

19.0 PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENTS

This chapter describes the plant specific probabilistic risk assessment (PRA) and severe accident evaluations and corresponding regulatory requirements.

19.1 Probabilistic Risk Assessment

This section of the safety evaluation report (SER) provides an integrated review of Sections 19.1, 19.2, 19.4, 19.5 and Appendix 19.AA of the North Anna 3 Combined License (COL) Final Safety Analysis Report (FSAR). These FSAR sections describe the objectives of the design-specific PRA, an overview of the Economic Simplified Boiling-Water Reactor (ESBWR) PRA and a summary of PRA maintenance, and PRA results and insights.

19.1.1 Introduction

In accordance with Title 10 *Code of Federal Regulations* (CFR) 52.79(d)(1), a COL application is required to contain a description of the plant-specific PRA and its results. In addition, if the COL application references a design certification (DC), then the plant-specific PRA information should use the PRA information for the DC and be updated to account for site-specific design information and any design changes or departures.

19.1.2 Summary of Application

Sections 19.1 and 19.4 of the North Anna 3 COL FSAR, incorporate by reference Sections 19.1 and 19.4, of the ESBWR design control document (DCD), Revision 5, with no departures or supplements. The applicant added Appendix 19AA providing a summary of plant specific PRA review. Sections 19.2 and 19.5 of the COL FSAR incorporate by reference Section 19.2 and 19.5 of the ESBWR DCD, Revision 5, with no departures and the following supplemental information:

- COL Item STD COL 19.2.6-1-H Seismic High Confidence Low Probability of Failure Margins

In FSAR Section 19.2.3.2.4, the applicant provided supplementary information to address DCD COL Item 19.2.6-1-H. The applicant stated that an analysis of as-built structure, system, and component (SSC) high confidence low probability of failure (HCLPF) will be performed prior to fuel load and will be compared to those assumed in the ESBWR seismic margin analysis to determine if any new vulnerabilities have been introduced.

Supplemental Information

- NAPS SUP 19.5-1

In FSAR Section 19.5 and Appendix 19AA, the applicant provided supplementary information (NAPS SUP 19.5-1) which describes the results of its evaluation of site-specific information, plant-specific information, design changes or departures from the certified design, to determine if any changes from the certified design PRA are warranted.

19.1.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed within the final safety evaluation report (FSER) related to the DCD [9-4].

The regulatory basis for acceptance of the supplementary information on consideration of site-specific and plant-specific information and design features is established in 10 CFR 52.79(d)(1), which requires: (1) a COL applicant referencing a certified design to include, in the FSAR, information sufficient to demonstrate that the site characteristics fall within the site parameters specified in the design certification, and (2) that plant-specific PRA information in a COL application that references a standard design certification must use the PRA information from the design certification and must be updated to account for site-specific design information and any design changes or departures.

Consistent with 10 CFR 50.71(h), each COL holder shall maintain and upgrade the PRA. The upgraded PRA must cover initiating events and modes of operation contained in NRC-endorsed consensus standards on PRA in effect one year prior to each required upgrade.

19.1.4 Technical Evaluation

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed Sections 19.1, 19.2, 19.4, and 19.5 of the North Anna 3 COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the information in the COL represent the complete scope of information relating to this review topic.¹ The NRC staff's review confirmed that the information contained in the application and incorporated by reference addresses the required information related to PRA. Sections 19.1, 19.2, 19.4, and 19.5 of ESBWR DCD are being reviewed by the staff on Docket No. 52-010. The NRC staff's evaluation of the information incorporated by reference related to these sections will be documented in the staff SER on the design certification application for the ESBWR design.

In addition, the NRC staff reviewed Parts 4 and 7 of the North Anna 3 COL FSAR which includes the Technical Specifications and Departures Report, respectively. The NRC staff has determined from this review that the applicant has not taken any departures from the Certified ESBWR design and that the ESBWR Generic Technical Specifications (GTS) and Bases of the referenced certified design are incorporated by reference into the Unit 3 plant specific technical specifications with only minor modifications that would not impact the ESBWR design specific PRA.

The staff reviewed the information contained in the COL FSAR:

COL Item

- STD COL 19.2.6-1-H Seismic High Confidence Low Probability of Failure Margins

The applicant provided the following supplementary information to address DCD COL Item 19.2.6-1-H:

¹ See Section 1.2.2, "Finality of Referenced NRC Approvals," for a discussion on the staff's review related to verification of the scope of information to be included within a COL application that references a design certification.

