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MFN 10-159

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Subject: **Response to Request for Additional Information Letter No. 412 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.4-24 S02**

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) sent by NRC Letter Number 412 (Reference 1). The response to RAI 6.4-24 S01 was provided by Reference 2.

The GEH response to RAI Number 6.4-24 S02 is provided in Enclosure 1. Enclosure 2 contains markups to DCD Tier 2 as noted in the Enclosure 1 response.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 10-149, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No.412 Related to ESBWR Design Certification Application,* May 5, 2010
2. MFN 09-776 Supplement 2 Revision 1, Letter from Mr. Richard E. Kingston to U.S. Nuclear Regulatory Commission, *Revised Response to Portion of NRC Request for Additional Information Letter No. 405 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.4-24 S01*, February 19, 2010

Enclosures:

1. MFN 10-159 – Response to NRC Request for Additional Information Letter No. 412 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.4-24 S02
2. MFN 10-159 – Response to NRC Request for Additional Information Letter No. 412 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.4-24 S02 – DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
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	eDRFsection	0000-0112-7692 Revision 2

Enclosure 1

MFN 10-159

Response NRC Request for
Additional Information Letter No. 412
Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Number 6.4-24 S02

NRC RAI 6.4-24 S02

Clarification of the high humidity diurnal swing and daily temperature range site characteristic values in DCD Tier 2, Table 2.0-1.

The applicant provided a revised CRHA heat-up analysis in its response to RAI6.4-24 S01 using a new set of outside air conditions. The applicant stated that it chose conservative dry bulb diurnal swings for its revised CRHA heat-up analysis based on climatic data recorded at Pensacola, FL (WBAN #13899) on and around a heat wave on 13-July-1980 when the wet bulb temperature reached 88 °F. As a result of this analysis, the applicant defined the following two new site parameters which it added to DCD Tier 2 Table 2.0-1:

** Delta 4.4 °C (8 °F) High Humidity Diurnal Swing*

The high humidity diurnal swing is defined as the dry bulb temperature swing determined by the maximum and the minimum wet bulb temperatures for the worst 3-day period over which the 0% exceedance wet bulb temperature occurs. The coincident dry bulb temperature for the maximum wet bulb temperature is taken as the maximum dry bulb temperature for the 3 days. The coincident dry bulb temperature for the highest overnight low wet bulb temperature over the 3-day period is taken as the minimum dry bulb temperature. The difference between the coincident maximum dry bulb temperature and the highest overnight low dry bulb temperature is used as the high humidity diurnal swing.

** Delta 15 °C (27 °F) Daily Temperature Range*

The daily temperature range for summer conditions is defined as the dry bulb temperature difference between the 0% exceedance maximum dry bulb temperature and the dry bulb temperature that corresponds to the higher of the two overnight lows before or after the maximum. Similarly, the daily temperature range for winter conditions is the dry bulb difference between the 0% exceedance minimum dry bulb temperature and the dry bulb temperature that corresponds to the lower of the two daily highs before and after the minimum.

A COL applicant referencing the ESBWR DCD must demonstrate that site characteristics for a given site fall within the ESBWR DCD site parameter values per 10 CFR 52.79(d)(1). Consequently, the ESBWR DCD should provide clear guidance to COL applicants regarding the appropriate methodology to be use in calculating site characteristics for comparison with the corresponding site parameters. Pursuant to SRP 2.3.1, the site parameters postulated by a DC applicant should also be representative of a reasonable number of sites that have been or may be considered for a COL application.

a. Please clarify in DCD Tier 2 Table 2.0-1 that High Humidity Diurnal Swing and Daily Temperature Range site characteristic values fall within the *corresponding site parameter values specified in the ESBWR DCD if the site characteristic values are larger than the corresponding site parameter values.*

b. The introduction to Tier 2 Chapter 2.0 states that the ESBWR standard plant site parameters listed in Tier 2 Table 2.0-1 envelope most potential sites in the United States. Please revise the DCD to provide evidence that the values assigned to each of the two new site parameters added to DCD Tier 2 Table 2.0-1 (i.e., High Humidity Diurnal Swing and Daily Temperature Range) envelope most potential sites in the United States. For example, the ASHRAE Weather Data Viewer Version 4.0 states that the mean daily dry bulb temperature range coincident with the 5% dry bulb for the hottest month (July) at Pensacola, FL, is 9.8 °C (17.6 °F). This seems to imply that 15°C (27 °F) chosen as the Daily Temperature Range site parameter value may not bound many sites.

