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Subject: **Transmittal of ESBWR Responses to CRHA Open Topic Items #3 and #6 Arising from Meeting on June 23, 2009**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) responses to ESBWR Control Room Habitability Area (CRHA) open topic items #3 and #6. This letter is a follow-up to close GEH open items arising from an NRC review of the ESBWR CRHA systems conducted on June 23, 2009 (Reference 1).

Enclosures 1 and 2 contain the GEH responses to open topic items 3 and 6, respectively. The response to open topic item #5 was previously submitted to the NRC via Reference 2. Responses to open topic items #1, #2 and #4 will be submitted under separate future cover letter(s).

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

Sincerely,

Richard E. Kingston

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Vice President, ESBWR Licensing

Reference:

1. MFN 09-473, Summary of the June 23, 2009, Partially Closed Meeting with GEH regarding Control Room Habitability Area, July 1, 2009
2. MFN 09-525, Transmittal of ESBWR CRHA Heatup Calculation, including Applicable Input and Output Data Files, August 4, 2009

Enclosures:

1. Transmittal of ESBWR Responses to CRHA Open Topic Items #3 and #6 Arising from Meeting on June 23, 2009 - Response to Open Topic Item #3
2. Transmittal of ESBWR Responses to CRHA Open Topic Items #3 and #6 Arising from Meeting on June 23, 2009 - Response to Open Topic Item #6

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		0000-0105-8903 (Open Topic Item #6)

Enclosure 1

MFN 09-551

Transmittal of ESBWR Responses to CRHA Open Topic Items #3 and #6 Arising from Meeting on June 23, 2009

Response to Open Topic Item #3

Response to Open Topic Item #3

TOPIC ITEM

Provide a reassessment of Operator Action / Attention to control CRHA pressure variation in light of changing temperatures and densities with a constant volume supply flow rate (466 cfm) and a manually adjusted orifice control.

CONCLUSION

This GEH assessment has concluded that minimal, if any, operator action will be required for adjusting the Variable Orifice Relief Device during the post accident, changing inlet air temperature/density, time period. The following detailed discussion supports this conclusion.

DETAILED DISCUSSION / ANALYSIS

During the TelePresence call between GEH and the NRC on June 23, 2009, an open item was generated for GEH to review the RAI 9.4-30 S02 response and determine the level of Operator action required during EFU operation under DBA conditions (i.e. adjust orifice every 12 hrs to maintain positive pressure...). If the CRHA temperature increases 23°F (70°F to 93°F) over 72 hrs, what adjustment would be expected to maintain a positive 1/8 in. w.g. with respect to adjacent areas?

RAI 9.4-30 S02 discusses adequacy of the flow into the CRHA with respect to varying outside temperature and concludes, "Adjustment of the CRHA variable leakage device upon accident initiation is not anticipated". This discussion expands on that response using the outside air cyclical temperature variation and projected inside temperature, and evaluates the flow balance on MCR positive pressure variations.

The following assumed parameters affect the CRHA air mass / volumetric balance as shown in Figure 1:

1. The EFU delivers a minimum of 466 cfm to the MCR during accident conditions. The current CRHA Heatup analysis used 240 l/s (509 cfm) as documented in DCD Tier 2 Table 3H-12 (DCD Rev 6 Preliminary Version). This higher flowrate is conservatively assumed in this analysis since a higher airflow produces a greater differential pressure across the main control room.
2. The temperature of the EFU delivered air is at the 0% exceedance value. This, as stated in the latest CRHA Analysis, is assumed at 47.2°C (117°F db / 80°F wb) with a 15°C (27°F) profile (ref DCD Tier 2 Table 3H-14) or low temp of 90°F db / 73°F wb.

3. The Exhaust from the CRHA via exfiltration is through the Variable Orifice Relief Device. The temperature of this exfiltration is assumed at an initial temperature of 21.1°C (70°F) rising to 33.9°C (90°F) over 72 hrs. The 21.1°C (70°F) db (20% humidity) initial temperature is based on the lower temperature of the normal CRHA temperature band (ref DCD Tier 2 Table 6.4-1 & Table 9.4-1). Using this initial temperature results in the greatest temperature difference (conservative) upon loss of normal CRHA cooling. The 33.9°C (90°F) final temperature is based upon calculated temperature profile (ref. Gothic Heat Up Analysis Summary GEH 0000-0084-3844R5; MFN 09-525, Enclosure 2; August 4, 2009)
4. The heat sources and heat sinks in the MCR are assumed constant over the evaluation period.
5. The CRHA differential pressure is assumed constant at 0.125" w.g.
6. Airlock Operation: No consideration has been given to the change in CRHA differential pressure due to personnel ingress/egress during this time period since pressure fluctuation is assumed very minor and immediately recovers (first 72 hrs after loss of normal HVAC and initiation of EFU operation). Airlock Vestibule A (larger of two airlocks) volume is 42.5 m3 (1500 ft 3) or ~1.6 % of total CRHA 2724 m3 (96,197 ft 3) volume. If one considers the pressure in the airlock to be atmospheric, the CRHA pressure drops only to 0.121" w.g. during door opening.

