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Subject: **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 Part 1**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. The GEH response to Part 1 of RAI Number 6.4-24 S01 is provided in Enclosure 1. GEH responses to Parts 2, 3, and 4 of RAI Number 6.4-24 S01 will be provided in a separate letter.

Enclosure 2 contains markups to DCD Tier 1 and 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

D068
NRO

Reference:

1. MFN 10-011, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No.405 Related to ESBWR Design Certification Application,* January 11, 2010

Enclosures:

1. MFN 09-776 Supplement 1 - 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 Part 1
2. MFN 09-776 Supplement 1 - 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 Part 1 **– Markups to ESBWR DCD Tier 1 and Tier 2**

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH (with enclosures)
	DH Hinds	GEH (with enclosures)
	SC Moen	GEH (w/o enclosures)
	eDRFsection	0000-0112-0570

Enclosure 1

MFN 09-776 Supplement 1

Response to Portion of NRC Request for

Additional Information Letter No. 405

Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Numbers 6.4-24 S01 Part 1

NRC RAI 6.4-24 S01 Part 1

Justify use of psychometric wet bulb as a valid means to assess heat stress in the ESBWR CHRA, Alternatively amend DCD to provide a heat stress acceptance criterion and index that is in accordance with NUREG-0700 guidance. Provide demonstration that such criterion can be met for the ESBWR environmental footprint. Clarify associated ITAAC.

In letter MFN 09-776, dated December 16, 2009, GEH responded to staff RAI 6.4-24, which requested GEH to justify its proposed CRHA heat stress index and to submit a supporting demonstration that the proposed acceptance criteria using such index would not be exceeded for any location in the proposed ESBWR site envelope. Appendix A of Enclosure 1 of the response contained a supporting sensitivity study. NRC staff has reviewed the RAI response and sensitivity study.

The following additional information is needed.

1. In response to RAI 6.4-24 item number one, GEH stated that the psychometric wet bulb temperature is used as the basis for determining heat stress in the CHRA. The staff views this as an "alternate method" to the NRC guidance in Section 12.2.5.1 of NUREG-0700 which addresses heat stress in terms of the WBGT index.

While the use of this alternate method may be acceptable, GEH did not provide a necessary and sufficient demonstration of equivalency between WBGT and psychometric wet bulb temperatures for the range of expected control room environmental conditions. The staff understands that psychometric wet bulb measurement may be applicable to control room conditions but that does not provide a sufficient evaluation of why it is better than or equal to WBGT.

The staff requests that GEH provide additional information, including relevant test data that explains why the psychometric wet bulb temperature is an acceptable alternative for WBGT index.

Alternatively, GEH may propose a revised human performance measurement method in terms of the WBGT index and provide an associated acceptance criterion. Revise the DCD accordingly. Discuss how NUREG-0700 guidance for workplace design, particularly Engineering Controls, Work Practices and Water Replacement are addressed in the DCD.

GEH Response

NRC Request:

In response to RAI 6.4-24 item number one, GEH stated that the psychometric wet bulb temperature is used as the basis for determining heat stress in the CHRA. The staff views this as an "alternate method" to the NRC guidance in Section 12.2.5.1 of NUREG-0700 which addresses heat stress in terms of the WBGT index.

While the use of this alternate method may be acceptable, GEH did not provide a necessary and sufficient demonstration of equivalency between WBGT and psychometric wet bulb temperatures for the range of expected control room environmental conditions. The staff understands that psychometric wet bulb measurement may be applicable to control room conditions but that does not provide a sufficient evaluation of why it is better than or equal to WBGT.

The staff requests that GEH provide additional information, including relevant test data that explains why the psychometric wet bulb temperature is an acceptable alternative for WBGT index.

Alternatively, GEH may propose a revised human performance measurement method in terms of the WBGT index and provide an associated acceptance criterion. Revise the DCD accordingly.

GEH Response:

GEH has implemented a revised human performance measurement method in terms of WBGT index based on guidance from NUREG-0700. The acceptance criterion is a WBGT index limit of 32.2°C (90°F). DCD Tier 2 Subsections 6.4.4 and 6.4.10 have been updated as shown on the attached mark ups to provide the DCD temperature limit in terms of a WBGT index.