GEH Response

NRC Request:
a. Please clarify in DCD Tier 2 Table 2.0-1 that High Humidity Diurnal Swing and Daily Temperature Range site characteristic values fall within the corresponding site parameter values specified in the ESBWR DCD if the site characteristic values are larger than the corresponding site parameter values.

GEH Response:
DCD Tier 2 Table 2.0-1 has been revised as shown in the attached markup to clarify how the High Humidity Diurnal Swing and Daily Temperature Range are related to the 0% exceedance temperature site characteristic values. An average value of dry bulb temperature and Wet Bulb Globe Temperature index is provided for evaluation of site characteristics. Site-specific values have not been added to the DCD because site-specific information will be addressed by the COL applicant; however the clarification that has been added to the High Humidity Diurnal Swing and Daily Temperature Range allows for a check of whether or not specific site characteristic values are bounded by the ESBWR generic site parameter values.

When a specific site has the average temperature and 0% exceedance values that are within the ESBWR standard plant site parameter envelope, the CRHA analysis is bounding.

NRC Request:
b. The introduction to Tier 2 Chapter 2.0 states that the ESBWR standard plant site parameters listed in Tier 2 Table 2.0-1 envelope most potential sites in the United States. Please revise the DCD to provide evidence that the values assigned to each of the two new site parameters added to DCD Tier 2 Table 2.0-1 (i.e., High Humidity Diurnal Swing and Daily Temperature

Range) envelope most potential sites in the United States. For example, the ASHRAE Weather Data Viewer Version 4.0 states that the mean daily dry bulb temperature range coincident with the 5% dry bulb for the hottest month (July) at Pensacola, FL, is 9.8 °C (17.6 °F). This seems to imply that 15 °C (27 °F) chosen as the Daily Temperature Range site parameter value may not bound many sites.

GEH Response:
DCD Tier 2 Table 2.0-1 has been revised to allow a check of whether or not specific site characteristic values for the High Humidity Diurnal Swing and Daily Temperature Range are bounded by the ESBWR generic values. The DCD has not been revised to provide evidence that the values assigned to each of the three new site parameters added to DCD Tier 2 Table 2.0-1 envelope most potential sites because, "DC applications do not contain general descriptions of site characteristics because this information is site-specific and will be addressed by the COL applicant," according to SRP 2.3.1. However evidence that the three new site parameters added to DCD tier 2 Table 2.0-1 envelope most potential sites is provided in this RAI response.

As stated in RAI 6.4-25 response (MFN Letter 09-776 dated December 16, 2009), a Daily Temperature Range of 15°C (27°F) is conservative considering the 0% exceedance maximum dry bulb temperature of 47.2°C (117°F). These values correspond to an average dry bulb temperature of 39.72°C (103.5°F). When a daily temperature range and 0% exceedance maximum dry bulb temperature are considered that are lower than an average of 39.72°C (103.5°F), the generic ESBWR site parameter is bounding. The 0% exceedance minimum dry bulb temperature of –40°C (–40°F) with a Daily Temperature Range of 15°C (27°F) has an average dry bulb temperature of –32.5°C (–26.5°F). When a daily temperature range and 0% exceedance minimum dry bulb temperature are considered that are higher than an average of –32.5°C (–26.5°F), the generic ESBWR site parameter is bounding.

For example, considering the mean daily dry bulb temperature range of 6.3°C (11.3°F) for the hottest month and the 50-year maximum extreme dry bulb temperature of 39.9°C (103.9°F) for Palacios, Texas (WMO 722555 ASHRAE Fundamentals Handbook 2005) near South Texas Project, the average dry bulb temperature is 36.81°C (98.25°F), which is bounded by the ESBWR average dry bulb temperature. Considering the mean daily dry bulb temperature range of 7.2°C (12.9°F) for the coldest month and the 50-year minimum extreme dry bulb temperature of –31.6°C (–24.9°F) for the Detroit Metro Airport (WMO 725370 ASHRAE Fundamentals Handbook 2005) near Fermi, the average minimum dry bulb temperature is –28.03°C (–18.45°F), which is bounded by the ESBWR minimum average dry bulb temperature.

