

## 15.0 SAFETY ANALYSES

### 15.1 Introduction

This chapter provides analyses of the plant's responses to postulated disturbances in process variables and postulated equipment failures or malfunctions, determines their consequences, and evaluates the capability of the plant to control or accommodate these events. These analyses help determine the limiting conditions for operation, limiting safety system settings, and design specifications for safety-related components and systems.

The analyses in this chapter includes a discussion of: (1) the classification of the transients and accidents and their results in the context of a sufficiently broad spectrum of initiating events and postulated equipment failures, (2) the frequency of occurrence for initiating events for anticipated operational occurrences and highly unlikely accidents, (3) plant characteristics considered in the safety evaluation, (4) assumed protection system actions, (5) evaluation of individual initiating events and systems that operate to reduce the probability of occurrence of specific events, and (6) analysis of anticipated transients without scram. The safety analyses provide a significant contribution to the selection of limiting conditions for plant operation, limiting safety system settings, and design specifications for plant components and systems from the standpoint of public health and safety.

### 15.2 Summary of Application

Chapter 15 of the North Anna 3 combined license (COL) Final Safety Analysis Report (FSAR), Revision 8, incorporates by reference Chapter 15 of the Economic Simplified Boiling-Water Reactor (ESBWR) Design Control Document (DCD), Revision 10. In addition, in COL FSAR Chapter 15 the applicant provided the following additional information:

#### Supplemental Information:

- STD SUP 15.3-1 Radiological Consequences

The applicant added that procedures will detail the use of nuclear instrumentation to help in detecting a possible mislocated fuel bundle after fuel loading.

- NAPS SUP 15.3-2 Early Site Permit (ESP) Information

The applicant stated that Chapter 15 of the North Anna ESP Site Safety Analysis Report (SSAR) is incorporated by reference, except that plant parameter envelope (PPE) information in the ESP SSAR related to the ESBWR is replaced by DCD Chapter 15. This information is identified as NAPS ESP variance (VAR) 2.0-6.

- NAPS SUP 15.4-1

The applicant provided supplemental information related to NAPS COL 2A.2-2-A, which discusses administrative control of certain doors or personnel air locks during movement of irradiated fuel, as related to the design basis accident control room habitability dose analysis for the fuel handling accident.

### 15.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is in NUREG-1966, "Final Safety Evaluation Report Related to the Certification of the Economic Simplified Boiling-Water Reactor Standard Design".

Compliance with the non-seismic siting criteria of Title 10 of the *Code of Federal Regulations* (10 CFR) 100.21 and General Design Criterion (GDC) 19 requires that the applicant show that, for a plant located at the North Anna site, the radiological consequences of postulated accidents meet the criteria set forth in 10 CFR 52.79(a)(1) and for GDC 19 that the control room provides adequate radiation protection to ensure that radiation exposures shall not exceed 0.05 Sv (5 rem) TEDE to permit access and occupancy of the control room under accident conditions for the duration of the accident. Requirements for the technical information in the FSAR in the application for a combined license are given in 10 CFR 52.79. In particular, 10 CFR 52.79(a)(1)(vi) requires a description and safety assessment of the site on which the facility is to be located, including an evaluation of the offsite radiological consequences of postulated accidents to show that the site characteristics comply with 10 CFR Part 100.

Both 10 CFR 100.21, which references 10 CFR 50.34(a)(1), and 10 CFR 52.79(a)(1)(iv) have the same following offsite radiological consequence evaluation factors:

- (A) *An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of [0.25 Sv] 25 rem total effective dose equivalent (TEDE).*
- (B) *An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a radiation dose in excess of [0.25 Sv] 25 rem TEDE*

### 15.4 Technical Evaluation

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed Chapter 15 of the North Anna 3 COL FSAR and the referenced DCD to ensure that the combination of the ESBWR DCD and the information in the COL FSAR, which incorporates the ESP SSAR, represents the complete scope of information relating to this review topic.<sup>1</sup> The NRC staff's review confirmed that the information contained in and incorporated by reference addresses the required information related to the safety analyses. The staff's technical evaluation of the information in the ESBWR DCD related to accident analysis is documented in NUREG-1966.

In addition, the NRC staff confirmed that the information contained in the North Anna 3 COL application, including information incorporated by reference, addresses the required information related to the design basis accident (DBA) radiological consequence analyses. The NRC staff's technical evaluation of the information incorporated by reference in the North Anna ESP SSAR

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<sup>1</sup> See "Finality of Referenced NRC Approvals" in Section 1.2.2 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.

related to the DBA radiological consequence analyses is documented in the corresponding SER (i.e., NUREG-1835).

