10 STEAM AND POWER CONVERSION SYSTEM

This chapter of the final safety evaluation report (FSER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's (hereinafter referred to as the staff) review of Chapter 10, "Steam and Power Conversion System," of the NuScale Power, LLC (hereinafter referred to as the applicant), Design Certification Application (DCA), Part 2, "Final Safety Analysis Report." The staff's regulatory findings documented in this report are based on Revision 5 of the DCA, dated July 29, 2020 (Agencywide Document Access and Management System (ADAMS), Accession No. ML20225A071). The precise parameter values, as reviewed by the staff in this safety evaluation, are provided by the applicant in the DCA using the English system of measure. Where appropriate, the NRC staff converted these values for presentation in this safety evaluation to the International System (SI) units of measure based on the NRC's standard convention. In these cases, the SI converted value is approximate and is presented first, followed by the applicant-provided parameter value in English units within parentheses. If only one value appears in either SI or English units, it is directly quoted from the DCA and not converted.

The steam and power conversion system removes thermal energy from the reactor coolant system (RCS) and transfers it to the turbine generator where it is converted into electric energy. The main elements of the steam and power conversion system include the main steam, turbine generator, turbine bypass, main condensers (MCs), circulating water, condensate polishing, feedwater treatment, condensate and feedwater, and auxiliary boiler systems. In general, the steam and power conversion system is not safety related and is not required for safe shutdown. However, the main steam and main feedwater systems have piping that penetrates the containment and components that directly interface with safety-related structures, systems, and components (SSCs). The failure of these components can have an adverse impact on plant safety and the plant's ability to achieve a safe shutdown. In addition, failure of some system equipment may result in the potential for internal flooding or the creation of missiles that may have the potential to adversely impact SSCs important to safety.

Using a graded approach, the staff's review of the steam and power conversion system focused on the safety-related piping and the system components that are part of the main steam and main feedwater systems that support containment isolation and the operation of the safety-related decay heat removal system (DHRS). However, the staff also recognizes, as indicated above, that the failure of some portion of the steam and power conversion system may have the potential to adversely impact SSCs important to safety. Since the steam and power conversion system functions are not relied on to support the safety-related and safe-shutdown aspects of the NuScale plant, the staff reviewed the design to verify that failure of the SSCs that are not safety related and not risk significant will not adversely affect the ability of the plant to achieve and maintain safe shutdown or result in excessive releases of radioactivity to the environment.

In addition, although applicants for design certifications are not required to submit plans for an initial test program, Regulatory Guide (RG) 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants," acknowledges that design certification applicants have previously submitted these plans to assist a future combined license (COL) applicant referencing the design certification in meeting the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 52.79(a) (28). In each subsection of this chapter, the staff lists related tests from the initial test program that were evaluated as part of the design certification review and which are reviewed in DCA Part 2, Tier 2, Section 14.2, "Initial Plant Test Program."

10.1 Summary Description

DCA Part 2, Tier 2, Section 10.1, "Summary Description," contains an introductory description of the steam and power conversion system and provides summaries of the protective features incorporated in the design of the system. DCA Part 2, Tier 2, Table 10.1-1, "Major Steam and Power Conversion System Parameters," provides the major system operating parameters at rated thermal power. DCA Part 2, Tier 2, Figure 10.1-1, "Power Conversion System Block Flow Diagram," provides a high-level flow diagram of the system; DCA Part 2, Tier 2, Figure 10.1-2, "Flow Diagram and Heat Balance Diagram at Rated Power for Steam and Power Conversion System Cycle," depicts the heat balance of the system at rated power; and DCA Part 2, Tier 2, Figure 10.1-3, "Flow Diagram and Heat Balance Diagram at Stretch Power (valves wide open) for Steam and Power Conversion System Cycle," depicts the heat balance at stretch power.

Detailed descriptions of the main elements of the steam and power conversion system are provided in DCA Part 2, Tier 2, Sections 10.2 through 10.4.11. The staff's review is documented in Sections 10.2 through 10.4.11 of this report.

10.2 Turbine Generator

10.2.1 Introduction

The NuScale Power Plant comprises up to 12 individual NuScale Power Modules (NPMs), each of which has its own skid-mounted turbine generator and its own turbine control system.

The turbine generator system (TGS) is not a safety-related system. The TGS converts the energy of the steam produced in the steam generators (SGs) into mechanical shaft power and then into electrical energy. The TGS is not credited for mitigation of design-basis events (DBEs) and has no safe-shutdown functions, but a failure of the TGS may result in the generation of turbine missiles that could potentially adversely affect SSCs that are important to safety.

10.2.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the TGS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.2, "Turbine Generator," provides a complete description of the TGS. Information provided includes the TGS design bases, system descriptions, component descriptions, and TGS control and protection systems, including overspeed protection.

ITAAC: The applicant has not proposed any inspections, tests, analyses, and acceptance criteria (ITAAC) related to the TGS.

Initial Test Program: DCA Part 2, Tier 2, Section 14.2, Table 14.2-33, "Turbine Generator Test #33," and Table 14.2-34, "Turbine Oil Storage System Test #34," describe the preoperational tests related to the TGS that are being evaluated as part of the design certification review.

Technical Specifications: There are no technical specification (TS) requirements associated with the TGS.

Technical Reports: There are no technical reports associated with the TGS.

10.2.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are discussed in NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition” (SRP),” Section 10.2, “Turbine Generator,” Revision 3, issued March 2007, and are summarized below:

- 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion (GDC) 4, “Environmental and Dynamic Effects Design Bases,” as it relates to the protection of SSCs important to safety from the effects of turbine missiles by providing a turbine overspeed protection system (with suitable redundancy) to minimize the probability of generating turbine missiles

Review interfaces with other SRP sections also can be found in Item I, “Areas of Review,” of SRP Section 10.2.

10.2.4 Technical Evaluation

Since the TGS is not a safety-related or risk-significant system, the staff conducted its review using the enhanced safety-focus review approach as discussed in the SRP Introduction Part 2. The inability of the TGS to perform its normal intended function will have no direct effect on plant safety or the ability of the plant to achieve and maintain a safe-shutdown condition. Therefore, the staff’s review for the TGS focused on how the system design would preclude TGS failure from adversely affecting SSCs important to safety; in particular, how compliance with GDC 4 will be ensured in events in which TGS failures may result in the ejection of turbine missiles due to excessive turbine overspeed.

The staff’s evaluation of the TGS is based upon the information provided in the applicant’s DCA Part 2, Revision 4. A general description of the TGS is given in DCA Part 2, Tier 2, Section 10.2.2, “System Description,” as well as a simplified piping and instrumentation drawing of the system in DCA Part 2, Tier 2, Figure 10.2-1, “Turbine Generator System Piping and Instrumentation Diagram,” and TGS design parameters in DCA Part 2, Tier 2, Table 10.2-1, “Turbine Generator Design Parameters.” The review of the TGS was performed in accordance with guidance in SRP Section 10.2.

10.2.4.1 GDC 4, “Environmental and Dynamic Effects Design Bases”

Although the TGS is not safety related, missiles generated by turbine failure can adversely affect the integrity of SSCs important to safety. To satisfy GDC 4, and as discussed in Section 3.5.1.3, “Turbine Missiles,” of this SER, the turbine must have a low probability of rotor failure to minimize the likelihood that turbine missiles will affect SSCs important to safety. Alternatively, the applicant may propose to install barriers or take credit for existing structures or features such as barriers to reduce or eliminate turbine missile hazards to equipment, provided the barriers meet acceptance criteria described in SRP Section 3.5.3, “Barrier Design Procedures.” The arrangement and the orientation of the TGS relative to these essential SSCs are also to be considered in the overall minimization of turbine missiles.

The staff reviewed DCA Part 2, Tier 2, Section 3.5.1.3, “Turbine Missiles,” and Section 3.5.2, “Structures, Systems, and Components to be Protected from External Missiles,” to determine whether GDC 4 compliance was achieved based on plant layout or the incorporation in the plant design of missile barriers to protect essential SSCs from turbine missiles. The applicant stated in DCA Part 2, Revision 4, Section 3.5.2, that the reactor building (RXB) and control building

(CRB) below the 30-foot above-grade threshold are designed to withstand all design-basis missiles discussed in DCA Part 2, Tier 2, Sections 3.5.1.3 and 3.5.1.4, which includes turbine missiles.

As indicated in DCA Part 2, Tier 2, Section 3.5.1.3, the NuScale plant uses barriers in lieu of turbine rotor integrity and turbine missile generation probability as the basis for justifying adequate protection from turbine missiles. Since the protection of SSCs from turbine missiles will no longer be dependent on minimizing turbine missile generation probability and the overspeed protection system to prevent destructive overspeed conditions, the review of the overspeed protection system as it relates to ensuring compliance with GDC 4 is not necessary. The staff's review of compliance with GDC 4 as it relates to turbine missiles is included in Section 3.5.1.3 of the SER.

Based on the information provided in DCA Part 2, Tier 2, Sections 10.2, 3.5.1.3, and 3.5.2, the staff finds that the NuScale design is in compliance with GDC 4, with respect to the design and operation of the turbine generator, because all SSCs important to safety are housed in the RXB and the CRB, and the applicant indicated that these buildings are designed to protect against turbine missiles.

10.2.5 Initial Test Program

The preoperational tests related to the TGS for design certification are TGS test (#33) and turbine lube oil storage system test (#34), which ensure the various design aspects related to the TGS are implemented. These tests are performed in accordance with DCA Part 2, Tier 2, Tables 14.2-33 and 14.2-34. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2, "Initial Test Program," of this report.

10.2.6 Technical Specifications

There are no TS requirements associated with the TGS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36, "Technical Specifications," that would require a TS; therefore, the staff finds this acceptable.

10.2.7 Combined License Information Items

There are no COL items for Section 10.2.

10.2.8 Conclusion

Based on the review of the information that is provided and as discussed above in Section 10.2.4, "Technical Evaluation," the staff determined that the applicant has met the requirements of GDC 4 for DCA Part 2, Tier 2, Section 10.2.

10.3 Main Steam System

10.3.1 Main Steam System

10.3.1.1 Introduction

The main steam system (MSS) transfers steam produced in the SGs to the TGS. The NuScale design defines the MSS as only the portions from the flanges immediately downstream of the containment system (CNTS) main steam isolation valves (MSIVs) up to the turbine stop valves.

Portions of the main steam piping inside containment are identified as part of the SGs, and the portion upstream of the main steamline flange, including the MSIVs and main steam isolation bypass valves (MSIBVs), is identified as part of the CNTS. Regardless of how the NuScale design defines the MSS, the staff performed its review consistent with the system boundaries defined in NuScale Design-Specific Review Standard (DSRS) 10.3, “Main Steam Supply System.” For the purposes of this review, the staff considers the MSS to extend from the outlet of the reactor pressure vessel (RPV) steam plenum (on the secondary side of the SGs) up to and including the turbine stop valves. Such system includes the containment isolation valves (CIVs), connected piping that is 6.4 centimeters (2.5 inches) in nominal diameter or larger, and the steamline to the DHRS up to the DHRS actuation valves.

10.3.1.2 Summary of Application

DCA Part 2, Tier 1: The Tier 1 information concerning SSCs associated with the operation of the MSS is found in DCA Part 2, Tier 1, Section 2.1.1, “Design Description”; Table 2.1-1, “NuScale Power Module Piping Systems”; Table 2.1-2, “NuScale Power Module Mechanical Equipment”; Table 2.1-3, “NuScale Power Module Electrical Equipment”; and Section 2.8, “Equipment Qualification.”

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 5.4, “Reactor Coolant System Component and Subsystem Design,” describes the steam supply located inside containment. DCA Part 2, Tier 2, Section 6.2, “Containment Systems,” provides a discussion of steam supply associated with containment isolation. DCA Part 2, Tier 2, Section 10.3, “Main Steam System,” contains the MSS design basis, system and component descriptions, as well as system operation, inspections, and testing.

ITAAC: The applicant has not proposed system ITAAC for the MSS. However, in DCA Part 2, Tier 1, Table 2.8-2, “Equipment Qualification Inspections, Tests, Analyses, and Acceptance Criteria,” the applicant proposed ITAAC for the MSIVs, secondary MSIVs, and secondary MSIBVs. These ITAAC are evaluated in Section 14.3.7 of this SER.

Technical Specifications: The TS associated with the MSS are given in DCA Part 2, Tier 2, Chapter 16, “Technical Specifications.”

Technical Reports: There are no technical reports associated with the MSS.

10.3.1.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are discussed in NuScale DSRS 10.3 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15355A322) and are summarized below:

- GDC 2, “Design Bases for Protection against Natural Phenomena,” requires that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

- GDC 4 requires that SSCs important to safety be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents.

- GDC 5, “Sharing of Structures, Systems and Components,” requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

- 10 CFR 50.63, “Loss of All Alternating Current,” requires that a nuclear power plant have the ability to withstand for a specified duration and recover from a station blackout (SBO), as defined in 10 CFR 50.2, “Definitions.”

- GDC 34, “Residual Heat Removal,” requires that a system to remove residual heat be provided.

- 10 CFR 20.1406, “Minimization of Contamination,” relates to the design features that will facilitate eventual decommissioning and minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

Review interfaces with other SRP sections also can be found in Item I, “Review Interfaces,” of DSRS 10.3.

10.3.1.4 Technical Evaluation

Each NPM has two SGs and a dedicated MSS. Each of the two SGs has two steamlines that combine before exiting containment and ultimately terminate in the turbine generator building (TGB) at the turbine stop valve. Each steamline is supported by a pipe rack from the RXB to the TGB. A flow diagram of the system is provided in DCA Part 2, Tier 2, Figure 10.1-1, “Power Conversion System Block Flow Diagram,” and Figure 10.3-1, “Main Steam System Piping and Instrumentation Diagram.”

A design description of the NuScale MSS is provided in DCA Part 2, Tier 2, Section 10.3.2, “System Description.” The primary function of the MSS is to transport steam from the SGs to the TGS. Other functions of the MSS include delivering steam to the gland seal regulator, delivering steam directly to the condenser through turbine bypass, collecting the drainage condensed in the main steam piping and delivering it to the MC, and transporting extraction steam from the turbine to the feedwater heaters. The safety-related portions of the MSS are the piping and valves between each RPV and the flange immediately downstream of the MSIVs. The remainder of the MSS, including the turbine generator, is not safety related. Under accident conditions, the CNTS isolates the SGs and the safety-related portion of the system from the portion that is not safety related.

Safety-related active components in the MSS are designed to be tested during plant operation. DCA Part 2, Tier 2, Section 6.2.1.1.2, “Design Features,” states that the CNTS components (which include the MSIVs and MSIBVs) are designed such that the American Society for Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI inspection requirements for Class 1, Class 2, and Class 3 MC are met, including the preservice inspection requirements. DCA Part 2, Tier 2, Section 10.3.4, “Inspections and Tests,” states that the portion of the main steam lines that are not safety related are inspected and tested in accordance with the requirements of ASME B31.1, “Power Piping.” A description of periodic inservice inspection and inservice testing of ASME Code, Section III, Class 2 and 3, components is provided in DCA Part 2, Tier 2, Section 3.9.6, “Functional Design, Qualification, and In-Service Testing Programs for Pumps, Valves, and Dynamic Restraints," and Section 6.6, "In-Service Inspection and Testing of Class 2 and 3 Systems and Components."

The staff reviewed the NuScale design to ensure appropriate design margins for pressure relief capacity and set points for the secondary system. The applicant stated that overpressure protection of the steam piping is provided by two different methods, depending on location.

The MSS piping downstream of the secondary MSIVs has a design pressure of 1,000 pounds per square inch absolute (psia) as indicated in DCA Part 2, Tier 2, Table 10.3-1, "Main Steam System Design Data (Single NuScale Power Module)." Overpressure protection for this portion of the MSS is provided by two main steam safety valves shown in DCA Part 2, Tier 2, Figure 10.3-1.

The steam piping between the SG and the secondary MSIVs has a design pressure of 2,100 psia as indicated in DCA Part 2, Tier 2, Tables 10.3-1, "Main Steam System Design Data (Single NuScale Power Module,)" and 5.4-2, "Steam Generator Design Data." This design pressure is equal to the design pressure of the RCS. Due to the thermal coupling between the RCS and SG, the SG pressure is limited by the saturation pressure of the RCS fluid in the downcomer. The saturation pressure of the RCS is limited by the opening set point of the reactor safety valves. Through the SG thermal coupling, the SG design pressure, and the reactor safety valves' opening set point, the SG ASME service limits are not exceeded due to overpressurization for normal operation or during transients. As described in DCA Part 2, Tier 2, Section 5.2.2.2, "Design Evaluation," pressure-relieving devices are not needed as indicated by ASME Code, Section III, Paragraphs NB-7120(c) and NC-7120(b). The overpressure protection of the SG described above does not depend on the availability of either train of the DHRS.

The MSS operational aspects are provided in DCA Part 2, Tier 2, Section 10.3.2.3, "System Operation," which includes descriptions of plant startup, normal operation, abnormal operations, and shutdown operations. An evaluation of the MSS abnormal and anticipated operational occurrences (AOOs) is described in DCA Part 2, Tier 2, Chapter 15, "Transient and Accident Analyses," where the NuScale responses to postulated accidents are considered, including an evaluation of a main steamline break, feedwater line break, and SG tube rupture. The staff's evaluation of the transient and accident analyses regarding the MSS is provided in Chapter 15 of this SER.

An automatic actuation of the DHRS will automatically isolate the MSIVs and MSIBVs. Monitored variables that provide inputs to the DHRS actuation logic are shown on DCA Part 2, Tier 2, Figure 7.1-1I, "ESFAS—Decay Heat Removal System Actuation." In addition, main steam temperature, pressure, radiation, and flow instrumentation are shown on DCA Part 2, Tier 2, Figure 10.3-1. The staff's evaluation of the instrumentation and controls regarding main steam isolation is included in Chapter 7 of this SER.

For the DHRS to function properly, the main steamlines are isolated, and steam is routed to the DHRS passive condensers. The staff reviewed the capability of the main steamlines to isolate in the event of a postulated break in a main steamline, assuming a single active failure. In the event an MSIV fails to close, the NuScale design incorporates seismic Category I secondary MSIVs and secondary MSIBVs, neither of which are safety related. Surveillances for operability and inservice testing of the secondary MSIVs are included in the TS. The staff notes that the treatment of the secondary MSIVs and secondary MSIBVs is consistent with the previous staff position on the treatment of equipment that is not safety related when applying single failure criteria for steamline break accidents, as shown in NUREG-0138, “Staff Discussion of Fifteen Technical Issues Listed in Attachment to November 3, 1976, Memorandum from Director, NRR to NRR Staff,” issued November 1976 (ADAMS Accession No. ML13267A423). Therefore, the staff finds this acceptable. The staff evaluation of the DHRS is included in Section 5.4 of this SER.

DSRS 10.3, Subsection III, Item 6.C, states that the reviewer should verify that MSIVs and other shutoff valves can close against maximum steam flow. The applicant stated in DCA Part 2, Tier 2, Section 6.2.4.3, “Design Evaluation,” that all CIVs, which include the primary-side CIVs and the secondary-side CIVs, are required to isolate their flowpath with the required stroke time against the flow generated during line break conditions. These flow rates are derived from high-energy line break calculations and safety analysis calculations and represent the maximum steam flow conditions for the flowpath. DCA Part 2, Tier 2, Section 6.2.4.3, states that MSIVs are capable of stopping fully developed pipe break flow for steam conditions. The basis for these flow conditions is to bound the expected range of flows. DCA Part 2, Tier 2, Section 10.3.2.2, “Component Description,” states that the secondary MSIVs are capable of closing in steam conditions. Based on this information, the staff concluded that the MSIVs and the secondary MSIVs are capable of closing against maximum expected steam flow conditions.

The applicant stated that a CNTS failure modes and effects analysis is in DCA Part 2, Tier 2, Section 6.2, and in Table 6.2-6, “Failure Modes and Effects Analysis Containment System.” This table assesses the effect of CIV failures (including the MSIVs and MSIBVs). The staff’s evaluation of the failure modes and effects analysis of the CNTS on the MSIVs and the secondary MSIVs is included in Chapter 6 of this SER.

In DCA Part 2, Tier 2, Section 10.3.3, “Safety Evaluation,” the applicant provided its evaluation of the MSS and its compliance with the requirements of the GDC identified in the regulatory basis for this section of the SER. Following is the staff’s review of these GDC compliances.

10.3.1.4.1 GDC 2, “Design Bases for Protection against Natural Phenomena”

The staff reviewed the MSS for compliance with the requirements of GDC 2, with respect to its design for protection against the effect of natural phenomena such as earthquakes, tornados, hurricanes, and floods. Compliance with the requirements of GDC 2 is based on the MSS being designed to withstand the effects of natural environmental phenomena without losing the ability to perform its safety function and on adherence to Regulatory Position C.1 of RG 1.29, “Seismic Design Classification,” Revision 4, issued March 2007, for the safety-related portion of the system, and Regulatory Position C.2 for the portions of the system that are not safety related. The staff reviewed DCA Part 2, Tier 2, Sections 5.4, 6.2, and 10.3, to determine whether the portions of the main steamline important to safety are protected against natural phenomena.

DCA Part 2, Tier 2, Figure 10.3-1, indicates that the main steamline, including piping and valves between each SG and flange immediately downstream of the MSIVs (identified as removable spool piece in Figure 10.3-1), is located inside the RXB. In addition, DCA Part 2, Tier 2, Section 6.2.2.3, “Design Evaluation,” states that the CNTS (including the MSIVs) is located below grade in the RXB, which is designed to withstand the effects of natural phenomena hazards such as earthquakes, tornadoes, hurricanes, or floods while protecting the systems inside.

NuScale DSRS 10.3, Subsection III, Item 4, indicates that the essential portions of the MSS should be designed to Quality Group B or seismic Category I requirements. The staff reviewed

DCA Part 2, Tier 2, Sections 5.4, 6.2, and 10.3, to identify the quality group and seismic classification boundaries on system drawings and piping and instrumentation diagrams. The applicant stated that the safety-related portions of the MSS are contained in the CNTS. The division between the safety-related portion of the MSS and the portion of the MSS that is not safety related occurs on the outlet side of the MSIVs, as shown in DCA Part 2, Tier 2, Figure 10.3-1. The staff reviewed Figure 10.3-1 and finds that the MSIVs and the secondary MSIVs are both located inside the RXB and are both classified as seismic Category I. Because the portions of the MSS important to safety are protected from natural phenomena, the staff finds that the NuScale design meets the requirements of GDC 2.

10.3.1.4.2 GDC 4, "Environmental and Dynamic Effects Design Bases"

The staff reviewed the NuScale design to ensure the functions important to safety will be maintained in the event of adverse environmental phenomena and dynamic effects. DCA Part 2, Tier 2, Section 10.3.3, states that the portions of the MSS downstream of the MSIVs to the secondary MSIVs are protected from pipe whip and jet impingement forces resulting from breaks in nearby systems (including the MSS of adjacent power modules) by the piping design layout. The portions of the MSS downstream of the MSIVs to the secondary MSIVs are physically separated from safety-related systems in the RXB using walls and other restraints and have no adverse impacts on safety functions. The staff reviewed the above information and finds that the portions of the main steamlines and MSS that are subject to protection under GDC 4 are located inside the RXB, a seismic Category I structure designed for wind and missile loads, and therefore are acceptable. The staff's evaluation of the potential source of turbine missiles and the protection of SSCs important to safety from the adverse effects of postulated turbine missiles is included in Chapter 3 of this SER.

Further, regarding the GDC 4 requirements, the staff reviewed consideration for steam and water hammer effects on the MSS. DCA Part 2, Tier 2, Section 3.6.3.1.4, "Water Hammer/Steam Hammer," states that water hammer and relief valve discharge loads are considered and their effects minimized in the design of the MSS. Utilizing drain pots, proper line sloping, and drain valves minimizes this potential. The dynamic loads such as those caused by MSIV closure or turbine stop valve closure due to water hammer and steam hammer are analyzed and accounted for in the design and analysis of the main steam piping. These design features minimize the likelihood of water and steam hammer; therefore, the staff finds this acceptable.

10.3.1.4.3 GDC 5, "Sharing of Structures, Systems, and Components"

GDC 5 contains provisions restricting the sharing of SSCs important to safety between nuclear power units. The applicant stated that each NPM has a dedicated MSS. There are no important-to-safety components in the MSS that are shared among NPMs; therefore, the loss of components in one MSS does not significantly impair the ability of other NPMs to perform their safety functions. Therefore, the requirements of GDC 5 are met.

10.3.1.4.4 GDC 34, "Residual Heat Removal"

DCA Part 2, Tier 2, Section 3.1.4.5, Criterion 34, "Residual Heat Removal," states that the power provisions of GDC 34 are not applicable to the NuScale design and the following principal design criteria (PDC) had been adopted:

> A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded.
>
> Suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that the system safety function can be accomplished, assuming a single failure.

The staff evaluation of PDC 34 is included in Sections 5.4 and 8.3 of this SER.

The staff reviewed the MSS design against the decay and residual heat removal safety function requirements of PDC 34. The applicant stated that the decay and residual heat removal safety function per PDC 34 is performed by the DHRS flowpath, and the containment isolation function of the CNTS is performed by the MSIVs and the feedwater isolation valves (FWIVs). Consistent with PDC 34, the secondary MSIVs that are not safety related downstream of the MSIVs are credited as backup isolation components in the event that an MSIV fails to close and provides additional assurance that the blowdown of a second SG is limited if a steamline were to break upstream of the MSIV. As discussed above in Section 10.3.1.4, the staff notes that the treatment of the secondary MSIVs and secondary MSIBVs is consistent with the previous staff position on the treatment of equipment that is not safety related when applying single-failure criteria for steamline break accidents as shown in NUREG-0138.

Based on the information above, the staff finds that the MSS, including the steamlines between the SGs and disconnect flange, conforms to the requirements of PDC 34 with respect to the system function of transferring residual and sensible heat from the RCS, assuming a single failure.

10.3.1.4.5 10 CFR 50.63, "Loss of All Alternating Current Power"

The staff reviewed the MSS capability to supply steam to the DHRS for the removal of decay heat during an SBO. Successful operation of the DHRS relies on the MSIVs ability to isolate steam; this forms part of the DHRS flowpath and pressure boundary. In addition, secondary MSIVs that are not safety related are provided as a backup to the MSIVs. Both the MSIVs and secondary MSIVs fail closed during an SBO.

The staff finds this acceptable because the safety-related main steam components are designed such that they perform their safety function and the system has sufficient capability to cope with an SBO. Therefore, the staff concludes the requirements of 10 CFR 50.63 are met. Further staff evaluation of the SBO event is in Section 8.4 of this SER.

10.3.1.4.6 10 CFR 20.1406, "Minimization of Contamination"

The regulation in 10 CFR 20.1406, "Minimization of Contamination," requires, in part, that each design certification applicant describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and environment, as well as the generation of radioactive waste. The applicant stated that the MSS is not normally a radiation hazard in a pressurized-water reactor (PWR), and it is only in the unlikely event of a primary-to-secondary system leak or SG tube failure that the steam would become contaminated. DCA Part 2, Tier 2, Table 12.3-26, "Regulatory Guide 4.21 Design Features for Main Steam System," provides a list of the design features specific to the MSS for the minimization of contamination. Some examples of this includes the use of corrosion-resistant materials, proper chemistry controls, steamline radiation monitors, and collection and control of fluid leaks by the radioactive waste drain system and balance-of-plant drain system. Also, a minimum of two barriers are provided between clean systems (nonradioactive systems), such as the nitrogen distribution system and the auxiliary boiler system (ABS), and the MSS to prevent cross-contamination.

The staff reviewed DCA Part 2, Tier 2, Section 10.3 and Section 12.3, "Radiation Protection Design Features," as related to prevention and minimization of the contamination. Because the NuScale DCA Part 2 design provides adequate measures for early leak detection and controls in the MSS design to minimize contamination as described above, the staff concludes that the system as described in DCA Part 2 conforms to 10 CFR 20.1406.

10.3.1.5 Technical Specifications

The staff reviewed how DCA Part 2, Tier 2, Chapter 16, applies to the MSS. These TS provide limiting conditions for operation and surveillance requirements for the MSIVs, secondary MSIVs, and associated bypass valves. The staff also reviewed the associated TS bases and found the description to be consistent with the DCA Part 2, Tier 2, description of the components.

The staff concludes that the TS appropriately addresses the limiting conditions for operation and surveillance requirements for the MSIVs, secondary MSIVs, and associated bypass valves. The staff evaluation of TS and associated bases are in Chapter 16 of this report.

10.3.1.6 Combined License Information Items

There are no COL information items associated with the MSS.

10.3.1.7 Conclusion

Based on the review above, the staff concludes that the MSS for the NuScale design satisfies the relevant requirements for the MSS as described in Section 10.3.1.3, "Regulatory Basis," of this SER.

10.3.2 Steam and Feedwater System Materials

10.3.2.1 Introduction

To address the selection, fabrication methods, and compatibility of materials with the environments of the portions of the MSS, the portions of the condensate and feedwater system (CFWS), the TGS, the ABS, and their associated subsystems that are not safety related, NuScale submitted information in DCA Part 2, Tier 2, Section 10.3.6, "Steam and Feedwater System Materials." The portions of the CNTS that include the safety-related piping connected to the MSS and CFWS, as well as the MSIVs and the FWIVs, are reviewed in Section 6.1.1 of this SER.

The information that NuScale provided regarding the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related can be found in Revision 4 to the DCA, and in letters dated June 26, 2017 (ADAMS Accession No. ML17177A686); October 17, 2017 (ADAMS Accession No. ML17290B241); November 22, 2017 (ADAMS Accession No. ML17326B393); April 16, 2018 (ADAMS Accession No. ML18106A139); and July 3, 2018 (ADAMS Accession No. ML18184A597).

The NRC staff evaluation considered the system design and code of construction, the materials selection and fabrication, and the flow-accelerated corrosion (FAC) program for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

10.3.2.2 Summary of Application

DCA Part 2, Tier 1: There is no Tier 1 information related to this section.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Figure 10.1-1, "Power Conversion System Block Flow Diagram," shows the system breaks for the steam generator system (SGS), CNTS, MSS, CFWS, and TGS.

The portions of the MSS that are not safety related are described in DCA Part 2, Tier 2, Section 10.3, and extend from the flange immediately downstream of the safety-related MSIVs to the inlet of the turbine generator vendor package. Furthermore, the extraction steam points from the turbine to the feedwater heaters are also part of the portions of the MSS that are not safety related.

The portions of the CFWS that are not safety related are described in DCA Part 2, Tier 2, Section 10.4.7, "Condensate and Feedwater System," and extend from the entrance of the MC (Section 10.4.1) to the flange immediately upstream of the SG FWIVs. Another associated subsystem that is part of the portions of the CFWS that are not safety related is the condensate polishing system (CPS) (Section 10.4.6).

The TGS (which is entirely not safety related) is described in DCA Part 2, Tier 2, Section 10.2. Other associated subsystems that are part of the TGS are the turbine gland sealing system (TGSS) (DCA Part 2, Tier 2, Section 10.4.3) and turbine bypass system (TBS) (DCA Part 2, Tier 2, Section 10.4.4).

The ABS (which is entirely not safety related) is described in DCA Part 2, Tier 2, Section 10.4.10, "Auxiliary Boiler System."