Additionally, when considering climatological data taken from Laughlin, Nevada where the high dry bulb temperature for June 11, 1994 was 47.2°C (117°F) and the minimum dry bulb temperature was 24.4°C (76°F), a daily temperature range of 22.8°C (41°F) is obtained which is greater than the generic ESBWR daily temperature range. The average dry bulb temperature is 35.8°C (96.5°F), which is less than the ESBWR maximum average dry bulb temperature and is therefore bounded by the generic ESBWR site parameters.

As stated in response to RAI 6.4-24S01 Part 2, 3 and 4 (MFN 09-776 Supplement 2 dated January 31, 2010), conservative climatological data was considered in developing the ESBWR High Humidity Diurnal Swing. The high humidity diurnal swing was based on data from Pensacola Florida, which has a higher wet bulb temperature than the potential ESBWR sites according to ASHRAE Fundamentals 2005 and "Wet-Bulb Globe Temperature, A Global Climatology", USAF, October, 1990. A 0% exceedance wet bulb temperature of 31.1°C (88°F) with a coincident dry bulb temperature of 33.3°C (92°F) and a diurnal swing of 4.4°C (8°F) dry bulb temperature corresponds to an average WBGT index of 30.33°C (86.6°F). When a diurnal swing and 0% exceedance maximum WBGT index are considered that are lower than the WBGT index average of 30.33°C (86.6°F), the generic ESBWR site parameter is bounding.

Additionally, the average WBGT index considers the additional conservatism, with respect to the climatological data evaluated, of assuming that the overnight low dry bulb temperature is at 100% humidity, which adds additional assurance that the ESBWR generic High Humidity Diurnal Swing bounds most potential ESBWR sites. The WBGT index is calculated without including solar radiation to be consistent with the WBGT index value for the CRHA, which is shielded from the sun. The WBGT index value completely defines the thermodynamic state of the outside air. The DCD has been updated to demonstrate how the average WBGT index is calculated.

The average temperature criteria provides assurance that an equal or less limiting amount of energy is added or removed from the CRHA due to the specific site outside air atmosphere. From an energy addition standpoint, the average temperature values are equivalent or conservative for maximum and minimum dry bulb temperature calculations and the high humidity calculation. The 1st principles calculation transmitted in MFN letter 09-567 "Transmittal of ESBWR Responses to CRHA Open Topic Items #2 and #4 Arising from Meeting on June 23, 2009" was used to confirm that the average temperature values produced less limiting results from a heat transfer and thermal capacity standpoint. The calculation was executed with the average temperature values and was expanded to include latent heat load for the high humidity case.

DCD Impact

DCD Tier 2, Table 2.0-1 will be revised as noted in the attached markup.

DCD Tier 2, Section 3H.3.2.1 will be revised as noted in the attached markup.

Enclosure 2

MFN 10-159

Response NRC Request for Additional Information Letter No. 412 Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Number 6.4-24 S02

DCD Markups

Table 2.0-1

Envelope of ESBWR Standard Plant Site Parameters[1] (continued)

