 and IEEE STD 323-2003. However the DCD statement above is inconsistent IEEE STD 323-2003, Section 5.1.3, "Analysis," which states in part,

> *"However, analysis alone cannot be used to demonstrate qualification."*

Revise DCD Tier 1, Table 3.8-1, Item 3 to remove the option of demonstrating qualification by analysis alone and revise DCD Tier 2 Section 3.11.4.3 to state that analysis alone cannot be used to demonstrate qualification.

GEH Response

Section 3.11.4.3 will be updated to include the following text (excerpt from 10CFR50.49, part (f)).

> "In addition to Type Testing, analysis may be utilized per 10CFR50.49 to support digital I&C qualification in a mild environment via;
>
> (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."

Additionally, Table 3.8 –1, item 3 ii will be updated to reflect analysis will be consistent with 10CFR50.49 (f).

Qualification by analysis only will not be the sole determining factor for defining the Environmental Qualification of a component. However, as endorsed by 10CFR50.49, IEEE 603 -1991, and Reg. Guide 1.89, analysis has a role in defining acceptability of a component for its intended environmental environment.

Section 5.4 of IEEE 603-1991 "Equipment Qualification" states the following;

Safety system equipment shall be qualified by type test, previous operating experience, or analysis, or any combination of these three methods, to substantiate that it will be capable of meeting, on a continuing basis, the performance requirements as specified in the design basis. Qualification of Class 1E equipment shall be in accordance with the requirements of IEEE Std 323–1983 [2] and IEEE Std 627–1980 [11].

Reg Guide 1.189 R1, Appendix E, # 6 states the following;

Provide a summary of the test results that demonstrates the adequacy of the qualification program. If any analysis is used for qualification, justification for all analysis assumptions must be provided.

EPRI 107330 Section 6.1.1 "PLC System Qualification Overview" states the following;

Equipment can be qualified for safety-related use based on several methods individually or in combination (Section 4 of IEEE 323 - 1983) The PLC qualification is based on testing and analysis.

Qualification by analysis only will not be the sole determining factor for defining the Environmental Qualification of a component. However, as endorsed by 10CFR50.49, IEEE 603 -1991, and Reg. Guide 1.89, analysis has a role in defining acceptability of a component for its intended environmental environment.

In some cases, analysis may be performed to extend the qualification of a component to accommodate changes to a components position or orientation, account for physical changes to a component, or to fill in gaps in it's qualification. Experience has shown a need to perform analysis at times to ensure qualification test meet the final system configuration. The following examples come from real life experiences in which analysis was required to qualify a component, to ensure physical changes to a component did not affect it's qualification or to extend the type testing qualification of singular components to account for assembling the components into larger assemblies.

Example 1 - A relay was qualified per type testing. This relay was replaced with a newer model by the manufacturer and its part number was revised. The new relay is similar or identical in all critical properties to the existing one. An analysis is performed of all critical parameters (temp, RH, EMI, seismic, electrical separation) to ensure the new relay will exhibit the same characteristics as the relay originally qualified via type testing. In this case, engineering analysis of critical characteristics between the two relays could be expected to yield reasonable assurance that the new relay will perform in the same manner as the original.

Example 2 – An electronic assembly is qualified by type testing. All components inside are shown to be qualified as well as the complete assembly. Per IEEE 323 "Qualification of equipment mounted in other than the tested configuration requires analysis showing that equipment performance is not degraded by the differing configuration." Consequently, to accommodate different configurations or component combinations within the assembly, an analysis may be utilized to demonstrate continued qualification of the different versions of the assembly.

Example 3 - In some instances, it may not practical to qualify the equipment by type testing. This may be due to the size of the equipment, its complexity or the inability to establish a credible test environment. In these cases, analysis utilizing simulation or computer modeling may be required to demonstrate compliance with one or more of the EQ parameters. (ex. thermal ageing)

Example 4 – A grounding buss bar was qualified for terminating ground wires. The qualification test utilized clips to terminate the ground wires. But, upon delivery, the customer demanded that the buss bar be drilled so that grounding wires could be bolted to the buss bar. Analysis confirmed the integrity of the buss bar was not compromised nor was its electrical properties.

The above examples are typical instances in which analysis may be utilized in lieu of or in combination with type testing to recertify a component or to accommodate changes.

It will be difficult to define within the DCD an explanation of each instance we may use analysis as a part of the qualification process. But in all cases, analysis will be utilized following sound engineering practices and in compliance with 10CFR50.49, part (f).

