5 REACTOR COOLANT SYSTEM AND CONNECTED SYSTEMS

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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 5, "Reactor Coolant System and Connected Systems," Section 5.4.7, "Residual Heat Removal System," 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.

5.4.7 Residual Heat Removal System

5.4.7.1 *Regulatory Criteria*

In the GEH ABWR DCD, Revision 7, the applicant made a change to add a redundant alternating current (ac) independent water addition (ACIWA) mode to the residual heat removal (RHR) system Loop B. The modification would provide emergency water injection from the fire protection system (FPS) or from an external water source such as a fire truck through a cross connection in the RHR Loop B to the reactor vessel, the containment wetwell or drywell spray sparger, or the spent fuel pool. The proposed additional ACIWA RHR Loop B is configured similarly to the current ABWR ACIWA RHR Loop C components and piping arrangement with equivalent system design parameters.

In a letter dated July 20, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12125A385), the NRC staff identified 28 items for GEH's consideration as part of their application to renew the ABWR DC. In Item No. 26 of the letter, the applicant was requested to address ABWR DCD design changes related to aspects of the NRC Fukushima Near-Term Task Force Recommendation 4.2, regarding mitigation strategies for beyond-design-basis external events which was based on the NRC policy at that time. The policy on mitigation strategies, at that time, was outlined in a staff requirements memo SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," dated February 17, 2012, (ADAMS Accession No. ML12039A111).

In a public teleconference on March 17, 2016 (ADAMS Accession No. ML16124A049), the NRC staff requested that GEH clarify the ABWR response to a beyond-design-basis event with specific information items to be provided by a combined license (COL) applicant that would also address the draft mitigation of beyond-design-basis events (MBDBE) rule (10 CFR 50.155, "Mitigation of beyond-design-basis events"), that was pending at that time. Subsequently,

during the MBDBE rulemaking that created 10 CFR 50.155, the Commission decided not to impose mitigation strategies requirements on DCs.[1] The final rule was published in the *Federal Register* on August 9, 2019 (84 FR 39684) and became effective September 9, 2019.

In a letter dated January 23, 2017 (ADAMS Accession No. ML17025A386), GEH provided supplemental information for GEH's response to Item No. 26 of the July 20, 2012 staff letter. The applicant narrowed the scope of Item No. 26 to exclude changes directly related to 10 CFR 50.155. As such, GEH retained the addition of the ACIWA RHR Loop B as an operational enhancement to provide additional defense-in-depth. These proposed ABWR design enhancements could provide a potential COL applicant the means for meeting MBDBE rule requirements.

These proposed changes do not fall within the definition of a "modification," as described in Chapter 1 of this FSER supplement. Therefore, in accordance with 10 CFR 52.59(c), these design changes are "amendments," as this term is defined in Chapter 1 of this FSER supplement and the staff will evaluate the proposed changes using the regulations in effect at renewal. The regulatory requirements for evaluating the proposed DCD design changes to add an ACIWA subsystem to RHR Loop B and related changes are as follows:

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," (GDC) 34, "Residual Heat Removal," as it relates to the ABWR RHR system, which requires the capability to transfer decay heat and other residual heat from the reactor such that fuel and pressure boundary design limits are not exceeded. Compliance with GDC 34 enhances plant safety by providing assurance that decay and residual heat removal will be accomplished, and the reactor coolant system pressure boundary and fuel cladding integrity will be maintained, thereby minimizing the potential for the release of fission products to the environment.

The staff reviewed this amendment for renewal of the ABWR DC in accordance with NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," (SRP) Section 5.4.7, "Residual Heat Removal (RHR) System," Revision 5, issued May 2010. This ABWR DC renewal design change does not alter the previous staff safety findings regarding the ABWR RHR from NUREG-1503, the staff FSER for the ABWR DC, Chapter 5, Section 5.4.7.

