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Subject: **Response to a Portion of Request for Additional Information Letter No. 382 Related to ESBWR Design Certification Application, - DCD Tier 2 Section 3.11 - Environmental Qualification of Mechanical and Electrical Equipment; RAI 3.11-28 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 382 sent by NRC letter dated October 19, 2009 (Reference 1). RAI Number 3.11-28 S01 is addressed in Enclosure 1. Enclosure 2 contains the DCD changes as a result of GEH's response to this RAI.

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

Sincerely,

Richard E. Kingston

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Vice President, ESBWR Licensing

Reference:

1. MFN 09-675, Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No 382 Related to ESBWR Design Certification* Application dated October 19, 2009

Enclosures:

1. Response to a Portion NRC RAI Letter No. 382 Related to ESBWR Design Certification Application - Environmental Qualification of Mechanical and Electrical Equipment; RAI Number 3.11-28 S01

2. Response to a Portion NRC RAI Letter No. 382 Related to ESBWR Design Certification Application - Environmental Qualification of Mechanical and Electrical Equipment; DCD Markups for RAI Number 3.11-28 S01

cc:	AE Cubbage	USNRC (with enclosures)
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	eDRF Section	0000-0109-3574 (RAI 3.11-28 S01)

MFN 09-737

Enclosure 1

Response to a Portion of NRC Request for Additional Information Letter No. 382 Related to ESBWR Design Certification Application

Environmental Qualification of Mechanical and Electrical Equipment

RAI Number 3.11-28 S01

NRC RAI 3.11-28 S01

In response to RAI 3.11-28 GEH clarified that the temperatures listed in Tables 3H-2 through 3H4 represents the maximum normal ambient temperatures at the location of the safety-related equipment. Table 3H-3 lists RB room 1720 at 85°F maximum. Table 3H-4 lists the CRHA main control room panels at 74°F maximum. GEH stated that aging analysis and accelerated aging tests determines the service temperature, which considers sources of higher than ambient heat including internally generated heat. GEH stated that this is addressed in DCD Subsection 3.11.3.1.

A similar question was asked regarding the expected temperature inside electrical cabinets in these areas. In response to RAI 9.4-34, GEH acknowledged that the airflow through electrical cabinets is assumed to be reduced during the 72-hour post accident period and the normal nonsafety-related HVAC is assumed to be off. In this response, GEH further clarified that the EQ program ensures component performance for temperature, including if the event occurs during maximum summer design temperatures. In addition, in response to this RAI, additional detail was added to DCD Subsection 3.11 to more fully explain the temperature qualification process.

The staff has reviewed the changes to DCD Subsection 3.11. In Subsection 3.11.3.1, GEH states that for EQ safety-related computer-based I&C equipment in mild environments, the temperature qualification method would be by test. The maximum qualification temperature is 10°C higher than the maximum temperature to which the equipment is exposed for the worst-case AOO. In Subsection 3.11.3.2, GEH state that the AOO and test condition environments are bounded by the normal or accident conditions according to "the Appendix 3H tables."

In DCD Table 15.2-4a GEH indicate that the Loss of Non-emergency AC Power to Station auxiliaries is an Anticipated Operational Occurrence.

Table 3H-9 lists RB room 1720 at 122°F Maximum. Table 3H-10 lists the CRHA main control room panels at 93°F "Average Bulk Max". The title of both tables indicates that these temperatures apply for accident conditions.

Table 3H-15 contains a column headed "Max Environment Temperature from Table 3H-9". This column lists 122°F and 93°F for the RB room 1720 and the CRHA, respectively.

The staff requests the following information:

1. *Provide additional details on how the service temperature of electrical equipment, including Computer-based I&C systems, will be determined for the ESBWR. In particular provide details on this process for equipment that is planned to be located inside electrical cabinets/panels in the RB and the CB. Also, discuss how the service temperature will be determined for equipment in harsh environment.*

2. *Is the worst case AOO and test condition environments for EQ safety-related computer-based I&C equipment bounded by the temperatures in Tables 3H-2 through 3H4 or are they bounded by the temperatures in Tables 3H-9, 3H1 0 and 3H-15?*

3. *Does the worst case AOO for the ESBWR consider the environment resulting from the loss of non-emergency AC Power for a period of 72 hours?*

4. *The temperatures in Tables 3H-9, 3H10 and 3H-15 were derived from a passive cooling analysis. Such analyses have a degree of uncertainty. In addition, the service temperatures for EQ safety-related computer-based I&C equipment located in these environments, during the passive cooling period would be heavily dependent on the detailed design of the surrounding enclosure. In light of these considerations, what assurances have GEH provided in the DCD to indicate that systems are designed such that the derived bounding temperatures would be conservative?*

5. *What information in the DCD provides assurance that that temperatures inside cabinets or panels would not exceed the Table 3H-13 typical mild environment parameter limit of 145°F at the end of the passive cooling period?*

6. *What controls will GEH use to ensure that enclosures containing such equipment will be designed and tested to ensure that these key assumptions are met?*

<u>NRC Question # 1:</u>

Provide additional details on how the service temperature of electrical equipment, including Computer-based I&C systems, will be determined for the ESBWR. In particular provide details on this process for equipment that is planned to be located inside electrical cabinets/panels in the RB and the CB. Also, discuss how the service temperature will be determined for equipment in harsh environment.