DCD Impact

1. DCD Tier 2, Section 3.11.4.3 will be revised as noted in the attached markup.

2. DCD Table 3.8-1, Item 3ii will be revised as noted in the attached markup.

Revision 1 NRC Question

RAI 3.11-39 deleted the reference to the GE EQ program. The NRC questioned the basis for this deletion. GEH explained that the ESBWR design required more current standards and that the report was no longer in sync with current design. It was agreed this paragraph is still required for mechanical and electrical components.

GEH Response

GEH concurs and will revise the DCD to re-insert the paragraph.

DCD Impact

Section 3.11.4.4 was updated to reinsert the following paragraph. *"The compliance with the applicable portions of the GDC of 10 CFR 50, Appendix A, and the Quality Assurance Criteria of 10 CFR 50, Appendix B are described in the NRC approved Licensing Topical Report on GE's environmental qualification program (Reference 3.11-3)."*

Revision 1 NRC Question

The NRC pointed out that a recent change to EQ ITAAC Table 3.8-1 item # 2ii was changed with RAI 14.3-449 and that it was not consistent with 3.11-39 changes to that same item.

GEH Response

GEH noted the difference in the two documents and told the staff that the more recent change under RAI 14.3-449 was correct. The NRC accepted this.

DCD Impact

None

Revision 1 NRC Question

Section 7.2 of IEEE-2003 addresses the documentation requirements for harsh environment equipment but GEH references the section for the criteria placed on mild environment equipment. This is confusing without further clarification by GEH. GEH stated that since the documentation requirements are so vague in Section 7.1 of IEEE-2003, Mild equipment documentation requirements, GEH chose to use 7.2 instead. GEH and the NRC agreed that we would revise our response to more clearly define this application. This also includes other DCD references to Section 7.2.

GEH Response

GEH concurs and will revise the DCD.

DCD Impact

Changed DCD Sections 3.11.4.3 and 3.11.4.4. to reference section 7.2 of IEEE 323-2003.

Revision 1 NRC Question

The NRC questioned the use of IEEE-344, Seismic requirements, and which standard applied to digital I&C equipment. Section 3.10 in not clear on which standard, 323-1974 or 2003 version since it refers to GE EQ spec which was last revised in 1983. GEH committed to review DCD sections 3.10 and 3.11 for consistency on Seismic and environmental qualification of mechanical, electrical and I&C equipment and to correct if any are found.

GEH Response

A review of the applicable sections was made and several inconsistencies noted. These were corrected.

DCD Impact

- Subsection 3.11.3.1, Temperature - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

- Subsection 3.11.3.1, Pressure - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

- Subsection 3.11.3.1, Humidity - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

- Subsection 3.11.3.1, Radiation - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

- Subsection 3.11.3.1, Electromagnetic interference (EMI)/radio frequency interference (RFI) and Voltage Surges - Added “EPRI TR-102323 –1994 (as approved by NRC Safety Evaluation Report dated April 16 1996.)”

- Subsection 3.11.4.1 Deleted “and documentation”

MFN 09-701, Revision 2

Enclosure 2

Final Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application

Environmental Qualification of Mechanical and Electrical Equipment

RAI Number 3.11-39

NRC RAI 3.11-39, Revision 1

1. DCD Tier 2 Table 1.9-22 references Electric Power Research Institute (EPRI) TR-102323 Revision 3, 2004, which has not been reviewed or accepted by the NRC. The NRC has reviewed and accepted TR-102323 Revision 0, 1994 as discussed in RG 1.180-2003, "The NRC staff accepted the Electric Power Research Institute (EPRI) topical report TR-102323, "Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants," in a Safety Evaluation Report (SER) by letter dated April 17, 1996, as one method of addressing issues of electromagnetic compatibility (EMC) for safety-related digital I&C systems in nuclear power plants. The original Regulatory Guide 1.180 (January 2000) and this revision complement the position set forth in the SER." The staff notes that TR-102323 Revision 2 was reviewed by the NRC and not accepted.

Revise the reference for TR-102323 to the approved 1994 version (noting the 1996 SER) or submit TR-102323 Revision 3, 2004 for staff review.

2. In DCD Tier 2 Section 3.11 and 7.1, GEH committed to comply with RG 1.180 and RG 1.209.

RG 1.180 Section A states in part,

> *"Methods for addressing electromagnetic compatibility (EMC) constitute Tier 2* information under the 10 CFR Part 52 requirements." (Last sentence in top paragraph on page 2)*

DCD Tier 2 Section 3.11.4.4 references NEDE-24326-1-P, "General Electric Environmental Qualification Program," January 1983 as part of the environmental qualification licensing basis. However, NEDE-24326-1-P does not address conformance to RG 1.180 and RG 1.209 and neither NEDE-24326-1-P nor the DCD provide methods for Q-DCIS electromagnetic and radio-frequency interference (EMI/RFI) qualification. Provide methods for Q-DCIS EMI/RFI qualification.

