10 STEAM AND POWER CONVERSION SYSTEM

This chapter of the safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review of Chapter 10, "Steam and Power Conversion System," of the NuScale Power, LLC (the applicant), US460 Standard Design Approval Application (SDAA), Part 2, "Final Safety Analysis Report (FSAR)." The staff's regulatory findings documented in this report are based on Revision 1 of the SDAA, dated October 31, 2023 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23306A033). In the SDAA, the applicant used the English system of measure to provide the precise parameter values. 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 SDAA and not converted.

The steam and power conversion system removes thermal energy from the reactor coolant system and transfers it to the main 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, air-cooled condenser, condensate polishing, feedwater treatment, condensate and feedwater, and auxiliary boiler systems. In general, the steam and power conversion systems are not safety related and are not required for safe shutdown. However, the main steam and main feedwater system 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 adversely impact 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 primary review of the power conversion systems 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, as indicated above, the staff also recognizes that the failure of some portion of the power conversion system may have the potential to adversely impact SSCs that are important to safety. Since the 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 non-safety-related, non-risk-significant systems will not adversely affect the plant's ability to achieve and maintain safe shutdown or result in excessive releases of radioactivity to the environment.

In addition, although applicants for standard design approvals (SDA) 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 SDA applicants have previously submitted initial test program plans to assist a future combined license (COL) applicant referencing the SDA 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 SDAA review and reviewed in FSAR Section 14.2, "Initial Plant Test Program."

10.1 Summary Description

FSAR Section 10.1, “Summary Description,” contains an introductory account of the steam and power conversion system and summarizes the protective features incorporated in its design. FSAR Figure 10.1-1, “Power Conversion System Block Flow Diagram,” provides a high-level flow diagram of the system. FSAR Figure 10.1-2, “Heat Balance Diagram, shows the steam/condensate flow stream for the power conversion system. FSAR table 10.1.-1 and 10.1-2, provides representative values for the pressure, temperature, enthalpy, and flow at various point of the power conversion system. FSAR table 10.3-1 shows some of the major power and conversion system operating parameters at rated thermal power. These parameters, along with the secondary -side heat balance diagram, provide the basis for the power conversion system design.

FSAR sections 10.2 through 10.4.9 describe the main elements of the steam and power conversion system. Sections 10.2 through 10.4.9 of this SER document the staff’s review.

10.2 Turbine Generator

10.2.1 Introduction

The NuScale power plant comprises up to six individual NuScale power modules (NPMs), each of which has its own turbine generator and its own turbine control system.

The turbine generator system (TGS) is not safety related. 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 with the potential to adversely affect SSCs that are important to safety.

10.2.2 Summary of Application

FSAR Section 10.2, “Turbine Generator,” describes the TGS. The information provided includes the TGS design bases, system descriptions, component descriptions, and TGS control and protection systems. FSAR Section 14.2, Initial Plant Test Program, contains information on TGS initial testing (Test # 29, “Turbine Generator System”). There are no proposed inspections, tests, analyses, and acceptance criteria (ITAAC) or specific technical specification (TS) requirements 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,” requires, in part, 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.

The NRC staff's review of the TGS review interfaces with the review of certain other matters addressed in other SRP sections, identified in Section 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 of the TGS focused on how the system design would preclude TGS failure from adversely affecting SSCs important to safety and 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 on the information in the applicant's SDAA. A general description of the TGS is provided in SDAA Part 2, Section 10.2.2, "System Description," as well as in FSAR Figure 10.2-1, "Turbine Generator System Schematic," and TGS design parameters appear in FSAR Table 10.2-1, "Turbine Generator Design Details." The staff followed the guidance in SRP Section 10.2 in its review of the TGS.

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 of this safety evaluation, 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 that 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 Section 3.5.1.3, "Turbine Missiles," and Section 3.5.2, "Structures, Systems, and Components to be Protected from External Missiles," of the NuScale FSAR to determine if 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. FSAR section 3.5.2 states 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 the FSAR, Section 3.5.1.3 and Section 3.5.1.4, "Missiles Generated by Tornadoes and Extreme Winds" which includes turbine missiles.

As indicated in FSAR 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 depend on minimizing turbine missile generation probability and the overspeed protection system to prevent destructive overspeed conditions, review of the overspeed protection system as it relates to ensuring compliance with GDC 4 is not necessary. Section 3.5.1.3 of this SER includes the staff's review of compliance with GDC 4 as it relates to turbine missiles.

Based on the information provided in FSAR Sections 10.2, 3.5.1.3, and 3.5.2, the staff finds that the NuScale design complies 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. Section 3.5.1.3 of this SER includes the staff's review of compliance with GDC 4 as it relates to turbine missiles.

10.2.5 Initial Test Program

The preoperational test related to the TGS is TGS Test # 29, which ensures that the various design aspects related to the TGS are implemented. The test is performed in accordance with FSAR Table 14.2-29, "Test # 29 Turbine Generator System". Section 14.2 of this SER documents the staff's evaluation of the initial test program for the NuScale SDAA.

10.2.6 Conclusion

Based on its review and as discussed above in the technical evaluation section, the staff concludes that the applicant has met the requirements of GDC 4 for FSAR 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), Section 10.3, "Main Steam Supply System," Revision 0, issued June 2016 (ML15355A322). For the purposes of this review, the staff considers the MSS to extend from the outlet of the reactor pressure vessel steam plenum (on the secondary side of the SGs) up to and including the turbine stop valves. Such a system includes the containment isolation valves, connected piping that is 6.4 centimeters (2.5 inches) in nominal diameter or larger, and the steamline to the decay heat removal system (DHRS) up to the DHRS actuation valves.

10.3.1.2 Summary of Application

FSAR Section 10.3, "Main Steam System," contains the MSS design basis and system and component descriptions, as well as system operation, inspections, and testing information. The portion of the MSS located inside containment is described in FSAR Section 5.4, "Reactor Coolant System Component and Subsystem Design," and FSAR Section 6.2, "Containment Systems," discusses MSS SSCs associated with containment isolation.

There is no proposed system ITAAC for the MSS. However, in SDAA Part 8, "License Conditions; Inspections, Tests, Analyses & Acceptance Criteria (ITAAC)," the applicant proposes ITAAC for the MSIVs, secondary MSIVs, and secondary MSIBVs. Section 14.3.7 of this SER evaluates these ITAAC.

FSAR section 14.2 (Test # 24, "Main Steam System") provides information on MSS initial testing. Specific TS requirements associated with the MSS are provided in FSAR Chapter 16, "Technical Specifications," Revision 0, and SDAA Part 4, "US460 Generic Technical Specifications," Volumes 1 and 2, Revision 0.

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 section 10.3 and are summarized below. Review interfaces with other SRP sections also can be found in Item I, "Review Interfaces," of DSRS section 10.3.

- 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, "Environmental and dynamic effects design bases," 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 shall 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 power," 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.

- GDC 34, "Residual heat removal," requires that a system to remove residual heat be provided.

- 10 CFR 20.1406, "Minimization of contamination," as it relates to the design features that will facilitate eventual decommissioning, requires that SDA applicants describe how facility design 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.