<u>GEH Response – Question # 1:</u>

The additional details regarding how the service temperature of electrical equipment, including computer-based I&C systems, located in the Reactor Building (RB) and Control Building (CB) is determined in accordance with the ESBWR environmental qualification (EQ) program defined in the DCD. It is presented below in four parts; 1) design certification EQ basis for temperature, 2) clarification of “service temperature” in a mild environment, 3) clarification of “service temperature” in a harsh environment, and 4) process for determining “service temperature” within electrical equipment cabinets or enclosures as well as thermal management design techniques and equipment producibility in temperature range of interest.

1) Design Certification Basis for Environmental Qualification for Temperature:

DCD Tier 2, Sub-section 3.11.1, “Description Requirements”, states:

> “This section describes the requirements for the environmental qualification (EQ) elements of the equipment qualification program as related to electrical and mechanical equipment. The equipment qualification program also includes dynamic and seismic qualification of safety related electrical and mechanical equipment. Dynamic qualification is addressed in Sections 3.9 and 3.10 for Seismic Category I mechanical and electrical equipment, respectively, and the discussion in this section focuses on the environmental qualification elements of the equipment qualification program. The equipment qualification program includes safety-related electrical and mechanical equipment located in harsh and mild environments. Safety-related electrical equipment consists of all safety-related electrical power and instrumentation and control (I&C) equipment, which includes all safety-related analog (non-digital) and digital I&C components. Computer-based I&C equipment is a subset of digital I&C components.”

For electrical and mechanical equipment in general and computer-based I&C equipment specifically, the EQ program is composed of two parts; 1) mild environment and 2) harsh environment. Table 3H-13, “Typical Mild Environment Parameter Limits”, provides the characteristics and the limits that define the boundary between these two environments.

2) Clarification of “Service Temperature” in a Mild Environment:

As discussed in GEH’s response to Question # 2 of this RAI (see below), the worst case AOO and test condition environments for EQ safety-related computer-based I&C equipment are bounded by the temperatures in Table 3H-9, “Thermodynamic Environment Conditions Inside Reactor Building for Accident Conditions”, Table 3H-10 “Thermodynamic Environment Conditions Inside Control Building for Accident Conditions”, and Table 3H-15, “Analytical Room Environmental Temperatures”. From these Tables, the worst case

Normal Operation temperature is less than 50°C (122°F). This temperature limit condition is supplemented by Table 3H-9, Note (3), which states:

> "Electronic equipment is qualified for 50°C (122°F) during 72 hours; other equipment could be qualified for higher temperatures according to the above values. In locations within these zones where room temperature is higher than 50°C (122ºF), electronic equipment is qualified for the actual calculated temperature within the zone, or the equipment is protected from high temperatures."

There are no locations in which computer-based I&C equipment is placed where the ambient room temperature is higher than 50°C (122ºF) under anticipated operational occurrence (AOO) and design basis accident (DBA) conditions.

Test Margin and Design Margin defined:

With regards to EQ in general and the definition of "margin" specifically, the ESBWR EQ program is based on IEEE Std. 323-2003. IEEE Std. 323-2003, Section 6.2.3, "Margin", states:

> "Margin shall be included in qualification programs. This will account for reasonable uncertainties in demonstrating satisfactory performance and normal variations in commercial production and uncertainties in measurement and test equipment, thereby providing assurance that the equipment can perform under adverse service conditions. Increasing the severity of test parameter values, number of tests, or test duration (but not necessarily all at the same time) are acceptable methods of adding margin in testing, where necessary. If the specified service conditions contain the requisite margins, no additional margin is needed. Guidance for margin in design basis event testing is provided in 6.3.1.6."

"Test Margin" is associated with, "the severity of test parameter values, number of tests, or test duration … margin in testing…". "Design Margin" is associated with, "… specified service conditions contain the requisite margins…" The service conditions are those related to the equipment in its specific application.

An element of temperature "design margin" for the ESBWR computer-based I&C equipment is the service condition margin related to the rooms in which the equipment is located. This is the difference between the maximum room environmental temperature of 50°C (122°F) from Table 3H-9 (RB) and 3H-10 (CB) with respect to those from Table 3H-15 (Analytical). For Normal Operations, there are several rooms with the highest temperature calculated to be 30°C (86°F). This results in a Normal Operations "design margin" of 20°C (36°F). For the 72-hour post accident period, the highest temperature is calculated to be 49°C (120.2°F) occurring in the area from the Div 2 and 3 corridors rooms (access to penetration area), divisional electrical cables and safety-related DCIS RMUs Room Nos 1720, 1730 and the representative room being 1720. This results in a "design margin" for the 72-hour post accident period of 1°C (1.8°F). From this analysis, it is shown that the

ESBWR design contains service condition room temperature margins within the range of 1°C to 20°C.

