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No figures were included in this chapter.

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No tables were included in this chapter.

15 TRANSIENT AND ACCIDENT ANALYSIS

15.0 Transient and Accident Analysis

This chapter describes the results of the Nuclear Regulatory Commission (NRC) staff review of the applicant's Final Safety Analysis Report (FSAR) analyses of the U.S. EPR responses to postulated equipment failures or malfunctions. These analyses are used to determine the limiting conditions for operation, limiting safety system settings, and design specifications for safety-related components and systems. In general, the term "limiting" means the maximum or minimum allowed value of a safety system setpoint or other variable that supports the safe operation and prevention of accidents.

Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 FSAR Chapter 15 incorporates by reference U.S. EPR FSAR Tier 2, Chapter 15, with departures and supplements as discussed below. The regulatory basis of the information incorporated by reference is addressed within Chapter 15 of the Final Safety Evaluation Report (FSER) related to U.S. EPR FSAR Tier 2, Chapter 15.

The staff reviewed combined license (COL) FSAR Section 15.0 and checked the referenced U.S. EPR design certification FSAR chapter to ensure that the combination of the design certification and the information in the COL FSAR represents the complete scope of information relating to this review topic. A COL item in Section 15.0 of the referenced U.S. EPR design certification FSAR was identified by the COL applicant in COL FSAR Section 15.0. This COL item requires that the COL licensee provide for staff review, prior to the first cycle of operation, the analysis results demonstrating that the uncompensated departure from nucleate boiling ratio (DNBR) and linear power density (LPD) satisfies the specified acceptance fuel design limits (SAFDLs) with a 95/95 assurance in accordance with Topical Report ANP-10287P, "Incore Trip Setpoint and Transient Methodology for U.S. EPR Topical Report." The staff compared this COL item with the original requirements defined in the safety evaluation report on ANP-10287P. The staff finds that the COL item identified in COL FSAR Section 15.0 is consistent with ANP-10287P. Therefore, the staff finds the identified COL item acceptable.

The staff also confirmed that the information contained in the COL application and incorporated by reference addresses the required information relating to this section. U.S. EPR Tier 2, Chapter 15 is being reviewed by the staff under Docket No. 52-020. The staff's technical evaluation of the information incorporated by reference related to transient and accident analysis will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The staff notes that the safety evaluation report (SER) on the U.S. EPR is not yet complete. The staff issued request for additional information (RAI) 222, Question 01-5 to track the ongoing review of the U.S. EPR design certification application. **RAI 222, Question 01-5 is being tracked as an open item.** The staff will update Section 15.0 of this report to reflect the final disposition of the design certification application.

The staff reviewed the supplemental information contained in COL FSAR Section 15.0.3 as discussed below.

15.0.1 Radiological Consequence Analysis

COL FSAR Section 15.0.1 incorporates by reference, with no departures or supplements, U.S. EPR FSAR, Revision 2, Section 15.0.1. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.0.1 on Docket No. 52-020. The results of the staff's

technical evaluation of the information related to the radiological consequence analysis incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The safety evaluation report (SER) on the U.S. EPR is not yet complete. The staff will update Section 15.0.1 of this report to reflect the final disposition of the design certification application.

15.0.2 Computer Codes Used in Analysis

COL FSAR Section 15.0.2 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.0.2. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.0.2 on Docket No. 52-020. The results of the staff's review of the information related to the computer codes used in accident analysis incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the FSAR is not yet complete. The staff will update Section 15.0.2 of this report to reflect the final disposition of the design certification application.

15.0.3 Radiological Consequences of Design Basis Accidents

15.0.3.1 Introduction

Design-basis accidents (DBAs) that have radiological consequences are evaluated in this section and compared to the applicable regulatory acceptance criteria.

15.0.3.2 Summary of Application

COL FSAR Section 15.0.3 incorporates by reference U.S. EPR Tier 2, Revision 2, Section 15.0.3.

In addition, in COL FSAR Section 15.0.3, the COL applicant provided the following:

COL FSAR Tier 2 Departure: The COL applicant's COL FSAR states that CCNPP Unit 3 will depart from the U.S. EPR FSAR by utilizing the site-specific short-term atmospheric dispersion factors (χ/Q values) for the low population zone (LPZ). The CCNPP Unit 3 site-specific accident χ/Q values are provided in COL FSAR Tables 2.0-1 and 2.3-110, for the offsite receptors and COL FSAR Tables 2.3-111 through 2.3-115 for the main control room. The only site-specific accident χ/Q value that is not bounded by the corresponding U.S. EPR FSAR value is the LPZ accident χ/Q value for the 0 to 2-hour time period, which is equal to $2.151\text{E-}04 \text{ sec/m}^3$ (13.13sec/in^3). The CCNPP Unit 3 site-specific χ/Q values for the LPZ are also listed in COL FSAR Table 15.0-1.