10.3.1.4 Technical Evaluation

The staff reviewed the MSS design, described in FSAR section 10.3, in accordance with guidance in DSRS section 10.3, to evaluate whether the design complies with the regulatory requirements listed in section 10.3.1.3 of this SER.

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. FSAR figure 10.1-1 provides a flow diagram of the system, and FSAR Table 10.3-4, "Classification of Structures, Systems, and Components," presents information on the location, safety and system classifications, and any augmented design requirement for MSS components.

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 condensate collection tank, 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 reactor pressure vessel and 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. As specified in SDAA section 10.3.2, the MSS piping is protected from overpressure by Main Steam Safety Valves. Overpressure protection is discussed in SDAA section 5.2.2 and reviewed in the corresponding section of this SER.

An evaluation of the MSS abnormal and anticipated operational occurrences is described in FSAR Chapter 15, “Transient and Accident Analysis”, where the NuScale responses to postulated accidents are considered, including an evaluation of a main steamline break, feedwater line break, and SG tube rupture. Chapter 15 of this SER provides the staff’s evaluation of the transient and accident analyses for the MSS.

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

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

The staff reviewed the MSS to evaluate whether the design complies with the requirements of GDC 2, with respect to its design for protection against the effect of natural phenomena such as earthquakes, tornados, and hurricanes. Protection against internal flooding is evaluated in Section 3.4.1 of this SER. 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 for Nuclear Power Plants,” Revision 6, issued July 2021, 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 FSAR 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.

FSAR figure 10.1-1 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 10.1-1), is classified as seismic 1 and located inside the RXB. FSAR Section 10.3.3 states that the portions of the MSS downstream of the MSIVs to the secondary MSIVs are designed to remain functional during and after a safe-shutdown earthquake and meet the guidelines of RG 1.29. It also states that the RXB is designed as an engineered barrier to withstand a postulated design -basis missile as discussed in Section 3.7. This design satisfies the criteria of GDC 2 by the proper design and use of missile barriers to protect essential SSCs against potential missiles generated by tornado or hurricane winds.

NuScale DSRS section 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 FSAR section 6.2, figure 10.1-1, and table 10.3-4 and confirmed that SSCs important to safety, including the main steam isolation and backup main steam valves and the spool piece from which the system is disconnected during refueling, are located in the RXB. In FSAR Section 6.2.4.2.1, “General Description”, the MSIVs, the main steam backup isolation valves, and the feedwater isolation valves are classified as single secondary system containment isolation valves and as seismic Category I, Quality Group B, components capable of remote operation from the control room, as described in SDAA section 6.2.4.2.2.3. The secondary MSIV and the main steam backup isolation valves are also seismic Category I components as indicated in FSAR Table 10.4-4, “Classification of Structures, Systems, and Components”.

Based on its review, the staff finds that the MSS design complies with GDC 2, because the RXB is designed to protect essential SSCs against potential missiles generated by tornado or hurricane winds, and the essential portions of the MSS are designed to seismic Category I requirements, in accordance with the guidance of NuScale DSRS section 10.3.

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

The staff reviewed the MSS to evaluate whether the design complies with the requirements of GDC 4, as related to adverse environmental phenomena and dynamic effects associated with possible fluid flow instabilities, including steam hammer and effects of pipe breaks. Compliance with the requirements of GDC 4 is based on the important-to-safety SSCs being adequately protected from environmental phenomena or the dynamic effects that may result from such phenomena, including water and steam hammer, pipe whip, and jet impingement.

The staff reviewed the NuScale design to evaluate whether the functions important to safety will be maintained in the event of adverse environmental phenomena and dynamic effects. FSAR 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.

Further, regarding the GDC 4 requirements, the staff reviewed the applicant’s consideration of steam and water hammer effects on the MSS. FSAR section 10.3.3 states that the design uses drain pots, line sloping, and drain valves to minimize the effects of dynamic loads and water hammer. These design features are consistent with those identified in NUREG-0927, “Evaluation of Water Hammer Occurrence in Nuclear Power Plants,” Revision 1, issued March 1984, as being effective in minimizing the frequency and severity of water and steam hammer occurrences. Therefore, the staff finds that the MSS SSCs important to safety are adequately protected from adverse environmental phenomena and dynamic effects associated with possible fluid flow instabilities.

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 SGs and 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"

FSAR 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. NuScale adopted certain principal design criteria (PDC) including PDC 34, which states:

> 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 [RCPB] 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.

Sections 5.4 and 8.3 of this SER contain the staff's evaluation of the design's compliance with PDC 34.

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 required by 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 if an MSIV fails to close and provide additional assurance that the blowdown of a second SG is limited if a steamline breaks upstream of the MSIV. As discussed above in section 10.3.1.4 of this SE, the staff found 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 (ML13267A423).

Based on its review as discussed 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 reactor coolant system, 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 that the requirements of 10 CFR 50.63 are met. Section 8.4 of this SER further documents the staff evaluation of the SBO event.

10.3.1.4.6 10 CFR 20.1406, "Minimization of Contamination"

The regulation in 10 CFR 20.1406 requires, in part, that each standard design approval 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 MSS is not normally a significant 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. FSAR Table 12.3-26, "Regulatory Guide 4.21 Design Features for Main Steam System," lists the design features specific to the MSS for the minimization of contamination. Examples of these features include 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 (BPDS). 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 FSAR section 10.3 and Section 12.3, "Radiation Protection Design Features," as they relate to prevention and minimization of contamination. Because the NuScale FSAR 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 the FSAR conforms to 10 CFR 20.1406.

10.3.1.4.7 Additional Design Aspects Reviewed

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. The TS includes surveillances for operability and inservice testing of the secondary MSIVs. 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. Therefore, the staff finds this acceptable. Section 5.4 of this SER contains the staff's evaluation of the DHRS.

DSRS section 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 FSAR Section 6.2.4.3, "Design Evaluation," that all Containment Isolation Valves (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 and safety analysis calculations and represent the maximum steam flow conditions for the flowpath. FSAR 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. FSAR Section 10.3.2.1.2, "Secondary Main Steam Isolation Valves," states that the secondary MSIVs are capable of closing in steam conditions. Based on this information, the staff concludes that the MSIVs and the secondary MSIVs are capable of closing against maximum expected steam flow conditions.

10.3.1.5 Initial Test Program

The preoperational test related to the MSS is the TGS test # 24, which tests design functions of the TGS. The test is performed by the COL holder in accordance with FSAR Table 14.2–24, “Test # 24 Main Steam System.” Section 14.2 of this SER documents the staff’s evaluation of the initial test program for the standard design approval review.

Safety-related active components in the MSS are designed to be tested during plant operation. FSAR Section 6.2.1.1.2, “Design Features,” states that the CNTS components (which include the MSIVs and MSIBVs) are designed to meet the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI inspection requirements for Class 1, Class 2, and Class 3 main condensers (MCs), including the preservice inspection requirements. FSAR Section 10.3.4, “Inspections and Tests,” states that the portion of the main steamlines that are not safety related are inspected and tested in accordance with the requirements of ASME B31.1, “Power Piping.” FSAR 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,” describe periodic inservice inspection and inservice testing of ASME Section III, Class 2 and 3, components.