Basis for the ESBWR EQ Program as Found in Regulatory Guidance:

DCD Tier 2, Sub-section 3.11.1, “Description Requirements”, 5th paragraph states:

> “The equipment qualification program includes safety-related electrical equipment, including I&C equipment in a mild environment. Safety-Related Distributed Control and Information System equipment located in areas characterized as mild environments, also meets RG 1.209, Guidelines for Environmental Qualification of Safety-Related Computer-based Instrumentation and Control Systems in Nuclear Power Plants, (Reference 3.11-4), and type testing is the preferred method of qualification.”

The guidance in RG 1.209 endorses IEEE Std. 323-2003. Therefore, RG 1.209, RG 1.180 (Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Controls Systems) and IEEE Std. 323-2003 provide the guidance for environmental qualification in a mild environment, and the ESBWR EQ program conforms to such guidance through reference.

By way of further explanation, DCD Tier 2, Sub-section 3.11.1.3, “Temperature”, states:

> “For EQ safety-related computer-based I&C equipment in mild environments, the temperature qualification method is by test.”

RG 1.209 enhancement and exception (1) states:

> “For environmental qualification of safety-related computer-based I&C systems, type testing is the preferred method. Selective use of the service conditions mentioned in Section 6.1.5.1 of IEEE Std. 323-2003 should be based on the actual environmental conditions. The type tests may be manufacturer’s tests that document performance to the applicable service conditions with due consideration for synergistic effects, if applicable.”

Thus, there is agreement between the ESBWR EQ program described in the DCD and RG 1.209.

DCD Tier 2, Sub-section 3.11.1.3, “Definition”, *Margin* states:

> “The difference between service conditions and the conditions used for equipment qualification.”

IEEE Std. 323-2003, Section 3. “Definitions”, *Margin* is defined as:

> “The difference between service conditions and the conditions used for equipment qualification.”

This defines the “test margin” and it will be used in the ESBWR EQ program. Thus there is, again, agreement between the ESBWR EQ program described in the DCD and IEEE Std. 323-2003 which is endorsed by RG 1.209.

DCD Tier 2, Sub-section 3.11.1.3, “Definition”, *Temperature* states:

> “For EQ safety-related computer-based I&C equipment in mild environments… The maximum qualification temperature is 10°C (18°F) higher than the maximum temperature to which the equipment is exposed for the worst-case AOO, while the equipment is under its maximum loading, to comply with margin requirements.”

Per DCD Tier 2, Table 3H-9, Note (3) states:

> “Electronic equipment is qualified for 50°C (122°F) during 72 hours.”

Therefore, the ESBWR EQ type test temperature for all electronic equipment in a mild environment is 60°C (140°F).

Per IEEE Std. 323-2003, Section 6.3.1.6 *Margin*, a) Peak temperature states, the suggested temperature “test margin” is 8°C. The ESBWR EQ temperature “test margin’ is 10°C. The ESBWR EQ “test margin” of 10°C is 2°C higher than 8°C and is therefore conservative with respect to the recommendation.

Test Conditions:

DCD Tier 2, Sub-section 3.11.4, “Computer-based Instrumentation and Controls Systems”, 3rd paragraph, 6th bullet states:

> “When testing of a complete system is not practical, confirmation of the dynamic response to the most limiting environmental and operational conditions is based on type testing of the individual modules and analysis of the cumulative effects of environmental and operational stress on the entire system to demonstrate required safety-related performance.”

RG 1.209 enhancement and exception (2) states:

> "Although testing of a safety-related computer-based I&C system as a whole is preferred, type testing an entire system as a unit is not always practical. In those cases, conformation of the dynamic response to the most limiting environmental and operational conditions for electrical equipment, including computer-based I&C, is based on type testing of the individual modules and analysis of the cumulative effects of environmental and operational stress on the entire system."

There is agreement between the ESBWR EQ program described in the DCD and RG 1.209.

DCD Tier 2, Section 3.11.1.3 "Definitions", *Service Conditions* are defined as:

> "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."

This definition includes temperature. Therefore, the "service temperature" of electrical equipment (described by its cabinet or enclosure) is the ambient temperature of the environment (e.g.; room) in which the equipment is located. When the item of interest (e.g.; chassis, electronic assembly) is internal to the equipment cabinet, then the "service temperature" is the ambient temperature of the environment in which the item of interest is located (e.g.; inside the cabinet, inside the chassis).

Documentation:

DCD Tier 2, Sub-section 3.11.4.4, "Environmental Qualification Documentation", states:

> "The procedures and results of qualification by tests, analyses or other methods are documented, maintained, and reported in accordance with requirements of 10 CFR 50.49(j), RG 1.209, and IEEE 323-2003 Section 7.2."

RG 1.209 enhancement and exception (4) states:

> "For safety-related computer-based I&C systems intended for implementation in a mild environment, the NRC staff takes exception to Section 7.1 of IEEE Std. 323-2003. The evidence of qualification in a mild environment should be consistent with the guidance given in Section 7.2 selectively based on actual environmental conditions, and the records should be retained at a facility in an auditable and readily accessible form for review and use as necessary."

Thus, there is agreement between the ESBWR EQ program described in the DCD and RG 1.209.