The NRC guidance in section 12.2.5.1 of NUREG-0700 addresses heat stress in terms of WBGT index as applied in Tables 12.6 and 12.7. These tables indicate that stay times are unlimited for a WBGT of 32.2 °C (90°F) or less for work clothes (light clothing) and low metabolic rate. The ESBWR passive control room activities, 72 hours post design basis accident conditions (when temperature is at its peak), are low metabolic rate activities and the control room operator will be lightly clothed. Therefore, the 32.2°C (90°F) WBGT guidance on heat stress applies to the ESBWR control room post design basis accident conditions. Since GEH has implemented a revised human performance measurement method in terms of WBGT index, additional information beyond that provided above or test data is not needed to explain why the GEH psychrometric wet bulb temperature is an acceptable alternative for WBGT index.

NRC Request:

Discuss how NUREG-0700 guidance for workplace design, particularly Engineering Controls, Work Practices and Water Replacement are addressed in the DCD.

GEH Response:

With regard to engineering controls, the CRHA design described in DCD Section 6.4 provides a control room environment that is maintained at or below a WBGT index of 32.2°C (90°F), which preserves well-being and effectiveness of the control room staff for an unlimited duration. Additional engineering controls are not required because the CRHA is maintained at or below 32.2°C (90°F) WBGT index. With regard to work practices, there are many areas of a nuclear plant that present the potential for heat exposure. To minimize this risk, current plants employ administrative instructions and training programs. Such programs are established by employers to meet the employment safety requirements stipulated in "General Duty Clause," Section 5(a)(1) of the Occupational Safety and Health Act of 1970 (the Act). With regard to water replacement, the CRHA includes a supply of vital water for maintaining personnel life support. This provision is documented in DCD Sections 6.4 and 6.4.6.

Parts 2), 3) and 4) of the original RAI 6.4-24 S01 will be addressed in a separate letter.

DCD Impact

DCD Tier 2, Section 6.4.4 will be revised as noted in the attached markup.

DCD Tier 2, Section 6.4.10 will be revised as noted in the attached markup.

DCD Tier 1, Table 2.16.2-4 will be revised as noted in the attached markup.

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

DCD Tier 2, Table 1.9-23 will be revised as noted on the attached markup.

Enclosure 2

MFN 09-776 Supplement 1

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 Part 1

Markups to ESBWR DCD Tier 1 and Tier 2

Acceptance Criteria 3.B. This analysis included boundary leakage paths in the control room envelope such as CRHA doors, dampers, and penetrations for piping, electrical conduit, duct and HVAC equipment. Based on the control room total volume and design/construction features employed, the results of the analysis support the feasibility of maintaining the tested differential pressure with the design makeup air flow rate.

Interaction With Other Zones and Pressure-Containing Equipment

During normal operation the CRHA is heated, cooled, ventilated, and pressurized by either of a redundant set of recirculating AHUs and either of a redundant set of outside air intake fans for ventilation and pressurization purposes. See Figure 6.4-1 and Subsection 9.4.1 for a complete description of the CRHAVS.

During a radiological event or upon loss of normal AC power , the EFU maintains a positive pressure in the CRHA to minimize infiltration of airborne contamination. Interlocked double-vestibule type doors maintain the positive pressure, thereby minimizing infiltration when a door is opened.

The CRHA remains habitable during emergency conditions. To make this possible, potential sources of danger such as steam lines, pressure vessels, CO_2 fire fighting containers, etc. are located outside of the CRHA.

6.4.4 System Operation Procedures

The CRHA emergency habitability portion of the CRHAVS is not required to operate during normal conditions with the exception of the variable orifice relief device. This relief device is in service exhausting CRHA air during normal and emergency operation. The normal operation of the CRHAVS maintains the air temperature of the CRHA within a predetermined temperature range. This maintains the CRHA emergency habitability system passive heat sink at or below a predetermined temperature. The normal operation portion of the CRHAVS operates during all modes of normal power plant operation, including startup and shutdown. For a detailed description of the CRHAVS operation see Subsection 9.4.1.

The COL Applicant will verify procedures and training for control room habitability address the applicable aspects of NRC Generic Letter 2003-01 and are consistent with the intent of Generic Issue 83, Reference 6.4-3 (COL 6.4-1-A).

Emergency Mode

Operation of the emergency habitability portion of the CRHAVS is automatically initiated by either of the following conditions:

- High radioactivity in the main control room supply air duct, or
- Extended Loss of Normal AC power.