The staff notes that historically documents such as Generic Letter (GL) 89-08, "Erosion/Corrosion-Induced Pipe Wall Thinning," issued May 1989, have referred to FAC as erosion/corrosion. Therefore, FAC and erosion/corrosion are used interchangeably throughout this section of the SER.

10.3.2.2.1 System Design and Code of Construction

The quality group for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related is Quality Group D, and the piping is designed to ASME B31.1. The piping materials are also selected to meet ASME B31.1 requirements.

The quality group and seismic design classifications are provided in DCA Part 2, Tier 2, Table 3.2-1. The staff's review of the adequacy of the system quality group and seismic design classification is evaluated in Section 3.2 of this SER.

10.3.2.2.2 Materials Selection and Fabrication

The materials selected for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related are generally selected to minimize the impact of FAC. The FAC program itself is discussed later in this section of the SER.

DCA Part 2, Tier 2, Section 10.1.2.7, states the following:

> The MSS and feedwater system piping is designed considering the effects of flow-accelerated corrosion and erosion/corrosion. Erosion/corrosion resistant chromium-molybdenum material has been selected for piping downstream of the MSIVs. The feedwater system piping is also designed with chromium-molybdenum to avoid erosion damage.

DCA Part 2, Tier 2, Sections 10.3.5.1.1, 10.4.1.2.2, 10.4.6.2.1, 10.4.7.2.2, and 10.4.7.3, as well as Table 10.4-20, "Auxiliary Boiler System Component Design Parameters," also discuss either selecting FAC-resistant materials or ensuring that a corrosion allowance is included.

10.3.2.2.3 Flow-Accelerated Corrosion

The applicant stated that the piping design considerations of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related meet the guidance contained in GL 89-08 and Electric Power Research Institute (EPRI) NSAC-202L, Revision 3, "Recommendations for an Effective Flow-Accelerated Corrosion Program," issued August 2007, to minimize erosion and corrosion (including FAC). These piping design considerations include the following:

- material selection
- limits on flow velocity
- inspection programs
- limits on water chemistry to reduce FAC, corrosion, and erosion of piping and piping components

The applicant stated that the design and layout will also incorporate provisions to minimize FAC and other flow-induced degradation mechanisms in the high-energy portions of piping that are not safety related but that could adversely impact safety-related systems.

Erosion and corrosion are also minimized by the implementation of a secondary water chemistry control program, which is described and reviewed in Section 10.4.6 of this SER. The secondary water chemistry control program provides protection for the safety-related CNTS, SGS, and DHRS from contamination originating in the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

DCA Part 2, Tier 2, Table 10.3-5, "Power Conversion System Flow-Accelerated Corrosion Program Piping," provides the list of piping that is within the scope of the FAC program.

COL Item 10.3-2 states that the COL applicant will provide a description of the FAC monitoring program based on GL 89-08 and the latest revision to EPRI NSAC-202L at the time of the COL application.

DCA Part 2, Tier 2, Section 3.6.3, discusses FAC for the safety-related, stainless steel portions of the main steam and feedwater piping that are inside the containment vessel (CNV) and part of the CNTS. This is outside of the scope of DCA Part 2, Tier 2, Section 10.3.6, and not reviewed in this section of the SER.

ITAAC: There are no ITAAC related to this section.

Technical Specifications: There are no TS related to this section.

Technical Reports: The staff did not review any technical reports related to this section.

10.3.2.3 Regulatory Basis

The following NRC regulations contain the relevant requirements for this review:

- GDC 1, “Quality Standards and Records,” and 10 CFR 50.55a, “Codes and Standards,” require that SSCs important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- GDC 35, “Emergency Core Cooling,” states that a system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that (1) fuel and clad damage that could interfere with continued effective core cooling is prevented and (2) clad metal-water reaction is limited to negligible amounts.

- 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” Criterion XIII, “Handling, Storage and Shipping,” requires that measures be established to control the handling, storage, shipping, cleaning, and preservation of materials and equipment to prevent damage or deterioration.

- 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” requires that power reactor licensees monitor the performance or condition of SSCs against licensee-established goals in a manner sufficient to provide reasonable assurance that such SSCs are capable of fulfilling their intended functions.

The guidance in SRP Section 10.3.6, “Steam and Feedwater System Materials,” Revision 3, issued March 2007, lists the acceptance criteria adequate to meet the above requirements, as well as review interfaces with other SRP sections.

The following documents provide additional criteria or guidance in support of the SRP acceptance criteria to meet the above requirements.

- GL 89-08
- EPRI NSAC-202L, Revision 3

10.3.2.4 Technical Evaluation

10.3.2.4.1 System Design and Code of Construction

SRP Section 10.3.6 is based on using ASME Code, Section III, Class 2 and Class 3, components. However, the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related are designed to ASME B31.1. The selection of ASME B31.1 as the code of construction is consistent with the recommendations in RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," for Quality Category D components. The staff's review of the adequacy of system classifications is evaluated in Section 3.2 of this SER. Based on the staff's review of the adequacy of the system classification in Section 3.2 of this SER, the staff finds the use of ASME B31.1 acceptable for the design of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

SRP Section 10.3.6 lists four RGs with the caveat that RG 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," was withdrawn and replaced with RG 1.28, "Quality Assurance Program Criteria (Design and Construction)." SRP Section 10.3.6 will be updated at a future time to reflect the new staff guidance.

The following RGs are listed in the SRP but are not listed in DCA Part 2, Tier 2, Table 1.9-2, "Conformance with Regulatory Guides," as applicable to DCA Part 2, Tier 2, Section 10.3.6:

- RG 1.28, Revision 4
- RG 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," Revision 1, issued March 2011
- RG 1.71, "Welder Qualification for Areas of Limited Accessibility," Revision 1, issued March 2007

DCA Part 2, Tier 2, Table 1.9-3, "Conformance with NUREG-0800, Standard Review Plan (SRP) and Design Specific Review Standard (DSRS)," summarizes the differences between the DCA and SRP. While DCA Part 2, Tier 2, Section 1.9 and Section 10.3.6, do not state that any of these RGs are applicable to Section 10.3.6, the staff reviewed the applicability of these RGs based on the NuScale design and alternatives provided in DCA Part 2, Tier 2, Section 10.3.6. NuScale provided additional context in the letters referenced in Section 10.3.2.1 of this SER.

The staff reviewed the guidance in the SRP related to cleaning and handling of safety-related materials that were historically in RG 1.37 and incorporated in RG 1.28. Since the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems reviewed in this section of the SER are not safety related, these quality assurance requirements are not applicable. However, chemical contamination originating in the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related may have an impact on the safety-related portions of the DHRS, CNTS, and SGS. NuScale stated that the secondary water chemistry control program, and materials of the DHRS, CNTS, and SGS, provide protection to the safety-related systems. The staff reviewed the secondary water chemistry control program and safety-related materials in Sections 10.4.6 and 6.1.1 of this SER, respectively.

RG 1.50 and RG 1.71 state that they are only applicable to ASME Code, Section III, Class 1, 2, and 3, components. While the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related are not designed to ASME Code, Section III, the staff reviewed the guidance of RG 1.50 and RG 1.71 with consideration of the systems' safety significance and the requirements in ASME B31.1.

The staff compared the RG 1.50 guidance and the ASME B31.1 requirements. The staff found that ASME B31.1 contains requirements related to the regulatory positions in RG 1.50 for preheat temperature, interpass temperature, postweld heat treatment, and production weld temperature monitoring. Therefore, based on the similarity of the ASME B31.1 requirements and the RG 1.50 guidance, and the safety significance of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are reviewed in this section of the SER, the staff finds that NuScale has identified appropriate welding controls to the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

The staff compared the RG 1.71 guidance, the ASME B31.1 requirements, and the design and safety significance of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are reviewed in this section of the SER. RG 1.71 supplements the welder performance qualification requirements in ASME Code, Sections III and IX, based on welder access and visibility limitations. The portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are reviewed in this section of the SER use smaller diameter piping and are manufactured as modules, which may decrease the number of locations with limited accessibility. ASME B31.1 cites ASME Code, Section IX, for welder performance qualification, which has provisions for qualifying welders in special positions. Therefore, based on the similarity of the ASME B31.1 requirements and the RG 1.71 guidance, and the design and safety significance of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are reviewed in this section of the SER, the staff finds that NuScale has identified appropriate controls for welder performance qualification for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

The SRP states that acceptance criteria for nondestructive examination (NDE) of tubular products should follow the relevant paragraphs of Subsections NC and ND of ASME Code, Section III. ASME B31.1 states that NDE should be performed in accordance with the requirements in ASME Code, Section V. ASME Code, Section III, also states that NDE should be performed in accordance with the requirements in ASME Code, Section V. Additionally, ASME B31.1 has acceptance criteria related to tubular products. Therefore, the staff finds that ASME B31.1 can meet the intent of the SRP related to the NDE acceptance criteria of tubular products in the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related.

The staff reviewed SRP Section 10.3.6 related to requiring fracture toughness testing. The SRP states that fracture toughness testing is used to meet GDC 35, so that the steam and feedwater system integrity can be maintained to allow the systems to fulfill their safety functions of removing decay heat and supplying steam to engineered safety feature pumps. Since the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are reviewed in this section of the SER are not safety related, the staff finds not requiring additional fracture toughness requirements to be acceptable.

10.3.2.4.2 Material Selection and Fabrication

While the specific grades of piping components have not been selected, NuScale stated that the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related will be constructed with materials that are resistant to FAC, such as chrome-molybdenum (Cr-Mo) steel, or include a corrosion allowance. Cr-Mo steels have extensive history in steam and power conversion systems, and the material is suitable for steam and elevated temperature water service if controls are provided to prevent material degradation. Cr-Mo steels, such as SA-355 Grade P11 or P22, are listed in EPRI NSAC-202L, Revision 3, as FAC-resistant alloys. The staff finds NuScale's statements that the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related will be constructed with FAC-resistant materials or include a corrosion allowance acceptable to meet 10 CFR 50.65 provisions related to accounting for material selection and fabrication industrywide operating experience.

The applicant stated that it will prevent degradation of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related by controlling the water chemistry. The secondary water chemistry control program is evaluated by the staff in Section 10.4.6 of this SER. Since the portions of the MSS and CFWS piping that are not safety related enter the CNV through the CNV top head, they do not travel through the ultimate heat sink. Therefore, the findings in DCA Part 2, Tier 2, Section 9.1.3, related to the chemistry control of the ultimate heat sink were not considered in this section of the SER.

10.3.2.4.3 Flow-Accelerated Corrosion

SRP Section 10.3.6, Item III.3, states that EPRI NSAC-202L, Revision 2, provides acceptable methods to minimize FAC. The use of EPRI NSAC-202L, Revision 3, is also acceptable because both Revisions 2 and 3 of EPRI NSAC-202L are endorsed in ,Section XI.M17, “Flow-Accelerated Corrosion,” of NUREG-1801, “Generic Aging Lessons Learned (GALL) Report,” Revision 2, issued December 2010.

NuScale stated that the piping design of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related meets the guidance of GL 89-08 and EPRI NSAC-202L, Revision 3, to reduce FAC. Therefore, the staff finds meeting the guidance to minimize the occurrence of FAC acceptable to meet 10 CFR 50.65 provisions related to accounting for FAC industrywide operating experience.

10.3.2.5 ITAAC

There are no ITAAC required for the steam and feedwater system materials.

10.3.2.6 Technical Specifications

There are no TS requirements associated with the materials of the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related. Required TS for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are evaluated in the system sections in this chapter of the SER. Therefore, the staff finds this acceptable, in accordance with 10 CFR 50.36.

10.3.2.7 Combined License Information Items

Table 10.3.2-1 NuScale Combined License Information Items for DCA Part 2, Tier 2, Section 10.3.2

Item No.	Description	DCA Part 2 Tier 2 Section
COL Item 10.3-2	A COL Applicant that references the NuScale Power Plant design certification will provide a description of the flow-accelerated corrosion monitoring program for the steam and power conversion systems based on Generic Letter 89-08 and the latest revision of the Electric Power Research Institute NSAC-202L at the time of the COL application.	10.3.6

The applicant has proposed one COL item as described in the table above. The COL item describes site-specific features of the FAC program. The staff finds the wording of the COL item acceptable, as it will ensure that a COL applicant will develop an FAC program in accordance with the applicable guidance to meet pertinent requirements of 10 CFR 50.65 related to accounting for industrywide operating experience.

Additionally, the staff reviewed DCA Part 2, Tier 2, Table 1.8-2, "Combined License Information Items," which references COL Item 10.3-2. The staff confirmed the consistency of the wording.

10.3.2.8 Conclusion

Based on its review of the information provided by NuScale, the staff concludes that the NuScale DCA for the materials to be used for the portions of the MSS, the portions of the CFWS, the TGS, the ABS, and their associated subsystems that are not safety related is acceptable and meets the relevant requirements of 10 CFR 50.55a, GDC 1, GDC 35, Appendix B to 10 CFR Part 50, and 10 CFR 50.65.

10.4 Other Features of Steam and Power Conversion System

10.4.1 Main Condensers

10.4.1.1 Introduction

The MC is designed and built to condense and deaerate the exhaust from the turbine and the TBS. The components in the MC are not shared among NPMs, and each NPM has an MC, which is part of the CFWS addressed in Section 10.4.7 of this SER.

10.4.1.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the MC.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.1, "Main Condenser," includes the MC system description, as well as relevant information on the MC design, including the design bases, instrumentation, and the inspection and testing program.

ITAAC: The applicant has not proposed any ITAAC related to the MC.

Initial Test Program: The preoperational test related to the MC being evaluated as part of the design certification review is described in DCA Part 2, Tier 2, Section 14.2, Table 14.2-33.

Technical Specifications: There are no proposed TS requirements associated with the MC.

Technical Reports: There are no technical reports related to the MC.

10.4.1.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are given in SRP Section 10.4.1, “Main Condensers,” and are summarized below:

- GDC 4, as it relates to SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents

- GDC 60, “Control of Releases of Radioactive Materials to the Environment,” as it relates to provisions being included in the nuclear power unit design to control suitably the release of radioactive materials in gaseous and liquid effluents during normal operation, including AOOs

- GDC 64, “Monitoring Radioactivity Releases,” as it relates to provisions being included in the nuclear power unit design for monitoring the effluent discharge paths and the plant environs for radioactivity that may be released from normal operations, including AOOs, and from postulated accidents

Review interfaces with other SRP sections are also indicated in SRP Section 10.4.1.

10.4.1.4 Technical Evaluation

The staff reviewed the MC system design, described in DCA Part 2, Tier 2, Section 10.4.1, in accordance with guidance in SRP Section 10.4.1, to ensure compliance with the regulatory requirements listed in Section 10.4.1.3 of this SER.

The staff reviewed the design of the MC for compliance with the requirements of GDC 4. The staff’s review was performed to verify that the system was appropriately protected against environmental and dynamic effects or that a failure of the MC and the resulting discharging fluid (i.e., flooding) would not adversely affect safety-related SSCs. In DCA Part 2, Tier 2, Section 10.4.1.1, “Design Basis,” the applicant stated that the MC serves no safety-related functions, is not credited for mitigation of a design-basis accident (DBA), and has no safe-shutdown functions. Also, in DCA Part 2, Tier 2, Section 10.4.1.3, “Safety Evaluation,” the applicant stated that, for a failure of the MC hotwell that releases the water inventory, the resulting flooding does not prevent the operation of a safety-related system because no such systems are located in the TGBs.

The staff review of the information in DCA Part 2, Tier 2, Table 3.2-1, “Classification of Structures, Systems, and Components,” confirmed that no SSCs important to safety were located in or near the TGBs. Based on its review, the staff found that all SSCs important to safety are to be located in the RXB and CRB. In DCA Part 2, Tier 2, Section 3.4.1.4, “Flooding Outside the Reactor and Control Buildings,” the applicant stated that the site is graded to transport water away from those buildings, and therefore, failure of equipment outside the CRB and RXB cannot cause internal flooding.

