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MFN 08-288 Supplement 1

Docket No. 52-010

September 5, 2008

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 203 Related to ESBWR Design Certification Application - Control Room Habitability Area - RAI Number 6.4-9 S01**

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the subject NRC RAI originally transmitted via the Reference 1 letter and supplemented by an NRC request for clarification in Reference 2.

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 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
2. MFN 08-496, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 203 Related to ESBWR Design Certification Application*, May 27, 2008

Enclosures:

1. MFN 08-288 Supplement 1 - Response to Portion of NRC Request for Additional Information Letter No. 203 Related to ESBWR Design Certification Application - Control Room Habitability Area - RAI Number 6.4-9 S01
2. MFN 08-288 Supplement 1 - Response to Portion of NRC Request for Additional Information Letter No. 203 Related to ESBWR Design Certification Application - Control Room Habitability Area - RAI Number 6.4-9 S01 - DCD Markups

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Enclosure 1

MFN 08-288 Supplement 1

Response to Portion of NRC Request for Additional Information Letter No. 203 Related to ESBWR Design Certification Application

Control Room Habitability Area

RAI Number 6.4-9 S01

For historical purposes, the original text of RAI 6.4-9, and the GEH response, is included.

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:

$$V = 776 * 0.8 * 0.1042 * \sqrt{(2 * 0.065/0.074)} = 85.74\ \text{cfm. (or} \approx 86\ \text{cfm per airlock)}$$

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 during startup testing (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 6.4-9 S01:

The response to the RAI provided by GEH included an analysis which demonstrated the feasibility of maintaining the tested differential pressure with the design makeup air flow *rate. Please update the DCD to include a short summary of the analysis with conclusions and a reference to the SRP Section 6.4, Acceptance Criteria 3.B requirement for the analysis.*

GEH Response:

The control room makeup airflow is sized for leakage from the Control Room Habitability Area (CRHA) boundary when the CRHA is pressurized to a positive pressure differential of 1/8-inch water gage. An analysis of the CRHA boundary was performed based on the planned leak-tight design features in accordance with the requirements of NUREG-0800, Standard Review Plan (SRP), Section 6.4, Acceptance Criteria 3.B. This analysis included boundary leakage paths in the CRHA envelope such as doors, dampers, and penetrations for piping, electrical conduit, duct and HVAC equipment. Based on the CRHA 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 airflow rate. DCD Tier 2, Subsection 6.4.3, will be revised to include a description of the CRHA boundary leakage analysis.

DCD Impact:

DCD Tier 2, Subsection 6.4.3, will be revised as shown in the attached markups.

Enclosure 2

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Control Room Habitability Area

RAI Number 6.4-9 S01

DCD Markups

- Inside surfaces of penetrations and sleeves in contact with commodities are sealed.
- Penetration sealing materials are designed to withstand at least a 62 Pa (¼ inch w.g.) pressure differential. The bulk penetration sealing material is gypsum cement or equivalent, with epoxy or equivalent sealants applied to compliment penetration sealing.
- The CRHA utilizes internal recirculation AHUs that preclude any AHU ductwork external to the CRHA envelope.

The following isolation dampers penetrate the CRHA boundary envelope as shown on Figure 6.4-1:

a. Smoke purge intake CRHA isolation dampers, two dampers.

b. Normal Outside Air Intake Supply CRHA isolation dampers, two dampers.

c. Restroom exhaust CRHA isolation dampers, two dampers.

d. Smoke purge exhaust CRHA isolation dampers, two dampers.

e. EFU supply CRHA isolation dampers, two dampers per division, total of four dampers.

The control room makeup air flow is sized for leakage from the control room boundary when the control room is pressurized to a positive pressure differential of 31 Pa (1/8 inch water gage). An analysis of the control room boundary was performed based on the planned leaktight design features in accordance with the requirements of Standard Review Plan (SRP) Section 6.4, 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 airflow 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. 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