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Subject: Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-159

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the subject NRC RAI transmitted via the Reference 1 letter.

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

Reference:

1. MFN 07-327, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application*, May 30, 2007

Enclosure:

1. MFN 07-697 - Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-159

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
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Enclosure 1

MFN 07-697

Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-159

NRC RAI 6.2-159:

Concerning DCD Tier 2, Rev. 3, Section 6.2.1.3:

During the ABWR review, the staff expressed concerns regarding GE's statement proposing complete elimination of suppression pool temperature limits as applied to the safety relief valve (SRV) load evaluation. However, pending completion of the supporting analysis, GE committed itself to follow suppression pool temperature criteria documented in the NUREG-0783, "Suppression Pool temperature limits for BWR Containments." The ESBWR Technical Specification 3.6.2.1, "Suppression Pool Average Temperature," includes temperature thresholds of 110°F, 120°F and 130°F, for the reactor scram and reactor depressurization.

A. Are these temperature thresholds consistent with the NUREG-0783 guidance? If not, explain any inconsistencies.

B. Provide a description of the effect of pool temperature on the SRV load evaluation in the DCD.

GEH Response:

A. The basis for elimination of the NUREG-0783 suppression pool temperature limits as well as the basis for retention of the ESBWR Technical Specification 3.6.2.1 limits on suppression pool temperature are discussed below:

Basis for Elimination of NUREG-0783 Suppression Pool Temperature Limits

NUREG-0783 (Reference 6.2-159-1) identified threshold limits on the maximum local suppression pool temperature. These limits were established in NUREG-0783 to address concerns about unstable steam condensation behavior at elevated local suppression pool temperatures in the vicinity of the safety relief valve (SRV) discharge-piping exit. As identified in Reference 6.2-159-1, unstable condensation behavior could potentially result in excessive hydrodynamic loads on the suppression pool boundaries.

The local suppression pool temperature is defined as the fluid temperature in the vicinity of the SRV discharge line quencher device. The local pool temperature controls the condensation process. Without quencher devices, conditions, which include high suppression pool temperature and high SRV steam mass flux to the suppression pool, may cause unstable steam condensation. Quencher devices, such as the GEH X-Quenchers used in the ESBWR, mitigate these loads. The NRC has accepted the use of quencher devices to mitigate the SRV steam condensation loads and recommended in NUREG-0783 (Reference 6.2-159-1) that all BWR plants with Mark I, Mark II or Mark III containments use quencher devices.

However, due to limitations in the range of quencher pool temperature test data available at the time NUREG-0783 was issued, the NRC imposed local pool temperature limits in NUREG-0783 for plants with quencher devices. These limits were meant to ensure that the minimum local subcooling at the quencher location would remain within the range of the available test data used to demonstrate stable condensation. Analyses were also specified in NUREG-0783 to demonstrate compliance with these limits. These analyses assumed operator action per the Technical Specifications including manual scram at 110°F and initiation of manual depressurization at 120°F.

After NUREG-0783 was issued, GEH compiled additional quencher test data, which were used to confirm that with quenchers, stable condensation is ensured even with local pool temperatures approaching saturation conditions. GEH documented these findings in Reference 6.2-159-2, which was provided to the NRC for review and approval. Reference 6.2-159-2, which was approved by the NRC (Reference 6.2-159-3), provided justification for elimination of the local pool temperature limit for plants with quencher devices. The justification in Reference 6.2-159-2 applies to the ESBWR, which uses the GEH X-Quencher.

The Reference 6.2-159-3 NRC safety evaluation for Reference 6.2-159-2 did identify a new concern, which is not related to unstable SRV steam condensation. This new concern identified the potential transfer of non-condensed SRV steam to the Emergency Core Cooling System (ECCS) suction inlet strainer if locally saturated conditions existed at the quencher and the ECCS suction inlet strainer is at a higher elevation than the SRV quencher. Ingestion of non-condensed SRV steam into the ECCS suction piping in the suppression pool could negatively impact ECCS pump operation. The NRC in Reference 6.2-159-3 stated that the local pool temperature limits could be eliminated if the plant has ECCS pump inlets located below the elevation of the quencher elevation. The ESBWR design uses passive systems to maintain reactor pressure vessel (RPV) water inventory, and does not use active ECCS pumps that take suction from the suppression pool. Therefore, the concern raised in Reference 6.2-159-3 of steam ingestion into ECCS pump suction piping in the suppression pool would not apply to the ESBWR.

