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Subject: **Revised Response to Portion of NRC Request for Additional Information Letter No. 100 Related to the ESBWR Design Certification – RAI Number 21.6-103**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) revised response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter No. 100 (Reference 1). GEH is revising the Enclosure 1 response on page 1 of 13, paragraph 3 as follows (Reference 2):

"In the event of a Main Steam Line Break (MSLB), if Feed Water (FW) addition continues, it will be terminated by isolation on High-High Drywell pressure. The plant response sequence of events is given in DCD Tier 2 Table 6.2-7h. The containment pressure response to this event is shown in DCD Tier 2 Figure 6.2-14j1 through 6.2.14j3. *The detailed discussion on the chronology of progression is given in DCD Appendix 6E.5.* The containment pressure remains below the design pressure."

Additionally, the following changes shown in blue font are made to Attachment 1, page 8 of 13 of Enclosure 1:

Chapter	Document ID	Section	Content
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14l1	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – PCCS Heat Removal versus Decay Heat (72 Hrs)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14l2	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – PCCS Heat Removal versus Decay Heat (500s)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14l3	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – PCCS Heat Removal versus Decay Heat (2000 s)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m1	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – Drywell and GDCS NC Gas Pressure (72 Hrs)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m2	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – Drywell and GDCS NC Gas Pressure (500 s)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m3	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – Drywell and GDCS NC Gas Pressure (2000 s)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m4	Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – Drywell Annulus and Suppression Pool Levels (72 hours)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m5	Main Steam Line Break, (Bounding Case, with Offsite Power) – GDCS Pool Levels (72 hours)
Tier 2 Chapter 06	26A6642AT	Figure 6.2-14m6	Main Steam Line Break, (Bounding Case, with Offsite Power) – GDCS Pool Temperature (72 hours)
Tier 2 Chapter 06	26A6642AT	6.3.2.7.1	GDCS Design Basis
Tier 2 Chapter 06	26A6642AT	6.3.2.7.2	GDCS System Description
Tier 2 Chapter 06	26A6642AT	6.3.2.7.4	GDCS Testing and Inspection Requirements
Tier 2 Chapter 06	26A6642AT	6.3.2.7.5	Instrumentation Requirements
Tier 2 Chapter 06	26A6642AT	6.3.2.8.2	ADS System Description
Tier 2 Chapter 06	26A6642AT	Table 6.3-1	Significant Input Variables to the ECCS-LOCA Performance Analysis

Tier 2 Chapter 06	26A6642AT	Appendix 6E.5	Main Steam Line Break, (Bounding Case, with Offsite Power)
Tier 2	26A6642AB		Global Acronym List
Tier 2 Chapter 07	26A6642AW	7.1.2	Q-DCIS General Description Summary
Tier 2 Chapter 07	26A6642AW	7.1.2.8	Q-DCIS Major Systems Description Summary

DCD markups associated with this response are provided in Enclosure 1.
If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 07-327, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 100 Related To ESBWR Design Certification Application*, dated May 30, 2007
2. MFN 09-224, Letter from Richard E. Kingston to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request For Additional Information Letter No. 100 Related to the ESBWR Design Certification Application – RAI Number 21.6-103*, dated April 24, 2009

Enclosure:

1. Revised Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application –RAI Number 21.6-103 – DCD Markups – Appendix 6E.5

cc:	AE Cubbage	USNRC (with enclosure)
	JG Head	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRFs	0000-0097-6238R1

Enclosure 1

MFN 09-224, Supplement 1

Revised Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application –RAI Number 21.6-103

DCD Markups – Appendix 6E.5

Figures 6.2-14a~~a~~1 through 6.2-14d~~d~~3 and Figures 6.2-14f1 through 6.2-14i3 show the pressure, temperature, DW and GDCS airspace pressure responses and PCCS heat removal for the~~i~~se ~~analysis~~analyses. Table 6.2-5 summarizes the results of this calculation. The calculated maximum DW pressures during the 72 hours following a LOCA for these bounding cases are~~is~~ below the containment design pressure. The detailed discussion on the chronology of progressions of the Main Steam Line Break Bounding cases ~~-~~are~~is~~ given in Appendi~~x~~ces 6E.2 and 6E.4.