3. DCD Tier 1, Table 3.8-1, Item 3 provides ITAAC for the equipment qualification safety-related digital I&C equipment.

Inspection, Test, Analyses 3.ii. states,

> *"Type tests, analyses, or a combination of type tests and analyses will be performed on the equipment qualification program's digital I&C equipment located in a mild environment."*

The DCD identifies conformance to RG 1.180 and IEEE STD 323-2003. However the DCD statement above is inconsistent IEEE STD 323-2003, Section 5.1.3, "Analysis," which states in part,

> *"However, analysis alone cannot be used to demonstrate qualification."*

Revise DCD Tier 1, Table 3.8-1, Item 3 to remove the option of demonstrating qualification by analysis alone and revise DCD Tier 2 Section 3.11.4.3 to state that analysis alone cannot be used to demonstrate qualification.

GEH Response to RAI 3.11-39

Question 1

1. DCD Tier 2 Table 1.9-22 references Electric Power Research Institute (EPRI) TR-102323 Revision 3, 2004, which has not been reviewed or accepted by the NRC. The NRC has reviewed and accepted TR-102323 Revision 0, 1994 as discussed in RG 1.180-2003, "The NRC staff accepted the Electric Power Research Institute (EPRI) topical report TR-102323, "Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants," in a Safety Evaluation Report (SER) by letter dated April 17, 1996, as one method of addressing issues of electromagnetic compatibility (EMC) for safety-related digital I&C systems in nuclear power plants. The original Regulatory Guide 1.180 (January 2000) and this revision complement the position set forth in the SER." The staff notes that TR-102323 Revision 2 was reviewed by the NRC and not accepted.

Revise the reference for TR-102323 to the approved 1994 version (noting the 1996 SER) or submit TR-102323 Revision 3, 2004 for staff review.

GEH Response

GEH concurs and will revise the DCD.

Table 1.9-22 will be revised to reference TR-102323–1994 *"Guidelines for Electromagnetic Interference Testing in Nuclear Power Plants,"* which is the approved version based upon the 1996 SER.

DCD Impact

DCD Tier 2, Table 1.9-22 will be revised as noted in the attached markup.

Question 2

2. In DCD Tier 2 Section 3.11 and 7.1, GEH committed to comply with RG 1.180 and RG 1.209.

RG 1.180 Section A states in part,

> *"Methods for addressing electromagnetic compatibility (EMC) constitute Tier 2* information under the 10 CFR Part 52 requirements." (Last sentence in top paragraph on page 2)*

DCD Tier 2 Section 3.11.4.4 references NEDE-24326-1-P, "General Electric Environmental Qualification Program," January 1983 as part of the environmental qualification licensing basis. However, NEDE-24326-1-P does not address conformance to RG 1.180 and RG 1.209 and neither NEDE-24326-1-P nor the DCD provide methods for Q-DCIS electromagnetic and radio-frequency interference (EMI/RFI) qualification. Provide methods for Q-DCIS EMI/RFI qualification.

GEH Response

GEH concurs and will revise the DCD.

For Harsh Environments there is no change in the DCD. As stipulated in 3.11.4.1 "Electromagnetic interference (EMI)/radio frequency interference (RFI) and Voltage Surges" for a harsh environment, EMI qualifications follow the requirements defined in MIL-STD 461E and IEC 61000-4. The qualification for EMI/RFI and voltage surges for EQ equipment in harsh and mild environments is by test, consistent with RG 1.180.

For Mild Environments, the following clarifications will be added to section 3.11.4.2.

> "Safety-related equipment located in a mild environment will be qualified per guidelines of Regulatory Guide 1.209-2007 and IEEE 323-2003 for qualification of Safety Related or Important to Safety digital I&C to be installed in a mild environment."

For EMI/RFI, qualification methodology shall be in compliance with EPRI TR-102323-1994 (as approved in 1996 NRC SER), Mil Std 461E or IEC 61000 Series (as endorsed in RG 1.180, Rev 1.)

In the original RAI response the last paragraph of section 3.11.4.4 was deleted. Following discussion with the NRC, this statement is being reinserted into section 3.11.4.4 of the DCD per Rev 1.

DCD Impact

DCD Tier 2, Sections 3.11.4.2 and 3.11.4.4 will be revised as noted in the attached markup.