	0% Exceedance Values *- Maximum: 47.2°C (117°F) dry bulb* *26.7°C (80°F) wet bulb (mean coincident)* ~~*31.1°C (88°F) wet bulb (non-coincident)*~~ ~~*Δ 4.4°C (8°F) High Humidity Diurnal Swing*[17]~~ ~~*Δ 15°C (27°F) Daily Temperature Range*[17]~~ *- Minimum: -40°C (-40°F)* ***Maximum Average Dry Bulb Temperature for 0% Exceedance Maximum Temperature Day***[17] *39.7°C (103.5°F)* ***Minimum Average Dry Bulb Temperature for 0% Exceedance Minimum Temperature Day***[18] *-32.5°C (–26.5°F)* ***Maximum High Humidity Average Wet Bulb Globe Temperature Index for 0% Exceedance Maximum Wet Bulb Temperature Day***[19] *30.3°C (86.6°F)*
Soil Properties:[16]	*- Minimum Static Bearing Capacity*[7]*: Greater than or equal to the maximum static bearing demand multiplied by a factor of safety appropriate for the design load combination.* *- Maximum Static Bearing Demand:* *Reactor/Fuel Building: 699 kPa (14,600 lbf/ft^2)* *Control Building: 292 kPa (6,100 lbf/ft^2)* *Firewater Service Complex: 165 kPa (3,450 lbf/ft^2* *- Minimum Dynamic Bearing Capacity*[7]*: Greater than or equal to the maximum dynamic bearing demand multiplied by a factor of safety appropriate for the design load combination.* *- Maximum Dynamic Bearing Demand (SSE + Static):* *Reactor/Fuel Building:* *Soft: 1100 kPa (23,000 lbf/ft^2)* *Medium: 2700 kPa (56,400 lbf/ft^2)* *Hard: 1100 kPa (23,000 lbf/ft^2)* *Control Building:* *Soft: 500 kPa (10,500 lbf/ft^2)* *Medium: 2200 kPa (46,000 lbf/ft^2)* *Hard: 420 kPa (8,800 lbf/ft^2)* *Firewater Service Complex (FWSC):* *Soft: 460 kPa (9,600 lbf/ft^2)* *Medium: 690 kPa (14,400 lbf/ft^2)* *Hard: 1200 kPa (25,100 lbf/ft^2* *- Minimum Shear Wave Velocity:*[8] *300 m/s (1000 ft/s)* *- Liquefaction Potential:* *Seismic Category I Structures: None under footprint of Seismic Category I structures resulting from site-specific SSE.* *Other than Seismic Category I Structures: See Note (14)*

Notes for Table 2.0-1:

(1) The site parameters defined in this table are applicable to Seismic Category I, II, and Radwaste Building structures, unless noted otherwise.

(2) Probable maximum flood level, as defined in Table 1.2-6 of Volume III of Reference 2.0-4.

(3) Maximum speed selected is based on Attachment 1 of Reference 2.0-5, which summarizes the NRC Interim Position on Regulatory Guide 1.76. Concrete structures designed to resist Spectrum I missiles of SRP 3.5.1.4, Rev. 2, also resist missiles postulated in Regulatory Guide 1.76, Revision 1. Tornado missiles do not apply to Seismic Category II buildings. For the Radwaste building, the tornado missiles defined in Regulatory Guide 1.143, Table 2, Class RW-IIa apply.

(4) Based on probable maximum precipitation (PMP) for one hour over 2.6 km^2 (one square mile) with a ratio of 5 minutes to one hour PMP of 0.32 as found in Reference 2.0-3. See also Table 3G.1-2.

(5) See Reference 2.0-9 for the definition of normal winter precipitation and extreme winter precipitation events. The maximum ground snow load for extreme winter precipitation event includes the contribution from the normal winter precipitation event. See also Table 3G.1-2.

(6) Zero percent exceedance values are based on conservative estimates of historical high and low values for potential sites. Consistent with Reference 2.0-4, they represent historical limits excluding peaks of less than two hours. One and two percent annual exceedance values were selected in order to bound the values presented in Reference 2.0-4 and available Early Site Permit applications.

(7) At the foundation level of Seismic Category I structures. The static bearing pressure is the average pressure. The dynamic bearing pressure is the toe pressure. The maximum static bearing demand is multiplied by a factor of safety appropriate for the design load combination and is compared with the site-specific allowable static bearing pressure. The maximum dynamic bearing demand is multiplied by a factor of safety appropriate for the design load combination and is compared with the site-specific allowable dynamic bearing pressure. When a site-specific shear wave velocity is between soft soil and medium soil the larger of the soft or medium maximum dynamic bearing demand will be used. When a site-specific shear wave velocity is between medium soil and hard soil the larger of the medium or hard maximum dynamic bearing demand will be used. Alternatively, for soils with a site-specific shear wave velocity a linearly interpolated dynamic bearing demand between soft and medium soil or between medium and hard soil can be used. The shear wave velocities of soft, medium and hard soils are 300 m/sec (1000 ft/sec), 800 m/sec (2600 ft/sec) and greater than or equal to 1700 m/sec (5600 ft/sec), respectively.

(8) This is the minimum shear wave velocity of the supporting foundation material and material surrounding the embedded walls associated with seismic strains for lower bound soil properties at minus one sigma from the mean. The ratio of the largest to the smallest shear wave velocity over the mat foundation width of the supporting foundation material does not exceed 1.7.