ESBWR DCD Tier 2 Changes:

Based on the foregoing discussion, the following changes are being made to ESBWR DCD Tier 2:

- DCD Tier 2, Sub-section 3.11.1.3, “Definitions”, does not include a definition of what constitutes the description of the equipment with respect to computer-based I&C systems, as a whole or as a representative unit, to subject to type testing. The ESBWR DCD Sub-section 3.11.1.3 will be changed to add the following definition:

  “Equipment – The physical envelope of structures, systems and components which is the device or represents a collection of physically connected devices that perform the required function, or a group of related and representative functions, that as a whole unit is representative of how it will be installed in the plant. Specific to electrical equipment, including computer-based I&C, this physical envelope is defined as the cabinet or enclosure. The cabinet or enclosure contains representative and functional electrical or electronic assemblies and components (e.g.; chassis, controller packages, instruments, power supplies, video display units, fans, cabling, wiring, baffles, auxiliary devices. This does not include Interfaces which are defined separately.”

- DCD Tier 2, Sub-section 3.11.4.3, “Computer-based Instrumentation and Control Systems”, 3rd paragraph, 5th bullet states, “Testing of a complete system is preferred.” This is ambiguous in the context of the new definition of “Equipment”. The ESBWR DCD Sub-section 3.11.4.3, 3rd paragraph, 5th bullet will be changed to:

  “Testing of a representative sample of the equipment as a complete system contained within its cabinet or enclosure is preferred.”

3) Clarification of “Service Temperature” in a Harsh Environment:

For the ESBWR EQ program, the approach to determining the “service temperature” of electrical equipment located in a harsh environment is analogous to that for the mild environment as describe above.

The EQ program for equipment in a harsh environment must address the additional factor of *age conditioning*.

ESBWR DCD Tier 2, Sub-section 3.11.1.3, “Aging”, states:

> “EQ equipment in harsh environments is analyzed for significant aging mechanisms. If the equipment is determined to have a significant aging mechanism, then the mechanism is accounted for in the qualification program. Aging mechanisms include time-temperature degradation, cycle aging and normal radiation exposure. Artificial aging or natural aging simulate time-temperature degradation. Artificial aging is determined from the Arrhenius Equation.”

ESBWR DCD Sub-section 3.11.4.1, “Harsh Environment Qualification” states:

> “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. A type test subjects a representative sample of equipment, including interfaces, to a series of tests, simulating the effects of significant aging mechanisms during normal operation. The sample is subsequently subjected to DBA testing that simulates and thereby establishes the tested configuration for installed equipment service, including mounting, orientation, interfaces, conduit sealing, and expected environments. A type test demonstrates that the equipment performs the intended safety-related function(s) for the required operating time before, during, and/or following the DBA, as appropriate.”

NRC guidance in RG 1.89, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants”, Section B. Discussion, 2nd paragraph, 2nd sentence states:

> “Paragraph 50.49(e)(5) calls for equipment qualified by test to be preconditioned by natural or artificial (accelerated) aging to its end-of-installed-life condition and further specifies that consideration must be given to all significant types of degradation that can have an effect on the functional capability of the equipment.”

Thus, there is agreement between the ESBWR EQ program described in the DCD and RG 1.89.

In summary, *age conditioning*, if applicable, must occur prior to the final EQ test to assure that the equipment will perform its safety related function at the end of its service life.

4) Process for Determining “Service Temperature” within Electrical Equipment Cabinets or Enclosures, Thermal Management Techniques and Producibility:

The process for determining the “service temperature” within electrical equipment cabinets or enclosures is an established engineering design practice. It can be achieved by test, analysis or a combination of the two methods. This technique is essential if it is not practical to type test the electrical equipment as a whole unit. Then it is necessary to determine the “service temperature” for the individual modules to properly plan and conduct the elemental type test.

The “service temperature” of electrical equipment, including for computer-based I&C, is the ambient temperature of the environment adjacent to the exterior of the equipment’s physical envelope (e.g.; cabinet or enclosure). It is understood that the temperature inside an energized electrical equipment cabinet will be higher than the ambient room temperature of the environment in which it is exposed (see the example in Figure 1 below).