In summary, the concerns, which provided the basis for establishing NUREG-0783 local suppression pool temperature limits and for maintaining the Technical Specification limits of 110°F for reactor shutdown and 120°F for initiation of reactor depressurization identified in NUREG-0783 have been addressed for the ESBWR. The original concern related to unstable steam condensation loads was addressed in Reference 6.2-159-2 by demonstrating stable condensation, even with local pool saturation conditions, with use of quencher devices such as the GEH X-Quencher used for the ESBWR. The newer concern raised in Reference 6.2-159-3 related to steam ingestion into ECCS suction piping in the suppression pool is addressed by the ESBWR design, which does not rely on ECCS pumps to maintain RPV water inventory.

Basis for the ESBWR Technical Specification 3.6.2.1 for Suppression Pool Temperature Limits

Safety Analyses

The basis for the ESBWR Technical Specification (Technical Specification B3.6.2.1) is described in DCD Tier 2, Chapter 16B. As described in the basis for the ESBWR Technical Specification 3.6.2.1, Suppression Pool Average Temperature, the safety analyses in Chapters 6.2 and 15 use 110°F as an initial condition. DCD Tier 2, Chapter 6.2 documents the loss-of-coolant accident (LOCA) analyses and Chapter 15 documents the transient and special events. Reactor shutdown at a suppression pool temperature of 120°F, and vessel depressurization at a pool temperature of 130°F, are also assumed in the safety analyses.

LOCA Hydrodynamic Loads

The LOCA containment dynamic loads (e.g., pool swell, CO and chugging) are evaluated and defined in Reference 6.2-159-4. The LOCA hydrodynamic loads evaluated and defined in Reference 6.2-159-4 use the results of LOCA containment pressure and temperature response calculations performed using an initial suppression temperature of 110°F.

SRV Loads

The ESBWR SRV air bubble pressure loads on the suppression pool are also defined in Reference 6.2-159-4. The SRV bubble pressure loads defined in Reference 6.2-159-4 are calculated using the GEH X-Quencher correlation described in Reference 6.2-159-5, which includes suppression pool temperature as an input. The SRV bubble pressure loads for the suppression pool are defined for three load cases in Reference 6.2-159-4.

- Single SRV First Actuation
- Single SRV Subsequent Actuation
- Multiple SRV Actuation

Single Valve First and Subsequent Actuation

As described in Reference 6.2-159-4, single SRV discharge is not a normal operational event. However, since inadvertent actuation of a single SRV is a design condition, first and subsequent actuations of a single SRV are included as load definition cases. The SRV air bubble pressures defined in Reference 6.2-159-4 for first actuation of a single SRV are obtained with an input suppression pool temperature of 170°F. The Reference 6.2-159-4 SRV bubble pressure for the single SRV-subsequent actuation load case is obtained with an input suppression pool temperature of 200°F. These two load cases are calculated with the assumption that the SRV opens at the maximum analytical limit for SRV setpoint pressure and SRV flow rate to maximize the SRV air bubble pressure load. These loads are conservative in that expected ESBWR RPV pressures (and corresponding SRV open pressures) coincident at these elevated suppression pool temperatures would be significantly less and would therefore result in lower SRV bubble pressures.

Multiple SRV Actuation

The multiple SRV actuation load case is used to address the SRV load resulting from the simultaneous actuation of multiple SRVs, which may occur at the onset of limiting RPV overpressure transient events. This load case is also used to address the SRV bubble pressure load due to the opening of simultaneous multiple SRVs when performing the Automatic Depressurization System (ADS) function during transient or LOCA events.

