4.0 REACTOR

4.1 Introduction

This chapter describes the mechanical components of the AP1000 reactor and reactor core, including the reactor internals, control rod drive and core support structural materials, fuel system design (fuel rods and fuel assemblies), the nuclear design, and the thermal-hydraulic design. It also specifies the principal design criteria with which the mechanical design, the physical arrangement of the reactor components, and the capabilities of reactor control, protection, and emergency cooling systems (when applicable) must comply.

4.2 Summary of Application

Chapter 4 of the V.C. Summer Nuclear Station (VCSNS) combined license (COL) Final Safety Analysis Report (FSAR), Revision 2, incorporates by reference Chapter 4 of the AP1000 Design Control Document (DCD), Revision 17.

In addition, in VCSNS COL FSAR Section 4.4, the applicant provided the following:

AP1000 COL Information Item

- STD COL 4.4-2

The applicant provided additional information in Standard (STD) COL 4.4-2 to address COL Information Item 4.4-2. This item states that, upon selection of the actual instrumentation, the instrumentation uncertainties of the operating parameters shall be calculated and the validity of the design-limit departure from nucleate boiling ratio (DNBR) values shall be confirmed.

License Condition

Part 10, License Condition 2, Item 4.4-2

The license condition will require the completion of the actions described in STD COL 4.4-2 prior to initial fuel load.

4.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed in NUREG-1793, "Final Safety Evaluation Report [FSER] Related to Certification of the AP1000 Standard Design."

In addition, the acceptance criteria associated with the relevant requirements of the Commission regulations for the thermal-hydraulic design are identified in Section 4.4 of NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants."

To resolve the confirmatory item, the Nuclear Regulatory Commission (NRC) staff also used the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.72, "Immediate notification requirements for operating nuclear power reactors," and 10 CFR 50.73, "Licensee

event report system," and the guidance of NUREG-1022, "Event Reporting Guidelines: 10 CFR 50.72 and 50.73," Revision 2.

4.4 Technical Evaluation

The NRC staff reviewed Chapter 4 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents 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 relating to the reactor internals, control rod drive and core support structural materials, fuel system design (fuel rods and fuel assemblies), the nuclear design, and the thermal-hydraulic design. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

Section 1.2.3 of this safety evaluation report (SER) provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER for the reference COL application (Vogtle Electric Generating Plant [VEGP], Units 3 and 4) were equally applicable to the VCSNS Units 2 and 3 COL application, the staff undertook the following reviews:

- The staff compared the VEGP COL FSAR, Revision 2 to the VCSNS COL FSAR. In performing this comparison, the staff considered changes made to the VCSNS COL FSAR (and other parts of the COL application, as applicable) resulting from requests for additional information (RAIs).

- The staff confirmed that all responses to RAIs identified in the corresponding standard content evaluation were endorsed.

- The staff verified that the site-specific differences were not relevant.

The staff has completed its review and found the evaluation performed for the standard content to be directly applicable to the VCSNS COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting. Section 1.2.3 of this SER provides an explanation of why the standard content material from the SER for the reference COL application (VEGP) contains evaluation material from the SER for the Bellefonte Nuclear Plant (BLN), Units 3 and 4 COL application.

The following portion of this technical evaluation section is reproduced from Section 4.4 of the VEGP SER.

[1] See Section 1.2.2 for a discussion of the staff's review related to verification of the scope of information to be included in a COL application that references a design certification (DC).

AP1000 COL Information Item

- *STD COL 4.4-2*

The NRC staff reviewed STD COL 4.4-2 related to COL Information Item 4.4-2 and related COL Action Item 4.4-1 (from Appendix F of the NRC staff's FSER for the AP1000 DCD (NUREG-1793)), included under Section 4.4 of the BLN COL FSAR, Revision 1. STD COL 4.4-2 states:

> *Following selection of the actual plant operating instrumentation and calculation of the instrumentation uncertainties of the operating plant parameters as discussed in DCD Subsection 7.1.6, the design limit DNBR values will be calculated. The calculations will be completed using the revised thermal design procedure (RTDP) with these instrumentation uncertainties and confirm that either the design limit DNBR values as described in DCD Section 4.4 remain valid or that the safety analysis minimum DNBR bounds the new design limit DNBR values plus DNBR penalties, such as rod bow penalty. This will be completed prior to fuel load.*

License Condition

Part 10, License Condition 2, Item 4.4-2

The applicant provided a license condition in Part 10 of the BLN COL application, "Proposed Combined License Conditions," which will require the completion of the actions described in STD COL 4.4-2 prior to initial fuel load.