The site-specific accident χ/Q values for the LPZ were used in calculation of doses at the outer boundary of the LPZ for CCNPP Unit 3, resulting from the following accident scenarios:

- Loss-of-coolant accident
- Small line break outside of containment
- Main steam line break outside of the Reactor Building
- Reactor coolant pump locked rotor or broken shaft

- Rod ejection accident
- Fuel handling accident
- Steam generator tube rupture

The COL FSAR states that for each of the above postulated accidents, the resulting LPZ doses were determined to be below regulatory limits given below. The COL FSAR incorporates by reference the doses for the main control room and exclusion area boundary (EAB) for the design-basis accidents presented in the COL FSAR, so CCNPP Unit 3 site-specific dose analysis results were not reported for the control room and EAB.

15.0.3.3 *Regulatory Basis*

The relevant requirements of NRC regulations for the radiological consequences of DBAs, and the associated acceptance criteria, are given in NUREG-0800, Section 15.0.3, and are summarized below.

1. Title 10 of the *Code of Federal Regulations* (10 CFR) 50.34, "Contents of Applications; Technical Information," Section 50.34(a)(1), as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release
2. 10 CFR 52.79, "Contents of Applications; Technical Information in Final Safety Analysis Report," Section 52.79(a)(1), as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release
3. 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 19, "Control Room," as it relates to maintaining the control room in a safe condition under accident conditions by providing adequate protection against radiation
4. 10 CFR Part 100, Section 100.21 of "Non-seismic citing criteria," as it relates to the evaluation and analysis of the radiological consequences of postulated accidents for the type of facility to be located at the site in support of evaluating the site atmospheric dispersion characteristics
5. 10 CFR Part 50, Appendix E, Paragraph IV.E.8, "Emergency Planning and Preparedness for Production and Utilization Facilities," as it relates to adequate provisions for an onsite technical support center (TSC) from which effective direction can be given and effective control can be exercised during an emergency

Acceptance criteria adequate to meet the above requirements include:

1. Regulatory Guide (RG) 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors"
2. The dose criteria for various events are listed in NUREG-0800, Section 15.0.3, Table 1, "Accident Dose Criteria"

Requirements for the technical information in the COL FSAR 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 the following offsite radiological consequence evaluation factors:

1. An individual located at any point on the EAB 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 Sievert (Sv) (25 roentgen equivalent man (rem)) total effective dose equivalent (TEDE).
2. An individual located at any point on the outer boundary of the LPZ, 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.

Applications for design certifications must include similar evaluations to show compliance with 10 CFR 52.47(a)(2), which includes the same offsite radiological consequence evaluation factors as given in 10 CFR 52.79(a)(1). In other words, both the U.S. EPR FSAR and the COL FSAR must have DBA radiological consequences analyses that estimate a dose at or below 0.25 Sv (25 rem) TEDE at the EAB and LPZ receptors.

Compliance with the control room habitability dose requirements of 10 CFR Part 50, Appendix A, GDC 19 requires that the applicant show that, for a plant located at the Calvert Cliffs site, 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. The TSC radiological habitability requirements are equivalent to the control room requirements.

Review interfaces with other Standard Review Plan (SRP) sections also can be found in NUREG-0800, Section 15.0.3.

15.0.3.4 *Technical Evaluation*

The staff reviewed COL FSAR Section 15.0.3 and checked the referenced U.S. EPR FSAR to ensure that the combination of the U.S. EPR FSAR and the information in the COL FSAR represents the complete scope of information relating to this review topic. The staff confirmed that the information contained in the COL application and incorporated by reference addresses the required information relating to this section. U.S. EPR FSAR Tier 2, Section 15.0.3 is being reviewed by the staff under Docket No. 52-020. The staff's technical evaluation of the information incorporated by reference related to the radiological consequences of DBAs will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR.

COL FSAR Section 15.0.3 incorporated by reference the design basis accident radiological consequence analyses in the U.S. EPR FSAR. The U.S. EPR dose results at the EAB, in the control room, and in the TSC for each of the accidents are bounding for CCNPP3. The dose results at the CCNPP3 LPZ are site-specific and are discussed below in reference to the related COL FSAR Section 15.0.3 departure.

The design-basis accident radiological consequences analyses in the COL FSAR used design reference values for the offsite, control room, and TSC atmospheric dispersion factors in place

of site-specific values. The χ/Q values are the only input to the DBA radiological consequences analyses that are related to site characteristics.