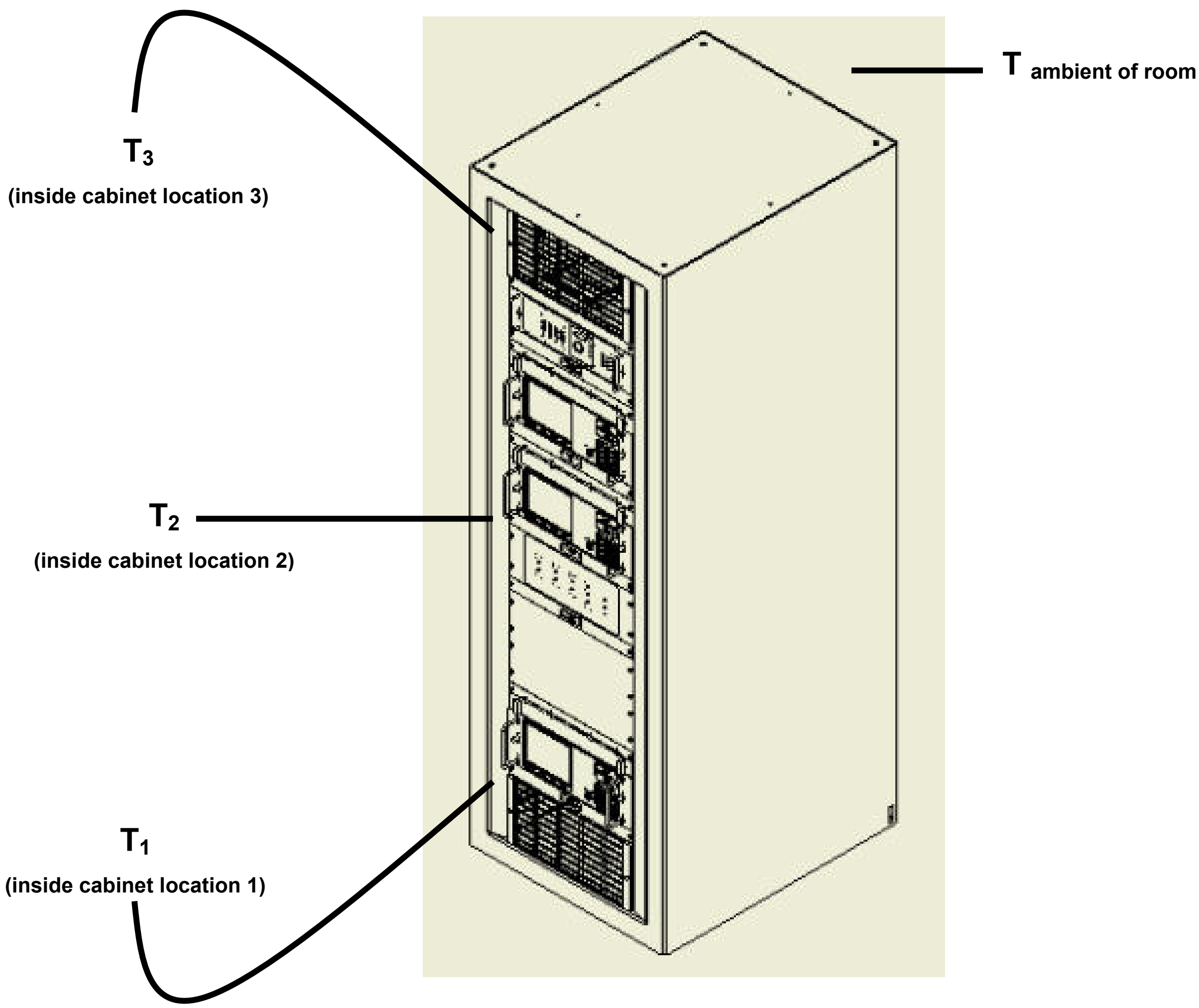

Figure 1

The temperature increase values at certain locations and gradients between locations inside a cabinet is based on many variables, including (but not limited to); thermal conductivity and emissivity of the cabinet itself, number and location of chassis installed, power output or thermal load of each chassis, airflow either natural or forced around and through the cabinet, as well as other heat sinking methods not involving airflow directly.

The "service temperature" of an energized electrical or electronic chassis contained within electrical equipment (e.g.; cabinet or enclosure) is the localized ambient temperature of the environment enveloping it (e.g.; T_1, T_2, T_3). It is understood that the temperature inside an energized chassis will be higher than its localized ambient temperature (see examples in Figure 2 below).

