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Subject: **Response to Portions of NRC Request for Additional Information Letter No. 103 Related to ESBWR Design Certification Application - Control Building Ventilation - RAI Numbers 6.4-8, 6.4-9, and 6.4-13**

Enclosure1 contains the GE Hitachi Nuclear Energy (GEH) responses to the subject NRC RAIs transmitted via the Reference 1 letter.

Verified DCD changes associated with this RAI response are identified in Enclosure 2 in the DCD markups by enclosing the text within a black box. The marked-up pages may contain unverified changes in addition to the verified changes resulting from this RAI response. Other changes shown in the markup(s) may not be fully developed and approved for inclusion in DCD Revision 5.

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

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 07-414, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 103 Related to ESBWR Design Certification Application*, July 23, 2007

Enclosures:

1. MFN 08-288 - Response to Portions of NRC Request for Additional Information Letter No. 103 Related to ESBWR Design Certification Application - Control Building Ventilation - RAI Numbers 6.4-8, 6.4-9, and 6.4-13
2. MFN 08-288 - Response to Portions of NRC Request for Additional Information Letter No. 103 Related to ESBWR Design Certification Application - Control Building Ventilation - RAI Number 6.4-13 – DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	eDRF	RAI 6.4-8: 0000-0082-8918
		RAIs 6.4-9 and 6.4-13: 0000-0083-0392

Enclosure 1

MFN 08-288

Response to Portion of NRC Request for
Additional Information Letter No. 103
Related to ESBWR Design Certification Application

Control Building Ventilation

RAI Numbers 6.4-8, 6.4-9, and 6.4-13

NRC RAI 6.4-8:

What surveillance requirements will ensure that the initial temperature assumptions on the heat sink are below acceptable limits? How often will these surveillances be performed? How are the effects of the following items accounted for in the surveillances:

(1) external temperatures such as 95 degree Fahrenheit day and

(2) heat loads in adjoining rooms and passageways?

The temperature of the CRHA is not necessarily the temperature of the heat sink because of the temperatures on the outside surface of the heat sink (concrete wall, ceilings, and floors) may be higher than the temperature in the control room.

GEH Response:

DCD Tier 2, Chapter 16, Technical Specification Surveillance Requirement 3.7.2.1 verifies the average Control Room Habitability Area (CRHA) air temperature is ≤ 25.6°C (78.0°F). This surveillance requirement is performed on a 24-hour frequency.

In response to RAI 16.0-5 S02, GEH will respond to the question regarding heat sink temperatures compared to average air temperatures associated with the CRHA and the frequency of the required surveillances.

The CRHA heatup analysis assumes external thermal conditions are at worst-case design summer conditions.

The CRHA heatup analysis conducted for summer conditions considers outside air supply to the CRHA at 200 l/s with a dry bulb maximum temperature of 117°F as discussed in the GEH response to RAI 9.4-33 (MFN 08-064, dated February 26, 2008). The typical daily temperature range of 28°F is considered with the outside air temperature profile assumed sinusoidal with a period of one day.

In response to RAI 16.0-5 S02, GEH will provide the Surveillance Requirements, including frequency, to ensure that the effects of external temperatures, (maximum design dry bulb temperature of 117°F applied as a daily temperature profile) are accounted for in the surveillances performed.

The CRHA heatup analysis assumes certain initial heat loads and temperatures in adjacent rooms and passageways. Therefore, additional surveillance requirements will be added to verify the temperature of the adjacent rooms, particularly the Q-DCIS rooms and access corridors to the CRHA envelope. In response to RAI 16.0-5 S02, GEH will provide the Surveillance Requirements, including frequency, to ensure areas adjacent to the CRHA do not adversely impact the CRHA temperature qualification.

DCD Impact:

No DCD changes will be made in response to this RAI.

NRC RAI 6.4-9:

DCD, Tier 2, Revision 3, Section 6.4.4 under Emergency Mode states that a constant airflow, sufficient to pressurize the CRHA boundary, is maintained. Standard Review Plan (SRP) Section 6.4, Revision 3, March 2007, in Acceptance Criteria Item 3 for Pressurization Systems, paragraph B states: "Systems having pressurization rates of less than 0.5 and equal to or greater than 0.25 volume changes per hour should have identical testing requirements as indicated in acceptance criteria [A] above. In addition, at the construction permit (CP), combined license, or standard design certification stage, an analysis should be provided (based on the planned leaktight design features) that ensures the feasibility of maintaining the tested differential pressure with the design makeup airflow rate."*

Provide the analysis underlined above so that the staff can evaluate the adequacy of make up flow rate. Include the results of the analysis in the DCD.