The staff reviewed the relevant information in the COL FSAR:

Supplemental Information:

- STD SUP 15.3-1                      Radiological Consequences
- NAPS SUP 15.3-2  
  (NAPS ESP VAR 2.0-6)              ESP Information

North Anna COL FSAR, Revision 0, incorporated by reference the analysis of the radiological consequences from the ESBWR DCD, Revision 4, Section 15.4 and from Chapter 15 of North Anna ESP SSAR. The staff review of the incorporated by reference sections noted that the isotopic time-dependent fission product release rates to the environment for each design-basis accident (DBA) analyzed in the ESBWR DCD, Revision 4 were not bounded by the values specified in Appendix B, "Controlling Values of Parameters and Design-Basis Accident Source Term Plant Parameters," in ESP No. ESP-003 issued for the North Anna site.

Therefore, the staff requested, in request for additional information (RAI) 15.06.05-1, that if the isotopic activity releases per time period specified in the radiological consequence analyses for each DBA analyzed in the ESBWR DCD and from Chapter 15 of North Anna ESP SSAR are not bounded by those specified in Appendix B to the North Anna ESP, that the applicant provide the site-specific radiological consequence doses for the exclusion area boundary (EAB), the low population zone (LPZ), and the control room for each DBA to demonstrate that North Anna site still meets the dose evaluation factors set forth in 10 CFR 50.34(a)(1)(ii)(D), 10 CFR 52.79(a)(1)(vi), and GDC 19.

In response to RAI 15.06.05-1, dated October 17, 2008 (Agencywide Documents Access and Management System ML082980134), the applicant clarified that that the COL FSAR would not incorporate by reference the information in the North Anna ESP PPE which was related to the ESBWR design, but instead would show compliance with the relevant regulations by incorporating by reference the DBA radiological consequence analyses from the ESBWR DCD. Revision 1 of the COL FSAR, and subsequent revisions, included this variance (NAPS ESP VAR 2.0-6) from the North Anna ESP, as described in Chapter 15 supplemental information NAPS SUP 15.3-2.

By taking a variance from the North Anna ESP with respect to the PPE information on the ESBWR, the analyses in the ESP SSAR which show compliance with the dose evaluation factors set forth in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1)(vi) are no longer being relied upon for the COL. Instead the COL FSAR is showing compliance with the relevant regulations by incorporating by reference the analyses from a more recent revision of the ESBWR DCD Chapter 15. Therefore, the staff agrees that it is unnecessary for the COL to show that the ESP PPE information is bounding for the COL, and the issue raised by the staff in RAI 15-06-05-1 is resolved.

1. Specifically, in the October 17, 2008 response to RAI 15.06.05-1, the applicant provided the following information: For the EAB and LPZ, the North Anna Unit 3 FSAR, Revision 0, Table 2.0-201, "Evaluation of Site/Design Parameters and Characteristics," shows that the site-specific atmospheric dispersion factor ( $\chi/Q$ ) values for Unit 3 fall

within those values in the DCD, Revision 5 and therefore, the North Anna Unit 3 meets the dose evaluation factors set forth in 10 CFR 50.34(a)(1)(ii)(D), and 10 CFR 52.79(a)(1)(vi).

The staff finds that this response is acceptable.

2. For the control room, the DCD, Revision 5  $\chi/Q$ s also remain bounding except for those associated with the DCD COL Item 2A.2-2-A, "Confirmation of Reactor Building  $\chi/Q$  values." This COL item specifies administrative controls to be implemented if the  $\chi/Q$  values for a release from certain reactor building or fuel building doors are not bounded by the DCD, Revision 5  $\chi/Q$  values. The North Anna FSAR, Revision 0 did not specify this condition in its administrative controls. In the North Anna FSAR, Revision 1, Chapter 2, "Site Characteristics," NAPS COL 2A.2-2-A, the applicant stated that the North Anna administrative controls will be such that the doors and personnel air locks on the east side of the Reactor Building or Fuel Building are promptly closed under conditions indicative of a fuel handling accident.

The staff finds that this response is acceptable. The staff's evaluation of this topic, including additional supplemental information provided at a later date, is discussed in more detail below with regard to NAPS SUP 15.4-1.