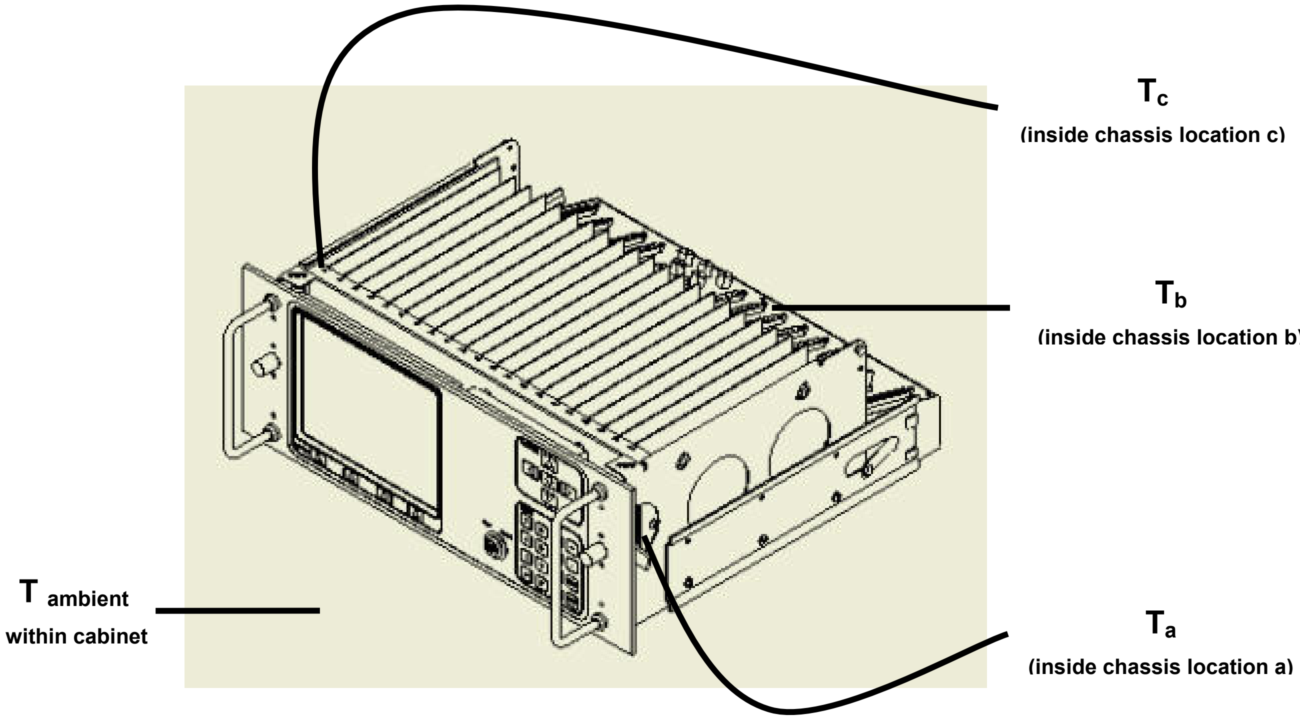

Figure 2

As stated above in the first example, the temperature increase values at certain locations and gradients between locations inside a chassis is based on many variables including but not limited to; thermal conductivity and emissivity of the chassis itself, number and location of chassis installed, power output or thermal load of each chassis, airflow either natural or forced around and through the chassis, as well as other heat sinking methods not involving airflow directly.

The "service temperature" of an energized electrical or electronic assembly or component contained within a chassis is the localized ambient temperature of the environment enveloping it (e.g.; T_a, T_b, T_c). It is thus understood that the temperature inside an energized chassis will be higher than its localized ambient temperature around the chassis (e.g.; T_1, T_2, T_3).

The electrical and electronic equipment designer's objective is to assure that the product meets or exceeds the performance requirements, including equipment service temperatures, included in the EQ type test parameters. This is accomplished through five main steps; 1) Design, 2) Analysis, 3) Test, 4) Demonstration and 5) Documentation.

Design:

The designer uses a systems engineering approach to allocate the thermal budgets and margins to the different elements associated with each level of the product structure or hierarchy; top level cabinet, intermediate level chassis, and lower level assemblies and components. Appropriate thermal analysis, thermal management design techniques, component and material selection and production technologies are used to assure that the temperature limits and margins throughout the product structure are not exceeded under the conditions specified for a particular application (e.g.; as described in a standard product specification or customer specific procurement specification).

For electrical equipment, including computer-based I&C in a mild environment, and as noted above, the ESBWR EQ type test temperature is 60°C (140°F). Electrical and electronic assemblies and components are commercially available in two temperature ranges; industrial grade at 85°C (185°F) and military grade at 125°C (257°F). With respect to the ESBWR EQ test temperature of 60°C (140°F), the design temperature range to work within is 25°C (45°F) for industrial and 65°C (117°F) for military grades. Component selection between these temperature grades is based on the requirements of the localized environment in which they are to be applied. Use of components within this temperature range provides adequate temperature "design margin" for the realization of robust electrical and electronic systems in their equipment cabinets.

As part of developing the detailed design configuration to meet requirements in a specification, appropriate thermal management techniques are used. They include (but are not limited to); limits on placing individual equipment cabinets adjacent to one another in a lineup within the room, vents in the cabinet (usually bottom and top), number of chassis in the cabinet, density and placement of assemblies (e.g.; electronic printed circuit assemblies (PBAs) or boards (PCBs)) within the chassis, selection of individual components and technologies with ratings that ensure they are operating in a lightly loaded thermal output condition, use of specific passive heat conducting design features and materials (used to draw heat from higher to lower structures), baffles placed within the cabinet and between its vertical bays (create draft for cooling), and use of fans (create forced air flow for cooling).

The producibility and robustness of an electrical and electronic equipment design including its cabinet is important to assure that the equipment will pass its EQ type test and that production units will perform to the requirements of the purchase specification.

Analysis:

Once a baseline detailed design configuration of the equipment is established, including component selection, then a thermal and temperature rise analysis is performed to assess if the design meets the specification requirements and with what "design margin". If there are regions within the equipment cabinet where the chassis, assemblies and components are exposed to service temperatures above their rating, then these aspects of the equipment are re-designed to meet the temperature limits. This process may result in multiple detailed design iterations (see design process description above).

Test:

After a detailed design configuration that meets the requirements in the specification is established and documented, then a representative example or sample of the equipment is submitted to a test program. Depending on various design approaches and initial "design margin" established, there may several iterative cycles of build and test. Ultimately, a specific equipment configuration is defined, built and subjected to the formal EQ type test program.

Demonstration:

Engineering design risk management includes investigating and assessing the performance of the same or similar equipment in applications with the same or similar environmental conditions. This "evaluation-by-similarity" (a form of analysis) is an essential part of the engineering design assurance process. However, analysis alone is not sufficient to meet the requirements of the ESBWR EQ program.