Question 3

3. DCD Tier 1, Table 3.8-1, Item 3 provides ITAAC for the equipment qualification safety-related digital I&C equipment.

Inspection, Test, Analyses 3.ii. states,

> *"Type tests, analyses, or a combination of type tests and analyses will be performed on the equipment qualification program's digital I&C equipment located in a mild environment."*

The DCD identifies conformance to RG 1.180 and IEEE STD 323-2003. However the DCD statement above is inconsistent IEEE STD 323-2003, Section 5.1.3, "Analysis," which states in part,

> *"However, analysis alone cannot be used to demonstrate qualification."*

Revise DCD Tier 1, Table 3.8-1, Item 3 to remove the option of demonstrating qualification by analysis alone and revise DCD Tier 2 Section 3.11.4.3 to state that analysis alone cannot be used to demonstrate qualification.

GEH Response

Section 3.11.4.3 will be updated to include the following text (excerpt from 10CFR50.49, part (f)).

> "In addition to Type Testing, analysis may be utilized per 10CFR50.49 to support digital I&C qualification in a mild environment via;
>
> (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."

Additionally, Table 3.8 –1, item 3 ii will be updated to reflect analysis will be consistent with 10CFR50.49 (f).

Qualification by analysis only will not be the sole determining factor for defining the Environmental Qualification of a component. However, as endorsed by 10CFR50.49, IEEE 603 -1991, and Reg. Guide 1.89, analysis has a role in defining acceptability of a component for its intended environmental environment.

Section 5.4 of IEEE 603-1991 "Equipment Qualification" states the following;

Safety system equipment shall be qualified by type test, previous operating experience, or analysis, or any combination of these three methods, to substantiate that it will be capable of meeting, on a continuing basis, the performance requirements as specified in the design basis. Qualification of Class 1E equipment shall be in accordance with the requirements of IEEE Std 323–1983 [2] and IEEE Std 627–1980 [11].

Reg Guide 1.189 R1, Appendix E, # 6 states the following;

Provide a summary of the test results that demonstrates the adequacy of the qualification program. If any analysis is used for qualification, justification for all analysis assumptions must be provided.

EPRI 107330 Section 6.1.1 "PLC System Qualification Overview" states the following;

Equipment can be qualified for safety-related use based on several methods individually or in combination (Section 4 of IEEE 323 - 1983) The PLC qualification is based on testing and analysis.

Qualification by analysis only will not be the sole determining factor for defining the Environmental Qualification of a component. However, as endorsed by 10CFR50.49, IEEE 603 -1991, and Reg. Guide 1.89, analysis has a role in defining acceptability of a component for its intended environmental environment.

In some cases, analysis may be performed to extend the qualification of a component to accommodate changes to a components position or orientation, account for physical changes to a component, or to fill in gaps in it's qualification. Experience has shown a need to perform analysis at times to ensure qualification test meet the final system configuration. The following examples come from real life experiences in which analysis was required to qualify a component, to ensure physical changes to a component did not affect it's qualification or to extend the type testing qualification of singular components to account for assembling the components into larger assemblies.

Example 1 - A relay was qualified per type testing. This relay was replaced with a newer model by the manufacturer and its part number was revised. The new relay is similar or identical in all critical properties to the existing one. An analysis is performed of all critical parameters (temp, RH, EMI, seismic, electrical separation) to ensure the new relay will exhibit the same characteristics as the relay originally qualified via type testing. In this case, engineering analysis of critical characteristics between the two relays could be expected to yield reasonable assurance that the new relay will perform in the same manner as the original.

Example 2 – An electronic assembly is qualified by type testing. All components inside are shown to be qualified as well as the complete assembly. Per IEEE 323 "Qualification of equipment mounted in other than the tested configuration requires analysis showing that equipment performance is not degraded by the differing configuration." Consequently, to accommodate different configurations or component combinations within the assembly, an analysis may be utilized to demonstrate continued qualification of the different versions of the assembly.

Example 3 - In some instances, it may not practical to qualify the equipment by type testing. This may be due to the size of the equipment, its complexity or the inability to establish a credible test environment. In these cases, analysis utilizing simulation or computer modeling may be required to demonstrate compliance with one or more of the EQ parameters. (ex. thermal ageing)

Example 4 – A grounding buss bar was qualified for terminating ground wires. The qualification test utilized clips to terminate the ground wires. But, upon delivery, the customer demanded that the buss bar be drilled so that grounding wires could be bolted to the buss bar. Analysis confirmed the integrity of the buss bar was not compromised nor was its electrical properties.

The above examples are typical instances in which analysis may be utilized in lieu of or in combination with type testing to recertify a component or to accommodate changes.

It will be difficult to define within the DCD an explanation of each instance we may use analysis as a part of the qualification process. But in all cases, analysis will be utilized following sound engineering practices and in compliance with 10CFR50.49, part (f).