Operation can also be initiated by manual actuation. Upon receipt of a high radiation level in the main control room supply air duct, the normal outside air intake and restroom exhaust are isolated from the CRHA pressure boundary by automatic closure of the isolation dampers in the system ductwork. At the same time, one of the EFUs automatically starts and begins to deliver filtered air from one of the two unique safety-related outside air intake locations. A constant air flow rate is maintained and this flow rate is sufficient to pressurize the CRHA boundary to at least 31 Pa (⅛ inch w.g.) positive differential pressure with respect to the adjacent areas. Excess air is exhausted from the CRHA via the variable orifice relief device. This device is a locked in place orifice or valve set up to maintain CRHA pressure at the delivered flow. The EFU system air flow rate is also sufficient to supply the fresh air requirement of 10.5 l/s (22 cfm) per person for up to 21 occupants (Reference 6.4-4).

Airflow in Emergency Mode

The mixing of the EFU supplied inlet air with the general CRHA air is performed via the following mechanisms:

1. Supply / Inlet registers mixing - The mixing is continuous as EFU provided outside air is delivered to the CRHA. For each cfm delivered it generates mixing with the CR air as it exits the supply registers. This is the most common type of space air diffusion called a Mixing System. The supply air jet is delivered by the air inlet registers, which create an air jet that then mixes the outside air with the room air by entrainment (induction), which helps to reduce the jet velocity and equalize the supply air temperature as it enters the CRHA.
2. Displacement (Ventilation) Supply / Exhaust - As air is supplied to the CRHA, an amount is similarly exhausted from the space. This exhaust air is designed to be at a remote location to ensure no short cycling and a properly scavenged control room.
3. Equipment and Personnel Convective Plumes due to air differential temperature / density – The higher temperature of the air surrounding operating equipment and personnel, generates convective air plumes which rise out of the occupied zone, along with any pollutants (body odors, etc.). The rising air is replaced by cooler air from below.
4. Personnel Movement – It is assumed that a certain activity level by the CRHA occupants which derived the airflow requirements. This activity generates mixing of the CRHA air.
5. Molecular Dispersion - For Contaminants, CO_2 and others, the movement of CO_2 and other molecules across a space is via molecular dispersion.

The airflow developed in the ESBWR control room during worst case (outside air temp of 117°F) accident conditions when the CRHA is isolated and the EFU is in operation with passive cooling is as follows and is illustrated in Figure 6.4-2.

The EFU is operating providing 466 cfm clean outside airflow into the CRHA. This is delivered to the occupied MCR area, primarily since this area has the personnel on duty and houses the active electronic equipment. This supply air exits the ductwork at supply air diffusers (4), which perform mixing, mechanism 1) above. Depending upon the delivered air temperature, the combined mixed volume either rises or drops. At the worst case outside air condition of 117°F, modeling shows this air mixture rises above the ceiling with a larger quantity of MCR heated air; the balance driven primarily by the equipment and personnel convective plumes, mechanism 3) above. The combined, rising air above the ceiling tiles draws the same quantity of air into the MCR space from the area below the raised floor volume, mechanism 2). This cooler, slow moving air slowly spreads over the raised floor and displaces the warmer, stale air toward the ceiling, where it leaves the room. The MCR with the high ceiling becomes thermally stratified, i.e., warmer stale air is concentrated above the occupied zone and cool, fresher air is concentrated in the occupied zone. When the cool air encounters a heat source, such as a person or heat generating equipment, the air heats up and buoyantly rises out of the occupied zone.

The hot air that collects above the suspended ceiling, with CO_2 and body generated odors, spills over into the adjacent rooms due to the air density difference due to differential temperature where heat is released to the cooler walls and concrete. Cooler lower temperature air in these adjacent rooms drops to the raised floor level where air continues to drop thru to the common space below the floor. Discharge flow of 466 cfm of this air, exits the main control room at a remotely opposite location from EFU supply to prevent any short cycle of the supply air and ensure a constant turnover of the CRHA air. This air then is drawn into the MCR and a circuit is complete.

A positive pressure is maintained in the CRHA. There is no buildup of any CO_2 in any of these areas since the areas are scavenged continuously by the EFU supply with exhaust airflow of 466 cfm. The exhaust is remote to the supply at one of the adjacent rooms lower common area.

With a source of AC power available, the EFU can operate and is controlled indefinitely through Q-DCIS. In the event that normal AC power is not available, the safety-related battery power supply is sized to provide the required power to the operating EFU fan for 72 hours of operation. For longer-term operation, from post 72 hrs, each EFU fan is powered via an electrical bus supplied by one (1) of two (2) ancillary diesel generators. The temperature and humidity in the CRHA pressure boundary following a loss of the normal portion of the CRHAVS remain within the limits for reliable human performance (References 6.4-1 and 6.4-2) over a 72-hour period. The CRHA isolation dampers fail closed on a loss of normal AC power or instrument air.