In operation today, there is complex electrical and electronic equipment which operates reliably for long periods of time without maintenance in more demanding temperature environments than that expected for safety related computer based I&C equipment in the ESBWR. Several examples of this equipment are electronic dashboards in the passenger compartment and electronic engine computers in automobiles as well as electronic products used in desert environments such as consumer (mobile phone), industrial (GPS navigation/tracker), military (guide weapons).

This established industrial practice provides design assurance that the service temperature requirements of the computer-based I&C equipment of the ESBWR can be met with equipment that can be designed and procured through the current supply chain.

Documentation:

The equipment designer and supplier are required to follow a configuration management process governing the data used to demonstrate the qualification of the equipment to assure that it is pertinent to the application and is organized in a readily understandable and traceable manner that permits independent auditing of the conclusions presented.

In summary, the design, analysis, test, demonstration and documentation approach in general and thermal management techniques specifically as described above represent common engineering design practice and will be employed in the detailed design of the ESBWR. Procurements specifications for electrical equipment, including computer-based I&C, will establish the requirements for the design, analysis, test, demonstration and documentation that will be met by the equipment designer and supplier.

DCD Impact:

DCD Tier 2, Sub-section 3.11.1.3, “Definitions”, will be revised as noted in the attached markup.

DCD Tier 2, Sub-section 3.11.4.3, “Computer-based Instrumentation and Control Systems”, 3rd paragraph, 5th bullet will be revised as noted in the attached markup.

NRC Question # 2:

Is the worst case AOO and test condition environments for EQ safety-related computer-based I&C equipment bounded by the temperatures in Tables 3H-2 through 3H4 or are they bounded by the temperatures in Tables 3H-9, 3H1 0 and 3H-15?

GEH Response – Question # 2:

The worst case AOO and test condition environments for EQ safety-related computer-based I&C equipment are bounded by the temperatures in Tables 3H-9, 3H-10 and 3H-15.

DCD Impact:

None.

NRC Question # 3:

Does the worst case AOO for the ESBWR consider the environment resulting from the loss of non-emergency AC Power for a period of 72 hours?

GEH Response – Question # 3:

The analysis presented in Appendix 3H of the DCD is for the worst case accident conditions and considers loss of non-emergency AC Power for a period of 72 hours.

DCD Impact:

None.

NRC Question # 4:

The temperatures in Tables 3H-9, 3H10 and 3H-15 were derived from a passive cooling analysis. Such analyses have a degree of uncertainty. In addition, the service temperatures for EQ safety-related computer-based I&C equipment located in these environments, during the passive cooling period would be heavily dependent on the detailed design of the surrounding enclosure. In light of these considerations, what assurances have GEH provided in the DCD to indicate that systems are designed such that the derived bounding temperatures would be conservative?

GEH Response – Question # 4:

GEH has provided assurance that the safety-related computer-based I&C equipment is designed such that the derived bounding temperatures are conservative in both Tier 2 and Tier 1.

ESBWR DCD Tier 2 bases for assurances are supported by GEH's response to Question # 1 of this RAI above, and are:

- EQ program that conforms to regulation, guidance and industry standards for both harsh and mild environments.
- Plant design contains service condition room temperature "design margins" within the range of 1°C (72 hours) to 20°C (Normal Operations).
- EQ temperature "test margin" of 10°C is 2°C higher than 8°C and is therefore conservative with respect to the recommendation in IEEE Std. 323.
- Table 3H-9, Note (3) which states; "… electronic equipment is qualified for the actual calculated temperature within the zone, or the equipment is protected from high temperatures."

ESBWR DCD Tier 1 bases for assurances are provided in Section 3.8, "Environmental and Seismic Qualification of Mechanical and Electrical Equipment", *Design Commitment 3* states:

> "The equipment qualification program's safety-related digital I&C equipment (including digital components in the safety-related electrical distribution system) located in a mild environment is designed to perform its safety-related function under normal and AOO environmental conditions. The associated Inspections, Tests, Analyses states; "The equipment qualification program's safety-related digital I&C equipment (including digital components in the safety-related electrical distribution system) located in a mild environment is identified and:
>
> i. Analysis will be performed to identify the environmental design bases including the definition of anticipated operational occurrences and normal environments.
> ii. Type tests, analyses, or combination of type tests and analyses will be performed on the equipment qualification program's digital I&C equipment located in a mild environment.

iii. Inspection will be performed to verify the equipment qualification program's as-built digital I&C equipment located in a mild environment."

Note that ESBWR DCD Tier 1 Section 3.8, "Environmental and Seismic Qualification of Mechanical and Electrical Equipment" is undergoing review in response to RAI 14.3-449 S02, but the principles stated herein as currently in Rev. 6 will remain valid.

DCD Impact:

None.

NRC Question # 5:

What information in the DCD provides assurance that the temperatures inside cabinets or panels would not exceed the Table 3H-13 typical mild environment parameter limit of 145°F at the end of the passive cooling period?

GEH Response – Question # 5:

As explained in response to Question 1 (above), the ESBWR DCD need not address temperatures inside cabinets housing electrical equipment, including computer-based I&C, because the procurement specifications will be based on the ambient temperatures and the equipment supplier will account for the appropriate temperature rise internal to the cabinets.

DCD Impact:

None.

NRC Question # 6:

What controls will GEH use to ensure that enclosures containing such equipment will be designed and tested to ensure that these key assumptions are met?