DCD Impact

3. DCD Tier 2, Section 3.11.4.3 will be revised as noted in the attached markup.

4. DCD Table 3.8-1, Item 3ii will be revised as noted in the attached markup.

Revision 1 NRC Question

RAI 3.11-39 deleted the reference to the GE EQ program. The NRC questioned the basis for this deletion. GEH explained that the ESBWR design required more current standards and that the report was no longer in sync with current design. It was agreed this paragraph is still required for mechanical and electrical components.

GEH Response
GEH concurs and will revise the DCD to re-insert the paragraph.

DCD Impact

Section 3.11.4.4 was updated to reinsert the following paragraph. *"The compliance with the applicable portions of the GDC of 10 CFR 50, Appendix A, and the Quality Assurance Criteria of 10 CFR 50, Appendix B are described in the NRC approved Licensing Topical Report on GE's environmental qualification program (Reference 3.11-3)."*

Revision 1 NRC Question

The NRC pointed out that a recent change to EQ ITAAC Table 3.8-1 item # 2ii was changed with RAI 14.3-449 and that it was not consistent with 3.11-39 changes to that same item.

GEH Response

GEH noted the difference in the two documents and told the staff that the more recent change under RAI 14.3-449 was correct. The NRC accepted this.

DCD Impact

None

Revision 2 NRC Question

The next several questions related to the use of IEEE-323-2003 on mild environment equipment and the reference to Section 7.2 of that standard. Section 7.2 of IEEE-2003 addresses the documentation requirements for harsh environment equipment but GEH references the section for the criteria placed on mild environment equipment. Regulatory Guide 1.209 states that IEEE-2003 Section 7.2 should be used for mild environment documentation requirements. GEH and the NRC agreed that we would revise our response to more clearly define this approach. This also includes other DCD references to Section 7.2.

GEH Response

GEH agrees to utilize applicable requirements of IEEE Std. 323-2003 Section 7.2, “Harsh environment documentation” to document mild equipment qualification.

DCD Impact

Changed DCD Sections 3.11.4.3 and 3.11.4.4 to reference section 7.2 of IEEE 323-2003.

Revision 1 NRC Question

The NRC questioned the use of IEEE-344, Seismic requirements, and which standard applied to digital I&C equipment. Section 3.10 in not clear on which standard, 323-1974 or 2003 version since it refers to GE EQ spec which was last revised in 1983. GEH committed to review DCD sections 3.10 and 3.11 for consistency on Seismic and environmental qualification of mechanical, electrical and I&C equipment and to correct if any are found.

GEH Response

A review of the applicable sections was made and several inconsistencies noted. These were corrected.

DCD Impact

• Subsection 3.11.3.1, Temperature - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

• Subsection 3.11.3.1, Pressure - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

• Subsection 3.11.3.1, Humidity - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

• Subsection 3.11.3.1, Radiation - Added “for Harsh Environment and IEEE 323-2003 for Mild Environment”.

• Subsection 3.11.3.1, Electromagnetic interference (EMI)/radio frequency interference (RFI) and Voltage Surges - Added “EPRI TR-102323 –1994 (as approved by NRC Safety Evaluation Report dated April 16 1996.)”

• Subsection 3.11.4.1 Deleted “and documentation”

Revision 2 - Additional NRC Comment

Section 3.11.1.1 lists MIL-STD 461E and IEC 61000-4. Your original response states that GEH uses MIL-STD 461E or IEC 61000-4. However the response revised subsection 3.11.4.2 to state;

"EMI qualifications follow the requirements defined in EPRI TR-102323 –1994 (as approved by NRC Safety Evaluation Report dated April 16 1996), MIL-STD 461E and IEC 61000-4."

This is confusing. Please clarify if you use a combined set of standards or a choice of either standard.

GEH Response

GEH will not combine standards. A single standard will be selected and utilized in its entirety.

All affected subsections have been revised to state "EMI qualifications follow the requirements defined in EPRI TR-102323-1994 (as approved by NRC Safety Evaluation Report dated April 16 1996) or MIL-STD-461E or IEC 61000-4 series." Affected DCD revisions are attached to this response.

Subsection 3.11.1.1 states "the environmental qualification of electrical and mechanical equipment meets the relevant requirements of the following regulations" and is only a list of regulations. Applicability is found in Subsections as described above.

DCD Impact

Subsections 3.11.3.1 and 3.11.4.2 will be revised to state EMI qualifications follow the requirements defined in "EPRI TR-102323–1994 (as approved by NRC Safety Evaluation Report dated April 16 1996) or MIL-STD-461E or IEC 61000-4 series".

