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Appendix A, "Design Certification Rule for the U.S. Advanced Boiling Water Reactor," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," constitutes the standard design certification (DC) for the U.S. Advanced Boiling Water Reactor (ABWR) design. To document the U.S. Nuclear Regulatory Commission (NRC) staff's review supporting initial certification of the ABWR, the staff issued a final safety evaluation report (FSER) in NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," in July 1994 and NUREG-1503, Supplement 1, in May 1997.

The staff is documenting its review of the GE-Hitachi Nuclear Energy (GEH or the applicant) application for renewal of the ABWR DC in Supplement 2 to NUREG-1503. Chapter 1 of this supplemental FSER describes the staff's review process for the ABWR DC renewal. This supplemental FSER section documents the NRC staff's review specifically related to Chapter 6, "Engineered Safety Features," Section 6.2.1.6, "Suppression Pool Dynamic Loads," of the GEH Design Control Document (DCD), Revision 7. Except as modified by this supplement to the FSER, the findings made in NUREG-1503 and its Supplement 1 remain in full effect.

6.2.1.6 Suppression Pool Dynamic Loads

6.2.1.6.1 Regulatory Criteria

The applicant added Combined License (COL) Information Item 3.8.6.5, "Loads Associated with Post-DBA [Design Basis Accident] Suppression Pool Water Level," to the DCD Tier 2, Section 3.8.6, "COL License Information." Because the applicant's change clarifies information in the original ABWR DC, it is a "modification," as this term is defined in Chapter 1 of this supplement. Therefore, this design change must comply with the regulations applicable and in effect at the time the certification was originally issued. The applicant's design change was made to correct an assumption on suppression pool water level used in hydrodynamic analysis.

The applicable regulatory requirement for evaluating the DCD change is based on 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," (GDC) 4, "Environmental and Dynamic Effects Design Bases (1997)," as it relates to the environmental and missile protection design. As pertinent here, GDC-4 requires that structures, systems, and components important to safety be designed to accommodate the dynamic effects (e.g., effects of missiles, pipe whipping, and discharging fluids) that may result from equipment failures and may occur during normal plant operation or following a loss-of-coolant accident (LOCA).

The staff reviewed the change using the guidance in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," (SRP), Section 6.2.1.1.C, "Pressure-Suppression Type BWR Containments," Revision 6, issued August 1984.

6.2.1.6.2 Summary of Technical Information

The applicant added the following to the GEH DCD Tier 2, Section 3.8.6, "COL License Information":

> "3.8.6.5 Loads Associated with Post-DBA Suppression Pool Water Level: The COL applicants will confirm that the suppression pool water level used in the containment loads evaluation is based on the maximum predicted post-accident suppression pool water level rise that can occur concurrent with each of the defined containment loads (Appendix 3B). This load will then be used to update the associated analyses in Section 3.8, Appendix 3G and Appendix 3H."

6.2.1.6.3 Technical Evaluation

In a letter dated March 31, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14090A068), the applicant provided the NRC a 10 CFR 21.21(a)(2) "60-day interim report notification: "Containment Loads Potentially Exceed Limits with High Suppression Pool Water Level in the ABWR Design." In Attachment 1 to the letter, the applicant stated the following:

> "Nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply[:] ABWR hydrodynamic loads have been calculated with the Suppression Pool water level defined at the Technical Specification Suppression Pool High Water Level (HWL). The Suppression Pool level during the postulated LOCA vessel blowdown may be greater than the Suppression Pool HWL during the pertinent timeframe for hydrodynamic loads because vessel coolant inventory is transferred into the suppression pool during blowdown. Additionally, certain containment structures previously thought uncovered may be submerged with the higher Suppression Pool water level. Increased hydrodynamic loads may correspondingly increase the totals in the design load combinations for which containment structures are designed to withstand."

In a letter dated August 29, 2014 (ADAMS Accession No. ML14241A306), the applicant informed the NRC that "[t]he GEH assessment has concluded that the predicted increase in the suppression pool water level above the value used for defining the ABWR loads and applied in the structural analysis will not result in the creation of a substantial safety hazard, nor will it lead to exceeding a technical specification [TS] safety limit for the US ABWR Certified Design."

To determine the effect of this error on the GEH ABWR DC renewal application, in a request for additional information (RAI) 06.02.01-1 dated April 16, 2015 (ADAMS Accession No. ML15110A122), the staff requested that the applicant describe the impact of the error on loads on suppression pool wall boundaries, the access tunnel, and structures submerged in the suppression pool in terms of loads from pool swell, condensation oscillation, chugging, and safety relief valve (SRV) discharge.

GEH responded in a letter dated May 29, 2015 (ADAMS Accession No. ML15149A232), that the ABWR DCD, Appendix 3B, only identifies methods to be used in defining loads on submerged structures by citation to references. This includes the methods for loads due to LOCA pool swell, condensation-oscillation, chugging and SRV discharge.

According to the applicant:

- The loads affecting structural integrity, that are affected by the predicted increase in suppression pool water level are condensation oscillation and chugging;

- Pool swell loads are unaffected as they occur at the beginning of a LOCA before a significant transfer of water to the suppression pool that would raise the water level;

- The increase in pool boundary loads from SRV discharge due to the higher suppression pool water level is insignificant because the expected water level rise during SRV discharge is small; and

- The effect on SRV load is negligible relative to the conservatism in the SRV loads definition.