**Note: Same criteria same as 1981 and 1996 versions of SRP Section 6.4*

GEH Response:

A. NUREG-0800, Standard Review Plan (SRP) Section 6.4, Acceptance Criteria II.3.B, requires a testing periodicity of 18 months for differential pressure testing of the control room envelope. DCD Tier 2, Subsection 6.4.7, Control Room Habitability – Testing and Inspection, states that the Control Room Habitability Area (CRHA) Heating, Ventilation, and Air Conditioning Subsystem (CRHAVS) is tested and inspected at appropriate intervals consistent with the plant Technical Specifications. DCD Tier 2, Chapter 16, Technical Specifications, Section 5.5.12, Control Room Habitability Area (CRHA) Boundary Program, Item d, describes this function:

> "Measurement, at designated locations, of the CRHA pressure relative to all external areas adjacent to the CRHA boundary during the pressurization mode of operation by one train of the CRHAVS, operating at the flow rate required by the VFTP [Ventilation Filter Testing Program], at a frequency of 24 months on a STAGGERED TEST BASIS. The results shall be trended and used as part of the 24 month assessment of the CRHA boundary."

GEH has committed to TSTF-448, Revision 3, Control Room Habitability. The 24-month periodicity based on a staggered test basis is consistent with TSTF-448 when considering the plant-specific allowance based on fuel cycle (RAI 16.2-54, MFN 07-022 dated January 19, 2007).

B. SRP Section 6.4, Acceptance Criteria 3.B, requires an analysis be performed that ensures the feasibility of maintaining the tested differential pressure with the design makeup airflow rate. The ESBWR CRHA pressure envelope design ensures that a 1/8" water gauge positive pressure can be maintained with a minimum flowrate of 424 scfm. The 424 cfm flowrate is based on ensuring adequate long-term air quality in accordance with ASHRE Standard 62. The design positive pressure above adjacent areas (1/8" water gauge minimum) is recommended by the Utility Requirements Document (URD) Section 8.2.2.1.2. If uncontrolled CRHA leakage is less than 424 cfm at 1/8" water gauge positive pressure, a positive pressure above adjacent areas (1/8" water gauge minimum) will be ensured. CRHA leakage will be equal to inlet flow once an equilibrium pressure is reached. The controlled leakage path will be adjusted so total CRHA leakage is 424 cfm or greater at a minimum of 1/8" water gauge pressure.

CRHA boundary leakage can be assumed to be due to two (2) factors: 1) leakage through CRHA airlocks, and 2) leakage through CRHA envelope penetrations such as piping, electrical conduit, duct, and equipment access penetrations.

1) CRHA Airlock Leakage

The design leakage for the CRHA airlocks can be estimated using the basic equation for calculation of airflows through an opening under certain pressure difference is:

From: Mechanical Engineers Reference Manual, Ninth Edition (1995)

Equation: 3.134 derived from Bernoulli's Equation

$$V = F_{va} \times C_d \times A \times \sqrt{[2 \times g_c (p_1 - p_2) / \rho]}$$

Per Eq. 3.133:

$$F_{va} = 1 / \sqrt{(1 - \beta^4)}, \text{ Where } \beta = D2 / D1$$

But with D2 ~ 1/16" door gap, and D1 ~ infinity, since this is the open side of the door gap, then:

$$\beta \sim 0, \text{ and } F_{va} = 1 / \sqrt{(1-0)} = 1$$

Therefore:

$$V = C_d \times A \times \sqrt{[2 \times g_c (p_1 - p_2) / \rho]}$$

Removing g_c from the $\sqrt{}$ and converting the units:

$$g_c = 32.2 \text{ ft / sec}^2 \times (60 \text{ sec/1 min})^2 = 115{,}920 \text{ ft / min}^2$$

and Δp (units) = $lb_f / in^2 / 27.68$ in-wc x 144 in^2 / ft^2:

So the $\sqrt{}$ (g_c x the units conversion for Δp) = 776.56

Leaving equation 3.134 as:

$$V = 776.56 \times C_d \times A \times \sqrt{(2 \times \Delta p / \rho)}$$

Where:

V = air flow rate, cfm

C_d = discharge coefficient for opening, dimensionless

A = cross sectional area of opening, ft^2

Δp = pressure difference across opening, in-wc.