Method:

A simple mass balance on the controlled volume is then performed to estimate changes in air specific volume (volumetric flowrate) due to daily temperature profile.

<u>EFU DELIVERED CRHA INLET AIR FLOW</u>

Using the Temperatures and assumptions 1 and 2 above, the change in air specific volume can be determined using the psychometric chart with this change proportional to the change in volumetric airflow:

Air specific volume at 117°F db & 80°F wb (20% humidity)
= 14.85 ft^3 / lb-air (Density = 0.0673 lb-air/ft^3)

Air specific volume at 90°F db & 73°F wb (45% humidity)
= 14.16 ft^3 / lb-air (Density = 0.0706 lb-air/ft^3)

$$\Delta\text{Supply Air Specific vol.} = [14.85\ ft^3/\text{lb-air} - 14.16\ ft^3/\text{lb-air}] / 14.85\ ft^3/\text{lb-air} = 0.0465 = 4.65\%$$

Considering the basic fan laws, the flow developed by a fan (Q) to create the same DP varies as a square of the change in density (ρ): (Ref Mechanical Engineering Reference Manual, Michael Lindeburg, 8th Ed, EQ 5.15)

$$Q(b) = Q(a)\sqrt{\frac{\rho(a)}{\rho(b)}}$$

$$Q(b) = Q(a)\sqrt{\frac{0.0673_lb-air/ft3}{0.0706_lb-air/ft3}}$$

$Q_b = 0.9763\ Q_a$

The change in EFU delivered airflow expected due to the temperature swing for a day is less than 2.4%. For an EFU flowrate of 509 cfm, this equals to a variation of 12.2 cfm over a 24-hour period. As reflected on Figure 2, EFU Fan Curve, a change in flow from 509 cfm to 497 cfm would result in a change of pressure developed of less than 0.05 inch w.g. With this change the variation in airflow and the change in EFU static pressure is minimal.

<u>EXHAUST AIR FLOW</u>

The CRHA exhaust flow is based purely on the differential pressure across the variable orifice and the density of the air flowing across it. Using assumption 3 above, the change in flow is calculated with the density change at the following temperatures with a constant CRHA differential pressure.

The specific volume / density the air at the various conditions is as follows:

Final Air temp / specific volume: 90°F db & 73°F wb (45% humidity)
= 14.16 ft^3 / lb-air (Density = 0.0706)
Initial Air temp / specific volume: 70°F db & 51.5°F wb (25% humidity)
= 13.45 ft^3 /lb-air (Density = 0.0743)

The following formula is from "Crane – Flow of Fluids Through Valves and Fittings":

$$q = YCA\sqrt{\frac{2g(144)\Delta P}{\rho}} \qquad \text{Equation 2-24}$$

where;

K = 1 from page A-21
Y = Net Expansion Factor from page A-21 (K=1.4 for Air)= 1.0
C=Flow Coefficient for Orifices and Nozzles from page A-20 using B ~ 0.20 = 1.0
A= Cross section of pipe / orifices (Ft^2)
ρ = Density lb/Ft^3
ΔP =Differential Pressure = 0.125" w.g. = (0.125" w.g. x 0.036092 #/in^2/w.g.) = 0.0045 #/in^2

$$q(90F) = YCA\sqrt{\frac{2g(144)\Delta P}{\rho}} = q = (1.0)(1.0)A\sqrt{\frac{2(32.2)(144)(0.0045)}{1/14.16}} = 24.31A$$

$$q(70F) = YCA\sqrt{\frac{2g(144)\Delta P}{\rho}} = q = (1.0)(1.0)A\sqrt{\frac{2(32.2)(144)(0.0045)}{1/13.45}} = 23.69A$$

Using an A (area) of 1/3 of a square foot for both conditions yields:
q_{90F} = 8.022 ft3/sec = 481 cfm
q_{70F} = 7.82 ft3/sec = 469 cfm

The difference in CRHA discharge flow yields approximately 12 cfm due to the temperature increase over the 72 hours following an accident. This temperature change and corresponding airflow change is less than that observed due to the daily swing in outside air temperature. No change in the CRHA variable leakage device adjustment position would be expected for this condition.