GEH Response – Question # 6:

GEH will employ the appropriate programs and processes to assure that the purchased equipment is designed and tested to assure that its capabilities meet key assumptions and requirements in the ESBWR design. The controls that GEH will use, in the role of plant designer under a commercial contact to a licensee, will be those that relate to design and procurement, which are based on compliance with the requirements of its 10 CFR 50 Appendix B Quality Program. Of specific note in this area are the following CRITERIA:

Criterion III – DESIGN CONTROL
Criterion IV – PROCUREMENT DOCUMENT CONTROL
Criterion VII – CONTROL OF PURCHASED MATERIAL, EQUIPMENT, AND SERVICES

To summarize, in accordance with appropriate GEH purchase specifications, it is the responsibility of the designer and supplier of the electrical equipment, including computer-based I&C, to assure that the equipment is designed, analyzed, tested, produced and documented to met the requirements in the purchase specification, including EQ requirements in general and temperature requirements specifically. GEH will use suppliers with an approved 10 CFR 50 Appendix B Quality Program. If obtaining electrical equipment from an Appendix B approved supplier is not practical, then -- by exception -- GEH will follow guidance in EPRI TR-104639-1996 for Commercial Grade Dedication of Software and Digital Components with embedded software for use in Safety Related Instrumentation and Control Applications.

By employing these quality assurance measures, EQ program requirements, and NRC and industry guidance (as referenced in the ESBWR DCD and discussed above), GEH will assure that the equipment is capable of performing its service in the applicable conditions.

DCD Impact:

None

MFN 09-737

Enclosure 2

Response to a Portion of NRC Request for Additional Information Letter No. 382 Related to ESBWR Design Certification Application

Environmental Qualification of Mechanical and Electrical Equipment

DCD Markups for RAI Number 3.11-28 S01

(2) The equipment environmental capability is demonstrated by appropriate testing and analyses.

(3) A quality assurance program meeting the requirements of 10 CFR Part 50, Appendix B, is established and implemented to provide assurance that all requirements have been satisfactorily accomplished.

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

3.11.1.3 Definitions

Normal Operating Conditions — Planned, purposeful, reactor operating conditions including startup, power range, hot standby (condenser available), shutdown, and refueling.

Anticipated Operational Occurrences (AOOs) – Conditions of normal operation expected to occur one or more times during the life of the nuclear power unit and include but not limited to loss of the turbine generator set, isolation of the main condenser and loss of offsite power.

Test Conditions — Planned testing including pre-operational tests.

Accident Conditions — A single event not reasonably expected during the course of plant operation that has been hypothesized for analysis purposes or postulated from unlikely but possible situations or that has the potential to cause a release of radioactive material (a reactor coolant pressure boundary rupture may qualify as an accident; a fuel cladding defect does not).

Design Basis Event (DBE) or Design Basis Accident (DBA) – Postulated events used in the design to establish the acceptable performance requirements for structures, systems, and components.

Equipment – The physical envelope of structures, systems and components which is the device or represents a collection of physically connected devices that perform the required function, or a group of related and representative functions, that as a whole unit is representative of how it will be installed in the plant. Specific to electrical equipment, including computer-based I&C, this physical envelope is defined as the cabinet or enclosure. The cabinet or enclosure contains representative and functional electrical or electronic assemblies and components (e.g.; chassis, controller packages, instruments, power supplies, video display units, fans, cabling, wiring, baffles, auxiliary devices). This does not include Interfaces which are defined separately.

Equipment Qualification – The generation and maintenance of evidence to ensure equipment will operate on demand to meet system performance requirements during normal and AOO service conditions and postulated design basis events.

Harsh Environment – An environment resulting from a design basis event, i.e., LOCA, HELB, and MSLB.

Interfaces – Physical attachments, mounting, auxiliary components, and connectors (electrical and mechanical) to the equipment at the equipment boundary.

- The system under test functions and performs with safety-related software that has been validated and verified and is representative of the software to be installed in the nuclear power plant.
- Testing demonstrates performance of safety-related functions at the specified environmental service conditions, including AOOs.
- Testing exercises all portions of the system under test that are necessary to accomplish the safety-related functions and those portions whose operation or failure could impair the safety-related functions.
- Testing confirms the response of digital interfaces and verifies that the design accommodates the potential impact of environmental effects on the overall response of the system.
- Testing of representative sample of the equipment as a complete system contained within its cabinet or enclosure is preferred.
- When testing of a complete system is not practical, confirmation of the dynamic response to the most limiting environmental and operational conditions is based on type testing of the individual modules and analysis of the cumulative effects of environmental and operational stress on the entire system to demonstrate required safety-related performance.

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.

The evidence of qualification in a mild environment is consistent with the guidance given in IEEE 323-2003 Section 7.~~2~~1.

3.11.4.4 Environmental Qualification Documentation

The procedures and results of qualification by tests, analyses or other methods are documented, maintained, and reported in accordance with requirements of 10 CFR 50.49(j), RG 1.209, and IEEE 323-2003 Section 7.~~2~~1. The EQD summarizes the qualification results for all equipment identified in Subsection 3.11.2. The EQD is developed during program implementation and includes the following: