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2 SITE CHARACTERISTICS

2.3 Meteorology

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 2, "Site Characteristics," Section 2.3.1, "Regional Climatology," 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.

2.3.1 Regional Climatology

2.3.1.1 Regulatory Criteria

In accordance with NRC regulations, nuclear plants must be designed so that they remain in a safe condition under extreme meteorological events, including those that could result in the most extreme wind events (tornadoes and hurricanes) that could reasonably be predicted to occur. The applicant added hurricane wind speed and hurricane missile spectra to the list of site parameter values presented in DCD Tier 1, Section 5.0, and DCD Tier 2, Section 2.0, of the GEH ABWR DCD, Revision 7. A combined license (COL) applicant that references the GEH ABWR DC will assess whether the actual site characteristics fall within the site parameters specified for the ABWR design.

The applicant made changes to the ABWR DCD, Revision 7, to provide criteria for a COL applicant to determine whether an ABWR located at a particular site is appropriately protected against the effects of hurricane winds and missiles. In September 2014, the staff issued request for additional information (RAI) 02-1 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14267A352), raising concerns about compliance with GDC 2 (1997) and 4 (1997) for hurricane loads and hurricane-generated missiles. In response, the applicant added information to DCD Tier 1, Section 5.0 and Tier 2, Section 2.0. Since the applicant's changes were in response to the staff's concerns regarding compliance with regulations in effect at initial certification, these changes are "modifications," as described in Chapter 1 of this FSER supplement, and the staff will therefore evaluate them using the regulations applicable and in effect at the time of initial certification.

The applicable regulatory requirements for evaluating the proposed changes are as follows:

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants" (GDC) 2, "Design Bases for Protection Against Natural Phenomena," (1997), requires, in part, that

structures, systems, and components (SSCs) important to safety be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety function.

- GDC 4, “Environmental and Dynamic Effects Design Bases,” (1997), requires, in part, that SSCs important to safety to be appropriately protected against dynamic effects, including the effects of missiles that may result from equipment failures and from events and conditions outside the nuclear power unit.
- 10 CFR 52.47(a)(1)(iii) (1997) states that DC applications must include the site parameters postulated for the design, and an analysis and evaluation of the design in terms of such parameters.

Additional information on the staff’s review of DC renewal applications with respect to hurricane wind and hurricane missile site parameters can be found in DC/COL-ISG-024, “Implementation of Regulatory Guide 1.221 on Design-Basis Hurricane and Hurricane Missiles,” issued May 2013.

2.3.1.2 Summary of Technical Information

The ABWR DCD, Revision 4, which is referenced in the original ABWR DC, contained tornado site parameters which included maximum tornado wind speed and missile spectra. Prior to 2007, the general engineering assumption was that tornado phenomena-controlled design with respect to wind loads and wind generated missiles and that these tornado site parameters bounded hurricane wind loads and hurricane missiles. Revision 1, to Regulatory Guide (RG) 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” issued March 2007, resulted in a decrease in tornado design-basis wind speeds due to the adoption of the Enhanced Fujita scale for classifying tornado intensity. Since design-basis tornado wind speeds were decreased as a result of the analysis performed to update RG 1.76, it was no longer clear that the revised tornado design-basis wind speed would bound design-basis hurricane wind speeds in all areas of the United States. This prompted studies into extreme wind gusts during hurricanes and their relation to design-basis hurricane wind and missiles, which ultimately resulted in the issuance of RG 1.221, Revision 0, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” issued October 2011.

The study of extreme wind gusts during hurricanes, NUREG/CR-7005, “Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants,” (ADAMS Accession No. ML11335A031), concluded that it is possible that the wind speeds from the design-basis tornado may not be bounding for certain locations along the United States Gulf Coast and the southern Atlantic Coast. The study of missile speeds during hurricanes, NUREG/CR-7004, “Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants,” issued November 2011 (ADAMS Accession No. ML11341A102), concluded that airborne missiles can fly faster in a hurricane wind field with the same 3-second gust wind speed at 10 meters (33 feet) above ground than in a tornado wind field. Because the size of the hurricane wind field with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum wind speed.