10.3.1.6 Conclusion

Based on its review as discussed 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 of this SER.

10.3.2 Steam and Feedwater System Materials

10.3.2.1 Introduction

To minimize flow-accelerated corrosion (FAC), the NuScale FSAR provides the design and fabrication codes, water chemistry and the compatibility of materials with the environment for portions of the power conversion system. These portions of the power conversion system include portions of the MSS and FWS that are not safety related, and consist of the TGS, including the turbine bypass system and the turbine gland sealing system, the MSS, including extraction steam, the condensate and feedwater system (FWS), including the condensate polisher skid and resin regeneration system(CPS), and the ABS.

10.3.2.2 Summary of Application

The materials used to minimize FAC described in FSAR Section 10.3.6, “Steam and Feedwater System Materials,” are for the portions of the MSS and CFWS that are not safety related, which include the following:

- The portions of the MSS that are not safety related, as described in FSAR section 10.3, and extend from the flange immediately downstream of the safety-related MSIVs to the inlet of the turbine generator vendor package.

- The portions of the CFWS that are not safety related as described in FSAR Section 10.4.6, “Condensate and Feedwater System,” and extend from the entrance of the MC (section 10.4.1, “Air-Cooled Condensers”) to the flange immediately upstream of the SG FWIVs. The CPS is another associated subsystem in the portions of the CFWS that are not safety related (section 10.4.5, “Condensate Polisher Skid and Resin Regeneration System”).

- The TGS (which is entirely not safety related) as described in FSAR, section 10.2. Other associated subsystems that are part of the TGS are the turbine gland sealing system (TGSS) (FSAR section 10.4.3) and turbine bypass system (TBS) (FSAR section 10.4.4).

- The ABS (which is entirely not safety related) as described in FSAR Section 10.4.7, “Auxiliary Boiler System.”

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 and constructed to ASME B31.1.

The materials are generally selected to minimize the impact of FAC. Erosion and corrosion are also minimized by the use 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 protects the safety-related steam generator system (SGS) and DHRS from contamination originating in the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related.

The piping design and layout considerations of the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related will meet the guidance in Generic Letter (GL) 89-08, “Erosion/Corrosion-Induced Pipe Wall Thinning,” dated May 2, 1989, 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). The staff notes that historically, documents such as GL 89-08 have referred to FAC as “erosion/corrosion.” Therefore, the terms FAC and erosion/corrosion are used interchangeably throughout this section of the SER.

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.

There are no proposed ITAAC, and no specific TS requirements associated with the main steam and feedwater materials.

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 can fulfill 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, “Erosion/Corrosion-Induced Pipe Wall Thinning”
- EPRI NSAC-202L, “ Recommendations for an Effective Program Against Erosive Attack,” Revision 4

10.3.2.4 Technical Evaluation

10.3.2.4.1 System Design and Code of Construction

The NRC staff considered the system design and code of construction, the materials selection and fabrication, water chemistry and the FAC program for the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related.

SRP section 10.3.6 is based on the use of ASME Code, Section III, Class 2 and Class 3 components. However, the portions of the NuScale 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 Group D components. ASME B31.1 provides requirements for piping design, construction (including welding procedure qualifications, welder qualifications, fabrication methods, welding preheat, and interpass temperatures) and examination. Section 3.2 of this SER presents the staff’s review of the adequacy of system classifications. 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 is acceptable for the design of the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related.

The staff also reviewed SRP section 10.3.6 related to the requirement of 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, CFWS, TGS, ABS, and their associated subsystems that are reviewed in this section of the SER are not safety related, the staff finds the standard toughness requirements in ASME B31.1 to be acceptable and that additional fracture toughness requirements are not required, considering that the systems are not safety related.

NuScale stated that the piping design and layout considerations of the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related will meet the guidance in GL 89-08 and EPRI NSAC-202L to minimize erosion/corrosion (including FAC). EPRI NSAC-202L provides guidance on design changes to minimize the rate of FAC damage to the piping systems. Since NuScale will use past operating experience and guidance to mitigate FAC using GL 89-08 and NSAC-202L, the staff finds that the design provides reasonable assurance that FAC will be minimized to ensure that the piping systems will perform their functions.

10.3.2.4.2 Material Selection and Water Chemistry

For effective control of FAC, several key areas of information are needed, including design, water chemistry, and materials. 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 chromium-molybdenum (Cr-Mo) steel, or stainless steel, consistent with the guidance in EPRI NSAC-202L. Cr-Mo steels and stainless steels have an 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 as FAC-resistant alloys. The staff finds the material for these systems to be acceptable because Cr-Mo steel or stainless will be used, which has acceptable resistance to FAC and is consistent with EPRI NSAC-202L. In addition to the materials (Cr-Mo steel or stainless steels) specified for these systems, FAC can be controlled by predicting FAC rates in accordance with EPRI NSAC-202L to ensure that these piping systems will be able to perform their functions. Therefore, the staff finds that the portions of the MSS, CFWS, TGS, ABS, and their associated subsystems that are not safety related will be constructed with Cr-Mo steels or stainless steels, which are FAC-resistant materials and therefore are acceptable and will meet 10 CFR 50.65 provisions related to accounting for material selection and fabrication using industrywide operating experience.

The staff reviewed the guidance in SRP section 10.3.6 related to cleaning and handling of safety-related materials in RG 1.28, “Quality Assurance Program Criteria (Design and Construction).” Since the portions of the MSS, CFWS, TGS, 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 affect the safety-related portions of the DHRS, CNTS, and SGS. Therefore, to mitigate any potential impact on the safety-related portions of the DHRS, CNTS, and SGS, the NuScale design includes a Secondary Water Chemistry Control Program, and the use of appropriate material for the DHRS, CNTS, and SGS provides protection to these safety-related systems. The staff reviewed the Secondary Water Chemistry Control Program and safety-related materials in sections 10.4.5 and 6.1.1 of this SER, respectively.

10.3.2.4.3 Flow-Accelerated Corrosion

SRP section 10.3.6, Item III.3, states that EPRI NSAC-202L provides acceptable methods to minimize FAC. The use of EPRI NSAC-202L is also acceptable because that document is 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 to reduce FAC. EPRI NSAC-202L provides guidance for nuclear power plants to implement an effective program to detect and mitigate FAC. This includes the identification of recommended FAC program tasks with key steps of identifying and ranking susceptible systems, performing FAC predictive analysis, selecting and scheduling components for inspection, performing inspections, evaluating inspection data, assessing worn components, and repairing or replacing components. In addition, GL 89-08 requires that a long-term FAC program be in place using a demonstrated analysis method, such as EPRI NSAC-202L. Therefore, the staff finds meeting the guidance in GL 89-08 and EPRI NSAC-202L for minimizing the occurrence of FAC acceptable, and the 10 CFR 50.65 provisions related to accounting for FAC industrywide operating experience are satisfied.