3. The bounding values for isotopic activity release rates to the environment for the DBAs in ESP No. ESP-003, Appendix B, were not available for inclusion in North Anna FSAR Revision 0 because the ESP was issued on the same day that the Unit 3 COL application was submitted. A subsequent review of the COL application with respect to the as-issued ESP by the applicant identified that the DBA source terms evaluated in the DCD Revision 4, Chapter 15 were not bounded by the ESP-003 source terms in all cases. Therefore, the applicant stated that it will revise the COL application to address the DCD Revision 5 source terms and will include a request for a variance to use the DCD Revision 5 source terms in lieu of the ESP values. In the North Anna FSAR, Revision 1, the applicant revised the FSAR to address the ESBWR DCD, Revision 5, Chapter 15 source terms and requested a variance, NAPS ESP VAR 2.0-6, to use the North Anna Unit 3 source terms from the DCD Revision 5 in lieu of those values specified in the North Anna ESP.

The staff finds that this variance is acceptable because the calculated doses in the ESBWR, Revision 5 are within the regulatory limits and the site-specific  $\chi/Q$  values are lower than those values specified in the ESBWR DCD, Revision 5.

4. The applicant stated that the North Anna 3 COL application Departure Report is being revised to clarify the criteria under which a variance is requested. In the North Anna COL Departure Report, Revision 1, the applicant revised the variance sections to clarify the criteria under which a variance is requested.

Therefore, RAI 15.06.05-1 is closed.

- NAPS SUP 15.4-1

By letter dated September 16, 2014, the applicant provided supplemental information to clarify operator actions that are related to the analysis of the design basis fuel handling accident (FHA) radiological consequences in the North Anna Unit 3 control room. Specifically, the applicant proposes to add the following site-specific supplemental information to the next revision of FSAR Section 15.4.1.2.3, "Identification of Operator Actions:"

During movement of irradiated fuel, those doors and personnel air locks on the plant east sides of the Reactor Building or Fuel Building that could act as a point source could result in control room  $\chi/Q$  values that are higher than the ESBWR  $\chi/Q$  values for a release in the Reactor Building or Fuel Building (See Section 2A.2.5). Therefore, those doors and personnel air locks on the plant east sides of the Reactor Building or Fuel Building that could act as a point source are administratively controlled to remain closed during movement of irradiated fuel. Administrative control of these doors and personnel air locks ensures that the control room habitability dose analysis for the fuel handling accident (FHA) incorporated by reference from DCD Section 15.4.1 is bounding for Unit 3 and control room doses do not exceed the requirements of GDC 19 in the event of an FHA.

ESBWR DCD, COL Item 2A.2-2-A, "Confirmation of the Reactor Building  $\chi/Q$  Values," gives guidance to COL applicants that if the site-specific point source control room receptor  $\chi/Q$  values for potential releases through doors or personnel air locks on the east sides of the reactor building (RB) and fuel building (FB) are greater than those used as site parameter values in the ESBWR DCD dose analysis for the FHA and would result in a higher radiological consequence than was reported in the DCD, then the affected doors or air locks are administratively controlled during movement of irradiated fuel. The applicant did not provide site-specific point source control room receptor  $\chi/Q$  values for releases through the doors and air locks on the east sides of the RB and FB or a comparison to the values used in the ESBWR DCD for the FHA to make a determination whether the dose in the control room for the FHA would be higher than reported in the ESBWR DCD. Instead, the applicant stated in NAPS COL 2A.2-2-A that those doors and personnel air locks on the plant east sides of the RB or FB that could act as a point source are administratively controlled to remain closed during movement of irradiated fuel. This statement was repeated in NAPS SUP 15.4-1 with additional information to include the relationship to the assumptions used in the FHA control room dose analysis. The staff found the supplemental information acceptable because administrative control of the doors and air locks on the east side of the RB and FB that could act as a point source during the movement of irradiated fuel provides assurance that in the event of an FHA, releases through the doors are sufficiently prevented so that the FHA dose analysis incorporated by reference from ESBWR DCD, Section 15.4.1 is bounding for North Anna Unit 3. The applicant's commitment to providing NAPS SUP 15.4-1 in a future revision of the FSAR is **Confirmatory Item 15-1**.

ESBWR DCD, Revision 10, Section 15.4 provided details and results of analyses of the radiological consequences for the DBAs. A list of the DBAs analyzed for radiological consequences and the sections where the radiological consequence analyses for those DBAs are discussed in the ESBWR DCD is given below.

