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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application - Containment Systems - RAI Numbers 6.2-36 S01 and 6.2-46 S02**

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) responses to the subject NRC RAIs originally transmitted via the Reference 1 letter and supplemented by NRC requests for clarification in Reference 2 and Reference 3, respectively.

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

Sincerely,

James C. Kinsey

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Vice President, ESBWR Licensing

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NRO

References:

1. MFN 06-113, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, *Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application*, April 24, 2006
2. E-Mail from Shawn Williams, U.S. Nuclear Regulatory Commission, to George Wadkins, GE Hitachi Nuclear Energy, dated May 24, 2007 (ADAMS Accession Number ML071490063)
3. MFN 07-556, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application*, October 15, 2007

Enclosure:

1. MFN 08-067 - Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application - Containment Systems - RAI Numbers 6.2-36 S01 and 6.2-46 S02

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	eDRF	0000-0056-7613R2

Enclosure 1

MFN 08-067

Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application

Containment Systems

RAI Numbers 6.2-36 S01 and 6.2-46 S02

NRC RAI 6.2-36 S01:

In GE's response to RAI 6.2-36, MFN 06-264, GE concluded that No DCD changes will be made in response to this RAI. While DCD Rev. 3 does contain the M&E tables for the various breaks, there is no analysis of record (AOR) for the M&Es - they just appear without explanation.

A. *The staff finds that the information provided in the response, except for the proprietary comparison of ABWR vs. ESBWR mass and energy release data for case 1 (bounding case), belongs in the DCD so that staff can reach a reasonable assurance finding that the M&Es are consistent with the SRP and that GDC 4 is met. In addition, Table 6.2-11 needs to be updated to reflect the break size for each break to ensure that the building ITAAC will confirm the validity of the assumptions used for these calculations.*

B. *The SAFER04V computer code is not mentioned in the ABWR DCD, Revision 4, yet your RAI response states that SAFER04V Computer Code was used for the mass and energy blowdown calculations for the ABWR. ABWR, DCD, Revision 4, Section 6.2.3.3.1.3, Design Evaluation, states that, for the postulated high energy line break, the blowdown mass and energy release rates from the break were determined using Moodys homogeneous equilibrium model for critical flow described in Reference 6.2-2, F.J. Moody, Maximum Discharge Rate of Liquid-Vapor Mixtures from Vessels, General Electric Company, Report No. NEDO-21052, September 1975. The SAFER04V computer code is a LOCA analysis code and it is not apparent that it was used for the mass and energy analysis of the ABWR. Please confirm that the SAFER04V code did generate the ABWR M&Es and provide the appropriate references for the analyses (to support, if necessary, a staff audit). Provide a reference were the staff has accepted this code for this purpose.*

C. *The dynamics of a break response is not provided. This type of information was presented in ABWR DCD, for example page 6.2-54, Section 6.2.3.3,1.3.1, and page 6.2-55, Section 6.2.3.3.1.3.2. This type of information needs to be captured in the ESBWR DCD as changes to valve types, process signals, etc. could change the M&Es. For each break in Table 6.2-11, update the DCD description to include the narrative of the event, including such items as timing of valve movements (open and close), process and safety signal and delay set point assumptions, and other relevant information (initial condition, such as pressures and temperatures) which will enable the staff to determine if a plant design change will require a new licensing analysis.*

GEH Response:

A. DCD Tier 2, Subsection 6.2.3.3 will be revised to include the information provided in the response to RAI 6.2-36, except for the proprietary comparison of ABWR versus ESBWR mass and energy release data for Case 1. The requested information will be included in the DCD Tier 2, Subsection 6.2.3.3, instead of DCD Tier 2, Subsection 6.2.1.2.3 as specified in the original RAI response. Subsection 6.2.1.2 is specifically for containment subcompartments. However, the subcompartment pressurization due to high energy line break in this RAI response were analyzed in the reactor building outside the containment. Therefore, it is more appropriate to include this information in Subsection 6.2.3.3 instead of Subsection 6.2.1.2.3. In addition, DCD Tier 2, Table 6.2-11 will be updated to reflect the break size for each break presented.