A loss of all power generation buses is not the limiting assumption and the effects of continued feedwater injection is more limiting, as it can potentially add water to the wetwell and compress the wetwell air space. The ESBWR design incorporates features that mitigate this challenge by isolating reactor inventory sources outside of containment and provides a method of GDCS initiation based on LOCA condition detection. These features ensure that containment remains within design pressure for the entire 72-hour event duration. These features also ensure acceptable performance for the full spectrum of LOCA events within containment, with or without the assumption of loss of external injection capability. Additionally, although power generation buses are considered available to add feedwater or HPCRD injection, no credit is given for heat removal systems powered by these buses. Table 6.2-7h shows the sequence of events for the Main Steam Line Break with failure of one SRV and with offsite power available. Figures 6.2-14j1 through 6.2-14m3 show the pressure, temperature, DW and GDCS airspace pressure responses and PCCS heat removal for this analysis. The noncondensable mass and the void fraction in the DW and GDCS are presented in Figures 6.2-14n1 through 6.2-14o3. The detailed discussion on the chronology of progression is given in Appendix 6E.5. The cases analyzed without offsite power and water addition assume higher initial pressure, and result in higher pressure as shown in Table 6.2-5. The highest value of Maximum DW Pressure in Table 6.2-5 is the calculated peak containment internal pressure for the design basis loss of coolant accident.

6.2.1.1.3.5.1 Post-LOCA Containment Cooling and Recovery Analysis

For post-LOCA containment cooling and recovery, the Main Steam Line Break with failure of one DPV is selected. The analysis results are not sensitive to the event selection (failure of one DPV versus one SRV) due to the fact that these two cases are nearly the same in transient responses up to 72 hours and the containment pressure and temperature are rapidly reduced upon the activation of the nonsafety-related SSCs.

After the first 72 hours of the accident, the following nonsafety-related SSCs are utilized to keep the reactor at safe stable shutdown conditions, to rapidly reduce containment pressure and temperature to a level where there is acceptable margin, and then to maintain these conditions indefinitely:

(1) SSCs to refill the IC/PCC pools;

(2) PCCS Vent Fans;

(3) Passive Autocatalytic Recombiner System (PARS); and

(4) Power supplies to the PCCS Vent Fans and the IC/PCC pool refill pumps.

Once a state of safe, stable reactor shutdown is reached, ~~and~~ containment pressure and temperature are maintained with sufficient margin to containment design limits for a long period

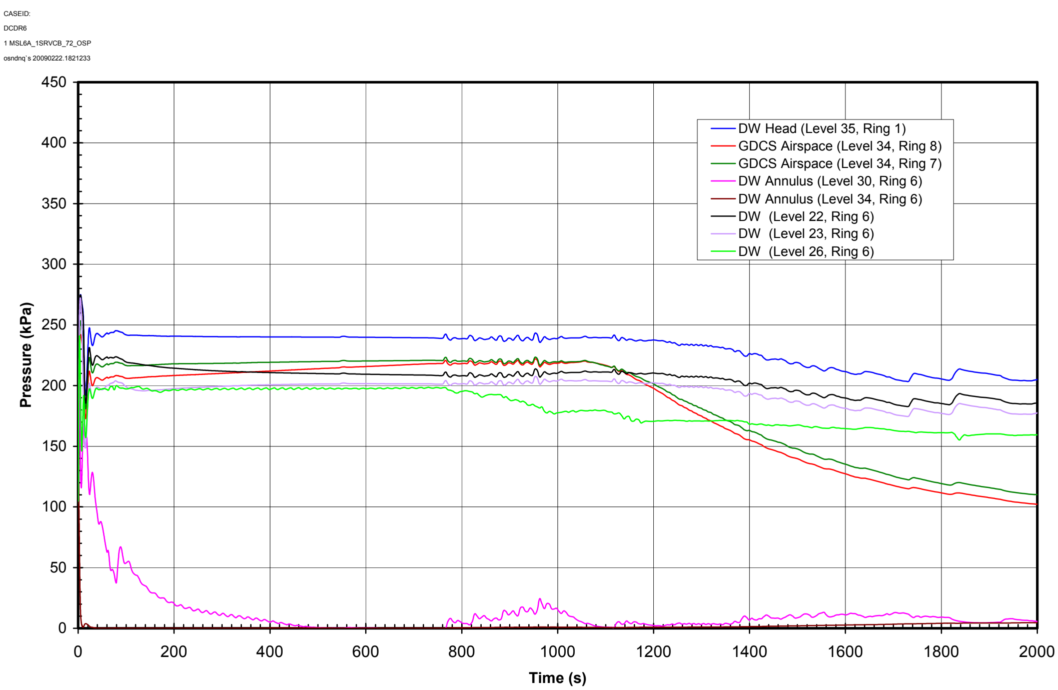

Figure 6.2-14m3. Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) – Drywell and GDCS Noncondensable Gas Pressures (2000 s)