“As-built SSC HCLPF will be compared to those assumed in the ESBWR seismic margin analysis shown in DCD Table 19.2-4. Deviations from the HCLPF values or other assumptions in the seismic margins evaluation will be analyzed to determine if any new vulnerabilities have been introduced. A minimum HCLPF value of 1.67*SSE will be met for the SSCs identified in DCD Table 19.2-4. This comparison and analysis will be completed prior to fuel load.”

This Holder item is described in ESBWR DCD Tier 2, Section 19.2.6, Revision 5. In the response to the request for additional information (RAI) 19.2-92 for Chapter 19 of ESBWR DCD Tier 2, General Electric-Hitachi (GEH) revised DCD Table 19.2-4 to clarify that the safe shutdown earthquake for HCLPF values is the ESBWR certified seismic design response spectrum (CSDRS). Therefore, the staff considers that the COL Holder will confirm the HCLPFs for SSCs in DCD Table 19.2-4 with respect to ESBWR CSDRS.

Supplemental Information

- NAPS SUP 19.5-1

In Section 19.5 of the FSAR, the applicant stated the following in support of the assertion that the requirement of 10 CFR 52.79(a)(46) for a description of the plant-specific PRA and its results has been met: “The review of site-specific information and plant-specific design information determined that: 1) the DCD PRA bounds site-specific, and plant-specific design parameters and design features and 2) these parameters and features have no significant impact on the DCD PRA results and insights.” In order to confirm the validity of the applicant’s assertion, the staff issued RAI Questions 19-1 and 19-2 requesting the applicant provide additional information regarding the site-specific and plant-specific design parameters and design features, and explain how the site-specific and plant-specific design parameters and design features were bounded by the DCD PRA. The applicant responded to these questions in their letter dated July 14, 2008 and numbered 005. In their response to the staff, the applicant described the key site-specific parameters and features considered in their evaluation and provided a summary of the evaluation for each specific parameter or feature.

The parameters and features evaluated by the applicant include:

- Loss of service water frequency
- Loss of preferred power frequency
- Loss of service water frequency
- Plant-specific flooding zones of the yard and service water building
- Seismic fragilities
- Site-specific terrain and meteorological data
- Sharing of systems with other facilities on the site (i.e., nuclear units 1 & 2)
- Plant-specific procedures for outage planning and control

The staff finds this list of parameters and features to be complete given that the applicant has not taken any departures from the Certified ESBWR design and that the ESBWR GTS and Bases of the referenced certified design are incorporated by reference into the Unit 3 plant specific technical specifications with only minor modifications that would not impact the ESBWR design specific PRA.

The applicant incorporated a summary of the evaluation into Chapter 19, Appendix AA of the FSAR. In their evaluation the applicant considers the extent to which the treatment in the DCD

of each parameter or feature is at variance with the corresponding parameter or feature. The staff finds that the information in the evaluation is sufficient to support the conclusion that differences between site specific parameters and features and assumptions in the DCD are small and do not invalidate the applicant's reference of the DCD PRA results and insights provided in Chapter 19 of the ESBWR DCD. The staff finds the applicant's evaluation as summarized in Appendix AA of Chapter 19 of the FSAR to be acceptable.

19.1.5 Post Combined License Activities

The following item was identified as the responsibility of the COL license holder:

- 19.2.6-1-H Seismic High Confidence Low Probability of Failure Margins

19.1.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information relating to the PRA and there is no outstanding information expected to be addressed in the COL FSAR related to this subsection.

The staff is reviewing the information in ESBWR DCD Sections 19.1, 19.2, 19.4, and 19.5 on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to the PRA incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the design certification application (DCA) for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as Open Item 1-1. The staff will update Section 19.1 of this SER to reflect the final disposition of the DCA.

In addition, the staff has compared the additional COL information within the application to the relevant NRC regulations. The regulatory basis for acceptance of the supplementary information on consideration of site-specific and plant-specific information and design features is established in 10 CFR 52.79(d)(1). The staff cannot make a conclusion on this section until the resolution of Open Item 1-1.

19.2 Severe Accident Evaluation

The regulations do not require that a COL application include a SAMA evaluation. It is, however, required to be in the Environmental Report. 10 CFR 52.79(a)(17) states that a COL application for a LWR must contain a FSAR that provides the information with respect to compliance with technically relevant positions of the relevant TMI requirements in 10 CFR 50.34(f). This material is included in Appendix 1A and Chapter 19 of the ESBWR DC D Tier 2, which has been incorporated by reference in the North Anna COL application.

This section of SER provides the staff's review of Section 19.3 of the North Anna 3 COL FSAR.

19.2.1 Introduction

This section provides the NRC staff's evaluation of the following topics related to severe accident evaluation in the North Anna 3 COL FSAR and Environmental Report [19-5]:

- a. Severe accident prevention,
- b. Severe accident mitigation,

- c. Containment performance capability,
- d. Accident management, and
- e. Consideration of potential design improvements under 10 CFR 50.34(f) [19-6].

19.2.2 Summary of Application

Sections 19.3 of the North Anna 3 COL FSAR, incorporates by reference Sections 19.3, of the ESBWR DCD, Revision 5 with no departures or supplements.

In the COL FSAR Chapter 18, Human Factors Engineering, the applicant incorporated by reference Section 18.1 of the ESBWR DCD with no departures or supplements. This section of the ESBWR DCD addresses accident management.

The applicant addresses consideration of potential design improvements under 10 CFR 50.34(f) in Section 7.3 (“Severe Accident Mitigation Alternatives”) of the North Anna, Unit 3 COL Environmental Report [19-5]. Section 7.3 addresses severe accident mitigation alternatives (SAMA) based on the ESBWR’s severe accident mitigation design alternatives (SAMDA) [19-7] and North Anna’s site and regional data.

19.2.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed within the FSER related to the DCD [19-4].

The regulatory basis also includes the requirements of 10 CFR 52.79(a)(17) for a COL application [19-8]. This regulation invokes 10 CFR 50.34(f)(1)(i) which requires applicants to “perform a plant/site-specific probabilistic risk assessment (PRA), the aim of which is to seek such improvements in the reliability of core and containment heat removal systems as are significant and practical and do not impact excessively on the plant.”

19.2.4 Technical Evaluation

19.2.4.1 Severe Accident Prevention, Severe Accident Mitigation, and Containment Performance Capability

Sections 19.3, 19B, and 19C of the North Anna, Unit 3 COL FSAR incorporate by reference, without any departures, Sections 19.3, 19B, and 19C, respectively, of the ESBWR DCD [19-3]. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review. The NRC staff’s review confirmed there is no outstanding issues related to these sections.

The staff is reviewing the information in ESBWR DCD Sections 19.3, 19B, and 19C on Docket No. 52-010. The results of the NRC staff’s technical evaluation of the information related to severe accident prevention, severe accident mitigation, and containment performance capability incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19.2 of this SER to reflect the final disposition of the DCA.

19.2.4.2 Accident Management

The staff is reviewing the information in the ESBWR DCD related to accident management on Docket No. 52-010. In particular, the staff's ongoing safety evaluation of the ESBWR DCD has an open item related to providing the technical basis for accident management. Resolution of this open item may lead to a revision to the North Anna, Unit 3 COL application, to ensure that the present applicant will develop procedures according to the ESBWR Human Factors Engineering Procedures Development Implementation Plan (NEDO-33274, Revision 2) that include the technical basis. In addition, the present applicant must ensure that accident management training will be implemented according to the ESBWR Human Factors Engineering Training Implementation Plan (NEDO-33275, Revision 1). These documents are being evaluated by the NRC staff as part of the Chapter 18 review. ITAACs 7 and 8 in Table 3.3-1 of the ESBWR DCD Tier 1, will ensure that the severe accident management technical basis will be incorporated into the severe accident management guideline procedures prior to operation of North Anna, Unit 3.

The results of the NRC staff's technical evaluation of the information related to accident management incorporated by reference in the North Anna, Unit 3 COL FSAR will be documented in the staff SER, on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19.2 of this SER to reflect the final disposition of the DCA.

19.2.4.3 Consideration of Potential Design Improvements Required by 10 CFR 50.34(f)

The applicant has submitted a Level 1 and Level 2 PRA, most of which has been incorporated by reference to Chapter 19 of the ESBWR DCD, which in turn references the ESBWR PRA. This PRA has estimated significant reductions in risk relative to the currently operating BWRs, reflecting improvements in the reliability of core and containment heat removal systems.

Candidate design improvements were evaluated in the ESBWR SAMDA analysis in the ER.