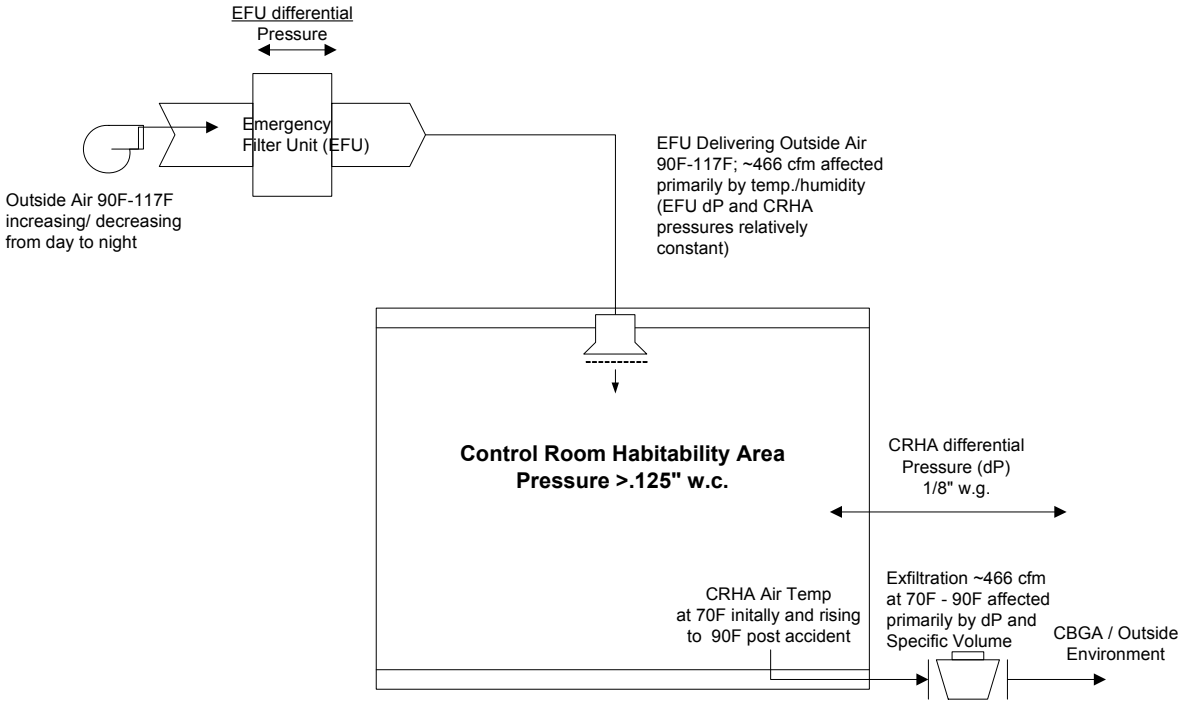

Figure 1 - CRHA Mass / Volumetric Balance

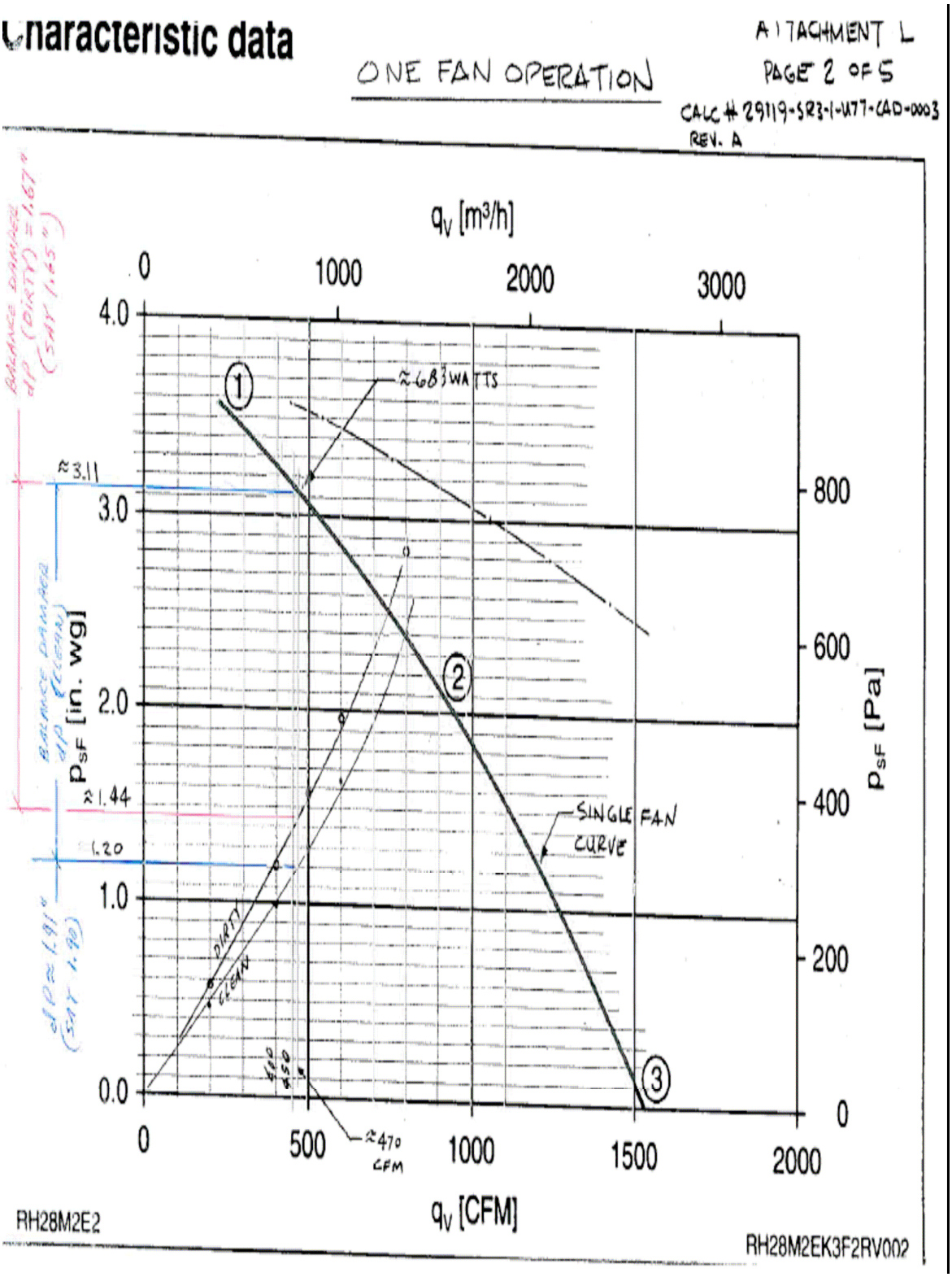

Figure 2 – EFU Fan Curve Example

Enclosure 2

MFN 09-551

Transmittal of ESBWR Responses to CRHA Open Topic Items #3 and #6 Arising from Meeting on June 23, 2009

Response to Open Topic Item #6

Response to Open Topic Item #6

TOPIC ITEM

In regards to tracer gas testing of the CRHA, the NRC requested that GEH identify the amount of unfiltered inleakage that is allocated for access and egress. Also confirmation that the tracer gas testing criteria identified in the Programs and Manuals section of the Technical Specification will be based on the unfiltered inleakage used in the dose consequence analyses minus the amount of unfiltered inleakage assumed for access and egress was requested.

GEH RESPONSE

The amount of unfiltered inleakage to be allocated for access and egress is unavailable at this time. The test procedure for determining unfiltered air inleakage past the CRHA boundary into the CRHA, (which includes the amount of unfiltered inleakage that is allocated for access and egress) will be developed under the Control Room Habitability Area (CRHA) Boundary Program by the COL Applicant. Details related to the CRHA Unfiltered Inleakage Test, including the acceptance criteria for measured unfiltered leakage, will be determined during development of the specific test. The requirement to develop procedures that address this aspect of Control Room Habitability is defined in DCD Tier 2 Section 6.4.4 under COL Applicant Item 6.4-1-A:

> **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 (Subsection 6.4.4).