B. There are a couple of issues that need to be clarified. First, it is confirmed that the SAFER04V computer code was not used in the ABWR DCD to calculate the mass and energy blowdown rate due to a Reactor Water Cleanup (RWCU) pipe break outside primary containment (Reference 1). Second, the statement that "mass and energy blowdown input data for break cases have been taken to be the same as for the ABWR design" in the previous response was incorrectly worded. It meant to state, "mass and energy blowdown input data for break cases have been taken to be the same as for an earlier BWR plant design." Justifications were provided in the previous response to RAI 6.2-36, and will be included in the revision to DCD Tier 2, Subsection 6.2.3.3, as mentioned in part A of this RAI supplemental response. A new Reference 6.2-8 will be added to DCD Tier 2, Subsection 6.2.9, to reference the methodology of the determination of the blowdown mass and energy release rates.

C. DCD Tier 2, Subsection 6.2.3.3 will be revised to include a narrative of the event, and will be applicable to all five cases analyzed since the breaks are all located downstream of the isolation valve and the dynamics of the break responses are similar.

<u>Reference</u>

1) NUREG 1503, "Final Safety Evaluation Report – Related to the Certification of the Advanced Boiling Water Reactor Design," Section 6.2.1.7, July 1994.

<u>DCD Impact:</u>

DCD Tier 2, Subsection 6.2.3.3, Subsection 6.2.9, and Table 6.2-11 will be revised as shown in the attached markups.

6.2.3.3 Design Evaluation

Fission Product Containment

There is sufficient water stored within the containment to cover the core during both the blowdown phase of a LOCA and during the long-term post-blowdown condition. Because of this continuous core cooling, fuel damage and fission product release is a very low probability event. If there is a release from the fuel, most fission products are readily trapped in water. Consequently, the large volume of water in the containment is expected to be an effective fission product scrubbing and retention mechanism. Also, because the containment is located entirely within the RB, multiple structural barriers exist between the containment and the environment. Therefore, fission product leakage from the RB is mitigated.

Compartment Pressurization Analysis

RWCU pipe breaks in the RB and outside the containment were postulated and analyzed. For compartment pressurization analyses, HELB accidents are postulated due to piping failures in the RWCU system where locations and size of breaks result in maximum pressure values. Calculated pressure responses have been considered in order to define the peak pressure of the RB compartments for structural design purposes. The calculated peak compartment pressures, which include a 10% margin, are listed in Table 6.2-12a, out of which the maximum is 32.6 kPag which is below the RB compartment pressurization design requirement as discussed in Subsection 3G.1.5.2.1.11.

For short term pressurization response due to postulated high energy line break (HELB) accidents outside the containment, mass and energy blowdown input data for break cases have been taken to be the same as for an earlier BWR plant design, since its RWCU is similar to the ESBWR RWCU/SDC system. For the postulated HELB, the blowdown mass and energy release rates from the break were determined by using Moody's homogeneous equilibrium model for critical flow described in Reference 6.2-8.

The analysis using this BWR plant's mass and energy release data for ESBWR is considered conservative for the following reasons:

(a) The break fluid specific enthalpy for energy release consideration is equal to the stagnation enthalpy of the fluid in the ruptured pipe. The specific stagnation enthalpy in the ESBWR is the same as in this BWR plant.

(b) The ESBWR RWCU/SDC system design has air/nitrogen-operated containment isolation valves whose closing times are much shorter than the motor-operated containment isolation valves used in this BWR RWCU system.

Additionally, a conservative ESBWR RWCU model based on RELAP5/Mod3.3 Code has been developed to evaluate the mass and energy release for the five break locations (listed in Table 6.2-11). It has been found that the mass and energy release data from this BWR bound the ESBWR data during the first few seconds of the transient, which is the important time period for subcompartment pressurization.

The total blowdown duration of 76 seconds is based on the assumption that the isolation valve starts to close at 46 seconds, which includes 1 second of instrument response time and 45 seconds built in time delay in blowdown differential flow detection logic, and fully closed in 30 seconds.

After the initial inventory depletion period, the steady RPV blowdown is choked at the venturi located upstream of the isolation valve since the venturi flow area is smaller than the isolation valve flow area. After the isolation valve starts closing, as soon as the valve area becomes equal to the venturi flow area, the break flow is chocked at the isolation valve. The break flow stops when the isolation valve is fully closed.