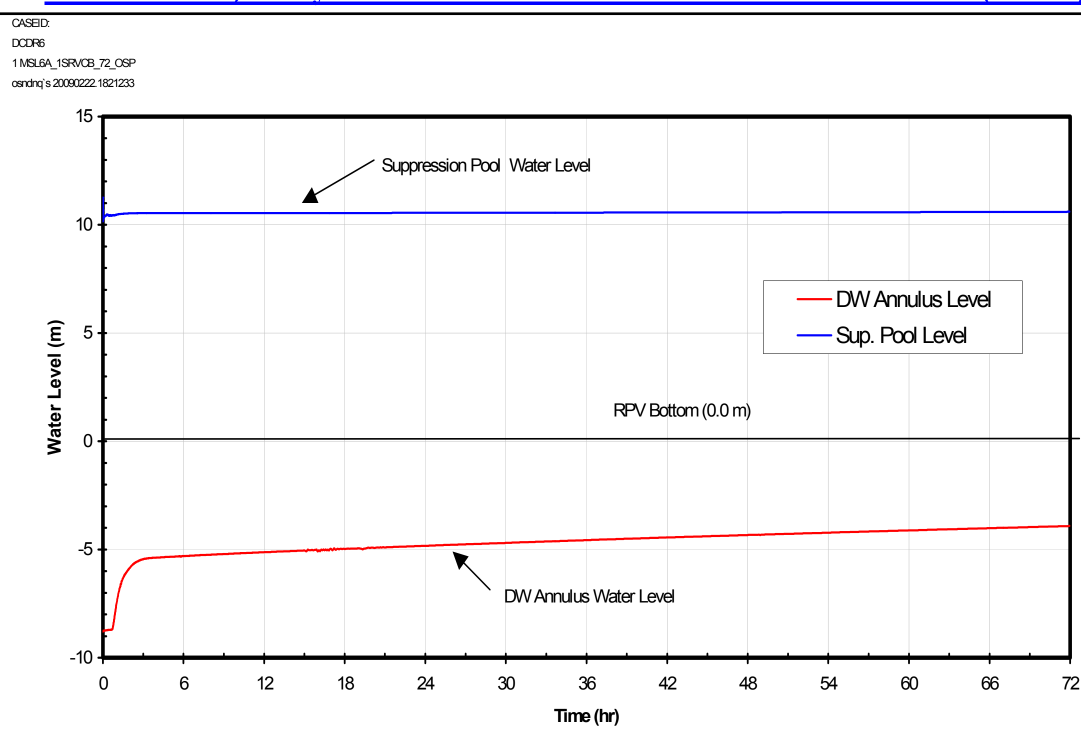

Figure 6.2-14m4. Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) Drywell Annulus and Suppression Pool Levels (72 hrs)