5.4.7.2 Summary of Technical Information

In Section 5.4.7 of the ABWR FSER, NUREG-1503, the staff provided its technical evaluation and regulatory approval of the original ABWR ACIWA subsystem which has the function of providing a beyond- design-basis emergency water source to the reactor vessel, containment and spent fuel pool through the ABWR RHR Loop C from the plant FPS supplemental water sources. The staff described the ACIWA subsystem piping and components arrangement that links the FPS water source or an alternate external water source such as a fire truck to the RHR Loop C pump discharge line downstream of the pump's discharge check valve. The ACIWA safety-related isolation valves are normally closed and designed to isolate the non-safety FPS

[1] In the MBDBE proposed rule regulatory analysis (ADAMS Accession No. ML15266A133), the Commission proposed to not make the MBDBE proposed rule applicable to existing DCs, which included the ABWR, because "[t]he issues that may be resolved in a DC and accorded issue finality may not include operational matters, such as the elements of the [MBDBE] proposed rule."

from the safety related RHR system. During a beyond-design-basis event including the loss of onsite and offsite ac (e.g., extended station blackout (SBO)), the valves can be operated manually and be placed into operation locally from the emergency core cooling systems (ECCS)/ RHR valve room. This flow path allows an additional water source for injection into the reactor vessel and the drywell during postulated beyond-design-basis conditions including an SBO condition where all ac power and all ECCS pumps are unavailable.

The GEH proposal to add a redundant ACIWA subsystem to the RHR Loop B discharge line, as described in the following Section 5.4.7.3 of this supplemental FSER, includes revisions to both DCD Tier 1, and DCD Tier 2, information.

5.4.7.3 Technical Evaluation

In the ABWR DCD, Revision 7, includes an additional ACIWA subsystem to RHR Loop B as an enhancement to the design features that provide water makeup from the FPS or backup external source to the reactor pressure vessel, containment, and spent fuel pool during degraded beyond-design-basis plant conditions (such as an extended SBO) when both onsite and offsite ac power sources are unavailable. The staff reviewed the proposed change to RHR Loop B and considers the additional ACIWA comparable to the RHR Loop C ACIWA. Each ACIWA subsystem will have connections to the FPS adjacent to the ECCS/ RHR valve room with a check valve upstream of two normally locked closed safety related manually operated valves in series to isolate and prevent back flow into the FPS. The external source connection for the additional ACIWA subsystem to RHR Loop B is configured the same as the original ACIWA connection, with the exception of an additional manual valve located outside of the reactor building. The staff finds the configuration acceptable because it provides isolation from the safety related RHR system during normal operation while preventing reverse flow if the manual valves in series are mis-aligned during operation of the RHR. The addition of a redundant ACIWA mode to the RHR system does not alter the function of the RHR system and adds additional capability, therefore the original staff findings in NUREG-1503 are not altered and the requirements of GDC 34 are maintained and enhanced.

The staff also finds that the ACIWA vessel injection, containment injection, or spent fuel pool makeup modes are not adversely affected by this additional design enhancement and adds additional flexibility to the ACIWA system. The staff considers the physical separation of the two ACIWA subsystems sufficient to ensure that at least one will be available during degraded plant conditions such as an extended SBO. In addition, the staff finds the ABWR DCD, Revision 7, complete and confirmed the changes against the GEH markups from it's January 23, 2017, letter, of the DCD Tier-1 and Tier-2 figures, sections, and tables.

5.4.7.4 Conclusion

Based on the evaluation provided in this FSER section supplement, the staff concludes that the proposed ABWR DCD design enhancements do not alter the safety findings made in the FSER for the original ABWR certification. In addition, the changes proposed by the applicant improve the reliability of the ACIWA to deliver water makeup to the reactor vessel, containment, and spent fuel pool during degraded plant conditions. Therefore, the staff finds that the changes are in compliance with GDC 34 and the changes are acceptable because they improve plant operational flexibility and safety by providing additional means of residual and decay heat removal.

References

1. 10 CFR 50.155, “Mitigation of Beyond-Design Basis Events,” MBDBE Rule.

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

3. 10 CFR Part 50, Appendix A, GDC 34, “Residual Heat Removal.”

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

5. 10 CFR 52.59, “Criteria for Renewal.”

6. NRC, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 5.4.7, “Residual Heat Removal (RHR) System,” Revision 5, May 2010 (ADAMS Accession No. ML100680577).

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

8. 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).

9. NRC, SECY-12-0025, “Proposed Orders and Requests for Information in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami,” dated February 17, 2012 (ADAMS Accession No. ML12039A111).

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

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

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