The Reference 6.2-159-4 SRV bubble pressure for this load case is calculated assuming all 10 SRVs actuate simultaneously, at the maximum analytical limit on SRV open pressure setpoint and SRV flow rate. The bubble pressure for this load case is obtained with a suppression pool temperature of 120°F which bounds the maximum expected initial suppression pool temperature based on the ESBWR Technical Specification Limiting Condition for Operation (LCO) limit for normal operation of 110°F.

The multiple SRV actuation load case is also used to address the SRV bubble pressures load that occur with simultaneous actuation of multiple SRVs when performing the ADS function during a transient or a LOCA. SRV actuations due to ADS initiation occur later in the event, and can occur at suppression pool temperatures higher than 120°F. However, the number of SRVs simultaneously actuating in the ADS mode will be less than the 10 assumed for the load definition. Additionally, SRV actuations in the ADS mode occur at reduced RPV pressures. The ESBWR ADS logic is designed to first open 5 ADS SRVs simultaneously followed by actuation of the remaining 5 SRVs after a 10 second delay. The SRV bubble pressure loads in the suppression pool last less than 1 second after an SRV actuation. Therefore, the calculated bubble pressures for ADS events should be based on a 5 SRV actuation. The ESBWR multiple SRV bubble pressure, which is defined for a 10 SRV simultaneous actuation, with a suppression pool temperature of 120°F is bounding relative to the SRV bubble pressure calculated for a simultaneous actuation of 5 SRV for pool temperatures up to160°F. This comparison conservatively assumes that the 5 SRVs in the ADS mode open at the analytical limit on SRV open setpoint. The margin between the ESBWR multiple SRV bubble pressure load definition and the bubble pressure calculated for a 5 SRV actuation in the ADS mode is greater when the lower RPV pressures coincident with elevated suppression pool temperature during ADS actuation are considered.

Conclusions

The concerns that produced the local suppression pool temperature limit requirements of NUREG-0783 have been addressed for the ESBWR. This permits elimination of the NUREG-0783 local suppression pool temperature limits and elimination of constraints on the ESBWR Technical Specification pool temperature limits related to NUREG-0783. Additionally, the ESBWR Technical Specification pool limits of 110°F for normal operation, 120°F for reactor shutdown, and 130°F for vessel depressurization are consistent with the assumptions used for the ESBWR safety analyses. Therefore, the ESBWR Technical Specification 3.6.2.1 suppression pool temperature limits are considered appropriate for the ESBWR.

B. The ESBWR SRV air bubble pressure loads are evaluated and defined in Reference 6.2-159-4. These are defined using the Reference 6.2-159-5 X-Quencher bubble pressure prediction methodology, which has been used to define the Mark III and ABWR X-Quencher bubble pressure loads. Sensitivity calculations with the GEH X-Quencher correlation indicate that SRV air bubble pressures do increase with higher suppression pool temperature. However, the SRV loads defined for the ESBWR have been calculated using conservative high values for suppression pool temperature.

References:

6.2-159-1. USNRC NUREG-0783, "Suppression Pool Temperature Limits for BWR Containments," November 1981.

6.2-159-2. General Electric Company, "Elimination of Limit on BWR Suppression Pool Temperature for SRV Discharge with Quenchers," NEDO-30832-A, May 1995.

6.2-159-3. USNRC, "Safety Evaluation Report by the Office of Nuclear Reactor Regulation on the Review of Two GE Topical Reports for the Elimination of Local Temperature Limits and Raising Pool Temperature Technical Specification Limits," Transmitted with Letter from G. Halahan (NRC) to R. Pinelli (BWROG), August 29, 1994. (Copy contained in NEDO-30832-A).

6.2-159-4. General Electric Company, "ESBWR Containment Load Definition," NEDE-33261P, Class III (Proprietary), Revision 1, October 2007, and NEDO-33261, Class I (Non-proprietary), Revision 1, October 2007.

6.2-159-5. 22A7007, GESSAR II, 238 Nuclear Island, General Electric Company, Docket No. STN 50-447, Amendments 1 through 21, Appendix B, (Attachments A-P).

DCD Impact:

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