Based on the above review, the staff finds that the MC design complies with GDC 4, because the potential flooding due to a failure to the MC does not result in SSCs important to safety being adversely affected.

The staff also reviewed the design of the MC for compliance with the requirements of GDC 60 with respect to control of release of radioactive materials and GDC 64 with respect to the monitoring of radioactive releases. Compliance with GDC 60 and GDC 64 requires provisions to be included in the nuclear power unit design to monitor and control suitably the release of radioactive materials during normal operation, including AOOs, and postulated accidents. Meeting these requirements provides a level of assurance that the release of radioactive materials in gaseous and liquid effluents from the MCs during normal operation, including AOOs, and postulated accidents is kept as low as is reasonably achievable, in accordance with 10 CFR Part 50, Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation To Meet the Criterion ‘As Low As Is Reasonable Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.”

In DCA Part 2, Tier 2, Section 10.4.1.3, “Safety Analysis,” the applicant stated that the MC is anticipated to contain negligible quantities of radioactive contaminants during power operation and during shutdown. To control the releases of radioactive contaminants, the air and noncondensable gases in the condenser are removed by the condenser air removal system (CARS). There is no buildup of noncondensable gases in the MC during normal operations because the CARS vacuum pump operates continuously during operation of the MC.

The applicant also stated that the CARS has process radiation monitors on the gaseous effluent lines that discharge to atmosphere capable of detecting radioactivity in the gaseous effluent, and that “[l]eakage from the hotwell is collected and retained by a leakage detection system.” Also, if required, operators in the main control room have the ability to manually shut down and isolate the CARS in response to an abnormal plant condition. The review of the CARS radiation monitoring instrumentation and sampling system is covered in Section 11.5, “Process and Effluent Radiation Monitoring Instrumentation and Sampling System,” of this report.

SRP Section 10.4.1, “Main Condensers,” Subsection II, Item 1.B, states that acceptance of GDC 60 is also based on mitigating the potential for explosive mixtures to exist in the MC. Because of the noncondensable gas evacuation provided by the CARS, a negligible amount of dissolved oxygen (DO) is present in the condensate and MC hotwell inventory; as such, the possibility of an explosion is considerably minimized.

Based on the design information provided in DCA Part 2, the staff finds that the design satisfies GDC 60 and GDC 64 because gaseous effluents from the MC are processed by the CARS that provides for monitoring and control of the gaseous effluents being released to the atmosphere, and that condenser hotwell leakage is collected and processed by a leakage detection system.

10.4.1.5 Initial Test Program

The preoperational test related to the MC for design certification is TGS test (#33), which ensures the various design aspects related to the MC are implemented. This test is performed in accordance with DCA Part 2, Tier 2, Table 14.2-33. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.1.6 Technical Specifications

There are no TS requirements associated with the MC. The system is not safety related, is not required for safe shutdown, and does not meet a criterion for 10 CFR 50.36 for inclusion in TS. Therefore, the staff finds this acceptable.

10.4.1.7 Combined License Information Items

There are no COL Items associated with the MC.

10.4.1.8 Conclusion

Based on the review of the MC above, the staff concludes the design is acceptable because it meets the appropriate regulatory requirements as stated under Section 10.4.1.3, "Regulatory Basis," of this SER.

10.4.2 Condenser Air Removal System

10.4.2.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.2, "Condenser Air Removal System," in accordance with guidance in SRP Section 10.4.2, "Main Condenser Evacuation System," to ensure the CARS is designed and built to establish and maintain MC vacuum and to monitor for radioactive material.

10.4.2.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the CARS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.2, includes the CARS description, as well as relevant information on the CARS design. DCA Part 2, Tier 2, Figure 10.4-2, "Condenser Air Removal System Piping and Instrumentation Diagram," provides a functional arrangement of the CARS. DCA Part 2, Tier 2, Section 11.5.2.1.2, "Condenser Air Removal System," describes the radiation monitoring instrumentation provided at the discharge of CARS.

ITAAC: The applicant has not proposed any ITAAC related to the CARS.

Initial Test Program: The preoperational test related to the CARS being evaluated as part of the design certification review is described in DCA Part 2, Tier 2, Section 14.2, Table 14.2-32.

Technical Specifications: There are no proposed TSs associated with the CARS.

Technical Reports: There are no technical reports associated with the CARS.

10.4.2.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are given in SRP Section 10.4.2 and are summarized below:

- GDC 60, as it relates to provisions being included in the CARS design to suitably control the releases of radioactive materials in gaseous and liquid effluents during normal operation, including AOOs

- GDC 64, as it relates to the CARS design for monitoring releases of radioactive materials to the environment during normal operation, including AOOs and from postulated accidents

Review interfaces with other SRP sections are also indicated in SRP Section 10.4.2, Item I.

10.4.2.4 Technical Evaluation

The CARS is used to remove air from the MC and, therefore, establishes a vacuum. To prevent loss of condenser vacuum, each MC is provided with two 100-percent capacity CARS in parallel. This way, if one system is unavailable due to maintenance or lost during normal operation, the redundant system is started. The CARS are located near each MC in the TGB. The components in the CARS are not shared among other NPMs; therefore, the failure of the CARS does not impair the ability of other NPMs to perform their safety functions. A failure of CARS results in an increase in pressure in the MC to which CARS is connected. The loss of MC vacuum is an AOO and is discussed in DCA Part 2, Tier 2, Section 15.2.3, "Loss of Condenser Vacuum."

The staff reviewed DCA Part 2, Tier 2, Section 10.4.2, in accordance with SRP Section 10.4.2, to ensure compliance with the regulatory requirements listed in Section 10.4.2.3 of this SER.

DCA Part 2, Tier 2, Section 10.4.2.2.3, "System Operation," provides a general discussion on CARS operation, and DCA Part 2, Tier 2, Section 11.5.2.1.2, provides information on discharge of CARS effluents to the atmosphere and the monitoring and control of those effluents. In DCA Part 2, Tier 2, Section 10.4.2.1, "Design Basis," the applicant stated that the CARS is designed to satisfy GDC 60 and GDC 64 with regard to the control and monitoring of radioactive material releases to the environment.

Upon review of the information in DCA Part 2, Tier 2, Section 11.5.2.1.2 and Table 11.5-1, "Process and Effluent Radiation Monitoring Instrumentation Characteristics," the staff finds that sufficient monitoring is provided of CARS exhaust to alert system operators of abnormally high levels of radiation in the CARS effluent releases. The applicant stated, in DCA Part 2, Tier 2, Section 11.5.2.1.2, that "alarm setpoints, control room monitoring capability, and operator response in accordance with site procedures ensures compliance with GDC 60 and 64 and ensures the objectives of 10 CFR 20 and 10 CFR 50 Appendix I are met." If required, operators in the main control room have the ability to manually shut down and isolate the CARS in response to an abnormal plant condition. As such, the staff finds the CARS plays a key role in the MC design conforming to the requirements of GDC 60. The review of the CARS radiation monitoring instrumentation and sampling system is covered in Section 11.5, "Process and Effluent Radiation Monitoring Instrumentation and Sampling System," of this report.

Based on the above, the staff finds that the sampling and monitoring provisions for CARS discussed in DCA Part 2, Tier 2, Section 11.5.2.1.2, meet the requirements of GDC 60 and GDC 64, as they relate to the system design to control and monitor the releases of the radioactive materials to the environment.

In Section 10.4.1.4 of this report, the staff addresses the role of the CARS in minimizing the possibility of an explosion in the MC system because of the continuous noncondensable gas evacuation provided by the CARS, leading to a negligible amount of DO present in the condensate and MC hotwell inventory.

10.4.2.5 Initial Test Program

The preoperational test related to the CARS for design certification is CARS test (#32). This test is performed in accordance with DCA Part 2, Tier 2, Table 14.2-32. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.2.6 Technical Specifications

There are no TS requirements associated with the CARS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36 that would require a TS; therefore, the staff finds this acceptable.

10.4.2.7 Combined License Information Items

There are no COL information items associated with the CARS.

10.4.2.8 Conclusion

The CARS does not serve any safety-related functions nor is it credited to achieve and maintain safe-shutdown conditions. Since the design of CARS adequately implements the requirements of GDC 60 and GDC 64 for controlling and monitoring of the release of radioactive material to the environment, the staff concludes that the applicant has provided reasonable assurance that the CARS will operate as designed and its postaccident failures have no adverse impact on the capability of any safety-related or safe-shutdown equipment in the plant to perform their designed functions.

10.4.3 Turbine Gland Sealing System

10.4.3.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.3, "Turbine Gland Sealing System," in accordance with guidance in SRP Section 10.4.3. The TGSS is designed and built to provide a source of sealing steam to prevent air leakage into the turbine under vacuum and steam leakage out of the turbine under pressure during certain load conditions. The TGSS is part of the TGS.

10.4.3.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the TGSS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.3, includes the TGSS description, as well as relevant information on the TGSS design, including the design bases, instrumentation, and the inspection and testing program. DCA Part 2, Tier 2, Section 11.5.2.1.3, "Turbine Gland Sealing System," includes a description of the effluent radiation monitoring system for the TGSS.

ITAAC: The applicant has not proposed any ITAAC related to the TGSS.

Initial Test Program: Preoperational tests related to the TGSS being evaluated as part of the design certification review are described in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-9 and 14.2-33.

Technical Specifications: There are no proposed TS requirements associated with the TGSS.

Technical Reports: There are no technical reports related to the TGSS.

10.4.3.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are given in SRP Section 10.4.3, “Turbine Gland Sealing System,” and are summarized below:

- GDC 60, as it relates to the TGSS design for the control of releases of radioactive materials to the environment

- GDC 64, as it relates to the TGSS design for monitoring releases of radioactive materials to the environment during normal operation, including AOOs and postulated accidents

Review interfaces with other SRP sections are also indicated in SRP Section 10.4.3.

10.4.3.4 Technical Evaluation

Sealing steam, supplied from either the ABS or from the MSS, is distributed to the turbine shaft seals. The gland seal steam prevents the escape of steam from the turbine shaft and casing penetrations and the glands of large turbine valves. At the outer ends of the turbine glands, collection piping routes the mixture of air and excess seal steam to the gland steam condenser. Condensate from the steam-air mixture drains to the MC while noncondensables are vented to the environment. The mixture of noncondensable gases discharged from the gland steam condenser is not normally radioactive; however, in the event of significant primary-to-secondary system leakage due to a SG tube failure, it is possible to discharge radioactively contaminated gases. The TGSS effluents are monitored by a radiation monitor and grab sample point located on the exhaust line to the gland seal steam vent.

The staff reviewed DCA Part 2, Tier 2, Section 10.4.3, in accordance with SRP Section 10.4.3 to ensure compliance with the regulatory requirements listed in Section 10.4.3.3 of this SER. The applicant stated that the TGSS has no safety-related functions, is not credited for mitigation of a DBA, and has no safe-shutdown functions; therefore, it is not required to operate during or after a DBA. DCA Part 2, Tier 2, Section 10.4.3.2.3, provides a general discussion on TGSS operation, and DCA Part 2, Tier 2, Section 11.5.2.1.3, provides information on the discharge of TGSS effluents to the atmosphere and the monitoring and control of those effluents. In DCA Part 2, Tier 2, Section 10.4.3, “Design Basis,” the applicant stated that the TGSS is designed to satisfy GDC 60 and GDC 64 with regard to the control and monitoring of radioactive material releases to the environment.

Upon review of the information in DCA Part 2, Tier 2, Section 11.5.2.1.3 and Table 11.5-1, “Process and Effluent Radiation Monitoring Instrumentation Characteristics,” the staff found that sufficient monitoring is provided of TGSS exhaust to alert system operators of abnormally high levels of radiation in the TGSS effluent releases. The applicant stated, in DCA Part 2, Tier 2, Section 11.5.2.1.3, that “system monitoring and operator response in accordance with site procedures ensures that gaseous effluents meet the objectives of 10 CFR 20 and 10 CFR 50 Appendix I prior to being released into the environment and ensures compliance with GDC 60 and 64.” The review of TGSS radiation monitoring is covered in Section 11.5 of this SER.

Based on the above, the staff finds that the sampling and monitoring provisions for the TGSS discussed in DCA Part 2, Tier 2, Section 11.5.2.1.3, meet the requirements of GDC 60 and GDC 64, as they relate to the system design to control and monitor the releases of the radioactive materials to the environment.

10.4.3.5 Initial Test Program

Preoperational tests related to the TGSS for design certification include the ABS test (#9) and TGS test (#33), which ensures the various design aspects related to the TGSS are implemented. These tests are performed in accordance with DCA Part 2, Tier 2, Tables 14.2-9 and 14.2-33. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.3.6 Technical Specifications

There are no TS requirements associated with the TGSS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36 that would require a TS; therefore, the staff finds this acceptable.

10.4.3.7 Combined License Information Items

There are no COL information items associated with the TGSS.

10.4.3.8 Conclusion

The staff concludes that the applicant has met the requirements of the applicable regulations as described in the regulatory basis in this section and provided reasonable assurance that the TGSS will operate as designed and its postaccident failures have no adverse impact on the capability of any safety-related or safe-shutdown equipment in the plant to perform their designed functions.

10.4.4 Turbine Bypass System

10.4.4.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.4, "Turbine Bypass System," in accordance with guidance in SRP Section 10.4.4, "Turbine Bypass System." The TBS is designed and built to allow passing steam directly from the SGs to the MC in a controlled manner to remove heat from an NPM following a reduction or loss of electrical load. The TBS is part of the TGS.

10.4.4.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the TBS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.4, includes the TBS description, as well as relevant information on the TBS design, including the design bases, instrumentation, and the inspection and testing program.

ITAAC: The applicant has not proposed any ITAAC related to the TBS.

Initial Test Program: Preoperational tests related to the TBS being evaluated as part of the design certification review are described in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-33 and 14.2-70.

Technical Specifications: There are no proposed TS requirements associated with the TBS.

Technical Reports: There are no technical reports related to the TBS.

10.4.4.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are given in SRP Section 10.4.4 and are summarized below:

- GDC 4, it relates to SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents

Review interfaces with other SRP sections are also indicated in SRP Section 10.4.4.

10.4.4.4 Technical Evaluation

The TBS allows main steam to flow directly from the SGs to the MC in a controlled manner to remove heat from the NPM following a reduction or loss of electrical load. The TBS has the capacity to bypass the rated power steam flow to the MC at full-power operation. The TBS total flow capacity, in combination with bypass valve opening time, pressurizer size, and the reactor power control system, is sufficient to sustain a rated power normal load rejection (electrical load), without generating a reactor trip and without requiring actuation of the main steam safety valve.

The staff reviewed DCA Part 2, Tier 2, Section 10.4.4, in accordance with SRP Section 10.4.4, to ensure compliance with the regulatory requirements listed in Section 10.4.4.3 of this SER. The applicant stated that the TBS is part of the TGS, has no safety-related function, is not credited for mitigation of a DBE, and has no safe-shutdown functions. The applicant also stated that the TBS is designed to satisfy GDC 4, and its failure will not affect any SSCs important to safety.

As indicated in DCA Part 2, Tier 2, Table 3.2-1, the entire system is located inside the turbine building and classified as not safety related and not risk significant. The TBS is part of the TGS and, therefore, is also located inside the turbine building. In DCA Part 2, Tier 2, Section 3.6.2.1.6, the applicant stated that there is no essential equipment outside of the RXB or CRB. As such, the failure of the TBS due to a pipe break or a malfunction of the TBS would not adversely affect SSCs important to safety since none of these is located in the turbine building. For these reasons, the staff agrees that the TBS meets the requirements of GDC 4.

