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MFN 08-718

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Subject: Response to Portion of NRC Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application - Containment Systems - RAI Numbers 6.2-182, 6.2-183, 6.2-187, and 6.2-190

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) responses to the subject NRC RAIs transmitted via the Reference 1 letter. DCD Markups related to RAI Numbers 6.2-182 and 6.2-183 are provided in Enclosures 2 and 3, respectively.

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 08-576, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application*, July 10, 2008

Enclosures:

1. MFN 08-718 - Response to Portion of NRC Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application - Containment Systems - RAI Numbers 6.2-182, 6.2-183, 6.2-187, and 6.2-190
2. MFN 08-718 - Response to Portion of NRC Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-182 - DCD Markups
3. MFN 08-718 - Response to Portion of NRC Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-183 - DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	eDRF	RAI 6.2-182: 0000-0090-8718
		RAI 6.2-183: 0000-0091-2482
		RAI 6.2-187: 0000-0090-5953
		RAI 6.2-190: 0000-0089-1596

Enclosure 1

MFN 08-718

Response to Portion of NRC Request for Additional Information Letter No. 224 Related to ESBWR Design Certification Application

Containment Systems

RAI Numbers 6.2-182, 6.2-183, 6.2-187, and 6.2-190

NRC RAI 6.2-182:

In Section 6.2.1.2, ESBWR DCD Revision 5, the statement "An acceptable vent critical flow correlations are the "frictionless Moody" with a multiplier for watersteam mixtures, and . . ." should be deleted because this multiplier was not used.

GEH Response:

The statement in the fourth dash bullet under the second dot bullet in DCD Tier 2, Subsection 6.2.1.2, will be removed as requested.

DCD Impact:

DCD Tier 2, Subsection 6.2.1.2, will be revised as noted in the attached markup.

NRC RAI 6.2-183:

Please list Chapter 6 appendices on the table of contents.

GEH Response:

DCD Tier 2, Chapter 6, Table of Contents, will be revised as requested.

DCD Impact:

DCD Tier 2, Chapter 6, Table of Contents, will be revised as noted in the attached markup.

NRC RAI 6.2-187:

Tier 2 Chapter 06 Revision 4 to Revision 5 Change List lists changes to ESBWR DCD figures and tables based on the following: "Updated the analysis results based on the design input changes, including: 30 inch main steam line, one vacuum breaker, relocation of DPV, SRV capacity, DW/WW leakage area, and initial nominal water level."

Please explain the reasons for changes for 30 inch main steam line, relocation of DPV, SRV capacity, and initial nominal water level and state where the changes noted in the DCD for them, except for the last change.

GEH Response:

The 30-inch main steam line is a change to control the steam velocity and meet the design requirements for the ESBWR. The result of this change affects the main steam line from the reactor pressure vessel (RPV) up to the outboard main steam isolation valve. This main steam line diameter change is noted in DCD Tier 2, Table 5.4-1.

As a consequence of the larger main steam line diameter and related changes to the main steam line venturi nozzle flow restrictors, the depressurization valves (DPVs) were moved. DCD Tier 2, Subsection 5.4.13.2, describe the location of the DPVs on the horizontal stub tubes connected to the RPV, instead of being connected directly to the main steam lines.

In relief mode, the safety relief valves (SRVs) operate as part of the Automatic Depressurization System (ADS). The relief mode of SRVs is modeled in the loss-of-coolant accident (LOCA) Emergency Core Cooling Systems (ECCS) performance analyses. SRV capacity was corrected to 138 kg/sec in DCD Tier 2, Revision 5, to be consistent with DCD Tier 2, Table 5.2-2. This change is noted in DCD Tier 2, Table 5.2-2 and Table 6.3-1.

The normal water level used in the LOCA ECCS performance analyses was revised to be consistent with the value listed in the DCD Tier 2, Table 15.2-1.

DCD Impact:

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

NRC RAI 6.2-190:

ESBWR DCD Revision 5 Section 6.2.2.2.2 states that vent fan is teed off of each PCCS vent line and that vent is powered by reliable sources. However, the DCD provides no design details, appropriate analysis or references. Please, revise the DCD to include the following or to provide appropriate references:

A. Design details of the added vent fan system, in particular the required characteristics of the fans, i.e., flow versus delta-P data.

B. Details of the system behavior, in particular a comparison of the containment pressure transients with and without fans active.

C. A minimum requirement for vent fans performance, i.e., the minimum number of fans operating to achieve the desired effect.