ρ = air density, lb/ ft^3

Calculation of a typical 3' X 7' air lock door:

Assumptions: Each access path has two doors in series as an airlock, so that there is only half of the 0.125" wc differential pressure across each door. Therefore, the differential pressure across each door of the airlock is 0.065" wc.

The bottom gap is 1/16", both the top and side gap are 1/16".

The air density is 0.074 lb/ ft^3 (@78°F and 50% RH).

The C_d value is 0.8 (conservative value).

Assuming the total opening area is:

A= (7'* 2 *1/16"/12) + (3' * 2 * 1/16"/12) =0.1042 ft^2

The air leakage rate is:

V = 776* 0.8 *0.1042*√ (2*0.065/0.074) = 85.74 cfm. (or ≈ 86 cfm per airlock)

There are two access paths with airlocks to the ESBWR control room. Thus total air leakage rate through these access paths is 86 x 2 = 172 cfm.

The ESBWR CRHA access doors are to be designed with self-closing devices, which close and latch the doors automatically. Industry experience with low-leakage type doors into the Control Room envelope show that leakage can be reduced with the installation of additional gaskets.

2) CRHA Envelope Penetration Leakage

While the number, type, size and location of ESBWR CRHA penetrations have not been finalized, the number of ESBWR CRHA penetrations will be minimal compared with existing nuclear plant control rooms. The following design features ensure that the ESBWR CRHA penetration leakage will be significantly less than existing control room envelope penetration leakage:

- ESBWR design results in a reduced number of electrical penetrations due to fiberoptic cabling and digital technology (eliminated cable spreading room). The Main Control Room Complex and subfloor volume is considered to be a low-risk fire area, due to the lack of high- or medium-voltage equipment or cabling (DCD Tier 2, Subsection 9.5.1).
- ESBWR Control Room is located below grade, out-leakage cannot pass directly from control room to environment.
- The outside surface of penetration sleeves in contact with concrete is sealed with epoxy or equivalent sealant. Piping and electrical cable penetrations are sealed with a qualified pressure resistant material compatible with penetration materials and/or cable jacketing.
- Inside surfaces of penetrations and sleeves in contact with commodities are sealed.
- Penetration sealing materials are designed to withstand the maximum pressure differential across the CRHA boundary. The bulk penetration sealing material is

gypsum cement or equivalent, with epoxy or equivalent sealants applied to compliment penetration sealing.

- The EFU filter train is located downstream of the EFU fan. This maintains the filter train and delivery ductwork to the CRHA at a positive pressure precluding any unfiltered in-leakage into the system. The EFU related ductwork, including the EFUs and the related ductwork outside the CRHA boundary, are designed in accordance with ASME AG-1, Article SA-4500, to provide low leakage components necessary to maintain the CRHA habitability.
- The CRHA utilizes internal recirculation Air Handling Units (AHUs) that preclude any AHU ductwork external to the CRHA envelope.

Based on these features, it is expected that the ESBWR CRHA boundary penetration leakage will be an order of magnitude less than boundary penetration leakage experienced in existing nuclear plant control rooms. A conservative leakage estimate for the total pressure envelope of an existing nuclear control room of dimensions similar to the ESBWR CRHA (e.g., Hope Creek) is 1000 cfm. Considering these ESBWR design features, 83 cfm of penetration leakage [i.e. 1/10 x (1000 - 172 cfm (airlock leakage)] is reasonable and conservative.

3) Result

Considering the leakage of the airlocks and penetrations, the estimated worst case ESBWR CRHA boundary leakage is 255 cfm (≈ 172 cfm + 83 cfm).

The estimated 255 cfm worst case ESBWR CRHA boundary leakage is less than the 424 cfm airflow supplied. The controlled CRHA leakage path (described in GEH response to RAI 9.4-29, MFN 07-687, dated December 21, 2007) is designed to be adjustable with a range of at least 0 cfm to 750 cfm discharge rate with a default or standard setting of about 169 cfm (424 cfm – 255 cfm) to ensure minimum air flow is maintained and the CRHA overpressure is not excessive (based on maximum output pressure of CRHA supply fans).