FSAR Section 10.3.6.3, "Flow-Accelerated Corrosion," includes COL Item 10.3-2 which makes a COL applicant responsible for developing the site-specific Flow-Accelerated Corrosion Monitoring Program based on GL 89-08 and the latest revision of EPRI NSAC-202L at the time of the application. Conforming FAC programs established throughout the domestic nuclear fleet allow licensees to identify, monitor, and mitigate FAC-related damage in advance of piping failure. The staff finds 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.

10.3.2.5 Inspections, Tests, Analyses, and Acceptance Criteria

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, 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 are evaluated in the related system sections in this chapter of the SER. Therefore, the staff finds the lack of TS requirements associated with the materials for these systems that are not safety-related is acceptable, in accordance with 10 CFR 50.36, "Technical specifications."

10.3.2.7 Conclusion

Based on its review of the steam and feedwater materials, the staff concludes that 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 are acceptable and meet appropriate regulatory requirements as identified in section 10.3.2.3 of this SER.

10.4 Other Features of Steam and Power Conversion System

10.4.1 Air-Cooled Condensers

10.4.1.1 Introduction

Each NPM has an air-cooled condenser in which turbine exhaust steam is directly condensed by the air and the condensate is returned to the SG as feedwater through the condensate and feedwater system (FWS). The Air Cooled Condenser System (ACCS), also referred to as the main condenser, is made up of the air-cooled condensers and its subsystem, i.e., the condenser air removal system (CARS). Each NPM has a condenser that provides adequate capacity for the FWS.

10.4.1.2 Summary of Application

FSAR section 10.4.1 contains the ACCS design basis, system, and component descriptions, as well as information on system operation, inspections, and testing. FSAR Figure 10.4-1, "Air Cooled Condenser System Piping and Instrumentation Drawing," provides a graphical representation of the ACCS. The ACCS receives steam from the MSS through the turbine exhaust piping and delivers condensate to the FWS through the condensate collection tank. FSAR figure 10.1-1 shows the general connections and interfaces with these systems. The ACCS operates under a vacuum maintained by the CARS, which is described in FSAR Section 10.4.2, "Condenser Air Removal System." CARS radiation monitoring instrumentation provided at the discharge of CARS monitors the radiation releases from the ACCS.

FSAR section 14.2 (Test # 07, "Air Cooled Condenser System") provides information on the ACCS initial testing. No proposed ITAAC and no specific TS requirements are associated with the ACCS.

10.4.1.3 Regulatory Basis

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

- GDC 4, requires, in part, 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 60, "Control of releases of radioactive materials to the environment," requires, in part, that provisions be 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," requires, in part, that provisions be included for monitoring 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, requires, in part, that 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.

10.4.1.4 Technical Evaluation

The staff reviewed the ACCS design, described in FSAR section 10.4.1, in accordance with guidance in SRP section 10.4.1, to evaluate compliance with the regulatory requirements listed in section 10.4.1.3 of this SER. Because the ACCS transports secondary-side fluids outside the RXB and into and through components outside in the yard, the staff also reviewed the system to evaluate whether the design complies with 10 CFR 20.1406.

*10.4.1.4.1 GDC 4, "Environmental and Dynamic Effects Design Bases***"**

The staff reviewed the design of the ACCS to evaluate whether the design complies 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 ACCS and the resulting discharging fluid (i.e., flooding) would not adversely affect SSCs important to safety. In FSAR 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 FSAR Section 10.4.1.3, "Safety Evaluation," the applicant stated that flooding resulting from a failure of the Condensate Collection Tank does not prevent operation of a safety-related system because no such systems are located in the TGB.

Since the ACCS is not credited for performing any accident mitigation, not relied on for safe shutdown, and serves no safety-related function, if the condenser loses its ability to perform its intended design function, nuclear safety will not be affected. Therefore, external missiles, pipe whip, and jet impingement would not affect nuclear safety. In addition, in regard to flooding that could occur as a result of a failure of the condensate collection tank, the design has provisions to prevent unacceptable flooding of areas containing safety-related equipment. FSAR Section 3.4.1, "Internal Flood Protection for Onsite Equipment Failures," states the following:

> Water from tanks and piping that are seismic category III and not protected against tornadoes or hurricanes are potential flooding sources outside the buildings. There are no large tanks or water sources near entrances to the RXB and CRB. The site is graded to transport water away from these buildings. Therefore, failure of equipment outside the CRB and RXB cannot cause internal flooding.

Based on the above review, the staff finds that the ACCS design complies with GDC 4, because the performance of the system's intended function is not necessary for nuclear safety or safe shutdown, and the potential flooding due to a failure of the ACCS does not result in adverse effects on SSCs important to safety.

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

The staff reviewed the design of the ACCS to evaluate whether the design complies 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 suitably control 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 ACCS 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 FSAR section 10.4.1.3, the applicant indicated that the control of radioactive materials to the atmosphere is covered in FSAR Section 10.4.2, "Condenser Air Removal System," which describes how gases in the condenser are removed by the CARS, which controls release of the ACCS radioactive effluents to the environment. FSAR section 10.4.2 states that the CARS maintains a vacuum on the condenser to remove gases. Removed gases pump through water separator tanks and vent to the atmosphere. The CARS and gland seal steam system exhausts have direct, unfiltered pathways out of the TGB to the atmosphere. Process and effluent radiation monitoring instrumentation for the ACCS is provided for the CARS common vent air evacuation line, two common liquid ring vacuum pumps shared among six ACCS units and six steam jet air ejector skids, one for each of the six ACCS units. The radiation ACCS process flow and identification of the radiation monitoring of the ACCS is shown in FSAR Figure 11.5-1b, “Radioactive Effluent Flow Paths with Process and Effluent Radiation Monitors,” and described in FSAR Table 11.5-1, “Process and Effluent Radiation Monitoring Instrumentation Characteristics.”

Based on the above review, the staff finds that the ACCS design complies with GDC 60 and 64, because the design includes provisions to monitor and suitably control the release of radioactive materials from the ACCS during normal operation.

10.4.1.4.3 10 CFR 20.1406, “Minimization of Contamination”

The regulations in 10 CFR 20.1406 require, in part, that each 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 MMS, and the contamination can then be transferred to the condenser through the turbine exhaust or the TBS. FSAR Table 11.1-5, “Secondary Coolant Design Basis Source Term,” and FSAR Table 11.1-7, “Secondary Coolant Realistic Source Term,” show, respectively, the secondary coolant design basis and realistic radiation source terms.

The staff reviewed the design of the ACCS to evaluate whether the design complies with the requirements of 10 CFR 20.1406. The staff finds that the ACCS includes design features that address the provisions of RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Live-Cycle Planning,” as described in FSAR Table 12.3-13, “Regulatory Guide 4.21 Design Features for Air Cooled Condenser System.” Section 12.3 of this SER presents the general review of NuScale conformance with RG 4.21.

10.4.1.5 Initial Test Program

The preoperational test related to the ACCS is test # 07, which ensures that the various design aspects related to the ACCS are implemented. The test is performed in accordance with FSAR Table 14.2-7, “Test # 07, Air Cooled Condenser System.” Section 14.2 of this SER documents the staff evaluation of the initial test program for the standard design approval review.

10.4.1.6 Conclusion

Based on its review of the ACCS as described above, the staff concludes the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.1.3 of this SER.