The estimated offsite, control room, and TSC design-basis accident doses calculated for a particular site are impacted by the site characteristics through the calculated χ/Q input to the analyses. Because the site-specific calculated χ/Q values would necessarily be different than those assumed in the U.S. EPR FSAR, the resulting site-specific dose would be different than that calculated generically for the U.S. EPR design. All other inputs and assumptions in the radiological consequences analyses remain the same as in the U.S. EPR FSAR. Smaller χ/Q values are associated with greater dilution capability, resulting in lower radiological doses. When comparing a U.S. EPR FSAR site parameter χ/Q value and a site characteristic χ/Q value, the site is acceptable for the design if the site characteristic χ/Q value is smaller than the site parameter χ/Q value. Such a comparison shows that the site has better dispersion characteristics than those required by the reactor design.

The CCNPP Unit 3 site-specific accident EAB and LPZ χ/Q values are given in COL FSAR Tables 2.0-1 and 2.3 110. The site-specific accident control room and TSC χ/Q values are given in COL FSAR Tables 2.3 111 through 2.3-115. In Section 2.3 of this report, the staff discusses its review of the CCNPP Unit 3 site-specific χ/Q values.

For each time averaging period, the CCNPP Unit 3 site-specific accident EAB, control room, and TSC χ/Q values are less than the design reference χ/Q values used in the U.S. EPR FSAR radiological consequences analyses for each of the design-basis accidents.

The staff notes that the result of the radiological consequences analysis for a DBA during any time period of radioactive material release from the plant is directly proportional to the χ/Q for that time period, and that the CCNPP Unit 3 site-specific accident χ/Q values are less than the comparable U.S. EPR FSAR χ/Q values at the EAB, control room, and TSC for all time periods and accidents. Therefore, the CCNPP Unit 3 site-specific total dose at the EAB, control room, and TSC for each design-basis accident is less than the U.S. EPR FSAR generic total dose for each design-basis accident. The U.S. EPR FSAR analyses show that the offsite, control room, and TSC radiological consequences meet the regulatory dose requirements of 10 CFR 100.21, 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2), GDC 19, and 10 CFR Part 50, Appendix E, Paragraph IV.E.8. The staff finds that the CCNPP Unit 3 site-specific accident χ/Q values for the EAB, control room, and TSC are less than those for the U.S. EPR design and the DBA radiological consequences are less than those calculated for the U.S. EPR design. Since the U.S. EPR design meets the regulatory dose requirements as stated above, the COL applicant has sufficiently shown that the DBA radiological consequences at the EAB, control room, and TSC comply with the requirements of 10 CFR Part 100, 10 CFR 50.34(a)(1), 10 CFR 52.47(a)(2), GDC 19, and 10 CFR Part 50, Appendix E, Paragraph IV.E.8. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.0.3 of this report to reflect the final disposition of the design certification application.

COL FSAR Tier 2 Departure: (related to Accident LPZ χ/Q)

In COL FSAR Section 15.0.3, the COL applicant stated that the CCNPP Unit 3 site-specific accident χ/Q values for the LPZ were used in calculation of site-specific doses for the design-basis accidents. The site-specific LPZ accident χ/Q values for five time averaging periods are given in COL FSAR Table 15.0-1, Table 2.0-1, and Table 2.3-110. The dose results

of the DBA analyses using the CCNPP Unit 3 site-specific LPZ accident χ/Q values are given in COL FSAR Table 15.0-2.

In RAI 11, Question 15.00.03-1, the staff requested that the COL applicant clarify its calculation of the site-specific DBA doses at the LPZ. The staff requested that the COL applicant discuss the method used to calculate the site-specific doses and provide calculation inputs not included in either the U.S. EPR FSAR or the COL FSAR, such as time-dependent isotopic activity releases for each DBA, if used in the calculation. In an October 6, 2008, response to RAI 11, Question 15.00.3-1, the COL applicant calculated the LPZ doses using the methodology in U.S. FEPR FSAR Tier 2, Section 15.0.3 for the analysis, but substituted the site-specific accident LPZ χ/Q value for each time period in place of those used in the COL FSAR analyses. Time-shifting of the χ/Q values was applied to conservatively calculate the dose as was done in the COL FSAR analyses. For the CCNPP Unit 3 calculations, the only dose analysis inputs that are different than those reported in U.S. EPR FSAR Tier 2, Section 15.0.3 are the LPZ accident χ/Q values. The staff performed confirmatory calculations to review the LPZ DBA dose results given in COL FSAR Table 15.0-2, and was able to determine that the dose results reflect only the site-specific inputs and meet the regulatory criteria.

15.0.3.5 *Post Combined License Activities*

There are no post COL activities related to this section.