As indicated in DCA Part 2, Tier 2, Section 10.4.4.1, “Design Bases,” the TBS can be used to provide a residual heat removal function for normal NPM shutdown, eliminating the need to rely solely on safety systems or components; however, the TBS is not credited for compliance with GDC 34. The decay and residual heat removal safety function per GDC 34, as modified by NuScale’s PDC 34, as discussed in Section 10.3.1.4.4 of this report, is performed by the DHRS, which is a passive design that consists of two independent trains, each capable of performing the system safety function in the event of a single failure. The review of the DHRS and compliance with PDC 34 is covered in Section 5.4.3 of this SER. Since the DHRS is used to comply with PDC 34, and the TBS is not credited for compliance, the staff finds that GDC 34 is not applicable to this system.

10.4.4.5 Initial Test Program

Preoperational tests related to the TBS for design certification include the TGS test (#33) and hot functional test (#70), which ensure the various design aspects related to the TBS are implemented. These tests are performed in accordance with DCA Part 2, Tier 2, Tables 14.2-33 and 14.2-70. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.4.6 Technical Specifications

There are no TS requirements associated with the TBS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36 that would require a TS; therefore, the staff finds this acceptable.

10.4.4.7 Combined License Information Items

There are no COL information items associated with the TBS.

10.4.4.8 Conclusion

The TBS does not serve any safety-related functions and is not credited to achieve and maintain safe-shutdown conditions. The staff finds that the design of the TBS adequately implements the requirements of GDC 4.

10.4.5 Circulating Water System

10.4.5.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.5, "Circulating Water System," in accordance with SRP Section 10.4.5, "Circulating Water System." The circulating water system (CWS) is designed and built to facilitate the transfer of heat load from the MC to the cooling towers. The applicant stated that up to six NuScale NPMs share one CWS, with up to two CWS systems per plant.

Portions of the CWS are identified as conceptual design information (CDI) as described in 10 CFR 52.47(a)(24).

10.4.5.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1 for the CWS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.5, includes the CWS description, as well as relevant information on the CWS design, including the design bases, instrumentation, and the inspection and testing program.

ITAAC: The applicant has not proposed any ITAAC related to the CWS.

Initial Test Program: Preoperational tests related to the CWS being evaluated as part of the design certification review are described in DCA Part 2, Tier 2, Section 14.2, Table 14.2-10.

Technical Specifications: There are no proposed TS requirements associated with the CWS.

Technical Reports: There are no technical reports related to the CWS.

10.4.5.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are given in SRP Section 10.4.5 and are summarized below:

- GDC 4, as it relates to design provisions provided to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS

- GDC 5, as it relates to sharing of systems and components important to safety such that sharing does not significantly impair their ability to perform required safety functions

- 10 CFR 52.47(a)(24), which requires that DCA Part 2 contain a representative conceptual design for those portions of the plant for which the application does not seek certification, to aid the NRC in its review of DCA Part 2 and to permit assessment of the adequacy of the interface requirements in 10 CFR 52.47(a)(25)

- 10 CFR 52.47(a)(25), which requires that DCA Part 2 contain interface requirements to be met by those portions of the plant for which the application does not seek certification, noting that these requirements must be sufficiently detailed to allow completion of DCA Part 2

- 10 CFR 20.1406, as it relates to the design features that will facilitate eventual decommissioning and minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste

Review interfaces with other SRP sections are also indicated in SRP Section 10.4.5.

10.4.5.4 Technical Evaluation

The CWS, being the normal heat sink for the NuScale Power Plant, provides a continuous supply of cooling water to the MCs and rejects heat to the environment. For the 12-NPM design, the CWS is composed of two identical circulating water subsystems, each responsible for delivering cooling water to the MCs of six CFWSs. There is no interconnected piping between the two circulating water subsystems. Three 33-percent capacity circulating water pumps take suction, through a traveling screen, from dedicated CWS pump bays that are connected directly to the cooling tower basin. Continuously moving traveling screens prevent debris from entering the CWS pump bay. The CWS uses a cooling tower arrangement to reject heat to the atmosphere. Each tower is sized to support the full-power operation of up to six NPMs.

In DCA Part 2, Section 10.4.5.3, “Safety Evaluation,” the applicant stated that the CWS serves no safety-related functions, is not credited for mitigation of a DBE, and has no safe-shutdown functions. Furthermore, the applicant stated that a failure of the CWS that releases the water inventory and the resulting flooding does not prevent the operation of a safety-related system because no such systems are located in the TGBs, and water from a CWS pipe or expansion joint leak would drain through the building doors and vent openings, and then away from other buildings as controlled by site grading. In addition, based on information provided in DCA Part 2, Section 1.2, "General Plant Description," the RXB and CRB are the only buildings on a NuScale site that contain SSCs important to safety. DCA, Part 2, Tier 2, Section 3.4.1.4 notes that flooding of the RXB or CRB caused by external sources does not occur and that failure of equipment outside the CRB and RXB cannot cause internal flooding. Additionally, the applicant indicated that a COL applicant is required to demonstrate the site is properly graded to prevent localized flooding as discussed in DCA Part 2, Tier 2, Table 2.0-1, under the hydrologic engineering subsection. Based on the above, the staff concludes that the applicant adequately addressed the issue related to the potential impact on safety-related SSCs or SSCs important to safety due to CWS failures per GDC 4.

Since a single CWS is shared by up to six NPMs, the staff also reviewed the design of the CWS for compliance with the requirements of GDC 5 with respect to shared systems. Compliance with GDC 5 requires that provisions be included in the nuclear power unit design to ensure an event with one NPM does not significantly impair any other NPM unit's ability to perform its safety functions, including the ability to safely achieve and maintain safe shutdown. The applicant stated, in DCA Part 2, Tier 2, Section 0.4.5.2.3, that, although each loop of the CWS is shared by six NPMs, a trip to one of the NPMs served by the CWS does not prevent the other five NPMs from performing their safety functions. If a CWS were to fail, however, it would require all six NPMs tied to that CWS to be shut down from normal operation. Upon review of the CWS for compliance with GDC 5, the staff determined that the CWS is not safety related, is not risk significant, has no safe-shutdown function, and is not credited in DBE mitigation. Therefore, the staff finds the CWS in compliance with GDC 5

The regulations in 10 CFR 20.1406 require, in part, that each design certification applicant describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste. Since the CWS interfaces with the MC, the staff reviewed the design of the CWS for compliance with the requirements of 10 CFR 20.1406. DCA Part 2, Tier 2, Section 10.4.5.3, states that "the CWS is anticipated to contain negligible quantities of radioactive contaminants during power operation and during shutdown." Furthermore, the applicant stated that "in the event of a SG tube leak, radioactive fluid would infiltrate the secondary loop, which would be detected in the main steam system (MSS). There would have to be a simultaneous failure of the SG tubes and MC tube leak for radiation to leak into the CWS. However, during normal operation the CWS is kept at higher pressure than the condenser shell side, which keeps the leakage into the condenser rather than to the environment. Grab sample locations are checked and blowdown is monitored for radiation."

The staff found in its review that the applicant also addresses the CWS design features adherence to RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," in DCA Part 2, Table 12.3-22, "Regulatory Guide 4.21: Design Features for Circulating Water System." The general review of NuScale compliance with RG 4.21 is included in Section 12.3 of this report. Based on the above discussion, the staff concluded that the CWS, as described in the DCA Part 2, complies with 10 CFR 20.1406.

SRP Section 10.4.5, Section III.2, states that the CWS design should have the capability to detect leaks and to secure the system quickly and effectively. DCA Part 2, Tier 2, Section 10.4.5.3, states that "large CWS leaks due to pipe failures will be indicated in the control room by a loss of MC vacuum. MC vacuum is a parameter that is monitored during normal operation (Section 10.4.2.2.3).”

DCA Part 2, Tier 2, Figure 1.2-3, “Schematic of a Single NuScale Power Module and Associated Secondary Equipment,” identifies several components of the CWS. The staff notes that the cooling tower and its associate pump are identified as CDI. DCA Part 2, Tier 2, Table 1.8-1, “Summary of NuScale Certified Design Interfaces with Remainder of Plant,” indicates that the cooling towers, pump houses, and associated SSCs (e.g., cooling tower basin, circulating water pumps, cooling tower fans, chemical treatment building) are CDIs. The staff finds that, while CDI is necessary to provide context for interface requirements, as specified in 10 CFR 52.47(a)(24) and (a)(25), such information is outside the scope of the certified design and, therefore, not reviewed by the staff as part of this design review. Instead, a future COL applicant must provide the necessary plant-specific information related to the conceptual design portion of the system, at which time, the staff will perform the review on the site-specific CWS design. The applicant has properly identified CDI design information for the CWS in DCA Part 2, Tier 2, Table 10.4-9, “Circulating Water System Design Parameters.”

10.4.5.5 Initial Test Program

Preoperational tests related to the CWS for design certification include the CWS test (#10). This test is performed in accordance with DCA Part 2, Tier 2, Table 14.2-10. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.5.6 Technical Specifications

There are no TS requirements associated with the CWS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36 that would require a TS; therefore, the staff finds this acceptable.

10.4.5.7 Combined License Information Items

There are no COL Items associated with the CWS.

10.4.5.8 Conclusion

The CWS does not serve any safety-related functions nor is credited to achieve and maintain safe-shutdown conditions. Since the design of the CWS adequately implements the requirements of GDC 4 and 5, 10 CFR 52.47(a)(24), 10 CFR 52.47(a)(25), and 10 CFR 20.1406, the staff concludes that the applicant provided reasonable assurance that the CWS will operate as designed and that its postaccident failures have no adverse impact on the capability of any safety-related or safe-shutdown equipment in the plant to perform its designed functions.

10.4.6 Condensate Polishing System

10.4.6.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.6, “Condensate Polishing System,” in accordance with SRP Section 10.4.6, “Condensate Cleanup System,” Revision 3, issued March 2007. SRP Section 10.4.6 references SRP Section 5.4.2.1, “Steam Generator Materials and Design,” Revision 4, issued July 2016, to provide the specific acceptance criteria to ensure the requirements of GDC 14, “Reactor Coolant Pressure Boundary,” are met as they related to PWR secondary water chemistry.

DCA Part 2, Tier 2, Section 10.3.5, “Water Chemistry,” describes the secondary water chemistry, but its evaluation is included under Section 10.4.6 of this SER because the CPS is one of the principal means of affecting secondary water chemistry control, and the staff has indicated it accordingly in SRP Section 10.4.6.

The CPS is designed to clean and treat feedwater to remove corrosion products and ionic impurities. The CPS also provides the capacity to treat feedwater during plant startup and during a condenser leak that may contaminate the CFWS. The CPS provides condensate cleanup capability and maintains condensate quality through filtration and ion exchange. It does not perform a safety-related function. Also discussed in this section is secondary plant water chemistry as described in DCA Part 2, Tier 2, Section 10.3.5.

10.4.6.2 Summary of Application

DCA Part 2, Tier 1: No Tier 1 information is provided in NuScale DCA Part 2 for this system.

DCA Part 2, Tier 2: The applicant provided a design description in DCA Part 2, Tier 2, Section 10.4.6, which is summarized here in part:

> The CPS is designed with two 100 percent redundant mixed-bed deionizers to remove ionic impurities from the condensate and feedwater system during plant startup, operations, and shutdown. The CPS is supported by the condensate polisher resin regeneration system. This restores the resin quality to polisher requirements for reuse. A condensate bypass valve is provided to bypass the condensate purification when not needed. The CPS consists of the following components: two condensate inlet filters, mixed-bed ion exchanger vessels, resin filters, spent-resin tanks, resin supply tanks, resin replacement equipment, and instrumentation.

DCA Part 2 states that the secondary water quality requirements are based on the EPRI “Pressurized Water Reactor Secondary Water Chemistry Guidelines” (EPRI Guidelines), Revision 7, dated February 17, 2009 (ADAMS Accession No. ML11220A116), as well as Nuclear Energy Institute (NEI) 97-06, “Steam Generator Program Guidelines,” Revision 3, issued January 2011. In addition, DCA Part 2 provides certain parameters that will be controlled under the secondary water chemistry program as well as the acceptable limits for these parameters. DCA Part 2 also describes how an all-volatile treatment amine will be used for pH control and how hydrazine will be added to scavenge DO. In addition, DCA Part 2 provides sampling parameters for the constituents to be monitored. The applicant also provided TS 5.5.5, “Secondary Water Chemistry Program,” to monitor and control the secondary water chemistry.

The CPS is designed to contain two 100-percent flow filters upstream of the condensate polishers. The CPS is also designed to have two 100-percent redundant polisher trains. The condensate polishers are mixed-bed deionizers and will provide the capacity needed to maintain the secondary water chemistry requirements in DCA Part 2, Section 10.3.5. The CPS will contain instrumentation to measure system performance and take samples of the parameters to be monitored.

The CPS components that will be exposed to wet steam, flashing liquid flow, or turbulent single-phase flow where significant loss of material could occur will be constructed with corrosion-, erosion-, and FAC-resistant materials.

ITAAC: There are no ITAAC specific to the CPS.

Initial Test Program: "Condensate Polishing System Test #30," and "Primary and Secondary System Chemistry Test #79," in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-30 and 14.2-79, respectively, related to this system are evaluated as part of the certified design review in Section 14.2 of this report.

Technical Specifications: The proposed TS associated with DCA Part 2, Tier 2, Section 10.4.6, located in DCA Part 4, TS 5.5.5, provides program requirements for monitoring secondary water chemistry.

10.4.6.3 Regulatory Bases

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are summarized below:

- GDC 14 requires that the RCPB be designed, fabricated, erected, and tested to ensure an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture.

Acceptance criteria adequate to meet the above requirements are given in SRP Section 10.4.6, Branch Technical Position 5-1, "Monitoring of Secondary Side Water Chemistry in PWR Steam Generators," Revision 3, issued March 2007, and SRP Section 5.4.2.1.

10.4.6.4 Technical Evaluation

10.4.6.4.1 Secondary Water Chemistry

Secondary water chemistry is focused on preventing corrosion in SGs, condensers, piping, and other equipment. Principal parameters that must be controlled are impurity ion concentrations, including sodium (Na^+), chloride (Cl^-), and sulfate (SO_4^{-2}) ions, pH, and DO.

The staff reviewed the information provided in DCA Part 2, Tier 2, Sections 10.3.5 and 10.4.6, as well as the supplemental letter dated December 15, 2017 (ADAMS Accession No. ML17349A838), against the requirements of GDC 14. GDC 14 is applicable to the CPS since the system is designed to maintain water quality and to avoid corrosion-induced failure of the RCPB, specifically the SG tubing. As described in SRP Section 10.4.6, an acceptable method of compliance with GDC 14 with respect to an extremely low probability of abnormal leakage, rapidly propagating failure, or gross rupture of the RCPB is for the applicant to meet the guidelines in the latest version of the EPRI Guidelines.

The EPRI Guidelines provide several criteria for the secondary water chemistry control program, including sampling frequency and other sampling requirements, guidelines for continuously monitoring water chemistry parameters, and operating limits for impurities and additives, as well as associated action responses to be carried out if limits are exceeded. Although the staff does not formally review or issue a safety evaluation of the various EPRI water chemistry guidelines (including the PWR Secondary Water Chemistry Guidelines), these guidelines are recognized as representing the industry's best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI Guidelines minimizes the occurrence of corrosion-related failures. Further, the EPRI Guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore, the staff accepts the use of the EPRI Guidelines as the basis for the NuScale secondary-side water chemistry program.

DCA Part 2, Tier 2, Section 10.3.5, addresses the water chemistry quality requirements for SG water and feedwater. In particular, DCA Part 2, Tier 2, Table 10.3-3a, "Steam Generator [SG] (Reactor Coolant System [RCS] ≤ 200°F)," Table 10.3-3b, "Feedwater Sample (Reactor Coolant System > 200 °F to <15% reactor power)," Table 10.3-3c, "Feedwater Sample (≥15% reactor power)," and Table 10.3-3d, "Condensate Sample (≥15% reactor power)," provide the normal values for certain secondary water chemistry parameters.