Therefore, this preliminary review of the ESBWR CRHA design supports the conclusion that a 1/8" water gauge positive pressure can be maintained with a minimum flowrate of 424 cfm. This design requirement will be validated via testing prior to fuel load (DCD Tier 1, Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) Table 2.16-2-6, ITAAC for Emergency Filtration Units), and verified during periodic surveillance testing in accordance with DCD Tier 2, Chapter 16, Technical Specification 3.7.2.

DCD Impact:

No DCD change will be made in response to this RAI.

NRC RAI 6.4-13:

DCD, Tier 2, Revision 3, Section 6.4.3 under "Component Descriptions" lists tornado dampers. The staff requests additional information to assure that appropriate protection is provided to the various intakes or discharge paths of the control room habitability area heating, ventilation and air conditioning (CRHAVS).

A. Identify in the DCD the location and quantity of the tornado dampers.

B. Identify in the DCD the supply louvers are considered safety-related and protected by tornado dampers.

C. Discuss the potential for the control building or control room habitability area to experience a sudden drop in pressure due to a tornado event as a result of an unprotected louver?

GEH Response:

A. The Control Building is designed as Seismic Category I, as stated in DCD Tier 2, Section 3.3. Seismic Category I structures are designed for tornado and extreme wind phenomena. Seismic Category I structures are required to withstand the effects of tornado missiles. The Control Building is enclosed (not vented) with the exposed exterior roofs and walls designed for the full pressure drop. Therefore, tornado protection would be required for all air intake and exhaust openings in the Control Building. Tornado dampers are provided on Emergency Filter Unit (EFU) air intake openings. There is one tornado damper for each of two trains of the EFU. Each tornado damper is located immediately downstream of the intake louver as shown in DCD Tier 2, Figure 6.4-1 and Figure 9.4-1, and DCD Tier 1, Figure 2.16.2-4. These safety-related dampers are designed to withstand the maximum tornado wind speed (330 mph) and full negative pressure drop (1.7 psi/sec) listed in DCD Tier 2, Chapter 2, Table 2.0-1, Envelope of ESBWR Standard Plant Site Design Parameters.

Tornado protection is also required for the following Control Building ventilation penetrations:

- 2 each – Control Room Habitability Area (CRHA) Outside Air Handling Unit Supply Damper
- 1 each - CRHA Restroom Exhaust Damper
- 1 each - CRHA Smoke Purge Exhaust Damper
- 1 each - Smoke Purge Intake CRHA Damper
- 1 each - CBGAVS Set A Supply Air Handling Unit Intake Damper
- 1 each - Control Building General Area Heating, Ventilation, and Air Conditioning (HVAC) Subsystem (CBGAVS) Set B Supply Air Handling Unit Intake Damper
- 1 each - CBGAVS Set A Return Exhaust Damper
- 1 each - CBGAVS Set B Return Exhaust Damper

All ventilation penetrations through the CRHA will be designed as Seismic Category I. The non-seismic Control Building ventilation penetrations will be designed (detailed design phase) to ensure that their physical collapse during a safe shutdown earthquake (SSE) will not adversely affect safety-related components.

B. DCD Tier 2, Table 9.4-2 describes the safety-related dampers required for CRHA isolation. The EFU outside air intake openings (stationary supply louvers) are safety-related. The GEH response to RAI 14.3-227 (MFN 08-086 S08, dated March 5, 2008) ensures that these components are listed as safety-related. The ductwork between the intake louver and the tornado damper will be constructed to withstand the required tornado induced pressures. The stationary louver air openings for the EFU outside air intake are also protected against missiles.

C. The Control Building is not vented (enclosed) with the exposed exterior roofs and walls designed for the full pressure drop. Tornado protection is required for all air intake and exhaust openings in the Control Building and penetrating the CRHA. As a result of these design considerations, neither the Control Building nor CRHA will experience a sudden drop in pressure due to a tornado event.

DCD Impact:

DCD Tier 2, Subsections 3.3.2.2 and 9.4.1.1, will be revised as shown in the attached markups.