15.0.3.6 *Conclusions*

The staff reviewed the COL application and checked the referenced design certification FSAR. The staff confirmed that the COL applicant addressed the required information relating to the radiological consequences of DBAs. The staff finds that with the exception of the open item identified above, the COL applicant has provided sufficient information for complying with the requirements of 10 CFR Part 100, 10 CFR 50.34(a)(1), 10 CFR 52.79(a)(1), GDC 19, and 10 CFR Part 50, Appendix E, Paragraph IV.E.8.

The staff is reviewing the information in the U.S. EPR FSAR on Docket No. 52-020. The results of the staff's technical review of the information related to the radiological consequences of DBAs incorporated by reference in the COL FSAR will be documented in the staff's safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.0.3 of this report to reflect the final disposition of the design certification application.

15.0.4 *Post Chapter 15 Events Cooldown*

COL FSAR Section 15.0.4 incorporates by reference, with no departures or supplements, U.S. EPR FSAR, Tier 2, Revision 2, Section 15.0.4. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.0.4 on Docket No. 52-020. The results of the staff's review of the information related to post Chapter 15 events cooldown incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.0.4 of this report to reflect the final disposition of the design certification application.

15.0.5 Compliance with Section C.I.15, “Transient and Accident Analyses,” of Regulatory Guide 1.206

COL FSAR Section 15.0.5 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.0.5. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.0.5 on Docket No. 52-020. The results of the staff’s review of the information related with conformance to RG 1.206, Section C.I.15 incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.0.5 of this SER to reflect the final disposition of the design certification application.

15.1 Increase in Heat Removal by the Secondary System

COL FSAR Section 15.1 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.1. The staff reviewed the COL application and checked the design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.1 on Docket No. 52-020. The results of the staff’s review of the information related to increase in heat removal by the secondary system incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.1 of this report to reflect the final disposition of the design certification application.

15.2 Decrease in Heat Removal by the Secondary System

COL FSAR Section 15.2 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.2. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.2 on Docket No. 52-020. The results of the staff’s review of the information related to decrease in heat removal by the secondary system incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.2 of this report to reflect the final disposition of the design certification application.

15.3 Decrease in Reactor Coolant System Flow Rate

COL FSAR Section 15.3 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.3. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.3 on Docket No. 52-020. The results of the staff’s review of the information related to decrease in reactor coolant flow rate incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.3 of this report to reflect the final disposition of the design certification application.

15.4 Reactivity and Power Distribution Anomalies

COL FSAR Section 15.4 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.4. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.4 on Docket No. 52-020. The results of the staff's review of the information related to reactivity and power distribution anomalies incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.4 of this report to reflect the final disposition of the design certification application.

15.5 Increase in Reactor Coolant Inventory

COL FSAR Section 15.5 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.5. The staff reviewed the COL application and checked the design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.5 on Docket No. 52-020. The results of the staff's review of the information related to increase in reactor coolant inventory incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.5 of this report to reflect the final disposition of the design certification application.

15.6 Decrease in Reactor Coolant Inventory Events

COL FSAR Section 15.6 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.6. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.6 on Docket No. 52-020. The results of the staff's review of the information related to decrease in reactor coolant inventory events incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.6 of this report to reflect the final disposition of the design certification application.

15.7 Radioactive Release from a Subsystem or Component

COL FSAR Section 15.7 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.7. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.7 on Docket No. 52-020. The results of the staff's review of the information related to radioactive release from a subsystem or component incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.7 of this report to reflect the final disposition of the design certification application.

15.8 Anticipated Transients Without Scram

COL FSAR Section 15.8 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.8. The staff reviewed the COL application and checked the referenced design certification FSAR to ensure that no issue relating to this section remained for review. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.8 on Docket No. 52-020. The results of the staff's review of the information related to anticipated transients without scram incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.8 of this report to reflect the final disposition of the design certification application.

15.9 Boiling Water Reactor Stability

This boiling water reactor stability event is not applicable to either the U.S. EPR design or CCNPP Unit 3, which utilize a pressurized water reactor design.

15.10 Spent Fuel Pool Criticality and Boron Dilution Analysis

COL FSAR Section 15.10 incorporates by reference, with no departures or supplements, U.S. EPR FSAR Tier 2, Revision 2, Section 15.10. The staff reviewed the COL application and checked the referenced design certification FSAR. The staff confirmed that the COL applicant addressed the required information relating to the spent fuel pool criticality and boron dilution analysis. The staff is reviewing the information in the U.S. EPR FSAR Tier 2, Section 15.10 on Docket No. 52-020. The results of the staff's review of the information related to the spent fuel pool criticality and boron dilution analysis incorporated by reference in the COL FSAR will be documented in the staff safety evaluation report on the design certification application for the U.S. EPR. The SER on the U.S. EPR is not yet complete. The staff will update Section 15.10 of this report to reflect the final disposition of the design certification application.