10.4.2 Condenser Air Removal System

10.4.2.1 Introduction

The staff reviewed FSAR Section 10.4.2, “Condenser Air Removal System,” in accordance with guidance in SRP Section 10.4.2, “Main Condenser Evacuation System,” to evaluate whether the

CARS is designed and built to establish and maintain ACCS vacuum and to monitor for radioactive material. CARS radiation monitoring instrumentation provided at the discharge of CARS monitors the radiation releases from the ACCS.

10.4.2.2 Summary of Application

FSAR section 10.4.2 contains a general description of the CARS system and specifies that its primary functions are to reduce dissolved oxygen in the feedwater and to maintain ACCS vacuum condition during plant startup, cooldown, and normal operating conditions by removing air and non-condensable gases from the MCs. The CARS subsystem has a non-safety-related with augmented requirements function to provide post-accident instrumentation to monitor variables such as radioactivity, the status of safety-related equipment, and the status of fission product barriers.

FSAR section 14.2 (Test # 07) provides information on the initial testing of the CARS. No proposed ITAAC and no specific TS requirements are associated with the CARS safety evaluation.

10.4.2.3 Regulatory Basis

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

- GDC 60requires, in part, that provisions be included in the CARS design to suitably control the release of radioactive materials in gaseous and liquid effluents during normal operation, including AOOs.
- GDC 64, requires, in part, that provisions be 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.

SRP section 10.4.2, item I, also indicates review interfaces with other SRP sections.

10.4.2.4 Technical Evaluation

The CARS is used to remove air from the ACCS and, therefore, establishes a vacuum. To prevent loss of condenser vacuum, each ACCS is provided with two 100 percent capacity CARS in parallel. Each NPM has a dedicated secondary system with independent condenser air ejector systems. If one system is unavailable because of maintenance or lost during normal operation, the redundant system is started. 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 ACCS vacuum is an AOO and is discussed in FSAR Section 15.2.3, “Loss of Condenser Vacuum.”

10.4.2.4.1 GDC 60, “Control of Releases of Radioactive Materials to the Environment,” and GDC 64, “Monitoring Radioactivity Releases”

The exhaust of the condenser air removal system (CARS) vacuum pumps is monitored for radioactive effluents and is serviced by the process sampling system. FSAR Figure 7.1-2, “Post-Accident Monitoring General Arrangement Drawing,” notes that the CARS is equipped for integrated sampling with a “PING” monitor to detect particulate/iodine/noble gases/argon-41 gamma and has provisions for representative grab samples through the takeoff and return path for monitoring process flow. If required, operators in the main control room can manually shut down and isolate the CARS in response to an abnormal plant condition. The alarm setpoints, control room monitoring capability, and operator response in accordance with site procedures enables the operation of the system and monitoring and control of radiation releases. Therefore, the staff finds that the CARS complies with GDC 60 and 64.

10.4.2.5 Initial Test Program

The preoperational test related to the CARS for standard design approval is Test # 07, which includes a test to verify that the system can maintain main condenser vacuum pressure, provide steam to the condenser deaerator as indicated by steam flow and supply gland seal steam to the turbine generator at design pressures. This test is performed is performed by the COL holder in accordance with FSAR table 14.2-7. Section 14.2 of this SER documents the staff evaluation of the initial test program for the standard design review.

10.4.2.6 Conclusion

Based on its review of the CARS as described above, the staff concludes that the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.2.3 of this SER.

10.4.3 Turbine Gland Sealing System

10.4.3.1 Introduction

The staff reviewed FSAR Section 10.4.3, “Turbine Gland Sealing System,” in accordance with guidance in SRP Section 10.4.3, “Turbine Gland Sealing System.” The TGSS is a turbine subsystem that provides 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.

10.4.3.2 Summary of Application

FSAR section 10.4.3 contains a general description of the TGSS and specifies that the system (1) prevents air leakage into the turbine under vacuum, (2) prevents steam leakage out of the turbine under pressure, and (3) provides for the use of redundant steam supplies and controlling devices.

10.4.3.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are provided in SRP section 10.4.3 and are summarized below:

- GDC 60requires, in part, that the TGSS design provides for the control of releases of radioactive materials to the environment.

- GDC 64requires, in part, that the TGSS design provide for monitoring releases of radioactive materials to the environment during normal operation, including AOOs and postulated accidents.

SRP section 10.4.3 also indicates review interfaces with other SRP sections.

10.4.3.4 Technical Evaluation

The staff reviewed FSAR section 10.4.3, in accordance with SRP section 10.4.3, to evaluate compliance with the regulatory requirements listed in section 10.4.3.3 of this SER. The applicant stated in FSAR Section 10.4.3.3 ,"Safety Evaluation," 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.

The staff reviewed the information in the FSAR on the TGSS including the system description and information in FSAR Sections 11.3, "Gaseous Waste Management System," and 11.5, "Process and Effluent Radiation Monitoring Instrumentation and Sampling System." The TGSS steam exhausts have direct, unfiltered pathways out of the TGB to the atmosphere. FSAR table 11.5-1 shows that process radiation monitoring for the gland steam outlet is provided at the turbine generator skid common exhaust vent point. Hence, the release to the turbine building from the turbine gland system is monitored.

FSAR Section 11.5.1.2, "Effluent Instrumentation Alarm Setpoints," states that "All process and effluent monitors provide local and Main Control Room (MCR) indication of radiation at each location and provide an alarm function in the MCR when predetermined thresholds are exceeded." Thus, design features are in place to control and monitor releases of radioactive materials in the effluents of the TGSS; accordingly, the staff finds these sampling and monitoring provisions for the TGS meet the requirements of GDC 60 and GDC 64, respectively, as they relate to control and monitoring of the releases of the radioactive materials to the environment.

10.4.3.5 Initial Test Program

Preoperational tests related to the TGSS for standard design approval include test # 29, which ensures that the various design aspects related to the TGS are implemented. These tests are performed by the COL holder in accordance with FSAR table 14.2–29. Section 14.2 of this SER documents the staff evaluation of the initial test program for the standard design approval review.

10.4.3.6 Conclusion

Based on its review of the TGSS above, the staff concludes that the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.3.3 of this SER.

10.4.4 Turbine Bypass System

10.4.4.1 Introduction

The staff reviewed FSAR Section 10.4.4, "Turbine Bypass System," in accordance with guidance in SRP Section 10.4.4, "Turbine Bypass System." The TBS is a turbine subsystem that provides main steam directly from the SGs to the air-cooled condenser in a controlled manner to remove heat from the NPM.

10.4.4.2 Summary of Application

FSAR section 10.4.4 contains a general description of the TBS. The TBS consists of a line connected to the main steam combined header with a regulating valve and an inline desuperheater discharging to the ACCS. The turbine bypass valve dumps steam from the main steam header through the desuperheater to the condenser. The valve is capable of throttling the full bypass flow from the turbine to the condenser without requiring actuation of the main steam safety valve.

FSAR section 14.2 (Test # 29) provides information on the initial testing of the TBS. No proposed ITAAC or specific TS requirements are associated with the TBS.