(9) Safe Shutdown Earthquake (SSE) design ground response spectra of 5% damping, also termed Certified Seismic Design Response Spectra (CSDRS), are defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Reactor/Fuel and Control Building structures. For the Firewater Service Complex, which is essentially a surface founded structure, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2 and is defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Firewater Service Complex structure.

(10) Values reported here are actually design criteria rather than site design parameters. They are included here because they do not appear elsewhere in the DCD.

(11) If a selected site has a X/Q value that exceeds the ESBWR reference site value, the COL Applicant will address how the radiological consequences associated with the controlling design basis accident continue to meet the dose reference values provided in 10 CFR 52.79(a)(1)(vi) and control room operator dose limits provided in General Design Criterion 19 using site-specific X/Q values.

(12) ~~If a selected site has X/Q values that exceed the ESBWR reference site values, the release concentrations in Table 12.2-17 would be adjusted proportionate to the change in X/Q values using the stack release information in Table 12.2-16. In addition, for a site selected that exceeds the bounding X/Q or D/Q values, the COL Applicant will address how the resulting annual average doses (Table 12.2-18b) continue to meet the dose reference values provided in 10 CFR 50 Appendix I using site-specific X/Q and D/Q values~~Subsection 12.2.2.1 provides a discussion regarding the X/Q and D/Q values in this table. Per Subsection 12.2.2.2, a COL applicant is responsible for ensuring that offsite dose (using site-specific generated X/Q and D/Q values) due to radioactive airborne effluents complies with the regulatory dose limits in Sections II.B and II.C of 10 CFR 50, Appendix I.

(13) Value was selected to comply with expected requirements of southeastern coastal locations.

(14) Localized liquefaction potential under other than Seismic Category I structures is addressed per SRP 2.5.4 in Table 2.0-2.

(15) Settlement values are long-term (post-construction) values except for differential settlement within the foundation mat. The design of the foundation mat accommodates immediate and long-term (post-construction) differential settlements after the installation of the basemat.

(16) For sites not meeting the soil property requirements, a site-specific analysis is required to demonstrate the adequacy of the standard plant design.

(17) ~~The High Humidity Diurnal Swing and Daily Temperature Range are~~ The Maximum Average Dry Bulb Temperature for 0% Exceedance Maximum Termperature Day is defined in Appendix 3H Subsection 3H.3.2.1.1~~]~~*

(18) The Minimum Average Dry Bulb Temperature for 0% Exceedance Minimum Temperature Day is defined in Appendix 3H.3.2.1.2.

*(19) The Maximum High Humidity Average Web Bulb Globe Temperature Index for 0% Exceedance Maximum Wet Bulb Temperature Day is defined in Appendix 3H.3.2.1.3.]**

- Reactor Building outside containment

The region inside the RB surrounding the containment encloses penetrations through the containment. The Control Room Habitability Area (CRHA) includes the main control room and areas adjacent to the control room containing operator facilities. Also located in the CB are safety-related Distributed Control and Information System (DCIS) rooms, located at elevation -7400 mm. Major equipment zones are shown on the RB arrangement drawing (Figures 1.2-1 to 1.2-9).

3H.3 ENVIRONMENTAL CONDITIONS

Table 3H-1 contains a cross listing of the environmental data tables arranged by location and by type of condition.

3H.3.1 Plant Normal Operating Conditions

Tables 3H-2 through 3H-4 define the thermodynamic conditions (pressure, temperature and humidity) for normal operating conditions for areas containing safety-related equipment. Figures showing equipment location and system configurations are referenced in each table. Section 12.3 defines the radiation conditions for the Reactor Building and Control Building for normal operating conditions. Table 3H-5 specifies the radiation environmental conditions inside the containment vessel for normal operating conditions. Specific radiation environment conditions for equipment are determined through the equipment qualification program based on actual location. Section 9.4 defines the Fuel Building thermodynamic conditions for normal operating conditions.