On October 28, 2015 (ADAMS Accession No. ML15357A292), the staff audited the applicant's analyses that was used as the basis for the DCD COL Information Item. The staff, in the course of the audit, determined that the applicant had identified the containment structural loads impacted by the predicted increase in suppression pool water level and has provided appropriate clarification for a COL applicant to perform the correct hydrodynamic load calculations that are based on a bounding predicted suppression pool water level.

The applicant evaluated predicted increases for LOCA condensation oscillation and chugging loads acting on the ABWR suppression pool boundaries. The applicant's evaluation along with the DCD COL Information Item will conservatively ensure, that a COL applicant will confirm the suppression pool water level used in the containment loads evaluation, based on the maximum predicted post-accident suppression pool water level rise. The applicant conservatively assumed that the predicted maximum suppression pool water level increase will result in increasing condensation oscillation and chugging forces by 50 percent and 20 percent. The resulting stresses in the reinforced concrete containment vessel and reactor pressure vessel pedestal for the governing faulted load combination will increase by less than 1 percent. The applicant concluded that potential increases or changes to hydrodynamic loads that were defined for the ABWR containment, that are associated with an elevated suppression pool water level, do not result in exceeding the original ABWR DC structural design limits.

The staff, as part of the audit, evaluated the applicant's analyses supporting this conclusion. The staff confirmed that the increase in resultant forces (less than 1 percent) due to the change in the level of the suppression pool water induced by the postulated LOCA event has a negligible effect on the containment structure loading.

On access tunnel structural integrity, the applicant's response in the letter dated May 29, 2015, states, "The access tunnel design is only described in the US ABWR DCD; there is no associated stress analysis results included in the US ABWR DCD."

On the integrity of submerged primary structure safety-related structures, components and equipment (SC&E) the applicant's May 29, 2015, response also stated the following:

> "Increases in the [condensation oscillation] and chugging contribution to the emergency and faulted load combinations can result in increases in the primary structure model responses that can impact the design margins for safety-related SC&E. The US ABWR DCD does not include design details for SC&E; there is no associated stress analysis results included in the US ABWR DCD."

Based on the applicant's response that the ABWR DCD does not contain the necessary design details of the access tunnel and submerged safety-related SC&E, the staff finds that the COL Information Item would provide the information for the detailed design to evaluate its impact.

In its response to RAI 06.02.01-1, the applicant stated that an evaluation of the access tunnel structural integrity was performed, for a non-domestic ABWR plant-specific design, in order to confirm that the predicted increase in the condensation oscillation and chugging loads do not result in exceeding the safety design margins of the access tunnel. The applicant stated that the evaluation determined that sufficient margins exist in the design to accommodate stress limits and buckling limits of the access tunnel.

As stated above in this SER Section 6.2.1.6.2, the applicant added COL Information Item 3.8.6.5 to ABWR DCD Tier 2, so that the COL applicant will use the appropriate suppression pool water level for the containment loads evaluation. The staff found this acceptable because the COL Information item directs the COL applicant to use the appropriate suppression pool water level for the containment load evaluation. However, the staff's acceptance of the ABWR design was not based on this COL Information Item; the existing DCD information is acceptable and revising the containment load evaluation, as confirmed in the staff audit, has negligible impact on the ABWR certified design.

Based on the review of the applicant's letter dated May 29, 2015, and the October 28, 2015, audit, the staff determined that the increased pool level induced by the postulated LOCA event does not have a significant impact on the design capacity of the containment structure and COL Information Item 3.8.6.5 will direct COL applicants to use the maximum predicted post-accident suppression pool water level rise that can occur concurrent with each of the defined containment loads in the designs of access tunnel and submerged primary structure safety-related SC&E. The staff concluded that the applicant addressed the staff's concerns raised in RAI 06.02.01-1, and therefore, the issue is closed.

The staff concluded that the containment structure, access tunnel, and primary structure safety-related SC&E meet the requirements of GDC 4 (1997).

6.2.1.6.4 Conclusion

The staff's review finds that the applicant's change to the ABWR DCD, Revision 7, is acceptable because it does not alter the safety findings made in NUREG-1503 and meets the applicable regulations in effect at the initial certification, including the requirements of 10 CFR Part 50, Appendix A, GDC 4.

References

1. 10 CFR 21.21, “Notification of failure to comply or existence of a defect and its evaluation.”

2. 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants.”

3. 10 CFR Part 50, Appendix A, GDC 4, “Environmental and dynamic effects design bases,” 1997.

4. 10 CFR Part 52, Appendix A, “Design Certification Rule for the U.S. Advanced Boiling Water Reactor.”

5. NRC, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 6.2.1.1.C, “Pressure-Suppression Type BWR Containments,” Revision 6 August 1984 (ADAMS Accession No. ML052340657).

6. NRC, NUREG-1503, “Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design,” July 1994 (ADAMS Accession No. ML080670592).

7. NRC, NUREG-1503, “Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design,” Supplement 1, May 1997 (ADAMS Accession No. ML080710134).

8. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 5, Tier 1 and Tier 2, November 2010 (ADAMS Accession No. ML110040323).

9. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 6, Tier 1 and Tier 2, February 2016 (ADAMS Accession No. ML16214A015).

10. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 7, Tier 1 and Tier 2, December 2019 (ADAMS Accession No. ML20007E371).