Additional DCD changes based on NRC feedback

1. Section 3.11.1.1 Added "series" to end of IEC 61000-4 to read IEC 61000-4 series.
2. Section 7.1.6.4, under RG 1.180 compliance. Deleted reference to MIL-STD-461E and IEC 61000-4. Replaced with a reference to section 3.11.3.1.
3. Section 7.1.6.6. Deleted third paragraph. This sentence is in the wrong place and incomplete.

MFN 09-701, Revision 2

Enclosure 3

Final Response to NRC Request for Additional Information Letter No. 378 Related to ESBWR Design Certification Application

Environmental Qualification of Mechanical and Electrical Equipment

DCD Markups for RAI Number 3.11-39

b. Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants."

c. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants."

d. Regulatory Guide 1.131, "Qualification Tests of Electric Cables, Field Splices and Connections for Light-Water-Cooled Nuclear Power Plants."

e. Regulatory Guide 1.153, "Criteria for Safety Systems."

f. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactor."

g. Regulatory Guide 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants."

h. Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems."

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

j. Regulatory Guide 1.40, "Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants."

k. Regulatory Guide 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants."

l. Regulatory Guide 1.156, "Environmental Qualification of Connection Assemblies for Nuclear Power Plants."

m. Regulatory Guide 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants."

(5) Department of Defense (DOD) Military Standards (MIL-STD)

a. MIL-STD 461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment."

(6) International Electrotechnical Commission (IEC)

a. 61000-4 series, "Electromagnetic Compatibility (EMC): Testing and Measurement Techniques."

3.11.1.2 General Requirements

Environmental design and qualification used to implement the relevant requirements of 10 CFR 50.49; General Design Criteria (GDC) 1, 2, 4 and 23; and 10 CFR 50, Appendix B, Quality Assurance Criteria III, XI, and XVII are as follows:

(1) The equipment is designed to have the capability of performing its design safety-related functions under all anticipated operational occurrences (AOOs) and normal, accident, and post-accident environments and for the length of time for which its function is required.

- EMI
- RFI
- Electrostatic Discharge
- Electrical Surge

EMI qualifications follow the requirements defined in EPRI TR-102323 –1994 (as approved by NRC Safety Evaluation Report dated April 16 1996), or MIL-STD 461E ~~and~~ or IEC 61000-4 series. The qualification for EMI/RFI and voltage surges for EQ equipment in harsh and mild environments is by test, consistent with RG 1.180. Nonsafety-related electrical and digital computer-based I&C equipment is tested for conducted emission via power leads and radiated emission from electric fields to ensure that emissions from nonsafety-related electrical and I&C equipment do not exceed allowable limits and do not affect the EQ equipment.

This ensures that safety-related equipment is qualified for EMI/RFI and voltage surges per the requirements of IEEE 323-2003.

3.11.3.2 Environmental Requirements

Environmental conditions for the zones where EQ equipment is located are calculated for normal, AOO, test, accident and post-accident conditions and are documented in Appendix 3H, Equipment Qualification Environmental Design Criteria. Environmental conditions are tabulated by zones contained in the referenced building arrangements. Typical equipment in the noted zones is shown in the referenced system design schematics.

Environmental parameters include thermodynamic parameters (temperature, pressure and relative humidity), radiation parameters (radiation type, dose rates and total integrated dose) and chemical spray parameters (chemical composition and the resulting pH).

AOO and test condition environments are bounded by the normal or accident conditions according to the Appendix 3H tables.

Margins are 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 3H tables do not include margins.

The environmental conditions shown in the Appendix 3H tables are upper-bound envelopes used to establish the environmental design and qualification bases for equipment. The upper bound envelopes indicate that the zone data reflect the worse case expected environment produced by a compendium of accident conditions.

3.11.4 Qualification Program, Methods and Documentation

3.11.4.1 Harsh Environment Qualification

Some EQ equipment is located in a harsh environment. All three categories of 10 CFR 50.49(b) electrical equipment that are located in a harsh environment are qualified by test or other methods as described in IEEE-323-1974 and permitted by 10 CFR 50.49(f) (Reference 3.11-2). Equipment type test is the preferred method of qualification.

The loading and capability under DBA conditions is analyzed in the equipment qualification process to establish 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. The qualification of mechanical equipment includes materials that are sensitive to environmental effects (e.g., seals, gaskets, lubricants, fluids for hydraulic systems, and diaphragms), required operating time, non-metallic subcomponents of such equipment; the environmental conditions and process parameters for which this equipment must be qualified; non-metallic material capabilities; and the evaluation of environmental effects.

The EQ equipment in a harsh environment has a maximum qualified life of 60 years. The qualified life is verified using methods and procedures of qualification ~~and documentation~~ as stated in IEEE-323-1974 and as addressed herein.