Backup power to the safety-related Control Room EFU fans (post 72 hours) if normal AC power is not available is provided by two (2) ancillary diesel generators. These generators are required to support operation of the Control Room EFU beyond 72 hours after an accident. For a period between 7 days and the duration of the design basis accident, the safety-related function of the EFU can be powered from either offsite power, onsite diesel generator powered Plant Investment Protection (PIP) bus, or by continued use of the ancillary diesel generators. The requirements for the ancillary generators are described in Appendix 19A.

Upon a loss of normal AC power, the initial ranges of temperature/relative humidity in the CRHA are 21.1-23.3°C (70-74°F) and 25%-60% RH. The CRHA temperature / humidity values calculated during the 72 hours following a design basis accident equate to less than ~~30~~32.2°C (~~86~~90°F) ~~wet bulb globe temperature and psychrometric wet bulb temperature~~Wet Bulb Globe Temperature (WBGT). The ~~30~~32.2°C (~~86~~90°F) WBGT value is the acceptability limit for minimizing performance decrements, potential harm, and preserving well-being and effectiveness of the control room staff for an unlimited duration. ~~is the recommended threshold limit for instituting hot weather practices and the recommended upper limit appropriate for assessing heat stress and predicting heat strain for moderate levels of work respectively. The pyschrometric wet bulb temperature is an appropriate index for assessing heat stress and predicting heat strain under conditions where radiant temperatures and air velocity are not large factors and where increased humidity exists. National Institute for Occupational Safety and Health (NIOSH) 86-113 provides a wet bulb temperature limit of about 30°C (86°F) for unimpaired performance on sedentary tasks (moderate levels of physical work) for normally clothed individuals at low airflows~~ (Reference 6.4-5). During the first two hours of loss of normal AC power, most of the equipment in the MCR remains powered by the nonsafety-related battery supply. Anytime during a loss of normal AC power, once either ancillary diesel is available, the environmental conditions are maintained indefinitely. This is accomplished via the

the specified limit. The temperature response of the CRHA heat sink area materials is slower than the response of the average air temperature on increasing temperature, i.e., a loss of normal cooling. Since the CRHA air temperature will respond quicker than the materials in the heat sink (notably concrete), this approach is conservative. If the average of the CRHA air temperatures exceed the specified limit, restoration of the CRHA heat sinks is verified by administrative evaluation considering the length of time and extent of the CRHA heat sink average air temperature excursion outside of limits, or by direct measurement of the CRHA heat sink area structural materials temperatures.

6.4.9 COL Information

6.4-1-A CRHA Procedures and Training

The COL Applicant will verify procedures and training for control room habitability address the applicable aspects of NRC Generic Letter 2003-01 and are consistent with the intent of Generic Issue 83, Reference 6.4-3 (Subsection 6.4.4) including statements under 6.4.7.

6.4-2-A Toxic Gas Analysis

The COL Applicant will identify potential site specific toxic or hazardous materials that may affect control room habitability in order to meet the requirements of TMI Action Plan III. D.3.4 and GDC 19. The COL Applicant will determine the protective measures to be instituted to ensure adequate protection for control room operators as recommended under RG 1.78. These protective measures include features to (1) provide capability to detect releases of toxic or hazardous materials, (2) isolate the control room if there is a release, (3) make the control room sufficiently leak tight, and (4) provide equipment and procedures for ensuring the use of breathing apparatus by the control room operators (Subsection 6.4.5).

6.4.10 References

6.4-1 MIL-HDBK-759C, Human Engineering Design Guidelines.

6.4-2 MIL-STD-1472E, Human Engineering.

6.4-3 A Prioritization of Generic Safety Issues, NUREG-0933, October 2006.

6.4-4 ASHRAE Standard 62.1/2007, Ventilation for Acceptable Indoor Air Quality.