The narrative of the event described above is applicable to all five cases analyzed since the breaks are all located downstream of the isolation valve and the dynamics of the break responses are similar. Descriptions of the break locations and break sizes are provided in Table 6.2-11. Mass and energy blowdown data are presented in Table 6.2-12b.

~~Values of the mass and energy releases produced by each break are in accordance with ANSI/ANS-56.4. The break fluid enthalpy for energy release considerations is equal to the stagnation enthalpy of the fluid in the rupture pipe. The mass and energy blowdown from the postulated broken pipe terminates when system isolation valves are fully closed after receiving the pertinent isolation closure signal. Mass and energy blowdown data are given in Table 6.2-12b.~~

Subcompartment pressurization effects resulting from the postulated breaks of high-energy piping have been performed according to ANSI/ANS-56.10. In order to calculate the pressure response in the RB and outside the containment due to high-energy line break accidents, CONTAIN 2.0 code was used according to the nodalization schemes shown in Figure 6.2-18. The nodalization contains the rooms where breaks occur, and all interconnected rooms/regions through flow paths such as doors, hatches, etc. Flow path and blow out panel characteristics are given in Table 6.2-12, and subcompartment nodal description are given in Table 6.2-12a. Blow out panels are passive, and blow out pressure listed in Table 6.2-12 is the upper bound. Heat sinks are credited and the characteristics are given in Table 6.2-12c.

The selected nodalization maximizes differential pressure. Owing to the geometry of the regions, each room-region was assigned to a node of the model. No simple or artificial divisions of rooms were considered to evaluate the sensitivity of the model to nodalization. A sensitivity study of pressure response was performed to select the time step. Additional sensitivity studies were performed to evaluate the impact of the heat sinks, dropout, and inertia term. Modeling follows the recommendations given by SMSAB-02-04, "CONTAIN Code Qualification Report/User Guide for Auditing Subcompartment Analysis Calculations."

6.2-9 REFERENCES

6.2-1 GE Nuclear Energy, "TRACG Application for ESBWR," NEDC-33083P-A, Class III, (Proprietary), March 2005, and NEDO-33083-A, Class I (non-proprietary), October 2005.

6.2-2 Galletly, G.D., "A Simple Design Equation for Preventing Buckling in Fabricated Torispherical Shells under Internal Pressure," ASME Journal of Pressure Vessel Technology, Vol.108, November 1986.

6.2-3 GE letter from David H. Hinds to U.S. Regulatory Commission, TRACG LOCA SER Confirmatory Items (TAC # MC 8168), Enclosure 2, Reactor pressure Vessel (RPV) Level Response for the Long Term PCCS Period, Phenomena Identification and Ranking Table, and Major Design Changes from Pre-Application Review Design to DCD Design, MFN 05-105, October 6, 2005

6.2-4 GE letter from David H. Hinds to U.S. Regulatory Commission, Revised Response – GE Response to Results of NRC Acceptance Review for ESBWR Design Certification Application – Item 2, MFN 06-094, March 28, 2006.

6.2-5 Moody, F J., "Maximum Flow Rate of a Single Component, Two-Phase Mixture," Journal of Heat Transfer, Trans. ASME, Series C, Vol. 87, P 134, February 1965.

6.2-6 Deleted.

6.2-7 GE-Hitachi Nuclear Energy, "ESBWR Feedwater Temperature Operating Domain Transient and Accident Analysis", NEDO-33338, ~~scheduled September~~October 2007.

6.2-8 Moody, F. J. "Maximum Discharge Rate of Liquid-Vapor Mixtures from Vessels," General Electric Company, Report No. NEDO-21052, September 1975.