The NRC staff reviewed the information provided in DCA Part 2, Tier 2, Section 10.3.5, to determine whether the applicant's proposed secondary water chemistry parameters provide reasonable assurance that the requirements of GDC 14 will be met. The staff compared the parameters monitored, locations of monitoring, and the conditions while monitoring to the values provided in the EPRI Guidelines. Based on this review, the staff has determined the water chemistry parameters provided by the applicant are consistent with the parameters that are given in the EPRI Guidelines. Because the applicant has proposed maintaining secondary water chemistry constituents at values that are within the EPRI Guidelines, the NRC staff has determined that the constituent limits for the NuScale secondary water chemistry are acceptable to provide the necessary purity of the secondary water.

The applicant stated that the COL applicant will be responsible for developing action levels for its site-specific water chemistry control program. The applicant also provided COL Item 10.3-1, which requires the COL applicant to develop a site-specific water chemistry control program based on the latest revision of the EPRI Guidelines and NEI 97-06 at the time of the COL application. As part of COL Item 10.3-1, the site-specific water chemistry control program will incorporate the appropriate aspects (i.e., the "mandatory," "shall," and "recommended" elements) of the EPRI Guidelines, including, but not limited to, action levels and the associated required actions. This COL item will be addressed as part of the COL application for the NRC staff's review. The staff finds this acceptable because it is appropriate to develop this information as part of a site-specific application. This information will allow the staff to determine whether aspects of the secondary water chemistry control program not contained in DCA Part 2, such as action levels and the associated required actions, meet the EPRI Guidelines.

As stated in DCA Part 2, Tier 2, Section 10.3.5.1.2, "Water Chemistry Treatment and Monitoring," an all-volatile treatment amine, such as ammonium hydroxide, is used as a pH controller, and hydrazine is added to control DO. The NRC staff finds this acceptable because these chemicals are commonly added to secondary water to control pH and DO. In addition, the use of these treatments is discussed in the EPRI Guidelines.

In addition to providing suitable water quality to prevent corrosion-induced failure of the RCPB, adequate instrumentation and sampling must be provided to verify the effectiveness of the CPS to meet GDC 14 and the guidance of SRP Section 10.4.6. Concentrations are monitored using continuous analyzers (supplemented by grab samples), as described in DCA Part 2, Tier 2, Section 9.3.2, "Process and Post-Accident Sampling Systems." The continuous monitors identified in this section are consistent with the EPRI Guidelines. The staff finds the instrumentation and sample points provided are acceptable, because they meet those recommended by the EPRI Guidelines.

The staff has determined the monitoring and control of secondary water chemistry is acceptable based on the applicant having met the applicable sections of the EPRI Guidelines, with respect to maintaining acceptable chemistry control for PWR secondary coolant during normal operation and AOOs, thereby reducing the likelihood and magnitude of reactor piping failures and of primary-to-secondary coolant leakage.

10.4.6.4.2 Condensate Cleanup Capacity

In DCA Part 2, Tier 2, Table 10.4-15, “Condensate Polishing System Instrumentation,” the applicant listed the instrumentation equipment as well as the parameters monitored by the equipment. This table provides monitoring equipment for differential pressure over the CPS filter, a flow meter for CPS inlet flow, and a temperature transmitter to detect the inlet condensate temperature, among other monitoring equipment. SRP Section 10.4.6 recommends that the CPS “contains adequate instrumentation to monitor the effectiveness of the system.” The NRC staff determined that the instrumentation available to measure pressure drop and flow across the CPS will be able to monitor the CPS filter for potential clogging, or other issues, that could impact the effectiveness of the CPS. In addition, the staff determined that the inlet temperature transmitter would be able to detect if the condensate temperature was hotter than the design temperature of the CPS resin. Combined with the alarms for CPS high inlet temperature, and inlet filter high-pressure differential shown in DCA Part 2, Tier 2, Table 10.4-16, “Condensate Polishing System Alarms,” the staff has reasonable assurance that the monitoring equipment and alarms described will be adequate to monitor the effectiveness of the CPS.

The CPS purifies secondary water by passing it through mixed-resin (cation and anion) deionizers. The CPS has two 100-percent redundant mixed-resin deionizers that have connections for resin transfer, condensate rinse, sampling, and drainage to balance-of-plant drains. COL Item 10.4-1 states that a COL applicant will determine the size and number of new and spent resin tanks for the CPS. The NRC staff has reasonable assurance that the CPS will have an adequate amount of capacity to maintain secondary water chemistry conditions based on the design capacity of the deionizers. The staff finds the COL Item acceptable because it is appropriate to develop information related to the size and number of resin tanks for the CPS as part of a site-specific application.

In DCA Part 2, Section 10.4.6, the applicant stated that design features will be in place to limit contaminants in the secondary water to allowable values until the CFWS is isolated in the case of a condenser tube leak. Additionally, the applicant has provided the allowable values for the secondary water chemistry constituents in Section 10.3.5, which are consistent with secondary water chemistry parameters in the EPRI Guidelines. The applicant has stated that contaminants resulting from small to moderate leakage will be removed by the condensate polishers. However, if there is a severe MC tube leak, it may necessitate a reactor trip and bypass of the CPS to prevent contaminants from being transported to the SGs. These actions, combined with the limits set by the secondary water chemistry control program, provide the NRC staff reasonable assurance that contaminant concentrations are held to the values in Section 10.3.5 until corrective action is taken.

SRP Section 10.4.6 recommends that the CPS system be connected to radioactive waste disposal systems to allow disposal of spent resin or regenerant solutions when necessary. DCA

Part 2, Tier 2, Section 10.4.6.2.3, states that CPS regenerant waste will be discharged to the balance-of-plant drain system to be monitored for contamination, and DCA Part 2, Tier 2, Section 11.4.2.2, states that condensate polishing resin may be transferred to the solid radioactive waste system via high integrity containers or other suitable containers. The staff finds this acceptable as the CPS is connected to radioactive waste disposal systems. The staff's evaluations of the liquid waste management system and the solid waste management system are documented in Sections 11.2 and 11.4 of this report.

10.4.6.4.3 Condensate Polishing System Materials of Construction

In DCA Part 2, Tier 2, Section 10.4.6.2.1, the applicant stated that "Corrosion, erosion, and flow-accelerated corrosion resistant materials are used for components exposed to wet steam, flashing liquid flow, or turbulent single-phase flow where loss of material could occur." The applicant also stated that these materials will be used consistent with the specific fluid conditions and that, for carbon steel piping used in the CFWS, there will be a corrosion allowance. Additionally, the applicant stated that the CPS is Quality Group D, ASME B31.1. In ASME B31.1, there are requirements for the design, materials, fabrication, erection, test, inspection, operating, and maintenance of piping systems and associated components.

Because corrosion-resistant materials will be used, and because the CPS will be built to standards that provide appropriate guidance for selecting materials of construction, the staff has reasonable assurance the CPS materials of construction will be compatible with the service environment and allow the system to serve its function. Additionally, the water chemistry parameters provided in DCA Part 2, Tier 2, Section 10.3.5, provide reasonable assurance that the service conditions will help to limit corrosion and preserve the integrity of the materials used to construct the CPS.

10.4.6.5 Inspections, Tests, Analyses, and Acceptance Criteria

There are no ITAAC for this system.

10.4.6.6 Initial Test Program

Preoperational tests, "Condensate Polishing System Test #30," and "Primary and Secondary System Chemistry Test #79," in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-30 and 14.2-79, respectively, which are related to the CPS, are evaluated in Section 14.2 of this report.

10.4.6.7 Technical Specifications

DCA Part 2, Tier 2, Chapter 16, contains certain requirements for the NuScale generic TS. However, DCA Part 4, "Generic Technical Specifications," contains the individual TS, including TS 5.5.5. This TS provides an administrative program for the monitoring and control of secondary water chemistry to inhibit SG tube degradation. The staff reviewed the TS for monitoring controls for the secondary water chemistry program for its applicability to the CPS and secondary water chemistry program.

The staff determined that the TS appropriately addresses control and monitoring of secondary water chemistry through the administrative secondary water chemistry program. The staff evaluation of the TS is located in Chapter 16 of this SER.

10.4.6.8 Table of Combined License Information Items

Table 10.4.6-1 lists COL information item numbers and descriptions related to the CPS, from DCA Part 2, Tier 2, Sections 10.3.5.1 and 10.4.6.2.2.

Table 10.4.6-1 NuScale Combined License Information Items for DCA Part 2, Tier 2, Section 10.4.6

Item No.	Description	DCA, Part 2, Tier 2 Section
COL Item 10.3-1	A COL applicant that references the NuScale Power Plant design certification will provide a site-specific chemistry control program based on the latest revision of the EPRI Pressurized Water Reactor Secondary Water Chemistry Guidelines and Nuclear Energy Institute (NEI) 97-06 at the time of the COL application.	10.3.5.1
COL Item 10.4-1	A COL applicant that references the NuScale Power Plant design certification will determine the size and number of new and spent resin tanks in the condensate polishing system.	10.4.6.2.2

The applicant proposed two COL items as described in the table above. The COL items describe site-specific features of the CPS and the plant secondary water chemistry control program. The staff find these COL items to be reasonable.

10.4.6.9 Conclusion

Based on the NRC staff's review of the CPS, the staff has determined that the CPS includes the necessary components and equipment to remove dissolved and suspended impurities from the condensate. Based upon the staff's review of the applicant's proposed design criteria and bases for the CPS and the criteria for operation of the system, the staff concludes that the design of the system is acceptable and meets the applicable requirements as stated in Section 10.4.6.3, "Regulatory Basis" of this SER. Additional details of the secondary-side water chemistry will be provided by the COL applicant as stated in COL Item 10.3-1 and will be based on the latest version of the EPRI Guidelines.

10.4.7 Condensate and Feedwater System

10.4.7.1 Introduction

The CFWS provides feedwater at the required temperature, pressure, and flow rate to the SGs. Condensate is pumped from the MC hotwell by the condensate pumps; passes through the CPS, the gland steam condenser, and the low- and intermediate-pressure feedwater heaters to the feedwater pumps; and then is pumped through the high-pressure feedwater heaters into the tube side of the helical coil SG. Each NPM is supplied with a separate CFWS, not shared with other NPMs.

NuScale DCA Part 2 describes the CFWS boundaries as extending from the MC to the flange immediately upstream of the SG FWIV. NuScale has not included, as part of the CFWS, the portions of the system between the SG and the SG FWIV, which functionally serve as part of the CFWS. For the purposes of this review, the staff considers the CFWS to extend from the outlet of the MC up to the tube side inlet of the SG, which includes the portion of the system from the SG to the SG FWIV as part of the CFWS per guidance in DSRS 10.4.7, "Condensate and Feedwater System."

10.4.7.2 Summary of Application

DCA Part 2, Tier 1: The Tier 1 information concerning SSCs associated with the operation of the CFWS is found in DCA Part 2, Tier 1, Table 2.8-1, "Module Specific Mechanical and Electrical/I&C Equipment," under the title, "Condensate and Feedwater System." Design information is included for the feedwater regulating valve and their position-indicating transmitters, and for the feedwater supply check valves.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.7, "Condensate and Feedwater System," provides a complete description of the CFWS. Information provided includes the CFWS design bases, system descriptions, component descriptions, system operation, safety evaluation, and information on inspection and testing of the CFWS.

In DCA Part 2, Tier 2, Section 10.4.7.2, "System Description," the applicant stated that the CFWS is not safety related and is primarily located within the TGB and RXB, with the exception of some piping and the condensate storage tank located outside. It also stated that downstream of the FWIVs, each feedwater line penetrates the CNV top head through separate CNV feedwater nozzles and that inside the CNV, each feedwater line is divided into two feedwater lines that connect to the respective SG. The redundant DHRS return lines connect to each feedwater line upstream of the junction for the SG inlet lines inside the CNV.

ITAAC: There are no ITAAC for the entire CFWS shown in Tier 1; however, in DCA Part 2, Tier 1, Section 2.8, "Equipment Qualification," the applicant proposed ITAAC for the following CFWS equipment: the feedwater supply check valves, the FWIV, and the feedwater regulating valve (FWRV). These ITAAC are evaluated in Section 14.3.7 of this SER.

Initial Test Program: Preoperational tests related to the CFWS being evaluated as part of the design certification review are described in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-28 and 14.2-31.

Technical Specifications: The TS associated with the CFWS are given in DCA Part 2, Tier 2, Chapter 16, Section 3.7.2.

Technical Reports: There are no technical reports related to the CFWS.

10.4.7.3 Regulatory Basis

The relevant requirements for this area of review and the associated acceptance criteria are given in Section 10.4.7, "Condensate and Feedwater System," of the NuScale DSRS and are summarized below:

- GDC 2, as related to important to safety portions of the CFWS designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions

- GDC 4, as related to the dynamic effects associated with possible fluid flow instabilities (e.g., water hammer) during normal plant operation, as well as during upset or accident conditions

- GDC 5, as related to sharing of systems and components important to safety such that sharing does not significantly impair their ability to perform required safety functions

- GDC 44 as related to—

  – the capability to transfer heat loads from the reactor system to a heat sink under both normal operating and accident conditions

  – the redundancy of components so that, under accident conditions, the safety functions can be performed assuming a single active component failure (which may be coincident with the loss of offsite power for certain events)

  – the capability to isolate components, subsystems, or piping if required so that the system safety function will be maintained

- GDC 45, as related to design provisions to permit periodic inservice inspection of system components and equipment

- GDC 46, as related to design provisions to permit appropriate functional testing of the system and components to ensure structural integrity and leak-tightness, operability and performance of active components, and capability of the integrated system to function as intended during normal, shutdown, and accident conditions

- 10 CFR 20.1406, as it relates to the design features that will facilitate eventual decommissioning and minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste

Review interfaces with other SRP sections are also indicated in DSRS 10.4.7.

10.4.7.4 Technical Evaluation

The staff reviewed the CFWS described in DCA Part 2, in accordance with the review procedure in DSRS 10.4.7, Revision 0, issued June 2016. As indicated in Section 10.4.7.1 of this SER, the applicant’s description of the CFWS boundaries is not consistent with the CFWS boundaries described in DSRS 10.4.7. Thus, SSCs that are functionally part of the CFWS are not identified as part of the CFWS in DCA Part 2. The staff performed its review based on the system boundaries identified in the DSRS as described in Section 10.4.7.1 of this SER. Use of the DSRS system boundaries ensures that the SSCs that are functionally part of the CFWS and located inside the RXB and containment are properly designed to ensure that they perform their safety-related functions under all normal and accident conditions and that their failure will not adversely impact other important-to-safety SSCs. The results of the staff’s review are provided below.

10.4.7.4.1 GDC 2, "Design Basis for Protection against Natural Phenomena"

The staff reviewed the CFWS for compliance with the requirements of GDC 2, with respect to its design for protection against the effect of natural phenomena such as earthquakes, tornados, hurricanes, and floods. Compliance with the requirements of GDC 2 is based on the CFWS being designed to withstand the effects of natural environmental phenomena without losing the ability to perform its safety function and on adherence to Regulatory Position C.1 of RG 1.29, Revision 4, for the safety-related portion of the system, and Regulatory Position C.2 for the portions of the system that are not safety related.

RG 1.29, Regulatory Position C.1.f, states that the pertinent quality assurance requirements of Appendix B to 10 CFR Part 50 shall apply to all activities affecting the safety-related function of those portions of the steam and feedwater systems of PWRs extending from and including the secondary side of the SG up to and including the outermost CIVs, and connecting piping of a nominal size of 6.35 centimeters (2.5 inches) or larger, up to and including the first valve that is either normally closed or capable of automatic closure during all modes of normal operation.