3H.3.2 Accident Conditions

Thermodynamic conditions for safety-related equipment in the containment vessel, CB and RB are presented in Tables 3H-8 through 3H-10 for accident conditions. Heat loads for the evaluated post accident periods are specified in Table 3H-12. In general, the most severe environmental conditions result from a postulated reactor coolant line break inside the containment, Loss-Of-Coolant-Accident (LOCA) (bounding case) plus Loss Of Offsite Power (LOOP), see Chapter 6 for detailed information. However, accident conditions were also considered for ruptures occurring in the steam tunnel and breaks in the RWCU/SDC System outside the containment, High Energy Line Break (HELB) plus LOOP, see Chapter 6 for detailed information. Tables 3H-6 and 3H-7 list typical radiation environmental qualification conditions inside the RB and the CB. Table 3H-11 specifies the radiation environment conditions inside the containment vessel. The EQ program confirms explicit radiation and thermodynamic conditions during accidents. The limiting thermodynamic conditions in the Fuel Building results from the boiling of the spent fuel pool. The thermodynamic conditions during an accident when the spent fuel pool boils is a limiting temperature of 104°C (219°F), with 100% relative humidity and a limiting pressure consistent with the full tornado pressure drop described in Subsection 3.3.2.2.

3H.3.2.1 Transient Room Temperature Analysis

The performance evaluation for environmental qualification show conformance to the requirements identified in Section 3.11. The maximum temperature Control Building and Reactor Building Environmental Temperature Analysis for ESBWR is presented in Reference

3H.4-8 and is summarized below. Reference 3H.4-8 is designated as Tier 2*. Prior NRC approval is required to change Tier 2* information. The Control Room Habitability Area Minimum Temperature Analysis and high humidity analysis is also summarized below.

Acceptance Criteria

The design meets the following Acceptance Criteria:

- **Environmental Qualification Maximum Temperatures** – The maximum temperature limit for which the safety-related equipment is qualified is not exceeded. The maximum temperature limit is specified in Tables 3H-9 and 3H-10.
- **Control Room Habitability Area Temperature** – The maximum bulk average temperature meets the acceptance criteria stated in Section 6.4. The minimum bulk average air temperature remains at or above 13°C (55°F) for 72 hours after an accident.

Analysis Assumptions

The analysis event assumptions are summarized below. Initial conditions and assumptions can be found in Table 3H-14. Heat loads used in the analysis are found in Table 3H-12.

- The event presented is the most limiting between LOCA or HELB with each concurrent with LOOP.
- Normal Heating, Ventilation and Air Conditioning (HVAC) heating and/or cooling is lost for the first 72 hours of the accident.
- After 72 hours the safety-related equipment heat loads are no longer accounted for because the safety-related equipment needed to maintain safe shutdown no longer requires power to perform their safety-related functions. Normal HVAC mitigates the safety-related equipment heat loads when power is available.
- During the first 2 hours of the event the nonsafety-related heat loads in the RB and in the CB outside of the CRHA powered by the nonsafety-related batteries are considered in the analysis.
- Safety-related heat loads are considered throughout the duration of the event when power is available.
- The CRHA calculation considers safety-related heat loads and additional heat loads for some nonsafety-related equipment. Select nonsafety-related equipment deenergizes if active cooling is not available.
- Room to room interactions are considered in all calculations.
- Outside air intake from the emergency filter unit (EFU) is considered for the CRHA calculation during maximum and minimum temperature conditions.

Analysis Results

As shown in Table 3H-15, the environmental qualification temperatures for safety-related equipment is not exceeded during the limiting event based on the detailed Control Building and Reactor Building Environmental Temperature Analysis for ESBWR performed with CONTAIN 2.0. The CRHA minimum bulk average air temperature acceptance criteria is met based on the detailed Control Room Habitability Area Minimum Temperature Analysis performed, which is benched marked against the Control Building CONTAIN maximum temperature analysis in Reference 3H.4-8. The CRHA Wet Bulb Globe Temperature (WBGT) index acceptance criteria are met. When rooms are located on the same level and have similar dimensions and internal heat loads, the most unfavorable room is taken to be the representative room for that group of rooms. Solar heat loads were applied to rooms located above grade. Table 3H-15 summarizes the representative room temperatures and locations of the room groups.

During the transient event concurrent with LOOP and loss of normal HVAC the heat generated in the rooms is absorbed by the surrounding walls, floor and ceiling. The building concrete acts as a heat sink for passive heat removal. The room temperature rises quickly because the heat absorption capacity of air is very low. The heat transfer to the walls, floor and ceiling maintain the environmental temperatures below the qualification temperature.