10.4.4.3 Regulatory Basis

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

- GDC 4, requires, in part, 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 34, requires, in part, the ability to use the system for shutting down the plant during normal operations. The operation of the TBS eliminates the need to rely solely on safety systems, which are required to meet the redundancy and power source requirements of this criterion.

SRP section 10.4.4 also indicates review interfaces with other SRP sections.

10.4.4.4 Technical Evaluation

The staff reviewed FSAR section 10.4.4, in accordance with SRP section 10.4.4, to evaluate 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.

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

The staff reviewed the design of the TBS to evaluate compliance with the requirements of GDC 4. Conformance to GDC 4 requires that failure of the TBS caused by a pipe break or malfunction of the system should not adversely affect essential systems or components that are necessary for safe shutdown or accident prevention or mitigation.

FSAR Section 10.4.4.1, "Design Basis," states that the TBS serves no safety function, is not risk-significant, is not credited for mitigation of a DBS, and has no safe-shutdown functions. FSAR section 10.4.3.3 states that the TGB does not contain safety-related equipment. The staff reviewed the TGS design in FSAR section 10.2 and verified that the piping and valves associated with the TBS are located completely within the turbine building and that the turbine building does not contain any SSCs important to safety.

Based on the above discussion, the staff finds that the TBS meets the GDC 4 criterion as it relates to the adverse effects of a pipe break or malfunction on those components of the system necessary for safe shutdown or accident prevention or mitigation since the turbine building does not contain such components.

10.4.4.4.2 GDC 34, "Residual Heat Removal"

The staff reviewed the TBS to evaluate whether the design complies with the requirements of GDC 34 as related to the ability to use the system to shut down the plant during normal operations by removing residual heat without using the turbine generator. 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 and as discussed in section 10.3 of this SER, 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. Section 5.4.3 of this SER covers the staff's review of the DHRS and compliance with PDC 34. 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 standard design approval include the test # 29Test and # 63, "Hot Functional Testing," which ensure that the various design aspects of the TBS are implemented. These tests are performed in accordance with FSAR table 14.2-29 and FSAR Table 14.2-63, "Hot Functional Testing." Section 14.2 of this SER documents the staff evaluation of the initial test program for the standard design approval review.

10.4.4.6 Conclusion

Based on its review of the TBS above, the staff concludes that the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.4.3 of this SER.

10.4.5 Condensate Polisher Skid and Resin Regeneration System

10.4.5.1 Introduction

A condensate polisher skid in the TGB is part of the FWS for each NPM. The purpose of the condensate polisher skid is to treat and clean feedwater to remove corrosion products and ionic impurities. The cation resin used in the condensate polisher skid is regenerated in the CPS, shared among all NPMs. The CPS is designed to receive the cation resin from the condensate polisher skids, regenerate the resin, and return it to the condensate polisher skids. FSAR Section 10.3.5, "Water Chemistry," describes the water quality requirements, but the evaluation of that information is included here in this SER because the condensate polisher skid and resin regeneration systems are a principal means of controlling secondary water chemistry.

10.4.5.2 Summary of Application

FSAR section 10.4.5 contains the system design basis and descriptions of the condensate polisher skid and the CPS, system operation, components, instrumentation, and the inspection and testing provisions. FSAR Section 10.4.5.1 , "Design Basis," states that the condensate polisher skid and CPS serve no safety-related functions, are not risk-significant, are not credited for mitigation of a DBA, and have no safe-shutdown functions. FSAR section 10.3.5 is also reviewed with section 10.4.5 in this SER section because it describes the Secondary Water Chemistry Control Program, including the chemistry requirements, methods of treatment, monitoring, and sampling, and contaminant ingress sources and response. FSAR Section 9.3.2, "Process Sampling System," describes collection of representative samples of the secondary water. FSAR section 11.5 addresses detection of radioactivity in the secondary coolant (for example, from a primary-to-secondary leak). FSAR Section 10.4.8, "Feedwater Treatment System," describes chemical additions to the feedwater as part of the Secondary Water Chemistry Control Program.

FSAR figure 10.1-1 shows the locations of the condensate polisher skid and CPS, as well as the feedwater treatment system (FWTS) chemical injection.

FSAR section 14.2, Test # 27, "Condensate Polisher Resin Regeneration System," and Test # 72, "Primary and Secondary System Chemistry," provides information on initial testing. SDAA Part 4, Section 5.5.5, "Secondary Water Chemistry," contains TS requirements associated with the Secondary Water Chemistry Control Program.

10.4.5.3 Regulatory Basis

The relevant regulatory requirements for this area of review and the associated acceptance criteria are summarized below.

- GDC 14, "Reactor coolant pressure boundary," in Appendix A to 10 CFR Part 50, 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.

NUREG-800 SRP Section 10.4.6, "Condensate Cleanup System," identifies acceptance criteria that are adequate to meet applicable requirements for the condensate polisher skid and CPS.

10.4.5.4 Technical Evaluation

10.4.5.4.1 Secondary Water Chemistry

Secondary water chemistry is focused on preventing corrosion in SGs, condensers, piping, and other components. Principal parameters that must be controlled are pH, dissolved oxygen, and impurity ion concentrations, including sodium, chloride, and sulfate ions.

The staff reviewed the information in FSAR sections 10.3.5 and 10.4.5, against the requirements of GDC 14. GCD 14 applies to the condensate polisher skid and CPS because they support secondary water quality to prevent corrosion-related failure of the RCPB, specifically the SG tubing. ("CPS" is the abbreviation for the resin regeneration system that serves the condensate polisher skid.) Water purity can also affect the accumulation of deposits on the secondary side of the SG tubing, which may in turn affect the ability to perform the required tube inspections. As described in SRP section 10.4.6, an acceptable method of compliance with GDC 14, as it relates to maintaining 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 report series, "PWR Secondary Water Chemistry Guidelines." In addition to protecting SG tubes and the condensate and feedwater components, secondary water chemistry is also selected with the goal of minimizing corrosion and performance losses for all secondary system components. The EPRI Guidelines are applicable because the NPM design of secondary-side materials (including SG tubing) and water chemistry for which there is extensive operating experience and for which the EPRI Guidelines were developed.

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. The EPRI Guidelines include associated actions to be performed if limits (“action levels”) are exceeded. Although the staff does not perform reviews or issue safety evaluations of EPRI water chemistry guidelines, EPRI Guidelines are recognized as representing the industry’s best practices in water chemistry control. The Guidelines are reviewed regularly by industry and updated periodically. All PWR licensees are committed to following the EPRI secondary water chemistry guidelines through their commitment to Nuclear Energy Institute (NEI) 97-06, “Steam Generator Program Guidelines.” FSAR Section 5.4.1.6, Steam Generator Program,” states that the Steam Generator Program is based on NEI 97-06.

FSAR section 10.3.5 addresses the secondary water chemistry requirements for SG water and feedwater. FSAR Tables 10.3-3a, “Steam Generator Sample (Wet Layup) (Reactor Coolant System ≤ 200°F),” 10.3-3b, “Feedwater Sample (Reactor Coolant System > 200°F to <15% reactor power),” 10.3-3c, “Feedwater Sample (≥15% reactor power),” 10.3-3d, “Condensate Sample (≥15% reactor power,” and 10.3-3e, “Steam Generator Fill Water (initial fill subsequent to a shutdown),” provide the values for certain secondary water chemistry parameters.