NuScale DCA Part 2, Section 10.4.7.2, "System Description," states that the CFWS is not safety related and is primarily located within the TGB and RXB, with the exception of some piping and the condensate storage tank located outside. Since the CFWS provides feedwater to the SGs, which are integral to the reactor module, the CFWS penetrates the reactor containment and has piping located inside containment. The applicant stated, in DCA Part 2, Section 10.4.7.2.1, that "the containment penetrating systems are divided into three portions: internal to containment, the containment and safety-related isolation valve(s), and the nonsafety-related portion external to the NPM." The applicant also indicated that the three portions of the system are shown on DCA Part 2, Tier 2, Figure 10.1-1.

The staff reviewed DCA Part 2, Figure 10.1-1, and confirmed that SSCs important to safety, including the feedwater isolation and check valves as well as the regulating valves and the spool piece from which the system is disconnected during refueling, are all designed to seismic Category I and thus comply with Regulatory Position C.1 of RG 1.29.

DCA Part 2, Tier 2, Section 3.2, "Classification of Structures, Systems and Components," categorizes SSCs based on safety importance and other considerations. The location, safety classification, and seismic category for the CFWS are given in DCA Part 2, Tier 2, Table 3.2-1. All of the CFWS SSCs located in the TGB are listed as nonsafety related, quality group D, and seismic Category III, except for the FWRVs, feedwater supply check valves and the feedwater regulating valve limit switch, which are seismic Category I.

DCA Part 2, Tier 2, Figure 10.1-1, identifies the feedwater piping from the CIVs to the disconnect flange outside of containment as being seismic Category I, and the portion of the system beyond the seismic anchor located at the exit from the RXB as seismic Category III, which the staff finds to be in compliance with Regulatory Positions C.1 and C2 of RG 1.29.

The feedwater SSCs inside containment include the feedwater supply to the SGs and DHRS heat exchanger FWIVs and feedwater supply piping inside containment. These SSCs are classified as seismic Category I in Table 3.2-1. In addition, the feedwater regulating and feedwater supply check valves located inside the RXB are also classified as seismic Category I in Table 3.2-1. The classification of these SSCs is consistent with the guidance provided in Regulatory Position C.1 of RG 1.29 and is therefore considered appropriate. Also, the feedwater piping from the CIVs to the seismic anchor located at the exit from the RXB is seismic

Category I, and the portion of the system beyond the seismic anchor at the exit from the RXB is seismic Category III, which the staff finds to be in compliance with Regulatory Positions C.1 and C.2 of RG 1.29.

As indicated above, the safety-related SSCs associated with the CFWS are seismic Category I and are located inside the RXB, which is a seismic Category 1 structure designed to protect SSCs from extreme winds and missiles that may result from natural phenomena such as earthquakes, tornadoes, and hurricanes. DCA Part 2, Tier 2, Section 3.5.2, describes the RXB as being designed in accordance with RG 1.13, Revision 2, "Spent Fuel Storage Facility Design Basis," issued March 2007; RG 1.117, Revision 2, "Protection Against Extreme Wind Events and Missiles for Nuclear Power Plants," issued July 2016; and RG 1.221, Revision 0, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," issued October 2011. The RXB also protects the safety-related SSCs associated with the CFWS from the effects of external flooding as described in DCA Part 2, Tier 2, Section 3.4.2, "Protection of Structures Against Flood from External Sources."

Based on the above discussion, the staff concludes that the CFWS, as described in DCA Part 2, complies with the requirements of GDC 2.

10.4.7.4.2 GDC 4, "Environmental and Dynamic Effects Design Bases"

The staff reviewed the CFWS for compliance with the requirements of GDC 4, as related to dynamic effects associated with possible fluid flow instabilities, including water hammer and effects of pipe breaks. Compliance with the requirements of GDC 4 is based on identification of SSCs important to safety that need to be protected from dynamic effects, including internally and externally generated missiles, pipe whip, and jet impingement due to high- and moderate-energy missiles and water hammer.

The CFWS CIVs perform the safety-related function of containment isolation. The FWIVs provide for isolation of feedwater and support DHRS operation by providing isolation of DHRS from the CFWS. DCA Part 2, Tier 2, Section 10.4.7.3, states that GDC 4 was considered in the design and arrangement of the CFWS and that internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks do not prevent the CFWS from performing safety functions. It also states that isolation backup portions of the CFWS are protected from pipe whip and jet impingement forces resulting from breaks in nearby systems (including the CFWS of adjacent NPMs) by the piping design layout and that portions of the CFWS are physically separated from safety-related systems in the RXB and have no adverse impacts on safety functions. The FWRVs, feedwater supply check valves, FWRV accumulators, and feedwater regulating valve limit switches are located in the RXB, which provides protection from externally generated missiles.

The applicant addressed water hammer prevention in DCA Part 2, Tier 2, Section 10.4.7.3, by stating that the potential for water hammer in the CFWS is minimized by design features such as pipe slope, the use of available drains before startup, and adjustment of valve closure timing. The applicant also stated, in DCA Part 2, Tier 2, Section 3.6.3.1.4, that "The feedwater system (FWS) and steam generator (SG) contain design features and operating procedures that minimize the potential for and effect of water hammer," and in DCA Part 2, Section 13.5, "Plant Procedures," that "Administrative and operating procedures are utilized by the operating organization (plant staff) to ensure that routine operating, off-normal, and emergency activities are conducted in a safe manner."

The staff recognizes that, while the design aspect related to water hammer prevention is reviewed as part of the DCA Part 2 review, the procedures are in the scope of the COL application. Therefore, the site-specific items will be completed in the COL review. Based on the staff's review of the CFWS design as described in DCA Part 2, Tier 2, Section 10.4.7, the staff finds the NuScale CFWS design to be consistent with guidance in NUREG-0927, "Evaluation of Water Hammer Occurrence in Nuclear Power Plants," Revision 1, issued March 1984, and in compliance with GDC 4.

10.4.7.4.3 GDC 5, "Sharing of Structures, Systems, and Components"

The staff reviewed the design of the CFWS for compliance with the requirements of GDC 5 with respect to shared systems among NPMs. Compliance with GDC 5 requires that provisions be included in the nuclear power unit design to ensure an event with one NPM does not adversely impact the ability of the shared systems to perform their safety functions in other NPM units or their ability to safely achieve and maintain safe shutdown. The CFWS is not shared among NPMs; therefore, the failure of CFWS or components in the CFWS will not impair the ability of SSCs important to safety in other NPMs to perform their safety functions and, therefore, the requirement of GDC 5 for sharing of systems between units is satisfied.

10.4.7.4.4 GDC 44, "Cooling Water"

The staff reviewed the CFWS for compliance with the requirements of GDC 44, "Cooling Water," as related to the capability to transfer heat from SSCs important to safety to an ultimate heat sink. The DHRS performs this function for the NPM. The feedwater system does have a connection with the DHRS but does not have the safety function to transfer heat under accident conditions and, therefore, GDC 44 is not applicable to the CFWS. The description of the DHRS system is in DCA Part 2, Tier 2, Section 5.4.3, and the staff's evaluation of the DHRS system is in Section 5.4.4 of this report.

10.4.7.4.5 GDC 45, "Inspection of Cooling Water System," and GDC 46, "Testing of Cooling Water System"

The staff reviewed the CFWS design to ensure design provisions are provided for periodic inspections of components, as required by GDC 45, "Inspection of Cooling Water System," and periodic functional testing of the system and components, as required by GDC 46, Testing of Cooling Water System." Utilizing the enhanced safety-focus review approach, the staff's review focused on the SSCs that are functionally part of the CFWS that perform or support feedwater and containment isolation functions. The isolation functions are important to nuclear safety because CFWS isolation is required to establish and maintain the pressure boundary for the DHRS and thus preserve DHRS inventory and ensure proper operation of the safety-related DHRS.

Despite the fact that the feedwater system SSCs are relied on for feedwater system isolation, which is necessary for DHRS operation, the applicant concluded that GDC 45 and GDC 46 are not applicable to the CFWS because the applicant does not consider the CFWS a cooling system as described in GDC 44. The applicant's position is based, in part, on the applicant defining the boundaries of the feedwater system differently than the way it is defined in guidance (DSRS 10.4.7). In the NuScale DCA Part 2, the feedwater system SSCs relied on for feedwater system isolation, which is necessary for DHRS operation, were not included as part of the CFWS, thus leaving important-to-safety SSCs, generally covered in this system review, out of scope of the system. The staff position is that, because the SSCs that are functionally part of the CFWS are credited for isolating the CFWS and providing and maintaining the pressure boundary, the provisions for inspection and testing called for in GDC 45 and 46 are applicable.

The CFWS components that perform the isolation functions are the FWIV and the feedwater isolation check valves. These valves are considered CIVs and are discussed in Section 6.2 of DCA Part 2. The valves are described as being located such that there is sufficient access to allow for inservice inspection, 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors," type C testing, and maintenance and repair.

The applicant stated, in DCA Part 2, Section 10.4.7.4, that the CFWS is inspected and tested before plant operation and, because the CFWS is in use and the system parameters are monitored during normal plant operation, the satisfactory operation of the system components demonstrates system operability. In its review of the NuScale application, the staff found that the feedwater system components that were used to support containment isolation and feedwater isolation in support of DHRS operation were included in DCA Part 2 as part of the CNTS and that information on inspection and testing of those SSCs was contained in Chapters 6 and 3 of DCA Part 2.

The staff also confirmed that the CFWS SSCs were included as part of the inservice testing program in Chapter 3 of DCA Part 2. DCA Part 2, Table 3.9-16, identifies components that are subject to preservice and inservice testing plans. Among the valves that are included for the CNTS are the feedwater isolation and the feedwater check valves, and the identified function for the valves are feedwater isolation, containment isolation, and decay heat removal boundary. Since provisions are provided to permit periodic inservice inspection of the feedwater isolation and check valves, and they are included in the inservice test program, as indicated in DCA Part 2, Table 3.9-16, the staff finds that the NuScale design provides for periodic inspection and testing and therefore addresses the requirements of GDC 45 and 46.

10.4.7.4.6 Compliance with 10 CFR 20.1406, "Minimization of Contamination"

The regulations in 10 CFR 20.1406 require, in part, that each design certification applicant describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste. Primary-to-secondary leakage through the SG tubes has the potential to introduce radioactive material into the CFWS. The applicant stated, in DCA Part 2, Tier 2, Section 10.4.7.3, that the CFWS design satisfies the requirements of 10 CFR 20.1406, minimizing the contamination of the facility and the environment in accordance with RG 4.21.

The staff reviewed the design of the CFWS for compliance with the requirements of 10 CFR 20.1406. In DCA Part 2, Tier 2, Section 10.4.7.3, the applicant stated that main steam and condensate monitoring with MSS and CFWS isolation capabilities minimize the contamination and release to the environment and that the CFWS drains to the balance-of-plant drain system, which discharges to the radioactive waste drain system should the CFWS become contaminated. The staff found that the applicant has also addressed the CFWS design features for compliance with RG 4.21 in DCA Part 2, Tier 2, Table 12.3-18, "Regulatory Guide Features for Condensate and Feedwater System." The general review of NuScale compliance with RG 4.21 is included in Section 12.3 of this report.

Based on the above discussion, the staff concludes that the CFWS, as described in DCA Part 2, complies with 10 CFR 20.1406.

10.4.7.5 Initial Test Program

Preoperational tests related to the CFWS for design certification include the CWS tests (#28 and #31). These tests are performed in accordance with DCA Part 2, Tier 2, Tables 14.2-28 and 14.2-31. The staff evaluation of the initial test program for the design certification review is documented in Section 14.2 of this report.

10.4.7.6 Technical Specifications

The staff reviewed DCA Part 2, Tier 2, Chapter 16, TS 3.7.2, "Feedwater Isolation," for applicability to the CFWS. These TS provide limiting conditions for operation and surveillance requirements for the FWIVs and FWRV. The staff also reviewed the associated TS bases and found the description to be consistent with the DCA Part 2, Tier 2, description of the components.

The staff concludes that TS 3.7.2 appropriately addresses the limiting conditions for operation and surveillance requirements for the FWIVs and FWRVs. The staff evaluation of TS and associated bases is in Chapter 16 of this report.

10.4.7.7 Combined License Information Items

In accordance with DCA Part 2, Tier 2, Table 1.8-2 and Section 10.4.7, the applicant has not identified any COL information items that are directly applicable to the CFWS.

10.4.7.8 Conclusion

The staff finds the CFWS design acceptable because it meets applicable regulatory requirements, including GDC 2, regarding protection from natural phenomena; GDC 4, on protection against missiles and effects of pipe break; GDC 5, on shared systems; GDC 45, on inspections; GDC 46, on periodic testing; and 10 CFR 20.1406.

10.4.8 Steam Generator Blowdown System (PWR)

This system is not applicable to the NuScale design because it does not use a blowdown system.

10.4.9 Auxiliary Feedwater System

The staff reviewed DCA Part 2, Tier 2, Section 10.4.9, "Auxiliary Feedwater System." This section states the following:

> The NuScale Power Plant design neither requires nor uses an auxiliary feedwater system. Therefore, this section is not applicable to the NuScale design.
>
> The decay heat removal system (DHRS) (in Section 5.4.3 of DCA, Part 2, Tier 2) performs some functions similar to an auxiliary feedwater system. However, as compared to an auxiliary feedwater system, the DHRS differs substantially in its

design, operation, and relationship to the small break loss-of-coolant accident (LOCA) plant response.

The staff reviewed the NuScale design and confirmed the applicant's statement above.

In a typical U.S. PWR, the auxiliary feedwater system supplies emergency feedwater to the secondary side of the SG to remove core decay heat in the case of a loss of normal feedwater. In the NuScale design, if normal feedwater is lost or not available, the DHRS acts like an auxiliary feedwater system, removing residual decay heat from the reactor via the SG. Since NuScale uses the DHRS to perform the safety-related heat removal function typically performed by the auxiliary feedwater system in PWRs, the staff agrees with the applicant's determination that an auxiliary feedwater system is not required. The DHRS is reviewed in Section 5.4.3 of this report, and no further review is required for Section 10.4.9.

10.4.10 Auxiliary Boiler System

10.4.10.1 Introduction

The staff reviewed DCA Part 2, Tier 2, Section 10.4.10, "Auxiliary Boiler System." There is no specific SRP section applicable for the review of the ABS. However, the staff appropriately used similar regulatory requirements for similar systems in SRP Chapter 10, "Steam and Power Conversion System," such as the TGSS and CWS, among others, for this area of review. The ABS is designed to supply steam to systems where main steam is not available or not preferred. The applicant stated that up to 12 NPMs share one ABS, with one ABS system per plant.

10.4.10.2 Summary of Application

DCA Part 2, Tier 1: There are no entries in DCA Part 2, Tier 1, for the ABS.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 10.4.10, includes the ABS description, as well as relevant information on the ABS design, including the design bases, instrumentation, and the inspection and testing program. DCA Part 2, Tier 2, Section 11.5.2.2.14, "Auxiliary Boiler System," includes a description of the effluent radiation monitoring system for the ABS.

ITAAC: The applicant has not proposed any ITAAC related to the ABS system.

Initial Test Program: Preoperational tests related to the ABS being evaluated as part of the design certification review are described in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-9, 14.2-33, 14.2-70, and 14.2-97.

Technical Specifications: There are no proposed TS requirements associated with the ABS.

Technical Reports: There are no technical reports related to the ABS.