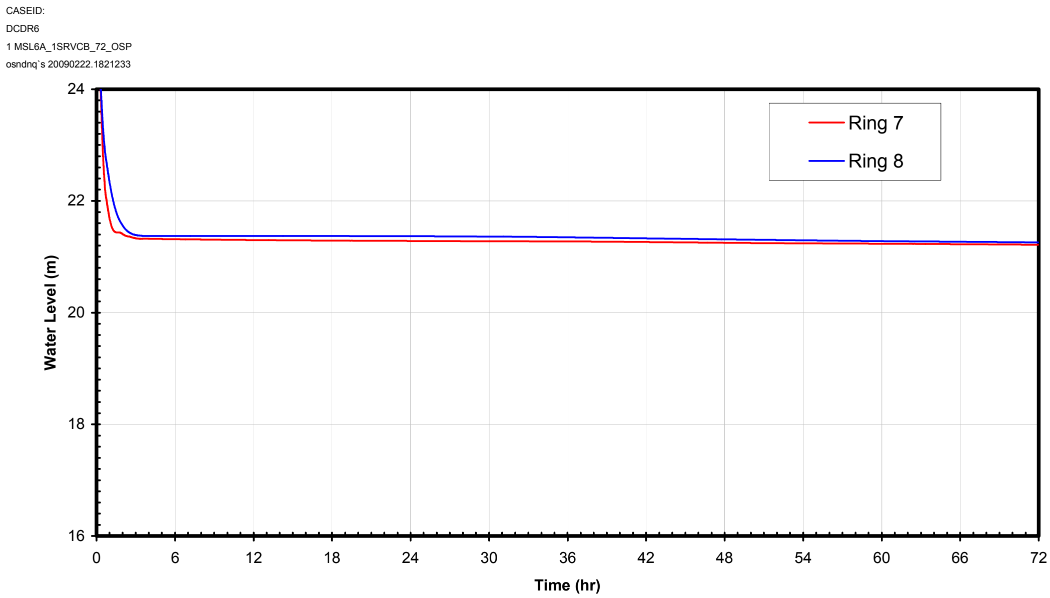

Figure 6.2-14m5. Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) GDCS Pool Levels (72 hrs)

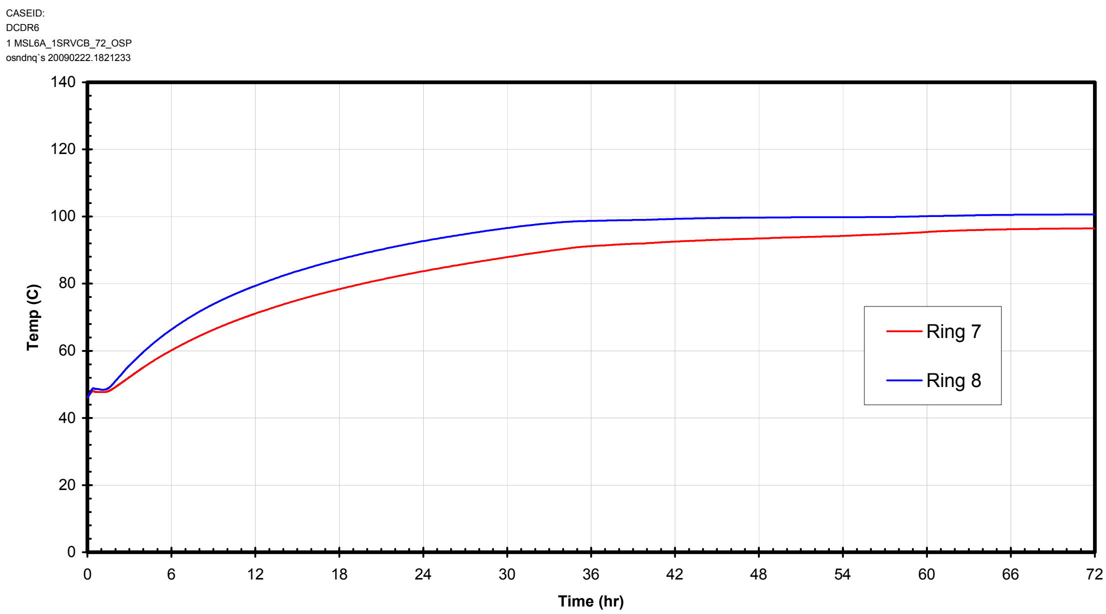

Figure 6.2-14m6. Main Steam Line Break, 1 SRV Failure (Bounding Case, with Offsite Power) GDCS Pool Temperature (72 hrs)

vent discharge. The bulk DW gas temperature peaks at 173.6°C (344.5ºF) immediately following the blowdown, which is slightly above the DW design temperature of 171°C (340°F), due to adiabatic compression by the steam discharging from the break. In the long-term (72 hours), the temperature remains below 171°C (340°F), while the WW gas temperature remains below the WW temperature design limit of 121°C (250°F) in 72 hours.

Figure 6.2-14i4 compares the water levels in the DW annulus and suppression pool. The DW annulus water level rises due to the break flow discharges from the main steam line broken piping. The DW annulus water level remains in the lower DW and does not enter into the bottom of the suppression pool via the spillover holes.