D. A discussion of potential adverse effects of the modification, if any, including effects of fans failure.

GEH Response:

A. The Passive Containment Cooling System (PCCS) vent fan characteristics are described in the acceptance criteria established in DCD Tier 1, Revision 5, Table 2.15.4-2, Item 11. It is understood that piping changes due to detail design are to be taken into account, and their hydraulic resistance determined and reflected in the PCCS vent fan design characteristics. Detail design of the PCCS vent fan system is in process, and is not included in this RAI response. However, the current characteristics required for the PCCS vent fan system to ensure the containment pressures remain below design pressure with ample margin are discussed below.

The PCCS vent fan system design characteristics required to ensure the containment pressures and temperatures are maintained below design values are described in different sections of the DCD Revision 5, as described in the response to RAI 6.2-139 (MFN 08-357, dated April 19, 2008).

DCD Tier 2, Revision 5, Figure 6.2-16 and Figure 6.2-15 provide a schematic diagram of the added PCCS vent fan system design. The system contains piping branching from each of the main PCCS vent lines and discharging to the Gravity-Driven Cooling System (GDCS) pool with a minimum submergence of 10 inches (after the GDCS pool drain down). The piping includes a check valve at the discharge end to ensure no backflow occurs through a vent fan. The vent fan included in the piping provides enough differential pressure to overcome the hydraulic resistances from the hydrostatic head and fluid dynamics due to submergence, contributions from the piping, and the pressure drop required to remove the accumulation of non-condensable gases from the PCCS condensers such that steam condensation and heat removal is enhanced. The piping diameter corresponds to the same diameter assigned to the main PCCS vent lines, reflecting similar friction factors. The piping length considered is about 6.47 m (21.23 feet), starting from the PCCS condenser lower drum and ending submerged at the GDCS pool.

B. Details for the PCCS behavior due to the PCCS vent fan system are discussed in the response to RAI 6.2-139 (MFN 08-357) and DCD Tier 2, Revision 5. DCD Tier 2 Revision 5 changes as described in the response to RAI 6.2-139 reflect the PCCS vent fan system design, including DCD Tier 2, Subsection 6.2.2.2.2 and Figures 6.2-14e1 through 6.2-14e10. The comparisons of the containment pressure and temperature responses with and without PCCS vent fans operating were not provided in DCD Tier 2, Revision 5. However, these comparisons are provided in this response as requested in Figures 6.2-190-1 and 6.2-190-2.

C. The minimum number of PCCS vent fans available for operation to achieve the desired containment pressure drop and margin is stated in DCD Tier 2, Revision 5, Subsection 19ACM.3.6.3, and this value is considered conservative. This number of PCCS vent fans is higher than the minimum of four PCCS vent fans analyzed and documented in DCD Tier 2, Revision 5.

D. The only expected adverse impact is due to the failure of all PCCS vent fans during the event (72 to 168 hours following a LOCA). Failure of all PCCS vent fans results in a small and continuous increase of the containment pressures and temperatures. The increase average value for the drywell (DW) pressure at the end of 168 hours is small; and ends up only slightly above design pressure. The average DW pressure slowly increases about 30.70 kPa (4.45 psi) above the initial pressure of 396.25 kPa, or about 15.63 kPa (2.27 psi) above design pressure. The wetwell (WW) pressure also has a similar increase, increasing about 34.09 kPa (4.94 psi) above the 384.84 kPa initial value (See Figure 6.2-190-1).

   The containment temperatures also show a similar increasing pattern. The results indicate that the DW temperature increases the least. It increases about 2.63°K at the end of the time period. The Suppression Pool (SP) shows a maximum increase of about 7.30°K. The intermediate increase corresponds to the WW temperature, which increases about 5.55 K (See Figure 6.2-190-2).

DCD Impact:

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

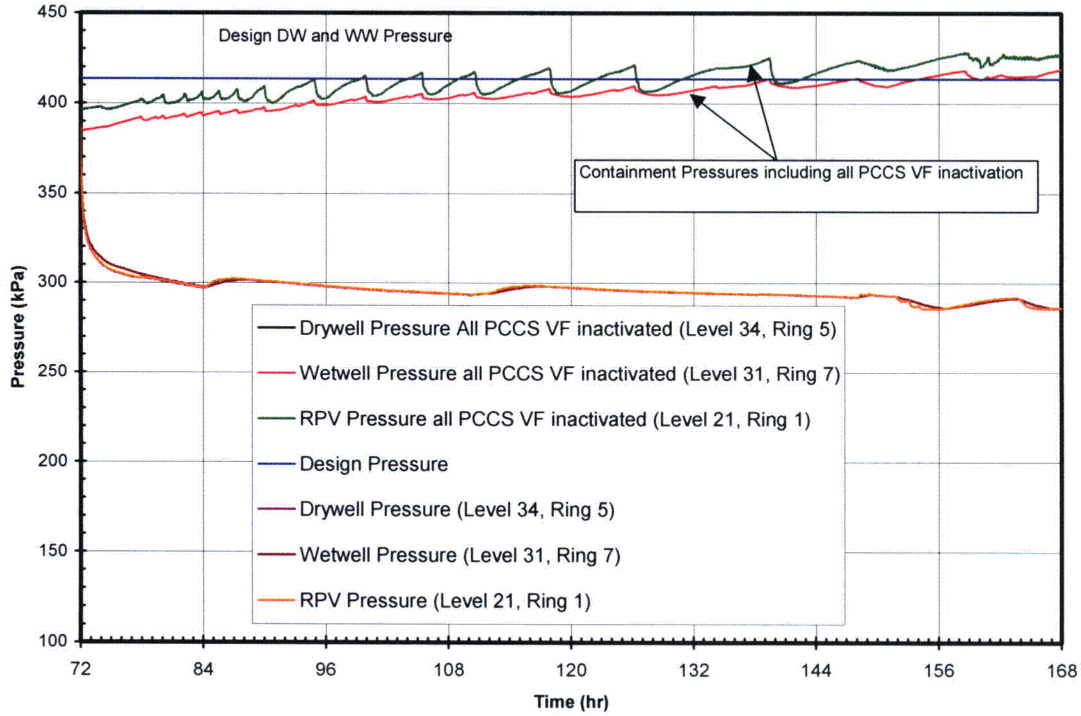

Figure 6.2-190-1. Containment Drywell, Wetwell, and Reactor Pressure Vessel Pressures With and Without PCCS Vent Fans

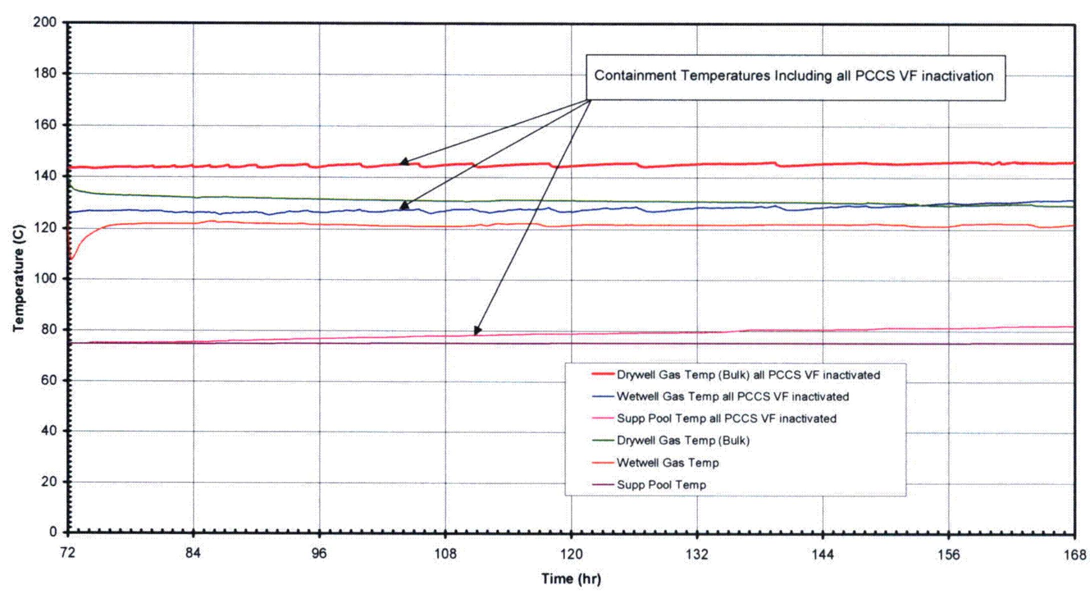

Figure 6.2-190-2. Containment Drywell, Wetwell, and Suppression Pool Temperatures With and Without PCCS Vent Fans

Enclosure 2

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Containment Systems

RAI Number 6.2-182

DCD Markups

the pool walls. The piping is seismic Category II, and the pipes are sized to provide enough capacity to prevent any overflow.