10.4.10.3 Regulatory Basis

There is no specific SRP applicable for the review of the ABS. Therefore, based on similar systems, the staff used the following relevant regulatory requirements for this area of review:

- GDC 2, as it relates to SSCs important to safety being designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods; this includes consideration of the failure of SSCs that are not safety related due to natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, which could adversely affect SSCs that are important to safety

- GDC 4, as it relates to SSCs important to safety that shall be appropriately protected against the dynamic effects of external missiles, internal missiles, pipe whip, and jet impingement forces associated with pipe break; this includes consideration of a failure of the ABS due to pipe break or malfunction that could adversely affect essential systems or components necessary for safe shutdown or accident prevention or mitigation

- GDC 5, with respect to shared systems among the NPMs

- GDC 60, as it relates to the ability of the auxiliary steam system design to control releases of radioactive materials to the environment

- GDC 64, as it relates to provisions being included in the nuclear power unit design for monitoring the effluent discharge paths and the plant environs for radioactivity that may be released from normal operations, including AOOs, and from postulated accidents

- 10 CFR 20.1406, as it relates to the design features that will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste

10.4.10.4 Technical Evaluation

The ABS is not safety related. The ABS is a nonseismic system designed to supply steam to systems where main steam is not available or not preferred. The ABS consists of two separate systems. The high-pressure system is dedicated to supplying steam to the module heatup system heat exchangers during startup and shutdown. The primary functions of the low-pressure system are to provide steam to the turbine gland seals, to the MC for deaeration, and to the condensate polishing resin regeneration system. The ABS is not credited for mitigation of a DBE and has no safe-shutdown functions.

10.4.10.4.1 GDC 2, "Design Basis for Protection against Natural Phenomena"

Compliance with the requirements of GDC 2 is based on the staff's determination that the ABS is designed to withstand the effects of postulated natural phenomena, including earthquakes, such that it would not result in the loss of the capability of SSCs important to safety to perform their safety functions. DCA Part 2, Tier 2, Section 10.4.10.3, "Safety Evaluation," states that the ABS serves no safety function, is not credited for mitigation of a DBA, and has no safe-shutdown functions. Therefore, acceptance of GDC 2 is based on the design codes and the guidance provided by Regulatory Position C.2 of RG 1.29, which specifies that failure of systems that are not safety related should not have an adverse effect on safety-related systems. In DCA Part 2, Tier 2, Section 10.4.10.2.1, "General Description," the applicant stated that "the ABS is designed to the requirements of Quality Group D and Seismic Category III." DCA Part 2, Tier 2, Section 10.4.10.3, states that "the portions of the ABS inside the RXB are designed to preclude adverse seismic interactions during and after a safe-shutdown earthquake consistent with Regulatory Guide 1.29." The staff also notes, as indicated in Note 5 in Table 3.2-1 of Revision 4 to DCA Part 2, Tier 2:

where SSC (or portion thereof) as determined in the as-built plant which are identified as seismic Category III in this table could, as the result of a seismic event, adversely affect seismic Category I SSC or result in incapacitating injury to occupants of the control room, they are categorized as seismic Category II consistent with Section 3.2.1.2 and analyzed as described in Section 3.7.3.8.

The staff evaluated the design of the ABS and agrees that the system performs no safety-related function. The portions of the ABS located in the TGB are not in the vicinity of safety-related SSCs; therefore, failure of these system portions would not impact safety-related systems. The portions of the ABS located in the RXB are designed such that failure of the portions would not adversely impact safety-related SSCs. Therefore, the staff finds that the ABS design meets the requirement of GDC 2.

10.4.10.4.2 GDC 4, "Environmental and Dynamic Effects Design Bases"

The staff also performed the review to verify that the system was protected against environmental and dynamic effects or that a failure of the ABS and the resulting discharging fluid (i.e., flooding) would not adversely affect SSCs important to safety per GDC 4. Compliance with the requirements of GDC 4 is based on the determination that failures of the ABS due to pipe break or malfunction would not adversely affect any of the plant's SSCs important to safety. In DCA Part 2, Tier 2, Section 10.4.10.3, the applicant stated that "a failure of the ABS that releases the water inventory and the resulting flooding does not prevent the operation of a safety-related SSC."

The ABS does not have a safety function, and therefore its failure does not prevent the operation of SSCs important to safety from performing their safety functions. The staff's detailed evaluation of flooding prevention can be found in Section 3.4 of this SER. The staff evaluation of the effect of high- and moderate-energy line breaks are discussed in Section 3.6 of this report. Therefore, based on its conclusions documented in Sections 3.4 and 3.6 of this SER, the staff finds that the design of the ABS meets the requirements of GDC 4.

10.4.10.4.3 GDC 5, "Sharing of Structures, Systems, and Components"

Since the ABS serves all NPMs, the staff also reviewed the design of the ABS for compliance with the requirements of GDC 5 with respect to shared systems. Compliance with GDC 5 requires that provisions be included in the nuclear power unit design to ensure an event with one NPM does not significantly impair the ability of important-to-safety SSCs in any other NPM units to perform their safety functions, including the ability to safely achieve and maintain safe shutdown. The applicant stated in DCA Part 2, Tier 2, Section 10.4.10.3, that "there are no safety-related components in the ABS that are shared among NPMs; therefore, failure of the ABS does not significantly impair the ability of other NPMs to perform their safety functions."

The staff evaluated the design of the ABS and, as discussed in the previous section, failure of this system would not significantly impair the ability of SSCs important to safety from performing their safety function. Therefore, the staff finds that the ABS design meets the requirements of GDC 5.

10.4.10.4.4 GDC 60, "Control of Releases of Radioactive Materials to the Environment," and GDC 64, "Monitoring Radioactivity Releases"

The staff also reviewed the design of the ABS for compliance with the requirements of GDC 60 and GDC 64 with respect to control and monitoring of radioactive releases. Compliance with GDC 60 and GDC 64 requires provisions be included in the nuclear power unit design to monitor and control suitably the release of radioactive materials during normal operation, including AOOs and postulated accidents. Meeting these requirements provides a level of assurance that the release of radioactive materials in gaseous and liquid effluents from the ABS during normal operation, including AOOs and postulated accidents, is kept as low as is reasonably achievable, in accordance with 10 CFR Part 50, Appendix I. The ABS, normally a nonradioactive system, provides steam to the module heatup system that contains radioactive liquid. Therefore, the ABS may potentially contain radioactive effluents.

The ABS description in DCA Part 2, Tier 2, Section 10.4.10.3, and Section 11.5.2.2.14, indicates that the ABS includes a number of process radiation monitors throughout the system that monitor, identify, and notify the presence of high-radiation conditions in the ABS. Upon detecting high-radiation conditions, the system initiates a main control room alarm notifying the operators. If radiation is detected in the ABS that is greater than the high-high radiation isolation or if system power is lost, the ABS flash tank pressure regulating valve and the steam supply valves from both boilers isolate.

The staff finds that these features provide adequate monitoring and control of radioactive materials in gaseous and liquid effluents from the ABS, and therefore, the ABS meets the requirements of GDC 60 and 64.

10.4.10.4.5 10 CFR 20.1406, "Minimization of Contamination"

The staff also reviewed the design of the ABS for compliance with the requirements of 10 CFR 20.1406 with respect to minimizing contamination of the facility and the environment. The applicant stated, in DCA Part 2, Tier 2, Section 10.4.10.3, that radiation monitoring of the steam and the condensate return from the module heatup system heat exchangers with chemical and volume control system isolation capabilities minimizes the contamination and release to the environment, should the ABS become contaminated. The staff also found that the ABS includes design features that address the provisions of RG 4.21, as described in DCA Part 2, Tier 2, Table 12.3-14, "Regulatory Guide 4.21 Features for Auxiliary Boiler System." The general review of NuScale conformance with RG 4.21 is provided in Section 12.3 of this report.

Based on the above discussion, the staff concludes that the ABS design complies with 10 CFR 20.1406.

10.4.10.5 Initial Test Program

Preoperational tests related to the ABS for design certification include the ABS test (#9), TGS test (#33), hot functional test (#70), and thermal expansion test (#97), which ensure the various design aspects related to the ABS are implemented. These tests are performed in accordance with DCA Part 2, Tier 2, Tables 14.2-9, 14.2-33, 14.2-70, and 14.2-97. The staff evaluation of the initial test program is documented in Section 14.2 of this report.

10.4.10.6 Technical Specifications

There are no TS requirements associated with the ABS. The system is not safety related, is not required for safe shutdown, and does not meet a criterion in 10 CFR 50.36; therefore, the staff finds this acceptable.

10.4.10.7 Combined License Information Items

Table 10.4.10-1 lists the COL information item number and description related to the ABS. The COL item addresses site-specific features associated with the ABS. The staff finds COL Item 20.4-2 acceptable because it is appropriate to develop this information as part of a site-specific application.

Table 10.4.10-1 NuScale Combined License Information Items for DCA Part 2, Tier 2, Section 10.4.10

Item No.	Description	DCA, Part 2, Tier 2 Section
COL Item 10.4-2	A COL applicant that references the NuScale Power Plant design certification will describe the type of fuel supply for the auxiliary boilers.	10.4.10.2.1

10.4.10.8 Conclusion

Based on the review of the information that is provided and as discussed above in the technical evaluation section, the staff determined that the applicant has met the requirements as stated in Section 10.4.10.3, "Regulatory Basis," of this SER.

10.4.11 Feedwater Treatment System

10.4.11.1 Introduction

The purpose of the feedwater treatment system (FWTS) is to maintain secondary water quality in conjunction with the CPS by providing chemical addition and feedwater sampling. This is to control erosion and corrosion by monitoring and maintaining feedwater pH and DO levels.

10.4.11.2 Summary of Application

DCA Part 2, Tier 1: No Tier 1 information is provided in NuScale DCA Part 2, for this system.

DCA Part 2, Tier 2: The applicant provided a design description in DCA Part 2, Tier 2, Section 10.4.11, "Feedwater Treatment System," which is summarized here, in part:

> The FWTS is part of the CFWS [Condensate and Feedwater System] described in Section 10.4.7 and is designed to control erosion and corrosion of CFWS components by monitoring and maintaining feedwater pH and dissolved oxygen levels during plant modes except NPM [NuScale Power Module] transport.
>
> Two chemical injection points are provided downstream of the CFWS condensate pumps. The FWTS includes separate equipment for pH control and

oxygen scavenger injection. The equipment includes tanks, valves, piping, pumps, and instrumentation for each chemical addition.

The FWTS will have equipment for injecting chemicals to control feedwater potential hydrogen (pH) that is separate from the equipment to control DO levels.

DCA Part 2, Tier 2, Table 10.4-22, "Feedwater Treatment System Operating Parameters," also states that ammonia will be used for pH control, and that hydrazine will be added to scavenge DO.

ITAAC: There are no ITAAC specific to the FWTS.

Initial Test Program: "Feedwater Treatment System Test #29," and "Primary and Secondary System Chemistry Test #79," in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-29 and 14.2-79, related to this system are evaluated in Section 14.2 of this report.

Technical Specifications: There are no TS associated with DCA Part 2, Tier 2, Section 10.4.11.

10.4.11.3   Regulatory Bases

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are summarized below:

- GDC 14 requires that the RCPB be designed, fabricated, erected, and tested to ensure an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture.

10.4.11.4   Technical Evaluation

10.4.11.4.1   Chemical Injection Capability

The purpose of the FWTS is to help treat and clean feedwater by providing chemical addition and feedwater sampling. This is done to maintain feedwater pH and DO content.

The staff reviewed the information provided in DCA Part 2, Tier 2, Section 10.4.11, in conjunction with the information provided in DCA Part 2, Tier 2, Sections 10.3.5 and 10.4.6, against the requirements of GDC 14. GDC 14 is applicable to the FWTS since the system is designed to help maintain secondary water quality via chemical injection, which in turn helps to avoid erosion/corrosion-induced failure of the RCPB, specifically the SG tubing. The FWTS was reviewed in conjunction with the secondary water chemistry and CPS sections of DCA Part 2, because these systems and programs work together to maintain secondary water quality and to help prevent corrosion-induced failure of the RCPB.

The review for DCA Part 2, Tier 2, Section 10.4.11, focused on the ability of the FWTS to provide the appropriate chemical injection that allows for the control of certain secondary water chemistry parameters. DCA Part 2, Tier 2, Sections 10.3.5, and 10.4.6, describe how maintaining acceptable secondary water chemistry will demonstrate compliance with GDC 14 with respect to corrosion-induced failure of the RCPB.

The FWTS provides control of secondary water chemistry to limit erosion and corrosion of components in the CFWS. This is accomplished through monitoring and maintaining feedwater pH and DO levels. The FWTS controls feedwater pH and DO levels via chemical injection downstream of the CFWS condensate pumps. Hydrazine will be injected to control DO, and ammonia will be injected for pH control. As described in COL Item 10.4-3, a COL applicant that references the NuScale design will provide an analysis that shows the chemical injection equipment is able to satisfy the requirements of the secondary water chemistry program described in DCA Part 2, Tier 2, Section 10.3.5, and that the equipment is compatible with the chemicals used for feedwater injection. The FWTS also interfaces with the process sampling system, as described in DCA Part 2, Tier 2, Section 9.3.2, which monitors feedwater quality. If feedwater quality is outside of the specified secondary water chemistry parameters, the FWTS can provide chemical injections to control secondary water chemistry.

The FWTS is designed to have tanks, pumps, valves, piping, and instrumentation capable of injecting the appropriate agents to control feedwater pH and DO levels. The tanks will be constructed of erosion/corrosion-resistant materials. The FWTS will be designed to ensure that the size, materials, and capacity of the FWTS satisfy the water quality requirements of the secondary water chemistry program described in DCA Part 2, Tier 2, Section 10.3.5, and that it is compatible with the chemicals used, as described in COL Item 10.4-3. In addition, the FWTS includes flow control valves, flow elements, and transmitters to control the addition of chemical injection. The FWTS also includes an oxygen analyzer for the feedwater header.

The use of the FWTS to control feedwater pH and DO levels supports the ability of the secondary water chemistry program to maintain appropriate chemistry and reduce the likelihood of corrosion-induced failure of the RCPB. Control of the feedwater pH and DO levels is appropriate to help reduce corrosion in secondary systems, as well as for erosion/corrosion of the secondary systems. In addition, the FWTS contains the appropriate equipment, including the equipment described in COL Item 10.4-3, to meet chemical injection requirements. Therefore, the staff has determined that the FWTS assists the CPS in implementing the secondary water chemistry program and meeting the requirements of GDC 14. The full evaluations for the CPS and secondary water chemistry program are located in the SER evaluations for Sections 10.4.6, and 10.3.5, respectively.

10.4.11.5 Initial Test Program

Preoperational tests “Feedwater Treatment System Test #29,” and “Primary and Secondary System Chemistry Test #79,” in DCA Part 2, Tier 2, Section 14.2, Tables 14.2-29 and 14.2-79, respectively, which are related to the FWTS, are evaluated in Section 14.2 of this report.

10.4.11.6 Inspections, Tests, Analyses, and Acceptance Criteria

There are no ITAAC for this system.

10.4.11.7 Technical Specifications

There are no TS associated with DCA Part 2, Tier 2, Section 10.4.11. The system does not meet the criteria in 10 CFR 50.36 that would require a TS; therefore, the staff finds this acceptable.

10.4.11.8 Combined License Information Items

Table 10.4.11-1 NuScale Combined License Information Items for DCA Part 2, Tier 2, Section 10.4.11

Item No.	Description	DCA, Part 2, Tier 2 Section
COL Item 10.4-3	A COL applicant that references the NuScale Power Plant design certification will provide a secondary water chemistry analysis. This analysis will show that the size, materials, and capacity of the feedwater treatment system equipment and components satisfies the water quality requirements of the secondary water chemistry program described in Section 10.3.5, and that it is compatible with the chemicals used.	10.4.11.2.2

The applicant proposed one COL item as described in the table above. The COL item describes site-specific features of the FWTS and how it satisfies parts of the plant secondary water chemistry control program.

10.4.11.9 Conclusion

Based on its review of the FWTS, the staff has determined that the FWTS is able to support the CPS and the secondary water chemistry program to maintain acceptable secondary water quality. Based upon the staff review of the applicant's proposed design criteria and bases for the FWTS and the criteria for operation of the system, the staff concludes that the design of the system is acceptable and meets the applicable requirements of Section 10.4.11.3, "Regulatory Bases," of this SER. Additional details of the FWTS will be provided by the COL applicant as stated in COL Item 10.4-3 regarding the sizing, materials, and capacity of the FWTS.