<u>DCD Section</u>	<u>Design-Basis Accident</u>
15.4.1	Fuel Handling Accident
15.4.4	Loss of Coolant Accident
15.4.5	Main Steam Line Break Outside Containment
15.4.6	Control Rod Drop Accident
15.4.7	Feedwater Line Break Accident
15.4.8	Failure of Small Line
15.4.9	Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) System Line Failure
15.4.10	Spent Fuel Cask Drop Accident

The DBA radiological consequence analyses in the ESBWR DCD, Revision 10, used design reference site parameter values for the offsite atmospheric dispersion factors, in place of site characteristic (site-specific) values. The  $\chi/Q$  values are the only input to the DBA radiological consequence analyses that are affected by the site characteristics. The applicant provided and discussed the North Anna site characteristic short-term accident  $\chi/Q$  values in resolution of NAPS COL Item 2.0-10-A, "Short-Term Dispersion Estimates for Accidental Atmospheric Releases," and NAPS ESP COL Item 2.3-2, "Atmospheric Dispersion Factors for Control Room." The applicant also provided supplemental information in North Anna Unit 3 COL FSAR Table 2.3-207, "Unit 3 Cross Unit  $\chi/Q$  Result," for evaluating the impact of a postulated DBA in North Anna Units 1 and 2 on the North Anna Unit 3 control room. The North Anna site characteristic EAB and LPZ  $\chi/Q$  values are given in the North Anna COL FSAR Table 2.3.4-1.

In Section 2.3.4, "Short-Term Diffusion Estimates," of this SER, the staff discusses its review and resolution of (1) NAPS COL item 2.0-10-A, (2) NAPS ESP COL Item 2.3-2, and (3) the supplemental information, related to the North Anna site characteristic  $\chi/Q$  values as stated above, included under Section 2.3.4 of the North Anna COL FSAR.

The estimated DBA dose calculated for a particular site is affected by the site characteristics through the calculated  $\chi/Q$  input to the analysis; therefore, the resulting dose would be different than that calculated generically for the ESBWR design in the DCD. All other inputs and assumptions in the radiological consequences analyses remain the same as in the DCD. Smaller  $\chi/Q$  values are associated with greater dilution capability, resulting in lower radiological doses. When comparing a DCD site parameter  $\chi/Q$  value and a site characteristic  $\chi/Q$  value, the site is acceptable for the design if the site characteristic  $\chi/Q$  value is smaller than the site parameter  $\chi/Q$  value. Such a comparison shows that the site has better dispersion characteristics than that required by the reactor design.

For each time averaging period, the North Anna site characteristic offsite and control room short-term  $\chi/Q$  values are less than the site parameter  $\chi/Q$  values used by the ESBWR DCD, Revision 10, radiological consequence analysis for each of the DBAs. Since the result of the radiological consequence analysis for a DBA during any time period of radioactive material release from the plant is directly proportional to the  $\chi/Q$  for that time period, and because the North Anna site characteristic  $\chi/Q$  values are less than the comparable ESBWR DCD, Revision 10, site parameter  $\chi/Q$  values for all time periods and all accidents, the North Anna site-specific total dose for each DBA is therefore less than the ESBWR DCD, Revision 10, generic total dose for each DBA.

Since the ESBWR DCD, Revision 10, analyses show that the offsite and control room radiological consequences meet the regulatory dose requirements of 10 CFR 100.21, 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1), and GDC 19, and since, by the logic above, the North Anna site-specific DBA offsite and control room radiological consequences are less than those for the ESBWR DCD, Revision 10, the applicant has sufficiently shown that the DBA radiological consequences meet the requirements of 10 CFR 100.21, 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1), and GDC 19.

### **15.5 Post-Combined License Activities**

The applicant states in Supplemental Information NAPS SUP 15.4-1 that the doors and personnel air locks on the east sides of the Reactor Building and Fuel Building are administratively controlled to remain closed during movement of irradiated fuel.

### **15.6 Conclusion**

The NRC staff reviewed the application and checked the referenced DCD. The staff's review confirms that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this chapter. The results of the NRC staff's technical evaluation of the DCD information incorporated by reference is in NUREG-1966. With the exception of Confirmatory Item 15-1, pursuant to 10 CFR 52.63(a)(5) and 10 CFR Part 52, Appendix E, Section VI.B.1, all nuclear safety issues relating to "Safety Analyses" that were incorporated by reference are resolved.

In addition, the staff has compared the additional COL supplemental information within the application to the relevant NRC regulations, acceptance criteria defined in NUREG-0800, Chapter 15, and other NRC regulatory guides and concludes that the applicant is in compliance with NRC regulations.