The NRC staff reviewed the information in FSAR section 10.3.5 to determine if the applicant’s proposed secondary water chemistry parameters provide reasonable assurance that the requirements of GDC 14 will be met with respect to secondary water chemistry. The staff compared the parameters monitored and the allowable values to the threshold values for which corrective action is required in the EPRI Guidelines referenced in the FSAR and the latest version of the EPRI Guidelines. Based on this review, the staff determined that the water chemistry parameters in the application are consistent with the values in the EPRI Guidelines, which represent industry best practices for secondary water chemistry control.

FSAR section 10.3.5 includes COL Item 10.3-1, which makes a COL applicant responsible for developing the site-specific Secondary Water Chemistry Control Program, based on the applicable revisions of NEI 97-06 and the EPRI Secondary Water Chemistry Guidelines at the time of the application. The staff finds the COL item acceptable because it is appropriate for a COL applicant to account for site-specific factors in designing a secondary water chemistry program that meets the appropriate industry guidelines.

As stated in FSAR Section 10.3.5.1, “Treatment and Monitoring,” an all-volatile treatment, such as ammonium hydroxide or an amine, is used for pH control, and hydrazine is added to control dissolved oxygen. The NRC staff finds this acceptable because these chemicals are widely used for these purposes in operating plants and their use is allowed by and addressed in the EPRI Guidelines. The chemical additions to the secondary water, for pH control and oxygen scavenging, are part of the FWTS, discussed in FSAR section 10.4.8 and this SER.

In addition to providing acceptable water quality treatment to support RCPB integrity, adequate instrumentation and sampling must be provided to verify the effectiveness of the treatment system in order to meet GDC 14 and the guidance in SRP section 10.4.6. As described in FSAR Section 10.3.5.2, “Sampling,” Section 9.3.2.2.1, “General Description,” and Table 9.3.2-3, “Secondary Sampling System Normal Sample Points,” the secondary sampling system is designed to sample the parameters specified by the Secondary Water Chemistry Program using continuous and grab samples. FSAR Section 10.4.5.5, “Instrumentation,” states that instrumentation for pressure, pressure drop, temperature, level, and flow rate are provided for monitoring process conditions. FSAR Section 10.4.5.2, “System Description,” states that the system is designed such that the temperature at the condensate polishers does not exceed the design temperature for the resin during normal operation or planned transients. FSAR Section 10.3.5.3, “Contaminant Ingress,” states that the condensate collection tank, condensate polisher discharge, condensate pump discharge, and demineralized water are monitored for conductivity, chemistry, and oxygen to detect contamination from oxygen and ionic species. The staff finds the design for instrumentation and sampling acceptable because it is consistent with the EPRI Guidelines as recommended in SRP section 10.4.6.

10.4.5.4.2 Condensate Cleanup Capacity

The NRC staff reviewed the cleanup capacity of the condensate polisher skid and CPS with respect to compliance of the design with GDC 14. Based on SRP section 10.4.6, the system should have adequate capacity to provide effluent of the necessary purity. FSAR section 10.4.5.2 describes the condensate polisher skid and the CPS. The condensate polisher skid is designed with the capacity to treat 100 percent of the FWS flow for each module to bring the water quality within specifications during startup and maintain water quality during operation. The CPS is shared among the NPMs and has the capacity to regenerate the resin in each of the condensate polisher skids in cycle (one at a time).

The condensate polisher skid removes corrosion products and ionic impurities from secondary water by passing it through condensate inlet filters, condensate polisher trains, and resin filters. The condensate polisher trains contain cation and mixed-bed (cation and anion) deionizers for removing ionic impurities. The CPS regenerates spent resin in the lead cation vessel and is used to replace the mixed-bed resin in the condensate polisher skid. The CPS includes chemical skids, chemical storage, and neutralization tanks and pumps. FSAR Table 10.4-1, “Condensate Polisher Resign Regeneration System Resin Tanks,” lists the number and sizes of resin tanks in the CPS.

In FSAR Section 10.4.5.3, “System Operation,” the applicant states that design features ensure that in the event of condenser tube leaks, concentrations of contaminants are limited to allowable values until the FWS is isolated. FSAR section 10.3.5.3 discusses condenser leaks and other potential sources of contamination and how the contamination is detected. This includes monitoring or sample analyses at the condensate collection tank, condensate pump discharge, condensate polisher discharge, and the demineralized water. Condensate polishers are used in the event of upset chemistry conditions, and the allowable values follow the EPRI Guidelines as discussed and tabulated in FSAR section 10.3.5. The design features actions to detect contamination in the secondary water and return the water to conformance with the Secondary Water Chemistry Control Program requirements.

SRP section 10.4.6 recommends that the CPS be connected to the radioactive waste disposal systems to allow disposal of spent resin or regenerant solutions when necessary. FSAR section 10.4.5.3 states that the water drained from the exhausted resin vessel is discharged to the BPDS and monitored for contamination. Figure 9.3.3-2, “Balance-of-Plant Drain System Diagram,” shows schematically the flow of the regenerant solution to the BPDS tanks and liquid radwaste system. FSAR Section 11.4, “Solid Waste Management System,” provides more information about the management of resins that require processing as contaminated waste, including condensate polisher demineralizer resins.

Based on the design to establish and maintain the specified water quality at full FWS flow, respond to ingress of contaminants, and dispose of spent resin or regenerant solutions, the staff finds that the system meets the criteria for condensate cleanup capacity as recommended in SRP section 10.4.6.

10.4.5.4.3 Materials of Construction

The NRC staff reviewed the materials of construction of the condensate polisher skid and CPS with respect to compliance of the design with GDC 14. SRP section 10.4.6 recommends that materials of construction be compatible with the service environment. In FSAR section 10.4.5.2, the applicant states that materials resistant to corrosion, erosion, and flow-accelerated corrosion (FAC), as discussed in FSAR section 10.3.5, are used for components in which loss of material could occur. FSAR section 10.3.5 states that this applies to components and piping exposed to wet steam, flashing liquid flow, or turbulent single-phase flow in which loss of material could occur. FSAR section 10.3.5 also says emphasis is placed on excluding copper and copper alloy pipe, valves, and components from the secondary chemistry environment to eliminate copper transport to the SGs and allow a higher feedwater pH to reduce iron corrosion and transport to the SGs.

Requirements for the materials are described in FSAR section 10.3.6, which classifies the condensate and feedwater system, including the condensate polishing skid, as Quality Group D and design code ASME B31.1 ("Power Piping"). The ASME B31.1 code has requirements for design, materials, fabrication, erection, testing, inspection, operation, and maintenance of piping and piping systems and associated components, including requirements for a corrosion allowance. FSAR section 10.3.6.3 states that provisions to minimize FAC include the selection of Cr-Mo or stainless steel consistent with EPRI FAC guidelines. COL Item 10.3-2 requires a COL applicant to provide a description of its FAC program. Based on the design code, the materials specified, and the design of the condensate polisher skid and CPS to maintain the water quality according to the Secondary Water Chemistry Program, the staff finds that the design provides reasonable assurance that the materials of construction will be compatible with the service environment and enable the system to perform its functions.