6.4-5 Human-System Interface Design Review Guidelines, NUREG-0700, May 2002.~~NIOSH 86-113, Occupational Exposure to Hot Environments.~~

Table 2.16.2-4

ITAAC For The Control Building Habitability HVAC Subsystem

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	iii. A Control Building and Reactor Building Environmental Temperature Analysis for ESBWR will be performed using the as-built design inputs established in Table 2.16.2-4 Item 4i and using the ESBWR 0% exceedance wet bulb temperature and corresponding temperature swing. A reconciliation analysis will be performed for the as-built features and heat loads, and limiting outdoor conditions.	iii. The CRHA maximum bulk average wet bulb globe temperature is 32.2° C (90.0° F) or less on a loss of active cooling for the first 72 hours following a design basis accident, given post design basis accident conditions and as reconciled to as-built features and heat loads, and to limiting outdoor conditions.
5. Independence is provided between safety-related divisions, and between safety-related divisions and nonsafety-related equipment.	i. Tests will be performed on CRHA isolation damper and EFU operation by providing a test signal in only one safety-related division at a time. ii. Inspection of the as-built safety-related divisions in the system will be performed.	i. The test signal exists only in the safety-related division under test in the as-built CRHA isolation damper and EFU control. ii. Physical separation and electrical isolation exists between as-built CRHA isolation dampers and EFU safety-related divisions. Physical separation or electrical isolation exists between safety-related divisions and nonsafety-related equipment.
6. CRHA isolation damper and EFU operational status (Open/Closed) indication is provided in the MCR.	i. Inspection will be performed to verify CRHA isolation damper and EFU operational status indication is installed in the MCR.	i. The as-built CRHA isolation damper and EFU operational status indication is provided in the MCR.

Table 1.9-22

Industrial Codes and Standards[1] Applicable to ESBWR

Code or Standard Number	Year	Title
HMR No. 52	1982	National Weather Service Publication: "Application of Probable Maximum Precipitation Estimates United States East of the 105th Meridan"
(Deleted)~~NIOSH 86-113~~	~~1986~~	~~National Institute for Occupational Safety and Health, "Criteria for a Recommended Standard … Occupational Exposure to Hot Environments (Revised Criteria 1986)," NIOSH Publication No. 86-113, April 1986~~
SNT-TC-IA	1992	Recommended Practice for Non-Destructive Testing by American Society for Nondestructive Testing (Note 2001 version exists)
TEMA	1999	Standards of Tubular Exchanger Manufacturers Association, Eighth Edition
—	2000	Aluminum Design Manual by Aluminum Association

Notes:
Other Organizations that are Referenced Without Specific Standards Listed:
Department of Transportation (DOT)
Federal Aviation Administration (FAA)
Federal Occupational Safety and Health Administration (OSHA)
Table sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC~~NCR~~ approval is required to change.

Table 1.9-23

NUREGs Referenced in ESBWR DCD

No.	Issue Date	Title	Comment/ Section where Referenced
0696	12/1980	Functional Criteria for Emergency Response Facilities	1A, 9.4, 9.5, 13.3
0700 Rev. 2	03/2002	Human-System Interface Design Review Guidelines	1A, 6.4, 18.1
0711 Rev. 2	01/2004	Human Factors Engineering Program Review Model	7.1, 18.10, 14.3A
0718 Rev. 1	06/1981	Licensing Requirements for Pending Construction Permits and Manufacturing License Applications	1.9, 1A, 7.1, 8.1
0737	11/1980	Clarification of TMI Action Plan Requirements	1.1, 1.9, 1.10, 1.11, 1A, 1B, 5.4, 6.3, 7.1, 8.1, 9.3, 11.5, 12.3, 12.5, 13.2, 13.5, 16
0737 Supp.1	12/1982	Clarification of TMI Action Plan Requirements	1A, 1C, 13.5, 16, 18.1
0744 Rev. 1	10/1982	Resolution of the Task A-11 Reactor Vessel Materials Toughness Safety Issue	1.11
0763	05/1981	Guidelines for Confirmatory In-Plant Tests of Safety-Relief Valve Discharges for BWR Plants	1C, 5.2
0783	11/1981	Suppression Pool Temperature Limits for BWR Containments	1C
0800	Varies by SRP Section	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition	Throughout
0808	8/1981	Mark II Containment Program Load Evaluation and Acceptance Criteria	1.11
0927 Rev. 1	03/1984	Evaluation of Water Hammer Occurrence in Nuclear Power Plants	1.11, 10.3, 10.4
0933	10/2006	A Prioritization of Generic Safety Issues (Main Report and Supplements 1-30)	1.11, 6.2, 6.4, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 10.2, 19.1
1000	4/1983 8/1983	Generic Implications of ATWS Events at the Salem Nuclear Power Plant (Volumes 1 and 2)	1.11
1048 Supp. 6	07/1986	Safety Evaluation Report Relating to the Operation of Hope Creek Generating Station	10.2