The ESBWR SAMDA analysis [19-7] is being reviewed by the NRC staff as part of the ESBWR design certification review (Docket No. 52-010). The results of the NRC staff's technical evaluation of the information related to ESBWR SAMDA analysis will be documented in the staff SER safety evaluation report on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item [1-1]. The staff will update Section 19.2 of this SER to reflect the final disposition of the ESBWR SAMDA analysis, and this is being tracked as part of Open Item 1-1.

19.2.5 Post Combined License Activities

There are no post COL activities related to this section.

19.2.6 Conclusions

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information and there is no outstanding information expected to be addressed in the COL FSAR related to severe accident prevention, severe accident mitigation, containment performance capability, accident management and consideration of potential design improvements under 10 CFR 50.34(f).

The staff is reviewing the information in ESBWR DCD related to severe accident evaluation on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to severe accident evaluation incorporated by reference in the North Anna 3 COL FSAR and Environmental Report will be documented in the staff SER on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19.2 of this SER to reflect the final disposition of the DCA.

19A Regulatory Treatment of Non-Safety Systems

This section provides the selection criteria and processes used to develop the regulatory treatment of non-safety systems (RTNSS).

Section 19A of the North Anna 3 COL FSAR incorporates by reference Section 19A of the ESBWR DCD, Revision 5 without any departures or supplements. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review. The NRC staff's review confirmed that there is no outstanding issue related to this section.

The staff is reviewing the information in DCD Section 19A on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to RTNSS incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19A of this SER to reflect the final disposition of the DCA.

19B Deterministic Analysis for Containment Pressure Capability

This section provides the selection criteria and processes used to develop the evaluation of external seismic event. This section includes the deterministic analysis for containment pressure capability.

Section 19B of the North Anna 3 COL FSAR, incorporates by reference Section 19B of the ESBWR DCD, Revision 5 without any departures or supplements. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review. The NRC staff's review confirmed that there is no outstanding issue related to this section.

The staff is reviewing the information in DCD Section 19B on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to RTNSS incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19B of this SER to reflect the final disposition of the DCA.

19C Probabilistic Analysis for Containment Pressure Fragility

This section provides the selection criteria and processes used to develop the evaluation of external seismic event. This section includes the probabilistic analysis for containment pressure fragility.

Section 19C of the North Anna 3 COL FSAR, incorporates by reference Section 19C of the ESBWR DCD, Revision 5 without any departures or supplements. The NRC staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review. The NRC staff's review confirmed that there is no outstanding issue related to this section.

The staff is reviewing the information in DCD Section 19C on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to RTNSS incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the DCA for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 19C of this SER to reflect the final disposition of the DCA.

REFERENCES

- 19-1. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," U.S. Nuclear Regulatory Commission, April 2, 1993 (SRM dated July 21, 1993).
- 19-2. Dominion, "North Anna 3 Combined License Application, Part 2: Final Safety Analysis Report," Revision 1, December 2008.
- 19-3. GE-Hitachi Nuclear Energy, "ESBWR Design Control Document," Revision 5, May 2008.
- 19-4. Dominion, "North Anna 3 Combined License Application, Part 3: Applicants' Environmental Report - Combined License Stage," Revision 1, December 2008.
- 19-5. Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the Code of Federal Regulations, Section 34, "Contents of Construction Permit and Operating License Applications; Technical Information," U.S. Nuclear Regulatory Commission.
- 19-6. NEDO-33306, "Licensing Topical Report ESBWR Severe Accident Mitigation Design Alternatives," Revision 1, GE-Hitachi Nuclear Energy, August 2007.
- 19-7. Title 10, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," of the *Code of Federal Regulations*, Section 79, "Contents of Applications; Technical Information in Final Safety Analysis Report," U.S. Nuclear Regulatory Commission.
- 19-8. NEI 91-04, "Severe Accident Issue Closure Guidelines," Revision 1, Nuclear Energy Institute, Report NEI 91-04, 1994.
- 19-9. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," U.S. Nuclear Regulatory Commission, June 2007.
- 19-10. NEDE-33217P, Class III (Proprietary) and NEDO-33217, Class I (non-proprietary), "ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan," Revision 3, GE Energy, March 2007.

19-11. "Response to Portion of NRC Request for Additional Information Letter No. 121 Related to ESBWR Design Certification Application - PRA & Severe Accidents - RAI Number 19.2.4-1 Supplement 2," GE Hitachi Nuclear Energy, MFN 05-169, Supplement 3, April 3, 2008, Docket No. 52-010.