Figure 6.2-15 summarizes all of the above systems in the framework of the ESBWR containment. From top down:

- PCCS pool and heat exchangers provide passive containment cooling;
- ICS pool and heat exchangers provide natural circulation decay heat removal from RPV;
- GDCS (three pools, four divisions) with ADS (DPV, SRV) makes up the ECCS; GDCS deluge line supplies BiMAC for long-term coolability;
- Manual Containment Overpressure Protection Subsystem provides manual venting from the WW in a controlled manner; and
- BiMAC device, commonly call a core catcher, (shown by the insert to Figure 6.2-15) is initially fed by water flow from squib-valve-operated GDCS deluge lines into a distributor channel, and through a pipe jacket (with inclined and vertical portions) into the Lower Drywell (LDW) cavity. The cooling in a later phase is provided by natural circulation of water in the LDW feeding into the distributor channel through downcomers (at the end of LDW, not shown in the insert).

6.2.1.2 Containment Subcompartments

This subsection addresses or references to other DCD locations that address the applicable requirements of GDC 4 and 50 discussed in SRP 6.2.1.2 R2 relevant to ESBWR containment subcompartment design. The plant meets the requirements of:

- GDC 4, as it relates to the environmental and missile protection provided to ensure that safety-related structures, systems and components be designed to accommodate the dynamic effects (for example, effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures) that may occur during plant normal operations or during an accident; and
- GDC 50, as it relates to the subcompartments being designed with sufficient margin to prevent fracture of the structure due to pressure differential across the walls of the subcompartment. In meeting the requirements of GDC 50, the following specific criterion or criteria that pertain to the design and functional capability of containment subcompartments are used as indicated below.
  - The initial atmospheric conditions within a subcompartment are selected to maximize the resultant differential pressure. The model assumes air at the maximum allowable temperature, minimum absolute pressure, and zero percent relative humidity (RH). For a restricted class of subcompartments, another model is used that involves simplifying the air model outlined above. For this model, the initial atmosphere within the subcompartment is modeled as a homogeneous water-steam mixture with an average density equivalent to the dry air model. This approach is limited to subcompartments that have choked flow within the vents. This simplified model is not used for subcompartments having primarily subsonic flow through the vents.

- Subcompartment nodalization schemes are chosen such that there is no substantial pressure gradient within a node, that is, the nodalization scheme is verified by a sensitivity study that includes increasing the number of nodes until the peak calculated pressures converge to small resultant changes. The guidelines of Section 3.2 of NUREG-0609 are followed, and a nodalization sensitivity study is performed which includes consideration of spatial pressure variation, for example, pressure variations circumferentially, axially and radially within the subcompartment, for use in calculating the transient forces and moments acting on components.
- When vent flow paths are used which are not immediately available at the time of pipe rupture, the following criteria apply:
  - The vent area and resistance as a function of time after the break are based on a dynamic analysis of the subcompartment pressure response to pipe ruptures.
  - The validity of the analysis is supported by experimental data or a testing program that supports this analysis.
  - In meeting the requirements of GDC 4, the effects of missiles that may be generated during the transient are considered in the safety analysis.
- The vent flow behavior through all flow paths within the nodalized compartment model is based on a homogeneous mixture in thermal equilibrium, with the assumption of 100% water entrainment. In addition, the selected vent critical flow correlation is conservative with respect to available experimental data. ~~An acceptable vent critical flow correlations are the "frictionless Moody" with a multiplier for water-steam mixtures, and the thermal homogeneous equilibrium model for air-steam-water mixtures.~~
- A factor of 1.2 is applied to the peak differential pressure calculated for the subcompartment, structure and the enclosed components, for use in the design of the structure and the component supports. The as-built calculated differential pressure is not expected to be substantially different from the design value. However, improvements in the analytical models or changes in the as-built subcompartment may affect the available margin.

6.2.1.2.1 Design Bases

The design of the containment subcompartments is based upon a postulated DBA occurring in each subcompartment.

For each containment subcompartment in which high energy lines are routed, mass and energy release data corresponding to a postulated double ended line break are calculated. The mass and energy release data, subcompartment free volumes, vent path geometry and vent loss coefficients are used as input to an analysis to obtain the pressure/temperature transient response for each subcompartment. At least 15% margin above the analytically determined pressures is applied for structural analysis.

Enclosure 3

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