During wintertime conditions the RB and CB are isolated and equipment room cool down is insignificant. The case for the CRHA post 72 hours presented in Table 3H-15 which accounts for heat loads from people and minimal lighting only, demonstrates that the cool down for the RB and CB are inconsequential. The injection of ambient air at wintertime conditions when safety-related heat loads are not present provides a faster cool down rate than the other rooms located in the RB and CB. See subsection 3H.3.2.1.1 for environmental conditions used for maximum temperature analysis, see subsection 3H.3.2.1.2 for environmental conditions used for minimum temperature analysis and see subsection 3H.3.2.1.3 for environmental conditions used for high humidity analysis. For the winter conditions the Control Room Habitability Area Minimum Temperature Analysis considers the 0% exceedance minimum dry bulb ambient outside air temperature (-40°C/°F). For the summer conditions the 0% exceedance coincident maximum dry bulb and wet bulb ambient outside air temperature [47.2°C (117°F) DBt and 26.7°C (80°F) WBt] was considered. The Daily Temperature Range applied for these analyses is Δ 15°C (27°F). The Daily Temperature Range for summer conditions is defined as the dry bulb temperature difference between the 0% exceedance maximum dry bulb temperature and the dry bulb temperature that corresponds to the higher of the two overnight lows before or after that maximum, and for winter conditions it is the dry bulb temperature difference between the 0% exceedance minimum dry bulb temperature and the dry bulb temperature that corresponds to the lower of the two daily highs before or after that minimum. For high humidity conditions the 0% exceedance non-coincident maximum wet bulb temperature [31.1°C (88°F) WBt] and High Humidity Diurnal Swing [Δ 4.4°C (8°F) DBt] are applied to the methodology for the analysis presented in Reference 3H.4-8. The High Humidity Diurnal Swing is defined as the dry bulb temperature swing determined by:

> The maximum and the minimum wet bulb temperatures for the worst three day period over which the 0% exceedance wet bulb temperature occurs. The coincident dry bulb temperature (33.3°C/92°F) for the maximum wet bulb temperature (31.1°C/88°F) is taken as the maximum dry bulb and wet bulb temperatures for three days. The coincident dry bulb temperature (28.9°C/84°F) for the highest overnight low wet bulb temperature (27.2°C/81°F) over the three day period is taken as the minimum dry bulb temperature. The difference between the coincident maximum dry bulb temperature (33.3°C/92°F) and the highest overnight low dry bulb temperature (28.9°C/84°F) is used as the diurnal swing. The simplified diurnal swing encompassing the highest wet bulb high and highest wet bulb low is 33.3°C (92°F) dry bulb/31.1°C (88°F) wet bulb and 28.9°C (84°F) dry bulb/27.2°C (81°F) wet bulb.

~~The overnight low wet bulb temperature in the high humidity CONTAIN analysis is 28.9°C (84°F), which is conservative relative to the 27.2°C (81°F) wet bulb temperature in the High Humidity Diurnal Swing.~~

The temperature in the CRHA remains below the temperature acceptance criteria outlined in Section 6.4. The temperature and humidity profiles for the 0% exceedance coincident maximum temperature case is presented in Figures 3H-2 and 3H-3 respectively. Cases were considered to ensure that the 0% exceedance maximum outside air temperature was bounding and 100% relative humidity with additional moisture created by CRHA occupants (latent load) would not lead to a 72 hour CRHA air temperature higher than the 0% exceedance coincident maximum temperature case, and ensure the heat absorbed by the CRHA structures would not be adversely impacted by the condensation created. The results of this analysis show that higher humidity ratios, and subsequently higher specific enthalpy, do not affect the maximum temperature reached with little condensation occurring on the walls of the control room. The concrete heat sink provides enough thermal mass to keep the CRHA within limits during the limiting event by absorbing heat loads or heating ambient air during summer or winter conditions.

3H.3.2.1.1 Maximum Temperature Analysis Conditions

For the summer conditions the 0% exceedance maximum dry bulb and coincident wet bulb ambient outside air temperature [47.2°C (117°F) DBt and 26.7°C (80°F) WBt] was considered. The Daily Temperature Range applied for this analysis is Δ 15°C (27°F).