In ABWR DCD, Revision 5, which GEH originally submitted in support of its ABWR DC renewal application, it contained tornado site parameters related to the maximum tornado wind speed and tornado-generated missile spectra but did not contain site parameters related to hurricane wind speed or hurricane-generated missile spectra. If a nuclear power plant using the ABWR certified design is located at a site where the hurricane loads and/or the hurricane-generated missile spectra are not bounded by tornado loads and tornado-generated missile spectra, then safety-related structures may not be able to withstand hurricane loads and hurricane-generated missiles as required. Consequently, the staff issued RAI 02-1, dated September 25, 2014 (ADAMS Accession No. ML14267A352), requesting the applicant to address how the ABWR design met GDC 2 (1997) and GDC 4 (1997) for hurricane loads and hurricane-generated missiles. The staff requested that the applicant add hurricane wind speed (e.g., 3-second gust at 10 meters above ground in open terrain) and hurricane-generated missile spectra (including missile dimensions, mass, and velocity) to the list of site parameter values presented in DCD Tier 1, Section 5.0, and DCD Tier 2, Section 2.0 of the GEH ABWR DCD. The staff also requested that the applicant revise the ABWR DCD to show how SSCs important-to-safety are protected from the effects of hurricane winds and missiles.

The applicant's responses to the staff's RAI 02-1 resulted in the following hurricane wind speed related changes:

- DCD, Tier 1, Table 5.0, "ABWR Site Parameters," contained changes to include a hurricane wind speed site parameter; and
- DCD, Tier 2, Table 2.0-1, "Envelope of ABWR Standard Plant Site Design Parameters," contained changes to include a hurricane wind speed site parameter.

In a subsequent RAI 02-1 response, Supplement 5, dated April 13, 2017 (ADAMS Accession No. ML17103A125), which was provided after submission of ABWR DCD, Revision 6, the applicant provided the following hurricane wind speed value to the list of site parameter values presented in DCD Tier 1, Section 5.0, and DCD Tier 2, Section 2.0:

- Maximum hurricane wind speed: 257 km/h

The applicant added footnotes to DCD Tier 1, Table 5.0 and DCD Tier 2, Table 2.0-1, that state 257 km/h is a fastest-mile wind speed, which corresponds to 286.5 km/h 3-second gust wind speed, as the design-basis hurricane wind speed parameter for the ABWR, in accordance with RG 1.221, Revision 0, measured at 10 meters above ground over open terrain. The staff notes that a wind speed of 286.5 km/h is equivalent to 178 mph or 79.6 m/s.

2.3.1.3 Technical Evaluation

In this supplemental FSER section the staff evaluates the proposed hurricane wind site parameters. Sections 3.5.1.4 and 3.3 of this supplemental FSER provide the staff's evaluation of the missiles generated by hurricane winds and the resulting extreme wind loadings on structures important to safety, respectively.

In the applicant's response to RAI 2.0-1 dated November 19, 2014 (ADAMS Accession No. ML14324A082), GEH provided: (1) DCD Tier 1 site parameters related to hurricane maximum wind speed, maximum pressure drop, and missile spectra, and (2) DCD Tier 2 site parameters related to hurricane maximum wind speed, maximum rotational speed, translational velocity, radius, maximum pressure drop, and missile spectra.

Subsequently, GEH revised its RAI 02-1 response in Supplement 1 dated June 26, 2015 (ADAMS Accession No. ML15177A038), by eliminating the following site parameters for the hurricane: (1) maximum pressure drop from the list of DCD Tier 1 site parameters, and (2) maximum rotational speed, translational velocity, radius, and maximum pressure drop from the list of DCD Tier 2 site parameters. As discussed in DC/COL-ISG-024, the load from the hurricane atmospheric pressure change is assumed to be small. The rate of pressure change at a specific location from the passage of a hurricane is slow compared to the passage of a tornado because the large pressure drop within a hurricane occurs over a distance of several miles, whereas the large pressure drop within a tornado occurs over a few hundred feet. Consequently, the staff evaluated these parameters and concludes that listing hurricane maximum rotational speed, translational velocity, radius, and maximum pressure drop as site parameters is not necessary as these site parameters are used to determine the rate of hurricane atmospheric pressure drop which is assumed to be small.