The duty cycle of safety-related batteries in ESBWR is different from the duty cycle basis in IEEE-535-1986. Safety-related batteries are qualified to meet IEEE-535-1986, with the exception that the duty cycle is 72 hours and supplemental discharge cycle testing is required to meet the harsh environment qualification process of IEEE-323-1974.

ESBWR's equipment qualification type test process for batteries includes evaluation of significant aging mechanisms that are related to failure mechanisms from radiation exposure, time-temperature aging, and cycle aging; age testing for significant aging mechanisms for a 20-year qualified life; seismic test; and performance testing for the 72-hour duty cycle (see Reference 3.11-6).

3.11.4.2 Mild Environment Qualification

EQ safety-related equipment located in a mild environment is qualified ~~as follows~~per guidelines of Regulatory Guide 1.209 – 2007 and IEEE 323-2003 for qualification of Safety Related or Important to Safety digital I&C to be installed in a mild environment.

For EMI/RFI qualification, as endorsed in Regulatory Guide 1.180, Rev 1, qualification methods shall be per EPRI TR-102323 –1994 (as approved by NRC Safety Evaluation Report dated April 16 1996)~~,~~ or ~~Mil Std~~MIL-STD- 461E or IEC 61000-4 s~~S~~eries.~~:~~

To assure EQ safety-related equipment located in a mild environment meets its safety-related functional requirements during normal environmental conditions and AOOs, the environmental design basis for normal environmental conditions and AOO requirements is specified in the design/purchase specifications. A qualified life is not required for equipment located in a mild environment that has no significant aging mechanisms.

For all EQ safety-related equipment, excluding EQ safety-related digital computer-based I&C systems, a Certificate of Conformance from the vendor of the safety-related equipment to be located in a mild environment needs to certify performance to the environmental design basis for normal environmental conditions and AOO requirements for the equipment location for the time that the safety-related function is required.

3.11.4.3 Computer-based Instrumentation and Control Systems

EQ safety-related digital computer-based I&C systems comply with RG 1.209 and RG 1.180. For all EQ safety-related digital computer-based I&C systems, located in a mild environment, type testing is the preferred qualification method to demonstrate performance to the

References 7.1-10 and 7.1-12, to develop portions of the overall SDP and STP and thus comply with RG 1.172.

RG 1.173, Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants:

- Conformance: RG 1.173 endorses IEEE Std. 1074. The standard describes, in terms of inputs, development, verification or control processes, and outputs, a set of processes and constituent activities that are commonly accepted as composing a controlled and well-coordinated software development process. It describes inter-relationships among activities by defining the source activities that produce the inputs and the destination activities that receive the outputs. The standard specifies activities that must be performed and their inter-relationships; it does not specify complete acceptance criteria for determining whether the activities themselves are properly designed. Therefore, the standard is used in conjunction with guidance from other appropriate RGs, standards, and software engineering literature. Safety-related systems use the guidance in this standard, as described in References 7.1-10 and 7.1-12, to develop portions of the overall SDP and thus comply with RG 1.173.

RG 1.180, Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems:

- Conformance: Electrical and electronic components in the I&C safety-related systems are qualified for anticipated levels of EMI at their as-installed locations. EMC of I&C equipment is verified through factory testing and site-specific testing for both individual equipment and interconnected systems to meet EMC requirements for protection against the following:
  - EMI,
  - RFI,
  - Electrostatic discharge, and
  - Electrical surge.

  EMI qualifications, including methods of evaluating EMI operating envelopes, follow the requirements defined in ~~Mil-Std-461E and IEC-61000-4~~ Section 3.11.3.1. Q-DCIS equipment is qualified to perform continuously within specified ranges even when exposed to EMI environmental limits at the hardware mounting location. To that end, EMI qualifications for safety-related systems meet the proposed requirements of RG 1.180, Rev 1 "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in safety-related Instrumentation and Control Systems."

RG 1.204, Guidelines for Lightning Protection of Nuclear Power Plants:

- Conformance: The surge withstanding capability of the safety-related I&C design conforms with IEEE Std. 1050. See Subsection 8A.1.2 for detailed information about the lightning protection system and conformance to RG 1.204.

RG 1.209, Guidelines For Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants:

- Conformance: The safety-related system design conforms to RG 1.209.

included in Section 7.8, and specifically addresses the issues of defense-in-depth and diversity and defense against common mode failures.

BTP HICB-16, Guidance on the Level of Detail Required for Design Certification Applications Under 10 CFR Part 52. BTP HICB-16 is applicable to all sections of Chapter 7 of the Design Control Document and all sections conform to it.