Table 6.2-11

RWCU/SDC Break Locations

Break Case	Description	Break size (mm)
1	Break in RWCU/SDC Non-Regenerative Heat Exchanger (NRHX) Room	300
2	Break in NRHX Valve Room	150
3	Break in Regenerative Heat Exchanger Room	150
4	Break in RWCU/SDC Pump Rooms	200
5	Break in RWCU/SDC Filter/Demineralizer Room	150

NRC RAI 6.2-46 S02:

MFN 06-264 Supplement 1, Enclosure 1, Table 6.2-12 (Subcompartment Vent Path Designation) on Page 9 inconsistently reports "FORWARD" in the Flow Direction column, and "TWO WAY PATH" in the last (Comments) column, for Flow Path No. 6. A review of Figure 6.2-18 on Page 23 shows that Flow Path No. 6 joining Cells 6 and 7 is indeed a two-way path and not a blow-out panel. Therefore, "BOTH" should rather be reported for Flow Path No. 6 in the Flow Direction column of Table 6.2-12. DCD, Tier 2, Revision 3, should be revised accordingly.

GEH Response:

It is confirmed that the flow direction of Flow Path No. 6 in DCD Tier 2, Table 6.2-12, is "both" instead of "forward" consistent with the "two way path" in the comments column. DCD Tier 2, Table 6.2-12, will be revised to reflect "both" instead of "forward."

DCD Impact:

DCD Tier 2, Table 6.2-12, will be revised as shown in the attached markup.

Table 6.2-12

Subcompartment Vent Path Designation

Flow Path No.	Type	Cell From	Cell To	P (m)	DH (m)	L/DH	T	K FORW	K REVER	K AVERA	K CONTAIN	Flow Condition	Flow Direction	Blow Out Pressure (k Pa)	Comments
1	DOOR	1	2	8.00	2.00	1.00	0.24	1.56	1.61	1.58	0.79	SUBSONIC	BOTH	NO	TWO WAY PATH
2	DOOR	2	3	8.00	2.00	0.50	0.97	1.51	1.24	1.38	0.69	SUBSONIC	FORWARD	10.34	
3	DOOR	2	3	8.00	2.00	0.50	0.97	1.52	1.26	1.39	0.70	SUBSONIC	FORWARD	10.34	
4	DOOR	3	4	8.00	2.00	0.35	1.13	1.25	1.24	1.24	0.62	SUBSONIC	FORWARD	10.34	
5	DOOR	3	5	8.00	2.00	0.25	1.19	1.31	1.32	1.31	0.66	SUBSONIC	FORWARD	10.34	
6	DOOR	6	7	8.00	2.00	1.00	0.24	1.56	1.61	1.58	0.79	SUBSONIC	~~FORWARD~~ BOTH	NO	TWO WAY PATH
7	DOOR	7	5	8.00	2.00	0.50	0.97	1.52	1.26	1.39	0.70	SUBSONIC	FORWARD	10.34	
8	DOOR	7	5	8.00	2.00	0.50	0.97	1.51	1.24	1.38	0.69	SUBSONIC	FORWARD	10.34	
9	DOOR	8	4	8.00	2.00	1.00	0.24	1.43	1.47	1.45	0.72	SUBSONIC	FORWARD	10.34	
10	DOOR	9	10	8.00	2.00	1.00	0.24	1.49	1.48	1.49	0.74	SUBSONIC	FORWARD	10.34	
11	DOOR	10	5	8.00	2.00	0.35	1.13	1.25	1.24	1.24	0.62	SUBSONIC	FORWARD	10.34	
12	DOOR	10	4	8.00	2.00	0.25	1.19	1.24	1.24	1.24	0.62	SUBSONIC	FORWARD	10.34	
13	DELETED														
14	OPEN SPACE	12	16	10.00	2.00	0.50	0.97	0.90	0.47	0.69	0.34	SUBSONIC	BOTH	NO	TWO WAY PATH
15	OPEN SPACE	13	16	10.00	2.00	0.50	0.97	0.90	0.47	0.69	0.34	SUBSONIC	BOTH	NO	TWO WAY PATH
16	OPEN SPACE	14	16	10.00	2.00	0.50	0.97	0.93	0.48	0.71	0.35	SUBSONIC	BOTH	NO	TWO WAY PATH
17	OPEN SPACE	15	16	10.00	2.00	0.50	0.97	0.93	0.48	0.70	0.35	SUBSONIC	BOTH	NO	TWO WAY PATH
18	OPEN SPACE	3	12	10.00	2.00	0.50	0.97	0.47	0.90	0.69	0.34	SUBSONIC	BOTH	NO	TWO WAY PATH