> The Daily Temperature Range for summer conditions is defined as the dry bulb temperature difference between the 0% exceedance maximum dry bulb temperature and the dry bulb temperature that corresponds to the higher of the daily lows before and after that maximum.
>
> The Maximum Average Dry Bulb Temperature for the 0% Exceedance Maximum Temperature Day is defined as the average of the 0% exceedance maximum dry bulb temperature of 47.2°C (117°F) and the dry bulb temperature resulting from a daily temperature range of 15°C (27°F), which is 39.7°C (103.5°F).

3H.3.2.1.2 Minimum Temperature Analysis Conditions

For the winter conditions the Control Room Habitability Area Minimum Temperature Analysis considers the 0% exceedance minimum dry bulb ambient outside air temperature (-40°C/°F). The Daily Temperature Range applied for this analysis is Δ 15°C (27°F).

> The Daily Temperature Range for winter conditions is defined as the dry bulb temperature difference between the 0% exceedance minimum dry bulb temperature and the dry bulb temperature that corresponds to the lower of the daily highs before and after that minimum.
>
> The Minimum Average Dry Bulb Temperature for 0% Exceedance Minimum Temperature Day is the average of the 0% exceedance minimum dry bulb temperature of –40°C (-40°F) and the dry bulb temperature resulting from a daily temperature range of 15°C (27°F), which is -32.5°C (–26.5°F).

3H.3.2.1.3 High Humidity Analysis Conditions

For high humidity conditions the 0% exceedance non-coincident maximum wet bulb temperature [31.1°C (88°F) WBt] and High Humidity Diurnal Swing [Δ 4.4°C (8°F) DBt] are applied to the methodology for the analysis presented in Reference 3H.4-8.

The High Humidity Diurnal Swing is defined as the dry bulb temperature range determined by the maximum and the minimum wet bulb temperatures for the worst three-day period over which the 0% exceedance wet bulb temperature occurs. The maximum wet bulb temperature (31.1°C/88°F) has a coincident dry bulb temperature of (33.3°C/92°F). These temperatures define the maximum dry bulb and wet bulb temperatures for three days in the analysis. The minimum dry bulb temperature is defined as the coincident dry bulb temperature (28.9°C/84°F) for the highest of the three daily low wet bulb temperatures (27.2°C/81°F) that occurs before and after the 0% coincident maximum wet bulb temperature. The High Humidity Diurnal Swing is the difference between the coincident maximum dry bulb temperature (33.3°C/92°F) and the highest daily low dry bulb temperature (28.9°C/84°F).

The overnight low wet bulb temperature in the high humidity CONTAIN analysis is 28.9°C (84°F), which is conservative relative to the 27.2°C (81°F) wet bulb temperature in the High Humidity Diurnal Swing.

The WBGT index value is determined by the dry bulb temperature multiplied by 0.3 plus the wet bulb temperature multiplied by 0.7.

The Maximum High Humidity Average Wet Bulb Globe Temperature Index for 0% Exceedance Maximum Wet Bulb Temperature Day is defined as the average of the WBGT index values for the temperatures used to determine the High Humidity Diurnal Swing. The WBGT index value for the maximum dry bulb 33.3°C (92°F) and wet bulb 31.1°C (88°F) temperatures is 31.8°C (89.2°F). The WBGT index value for the minimum dry bulb 28.9°C (84°F) and wet bulb 28.9°C (84°F) temperatures is 28.9°C (84°F). The average of the WBGT index values is then 30.3°C (86.6°F).

3H.3.3 Water Quality

Reactor water design quality characteristics during normal operation are:

- pH range: 5.6 to 8.6
- Silica (as SiO2) ≤ 200 ppb (100 ppb operating target)
- Conductivity at 25°C (77°F) ≤ 0.1 μS/cm (0.08 μS/cm operating target)
- Dissolved Oxygen (as O2) ≤ 300 ppb
- Corrosion product metals ≤ 6 ppb

The Standby Liquid Control (SLC) System injects borated water into the RPV during DBA LOCA. Although there is no caustic spray in the ESBWR design, the post-accident suppression pool pH can vary due to the production of cesium-hydroxide and radiation-induced acids, as described in detail in Subsection 15.4.4.