GEH further revised its RAI 02-1 response in Supplement 5, dated April 13, 2017, by proposing to modify the DCD to indicate that the severe wind and extreme hurricane wind site parameter values are fastest-mile values, consistent with the wind loading methodology at the time of initial certification as presented in American National Standards Institute/American Society of Civil Engineers (ASCE) Section 7-88, 1990, "Minimum Design Loads for Buildings and Other Structures." Additionally, as part of its response to RAI 02-1, the applicant proposed changes to the DCD that state the extreme maximum tornado wind speed site parameter value is a fastest quarter mile value that is consistent with the wind loading methodology at the time of initial certification as presented in the NRC approved Bechtel Topical Report BC-TOP-3-A, "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants," Revision 3, issued August 1974 (ADAMS Accession No. ML14093A218). The applicant also provided the corresponding equivalent 3-second gust values in DCD Tier 1, Table 5.0 and DCD Tier 2, Table 2.0-1.

The staff reviewed the hurricane wind speed contour maps in RG 1.221, Revision 0, and concluded that, except for certain locations along the Gulf and the Atlantic coasts, a design-basis hurricane 3-second wind speed site parameter value of 286.5 km/h (178 mph) is bounding. Because the proposed ABWR design-basis hurricane wind speed site parameter value bounds a reasonable number of potential COL sites, the staff finds the proposed site parameter value acceptable. If the design-basis hurricane wind speed site parameter value defined in the ABWR DCD does not bound a particular site, the COL applicant referencing the design will need to request an exemption from the Tier 1 site parameter as part of its application and submit analyses to demonstrate that the site-specific hurricane wind speed value does not exceed the capability of the design.

The applicant included the changes described in Supplement 5 of the response to RAI 02-1, dated April 13, 2017, in the ABWR DCD, Revision 7. Therefore, Confirmatory Item 2.3-1 from the staff advanced safety evaluation with no open items for the ABWR DC renewal is resolved and closed.

2.3.1.4 Conclusion

Based on the evaluation provided in this FSER section supplement, the staff concludes that the changes to add a maximum hurricane wind speed as a DCD Tier 1 and DCD Tier 2 site parameter to the ABWR DCD, Revision 7, are acceptable and do not alter the safety findings made in NUREG-1503 and meet the applicable regulations in effect at initial certification, including the requirements of GDC 2 (1997) and GDC 4 (1997).

The staff's review concludes that the applicant added an appropriate design-basis hurricane wind speed site parameter for the GEH ABWR, and therefore complies with 10 CFR 52.47(a)(1)(iii) (1997). This is consistent with the guidance in RG 1.221, Revision 0, for design-basis hurricane wind speeds for nuclear power plants and therefore is acceptable.

References

1. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants."
2. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection against Natural Phenomena," (1997).
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. 10 CFR 52.47, "Contents of Applications; Technical Information."
6. 10 CFR 52.59, "Criteria for Renewal."
7. NRC, DC/COL-ISG-024, "Implementation of Regulatory Guide 1.221 on Design-Basis Hurricane and Hurricane Missiles," May 2013 (ADAMS Accession No. ML13015A693).
8. NRC, NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," July 1994 (ADAMS Accession No. ML080670592).
9. 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).
10. NRC, NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants," November 2011 (ADAMS Accession No. ML11341A102),
11. NRC, NUREG/CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants," November 2011 (ADAMS Accession No. ML11335A031).
12. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 4, Tier 1 and Tier 2, December 2010 (ADAMS Accession No. ML11126A129).
13. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 5, Tier 1 and Tier 2, December 2010 (ADAMS Accession No. ML110040323).
14. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 6, Tier 1 and Tier 2, February 2016 (ADAMS Accession No. ML16214A015).
15. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 7, Tier 1 and Tier 2, December 2019 (ADAMS Accession No. ML20007E371).

16. NRC, RG-1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, March 2007 (ADAMS Accession No. ML070360253).
17. NRC, RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," Revision 0, October 2011 (ADAMS Accession No. ML110940300).
18. ANSI/ASCE, 7-88, 1990, "Minimum Design Loads for Buildings and Other Structures," October 5, 2018.
19. Bechtel Topical Report, BC-TOP-3-A, "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants," Revision 3, August 1974 (ADAMS Accession No. ML14093A218).