As reported in FSER Section 4.4 related to the DCD, expected instrument uncertainties are included in the methodology used by the applicant in calculating the design limit DNBR values. The final validation of the design limit DNBR values will be based on the actual uncertainties for instrumentations not yet procured. The quantification of instrument uncertainties includes activities that require procurement and installation of the instruments, including evaluation of changes in sensor design and location, and that can only be completed after installation of the instruments. Confirmation of instrument uncertainties after completion of the installation does not alter the methods of evaluation used to establish setpoints in the technical specifications, since the design limit DNBR values were based on the plant specifications for instrumentation uncertainties. The design limit DNBR values are expected to remain valid through plant procurement.

The NRC staff concluded in FSER Section 4.4 that the methodology for calculating the design limit DNBR values complied with the relevant regulatory requirements. The staff further concluded that it was acceptable to complete the final verification of the design limit DNBR values when the as-built specifications are available.

Therefore, the staff concludes that the supplemental information described in FSAR Section 4.4 meets COL Information Item 4.4-2 described in AP1000 DCD Subsection 4.4.7.2, complies with COL Action Item 4.4-1, and is acceptable.

The staff also finds the applicant's proposed license condition that will require completing this analysis prior to fuel load acceptable, since the applicant has committed to confirm that either the design limit DNBR values remain valid, or that the safety analysis minimum DNBR bounds the new design DNBR values plus DNBR penalties, such as rod bow penalty.

Conformance to Regulatory Guide 1.133, Revision 1

In BLN COL FSAR Section 1.9, "Compliance with Regulatory Criteria," Section 1.9.1, "Regulatory Guides," the applicant adds Appendix 1AA, which provides an evaluation of the degree of compliance with Division 1 regulatory guides (RGs) as applicable to the content of this FSAR, or to the site-specific design, construction and/or operational aspects, and Table 1.9-201, which identifies the appropriate regulatory guide to FSAR cross-reference. In Appendix 1AA, the applicant provides an evaluation of its loose-part detection program for compliance with RG 1.133, Revision 1, May 1981, "Loose Part Detection Program for the Primary System of Light-Water-Cooled Reactors." It states that conformance of the design aspects is as stated in the DCD. It also documents conformance with the programmatic and/or operational aspects described in paragraphs C.3a and C.6 of RG 1.133, Revision 1.

RG 1.133, Revision 1, describes a method acceptable to the NRC staff for implementing regulatory requirements with respect to detecting a potentially safety-related loose part in light-water-cooled reactors during normal operation. The AP1000 design includes a digital metal impact monitoring system, which is a non-safety-related system provided for monitoring the reactor coolant system for metallic loose parts. AP1000 DCD Section 4.4.6.4 documents the conformance of this monitoring system to RG 1.133. BLN COL FSAR Appendix 1AA documents its conformance to the design aspects described in DCD Section 4.4.6.4, and also states it conforms to Regulatory Position C.3a, regarding manual mode of data acquisition for detection of loose parts and Regulatory Position C.6, regarding notification to NRC of confirmation of the presence of a loose part.

The NRC staff noted that RG 1.133, Revision 1, was not included in Revision 1 of FSAR Table 1.9-201 for a cross-reference to the appropriate FSAR section, although an evaluation of compliance with RG 1.133 is provided in Appendix 1AA. In response to Request for Additional Information (RAI) 1-7, the applicant added RG 1.133, Revision 1, to Table 1.9-201, as part of Revision 1 to the FSAR. In addition, the response to RAI 1-7 was supplemented by adding a conformance discussion for regulatory guide positions related to the procedures and training program (positions 4g, 4h, 4i and 4j) in the proposed revision to BLN FSAR Appendix 1AA, "A Conformance with Regulatory Guides." The proposed change to BLN FSAR is acceptable subject to a formal revision to BLN FSAR. Accordingly, this is ***Confirmatory Item 4.4-1****. With the conformance of the programmatic and operational aspects of regulatory positions, the staff concludes*

that the applicant's loose parts detection program will conform to RG 1.133, Revision 1.