Enclosure 2

MFN 08-288

* Response to Portion of NRC Request for
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Control Building Ventilation

RAI Number 6.4-13

DCD Markups

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3.3.2.1 Applicable Design Parameters

The design basis tornado and applicable missiles are described in Table 2.0-1.

3.3.2.2 Determination of Forces on Structures

The procedures of transforming the tornado loading into effective loads and the distribution across the structures are in accordance with Reference 3.3-3. The velocity pressure used meets the SRP 3.3.2 discussion. The procedure for transforming the tornado-generated missile impact into an effective or equivalent static load on structures is given in Subsection 3.5.3. The loading combinations of the individual tornado loading components and the load factors are in accordance with SRP 3.3.2.

Loading combinations and load factors used are as follows:

$W_t = W_w$

$W_t = W_p$

$W_t = W_m$

$W_t = W_w + 0.5\ W_p$

$W_t = W_w + W_m$

$W_t = W_w + 0.5\ W_p + W_m$

Where:

W_t = total tornado load

W_w = total wind load

W_p = total differential pressure load

W_m = total missile load

The reactor building, fuel building, and control building are not vented (enclosed) structures. The exposed exterior roofs and walls of these structures are designed for the full pressure drop. Tornado dampers are provided on Control Building ~~EFU~~ Emergency Filter Unit air intake openings. These dampers are designed to withstand the full negative pressure drop.

All CRHA ventilation penetrations for outside air intake and exhaust openings are provided with tornado protection. In addition, the CBVS outside air intake and return/exhaust openings are provided with tornado protection.

3.3.2.3 Effect of Failures of Structures or Components Not Designed for Tornado Loads

Safety-related systems and components are protected within tornado-resistant structures. The remainder of plant structures and components not designed for tornado loads are arranged or designed such that their failures do not adversely affect the ability of any Seismic Category I structures, systems and components to perform their safety-related function(s). Any nonsafety-related, non-seismic (NS) structure ~~(except the Radwaste Building)~~ postulated to fail under tornado loading is located at least a distance of its height above grade from Seismic Category I structures. The Radwaste Building has sufficient design margin to resist RG 1.76 tornado wind

9.4.1.1 Design Bases

Safety (10 CFR 50.2) Design Bases

Only the CRHAVS performs safety-related design basis functions in support of CRHA habitability. The habitability requirements for the CRHA are discussed and described in Section 6.4.

The CRHAVS provides the following safety-related design basis functions:

- Monitors the CRHA air supply for smoke and radioactive particulate and/or iodine concentrations;
- Isolates the normal CRHA air supply and restroom exhaust, starts an EFU fan, and aligns the air supply through an EFU, upon a high radiation detection signal in the CRHA normal air supply, or upon an extended loss of AC power to support operation of a CRHA normal air supply fan; and
- Isolates the normal CRHA air supply and restroom exhaust upon detection of smoke in the CRHA normal air supply.

The portions of the CRHAVS which penetrate the CRHA envelope are nonsafety-related and designed as Seismic Category I to provide isolation of the CRHA envelope from the outside and surrounding areas in the event of a design basis accident (DBA). The EFU portion of the subsystem is safety-related and designed and supported as Seismic Category I including the air intakes, ductwork, dampers, fans, instrumentation and controls. The remaining CRHAVS functions are nonsafety-related. The penetrations contain safety-related isolation dampers or valves that fail closed upon a loss of control signal, power, or instrument air. EFUs are automatically actuated upon radiological isolation of the CRHA envelope or an extended loss of AC power.

CBVS equipment and ductwork whose failure could affect the operability of safety-related systems or components are designed as Seismic Category II. The remaining portion of the system is nonsafety-related and nonseismic.

The following CRHA components are safety-related and Seismic Category I:

- CRHA Boundary envelope including structures, doors, and components;
- EFUs including HEPA and carbon filters and related system components;
- Ductwork from the CRHA boundary envelope up to and including the CRHA isolation dampers
- Tornado dampers are provided on EFU air intake openings. These dampers are designed to withstand the full negative pressure drop.
- All CRHA ventilation penetrations for outside air intake and exhaust openings are provided with tornado and tornado missile protection.
- The CBVS outside air intake and return/exhaust openings are provided with ~~structures are nonsafety-related and do not require~~ tornado ~~dampers~~ and tornado missile ~~shields~~protection.