BTP HICB-16 states that the application should:

- Describe the resolution of unresolved and generic safety issues applicable to the I&C systems;
- Describe the interface requirements to be met by portions of the plant for which the application does not seek certification and which are necessary to ensure proper functioning of the I&C system; and
- Identify and describe the validation of innovative means of accomplishing I&C system safety-related functions.

Applications that propose the use of computers for systems with safety-related uses should describe the computer system development process. Applications that propose the use of computers for RTS and ESFAS functions should also describe the design of the overall I&C systems with respect to defense-in-depth and diversity requirements.

The I&C design has no unresolved or generic safety-related issues. The I&C related issues are either not applicable to safety-related I&C systems or are addressed by the safety-related I&C design. Within the scope of the DCD submitted for certification application, there are no interface requirements described here that fall into this category.

The design uses the voluminous data available from operating plants and from the testing and licensing efforts performed to license the predecessor designs and individual plants. The I&C design does not use innovative means for accomplishing safety functions.

BTP HICB-17, Guidance on Self-Test and Surveillance Test Provisions. Refer to Subsection 7.2.1.3.5 and 7.3.4.3 discussions. The Q-DCIS design conforms to BTP HICB-17.

BTP HICB-18, Guidance on the Use of Programmable Logic Controllers in Digital Computer-Based Instrumentation and Control Systems. The Q-DCIS design conforms to BTP HICB-18.

BTP HICB-19, Guidance for Evaluation of Defense-in-Depth and Diversity in Digital Computer-Based Instrumentation and Control Systems (Item II.Q of SECY-93-087). The Q-DCIS, DPS and associated N-DCIS interfacing systems design conform to BTP HICB-19. The implementation of an additional diverse instrumentation and control system is described in Section 7.8.

BTP HICB-21, Guidance on Digital Computer Real-Time Performance. The Q-DCIS design conforms to BTP HICB-21.

7.1.6.6 Industry Standards

The safety evaluation subsections throughout Chapter 7 address the RGs identified by the SRP. The IEEE standards that are endorsed by RGs are not addressed separately.

Some codes or standards that are not mentioned in the SRP are used in specific system applications. These are identified in the system description and the corresponding reference section. In accordance with the SRP format, the following IEEE standards applicable to the I&C equipment are addressed in other chapters.

~~IEC 61000-4 series. The design conforms to this series of standards.~~

IEEE Std. 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." Safety-related systems are designed to meet the requirements of IEEE Std. 323. Environmental qualification is addressed in Section 3.11.

IEEE Std. 344, "Recommended Practices for Seismic Qualification of Safety-related Equipment for Nuclear Power Generating Stations." Safety-related I&C equipment is classified as Seismic Category I and designed to withstand the effects of the safe shutdown earthquake (SSE). It remains functional during normal and accident conditions. Qualification and documentation procedures used for Seismic Category I equipment and systems satisfy the provisions of IEEE Std. 344 as indicated in Section 3.10.

IEEE Std. 379, "IEEE Standard for the Application of the Single Failure Criterion to Nuclear Power Generating Station Safety Systems." The Q-DCIS platforms, RTIF-NMS, SSLC/ESF, ATWS/SLC logic controllers, HP CRD isolation bypass logic controllers, and Vacuum Breaker Isolation Function (VBIF) logic controllers, are organized into four physically and electrically isolated divisions that use principles of redundancy and independence to conform to the single failure criterion.

IEEE Std. 383, "IEEE Standard for Type Test of Safety-related Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations." Electric cable conforms to this standard. Fiber-optic cable insulation/covering/jacketing also conforms to the requirements for flame tests in IEEE Std. 383.

IEEE Std. 384, "IEEE Standard Criteria for Independence of Safety-related Equipment and Circuits." See the discussion of RG 1.75 in Subsection 7.1.6.4.

IEEE Std. 497, "IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations." Accident monitoring instrumentation is discussed in Section 7.5.

IEEE Std. 518, "IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources." The design conforms to IEEE Std. 518.

IEEE Std. 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations." Conformance to IEEE Std. 603 is discussed in Subsection 7.1.6.6.1.

IEEE Std. 1050, "IEEE Guide for Instrumentation Control Equipment Grounding in Generating Stations." The design conforms to IEEE Std. 1050.

7.1.6.6.1 IEEE Std. 603 – IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

The scope of IEEE Std. 603 includes safety-related I&C systems that are described in Sections 7.1 through 7.8. IEEE Std. 603 does not directly apply to nonsafety-related systems, other than to require independence between nonsafety-related systems and safety-related systems. IEEE Std. 603 provides design criteria for safety systems. ESBWR divides safety systems into two parts: the Q-DCIS platforms, and the subsystems that contain the sensors and