Resolution of Standard Content Confirmatory Item 4.4-1

The staff notes that RAI 1-11 was mistakenly identified as RAI 1-7 in the standard content SER as it relates to the conformance discussion for RG 1.133. The RAI number related to conformance is 1-11. The staff also notes that the BLN SER did not address Position C.6 of RG 1.133.

Confirmatory Item 4.4-1, as modified by the discussion above, is related to the applicant's conformance with the RG 1.133, Positions C.4g, 4h, 4i, 4j, and 6 as documented in Appendix 1AA of the VEGP FSAR. The staff's review of the VEGP COL FSAR indicates that the VEGP FSAR Appendix 1AA was updated to include all the information identified in the Confirmatory Item 4.4-1 except for Position C.6.

The response to RAI 1-11 included a conformance discussion for RG 1.133, Position C.6, "Notification of a Loose Part." Position C.6 refers to RG 1.16, "Reporting of Operating Information." The applicant took an exception to this position because this RG had been withdrawn. The staff considered this justification to be inadequate. Although the staff agreed it was no longer relevant to refer to RG 1.16, there remained a need to address reporting requirements. In response to this staff concern, the applicant proposed a revision to Appendix 1AA of its FSAR. In a letter dated January 8, 2010, the applicant stated that it would follow reporting requirements in accordance with requirements of 10 CFR 50.72 and 10 CFR 50.73 using guidance of NUREG-1022. The staff considers the applicant's position adequately addresses reporting requirements for loose part notification and therefore considers the exception acceptable pending formal revision to the VEGP FSAR. Accordingly, ***Confirmatory Item 4.4-1*** *will remain as a confirmatory item.*

The VCNS applicant has endorsed RAI 1-7 and 1-11 and has also endorsed the 1-8-10 letter submitted by VEGP applicant. The applicant needs to revise Appendix 1AA of its FSAR to be consistent with VEGP response. This issue is being tracked as a VCSNS confirmatory item 4.4-1.

4.5 Post Combined License Activities

For the reasons discussed in the technical evaluation section above the staff finds the following,license condition proposed by the applicant, acceptable.

- License Condition (4-1) - Prior to initial fuel load, the instrumentation uncertainties of the actual plant operating instrumentation will be calculated to confirm that either the design limit DNBR values remain valid or that the safety analysis minimum DNBR bounds the new design limit DNBR values plus DNBR penalties, such as rod bow penalty.

4.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the application addressed the required information relating to the reactor internals, control rod drive and core support structural materials, fuel system design (fuel rods and fuel assemblies), the nuclear design, and the thermal-hydraulic design, and there is no outstanding information expected to be addressed in the VCSNS COL FSAR related to this chapter. The results of the NRC staff's technical evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff concludes that the relevant information presented within the VCSNS COL FSAR is acceptable once Confirmatory Item 4.4-1, related to RG 1.133, is resolved. The staff based its conclusion on the following:

- STD COL 4.4-2 is acceptable because it specifies a commitment on the part of the applicant to confirm the validity of the calculations of the design limit DNBR values, which are based on the plant specifications for instrumentation uncertainties. The confirmation of plant instrument uncertainties will be completed when the as-built specifications are available. The methodology for this calculation was previously approved by the staff in NUREG-1793.

outstanding information expected to be addressed in the VCSNS COL FSAR related to this chapter. The results of the NRC staff's technical evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff concludes that the relevant information presented within the VCSNS COL FSAR is acceptable once Confirmatory Item 4.4-1, related to RG 1.133, is resolved. The staff based its conclusion on the following:

- STD COL 4.4-2 is acceptable because it specifies a commitment on the part of the applicant to confirm the validity of the calculations of the design limit DNBR values, which are based on the plant specifications for instrumentation uncertainties. The confirmation of plant instrument uncertainties will be completed when the as-built specifications are available. The methodology for this calculation was previously approved by the staff in NUREG-1793.

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OFFICE	**DNRL/NWE1/LA**	**DNRL/NWE1/PM**	**DSRA/SRSB**	**DE/CIB**	**OGC**	**DNRL/NWE1/BC**
NAME	PBlechman	SGoetz	JDonoghue	DTerao	SPrice	JCruz
DATE	5/5/10	5/5/10	5/5/10	5/5/10	5/5/10	7/7/10

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