As stated in DCD Tier 2 Chapter 16, Section 5.5.12, Control Room Habitability Area (CRHA) Boundary Program, the program shall include the following elements:

> Requirements for (i) determining the unfiltered air inleakage past the CRHA boundary into the CRHA in accordance with the testing methods and at the Frequencies specified in Sections C.1 and C.2 of Regulatory Guide 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," Revision 0, May 2003,
>
> and
>
> (ii) assessing CRHA habitability at the Frequencies specified in Sections C.1 and C.2 of Regulatory Guide 1.197, Revision 0.

The CRHA boundary is maintained in accordance with Specification 5.5.12, "Control Room Habitability Area (CRHA) Boundary Program," to ensure that the inleakage of unfiltered air into the CRHA will not exceed the inleakage assumed in the licensing basis analysis of design basis accident (DBA) consequences to CRHA occupants. The inleakage acceptance criteria will include a value for inleakage that is due to ingress to and egress from the CRHA as required under RG 1.197 Clarification 2.5.

DISCUSSION

This GEH radiological analysis is modeled using RADTRAD (NEDE 33279P, Rev. 3, ESBWR Containment Fission Product Removal Evaluation Model). The RADTRAD computer code is discussed in detail in NUREG/CR-6604, "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation". The inputs for this analysis are presented in DCD Tier 2, Chapter 15, Table 15.4-5, Loss-of-Coolant Accident Dose Consequence Analysis Parameters.

The input parameters to the dose model were:

- CRHA (emergency zone) volume;
- EFU (emergency filter unit) efficiency;
- EFU flowrate; and
- Unfiltered Inleakage.

The Control Room EFU supplies air with a design flow rate of 220 l/s (466 cfm), and it is designed to maintain the control room envelope at a positive pressure with respect to adjacent compartments from the onset of a radiological event. An intake filter efficiency of 99% is assumed for particulate, elemental, and organic iodine species. The system does not include filtered recirculation. Although the control room is maintained at a positive pressure, the dose analysis assumes a 5.66 l/s (12.0 cfm) unfiltered inleakage. The discharge flow from the control room is adjusted proportionally to account for the additional inleakage.

Based on the ESBWR CRHA design and ventilation system operation, the acceptance criteria for inleakage associated with CRHA access and egress will be near zero or considered zero during development of the CRHA Unfiltered Inleakage Test.

- SRP 6.4 notes that CRHA ventilations systems consisting of zone isolation with filtered recirculated air (SRP System Type e.iii) and a positive pressure provided with an automatic isolation with immediate automatic pressurization mode ensures that infiltration (unfiltered) is reduced to near zero immediately upon accident detection. The ESBWR CRHA ventilation system provides automatic isolation while maintaining **continuous** positive pressure without recirculation (SRP System Type e.i). This ventilation design type does not need to consider inleakage prior to initiation of "immediate" pressurization (puff) or inleakage from

recirculation ductwork that is subject to vacuum (interface with suction side of fan). Therefore, unfiltered inleakage, including ingress/egress will be less than systems that must develop a positive pressure to mitigate inleakage.

- SRP 6.4 notes that CRHA ventilations systems consisting of zone isolation with filtered recirculated air normally assume 5 l/s (10 cfm) infiltration for conservatism. Note 4) of SRP 6.4 section III.3.E.iii states "*This flow could be reduced or eliminated if the applicant provides assurance that backflow (primarily as a result of ingress and egress) will not occur. This may mean installing two-door vestibules or equivalent.*" The ESBWR CRHA is provided with two sets of doors, with a vestibule between them that acts as an airlock, at each of the two access locations for the main control room. Therefore, unfiltered inleakage due to ingress/egress may be considered eliminated during development of the CRHA Unfiltered Inleakage Test.

- As noted in the ESBWR Containment Fission Product Removal Evaluation Model, unlike most current generation plants, the ESBWR control room is located below grade; therefore, radioactivity cannot leak directly from the environment into the control room. As such, any unfiltered inleakage would have to first leak into the Control Building where it would be diluted. After that, it would then leak from the Control Building's general atmosphere into the control room envelope itself. Limitations with the RADTRAD code prevent this phenomenon from being directly modeled. Therefore, the unfiltered inleakage term is conservatively assumed. This is another consideration for establishing a minimal limit for unfiltered inleakage due to ingress/egress during development of the CRHA Unfiltered Inleakage Test.

- Another consideration for establishing a minimal limit for unfiltered inleakage due to ingress/egress during development of the CRHA Unfiltered Inleakage Test is that nuclear grade airlocks, such as specified for the ESBWR CRHA two-door vestibules, are designed to provide virtually leak-free operation.