For MSLB, the GDCS pool level (Figure 6.2-14i5) drops to the elevation of the DPVs and stays above L33 (Figure 6.2-7). As no gas mass is stored below L33, gas masses stored in the top two levels (L34 and L35) are purged to minimal values in a few hours through the connection pipes. Approximately 60% (or 1200 m^3 (42380 ft^3)) of the initial GDCS cold water 46.1°C (115°F) remains inside the GDCS pools. The hot PCCS condensate mixes with the cold GDCS pool water. The temperature of the GDCS water injected into the RPV is lower than that of the FWLB. A portion of the decay heat is used to heat up the incoming colder GDCS water, which is shown in Figure 6.2-14h3 as the difference between the decay heat and the total PCCS condensation power. It takes approximately 60 hours to bring the mixture temperature to approximately 95°C (Figure 6.2-14i6).

Both the initial blowdown and the ensuing suppression pool heat up are larger in the MSLB than the FWLB, which leads to higher pool water temperature and higher suppression pool water level and smaller WW gas space volume. All these effects result in higher DW pressure in the MSLB than FWLB.

6E.5 Main Steam Line Break LOCA, 1 SRV Failure (Bounding Case, with Offsite Power)

Following the postulated LOCA, the DW pressure increased rapidly leading to clearing of the PCCS and main vents. The containment pressure responses of the DW, WW, and RPV are shown in Figures 6.2-14j1 through 6.2-14j3. During the initial blowdown phase, the noncondensable gases in the upper regions of the DW are cleared rapidly to the WW through the main vents, as shown by the DW and GDCS gas pressures in Figures 6.2-14m2 and 6.2-14m3. The DW pressure starts to turn around and decrease at approximately 1300 seconds after the GDCS flow initiates, as shown in Figure 6.2-14j3. The GDCS flow fills the reactor vessel to the elevation of the break, and then spills into the DW. The heat transfer process during the GDCS cooling period is characterized by condensation of steam in the vessel and DW. The DW pressure rises until flow is established through the PCCS, where condensate from the PCCS is recycled back into the vessel through the GDCS pool in the DW. The long-term (72 hours) response of the containment pressure is shown in Figure 6.2-14j1. The DW pressure levels off at around 2 hours and increases in a gradual pace. The peak DW pressure reaches 394 kPa (57 psia) at the end of 72 hours, but remains below the design pressure of 310 kPaG (45 psig).

Due to the presence of noncondensable gases, the effectiveness of condensation heat transfer in the PCCS is impaired for the first 48 hours, as shown by the PCCS heat removal versus decay heat in Figure 6.2-14l1. For the first 48 hours, the decay heat exceeds the PCCS heat removal capacity. Then after the noncondensable gases are purged from the GDCS and DW gas spaces, the PCCS heat removal capacity matches the decay heat. However, it still cannot remove radiation heating generated in the core. Hence, both the DW and WW pressures continue to increase continually over the 72 hour period.

The TRACG containment model predicts some noncondensable gases remain in the DW at 72 hours. As a conservative approach to determine the maximum DW pressure, an ideal gas calculation is performed to calculate the effect of purging these remaining gases to the WW. The calculation accounts for the total noncondensable gas in the containment, the noncondensable gas dissolved in the sodium pentaborate solution, and the safety/nonsafety-related pneumatic containment valves during the MSLB event. The increase in WW and DW pressure from additional noncondensable gas is based on the ideal gas equation. The result of this noncondensable addition is shown in Table 6.2-5a.

Figures 6.2-14k1 through 6.2-14k3 show the DW, WW and suppression pool gas space temperature responses at various elevations. Initially, all elevations heat up due to the main vent and break discharge. After the main vents close, only the upper levels are impacted by the PCCS vent discharge. The bulk DW gas temperature peaks at 175.0°C (347.0ºF) immediately following the blowdown, which is slightly above the DW design temperature of 171°C (340°F), due to adiabatic compression by the steam discharging from the break. In the long-term (72 hours), the temperature remains below 171°C (340°F), while the WW gas temperature remains below the WW temperature design limit of 121°C (250°F) in 72 hours.

Figure 6.2-14m4 compares the water levels in the DW annulus and suppression pool. The DW annulus water level rises due to the break flow discharges from the main steam line broken piping. The DW annulus water level remains in the lower DW and does not enter into the bottom of the suppression pool via the spillover holes.

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Both the initial blowdown and the ensuing suppression pool heat up are larger in the MSLB than the FWLB, which leads to higher pool water temperature and higher suppression pool water level and smaller WW gas space volume. All these effects result in higher DW pressure in the MSLB than FWLB.

~~6E.3~~ 6E.6 References

None.