10.4.5.5 Initial Test Program

Section 14.2 of this SER evaluates preoperational test # 27, described in FSAR section 14.2, Table 14.2-27, "Test # 27 Condensate Polisher Resin Regeneration System," and preoperational test # 72 in FSAR Section 14.2, Table 14.2-72, "Test # 72 Primary and Secondary System Chemistry." These preoperational tests are performed by the COL holder.

10.4.5.6 Technical Specifications

SDAA Part 4 includes TS 5.5.5, "Secondary Water Chemistry Program," which provides an administrative program for the monitoring and control of secondary water chemistry to inhibit SG tube degradation. In SDA Part 2, Chapter 16, "Technical Specifications," the applicant stated that the generic TS were developed with the content typified in NUREG-1431, "Standard Technical Specifications—Westinghouse Plants," Revision 5, issued September 2021, and NUREG-1432, "Standard Technical Specifications—Combustion Engineering Plants," Revision 5, issued September 2021. The staff reviewed NuScale TS 5.5.5 for applicability to the condensate polisher skid and CPS. The staff determined that TS 5.5.5 provides appropriate administrative requirements for control and monitoring of secondary water chemistry based on consistency with the Standard Technical Specifications for operating reactor designs. Chapter 16 of this SER contains the staff evaluation of the TS.

10.4.5.7 Conclusion

Based on its review of the secondary water chemistry, condensate polisher skid, and CPS above, the staff concludes that the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.5.3 of this SER.

10.4.6 Condensate and Feedwater System

10.4.6.1 Introduction

The FWS provides feedwater at the required temperature, pressure, and flow rate to the SGs. As depicted in the NuScale power conversion system block diagram (FSAR figure 10.1-1), condensate is pumped from the condensate collection tank 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 FWS, not shared with other NPMs.

The NuScale FSAR describes the FWS boundaries as extending from the ACCS to the downstream flange on the removable spool piece between the feedwater regulating valve (FWRV) and feedwater isolation valve (FWIV). As discussed in section 10.4.6.4 of this SER, the applicant's description of the FWS boundaries is not consistent with the FWS boundaries described in DSRS section 10.4.7. Specifically, NuScale has not included, as part of the FWS, the portions of the system between the SG and the SG FWIV, which functionally serve as part of the FWS. For the purposes of this review, the staff considers the FWS 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 FWS per guidance in DSRS Section 10.4.7, "Condensate and Feedwater System."

10.4.6.2 Summary of Application

FSAR Section 10.6, "Condensate and Feedwater System," contains the FWS design basis, system description, and the results of the FWS failure modes and effects analysis. The FWS 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.

FSAR section 14.2 (Test # 25, "Condensate and Feedwater System") provides information on the FWS initial testing. There are no proposed ITAAC related to the FWS; however, in SDAA Part 8, Section 2.4, "Equipment Qualification," the applicant proposed ITAAC for the following FWS equipment: the feedwater supply check valves, the FWIV, and the FWRV. Section 14.3.7 of this SER evaluates these ITAAC.

The TS associated with the FWS are provided in SDAA, Part 4, "US460 Generic Technical Specifications," section 3.7.2, "Feedwater Isolation."

10.4.6.3 Regulatory Basis

The relevant requirements for this area of review and the associated acceptance criteria are provided in section 10.4.7 of the NuScale DSRS and are summarized below:

- GDC 2 requires, in part, that important-to-safety portions of the FWS 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, in part, that structures, systems and components important to safety be appropriately protected against 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 requires, in part, that structures, systems and components 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.

- GDC 44, “Cooling water,” as related, in part, to the following:

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

  – suitable redundancy of components and features for onsite electric power systems 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)

▪ GDC 45, “Inspection of cooling water system,” requires, in part, that the cooling water system shall be designed to permit periodic in-service inspection of important system components and equipment.

▪ GDC 46, “Testing of cooling water system,” requires, in part, that the cooling water system shall be designed 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, requires, in part, that the design will facilitate eventual decommissioning and minimize, to the extent practicable, contamination of the facility and the environment, and minimize, to the extent practicable, the generation of radioactive waste.

DSRS section 10.4.7 also indicates review interfaces with other SRP sections.

10.4.6.4 Technical Evaluation

The staff reviewed the FWS described in the FSAR in accordance with the review procedure in DSRS section 10.4.7. As indicated in section 10.4.6.1 of this SER, the applicant’s description of the FWS boundaries is not consistent with the FWS boundaries described in DSRS section 10.4.7. Thus, SSCs that are functionally part of the FWS are not identified as part of the FWS in the FSAR. The staff performed its review based on the system boundaries identified in the DSRS as described in section 10.4.6.1 of this SER. Use of the DSRS system boundaries ensures that the SSCs that are functionally part of the FWS 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.

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

The staff reviewed the FWS to evaluate whether the design complies with the requirements of GDC 2, with respect to its design for protection against the effects of natural phenomena such as earthquakes, tornados, hurricanes, and floods. Compliance with the requirements of GDC 2 is based on the FWS 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 in 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.d, 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.

The staff reviewed FSAR figure 10.1-1 and table 10.4-4 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 in RG 1.29.

FSAR Section 3.2, “Classification of Structures, Systems and Components,” categorizes SSCs based on safety importance and other considerations. FSAR table 10.4-4 gives the location, safety classification, and seismic category for the FWS. All of the FWS SSCs located in the TGB are listed as non-safety-related, Quality Group D, and seismic Category III, except for the FWRVs, feedwater supply check valves, and the FWRV limit switch, which are seismic Category I.

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

The staff reviewed the FWS to evaluate whether the design complies 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 FWS CIVs perform the safety-related function of containment isolation. The FWIVs provide for isolation of feedwater and support DHRS operation by isolating the DHRS from the FWS. FSAR Section 10.4.6.3, “Safety Evaluation,” states that dynamic effects such as water hammer can be generated by FWIV or FWRV closure and opening, check valve closure, or pump start and stop. The section also states that “the potential for water hammer in the FWS is minimized by design features such as pipe slope, the use of available drains before startup, and adjustment of valve closure timing.” The applicant then concludes that the FWS piping arrangement and valve characteristics ensure water hammer loads are below SG design limits. FSAR Section 13.5, “Plant Procedures,” states 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 design aspect related to water hammer prevention was examined by the staff as part of the SDA FSAR review, while the procedures will be evaluated during the staff’s review of the COL application as site-specific items. Based on the staff's review of the FWS design as described in FSAR section 10.4.7, the staff finds the NuScale FWS 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.

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

The staff reviewed the design of the FWS to evaluate 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 that an event in 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 FWS is not shared among NPMs; therefore, the failure of FWS or components in the FWS will not impair the ability of SSCs important to safety in other NPMs to perform their safety functions. Therefore, the requirement of GDC 5 for sharing of systems between units is satisfied.

10.4.6.4.4 GDC 44, "Cooling Water"

The staff reviewed the design of the FWS to evaluate compliance with the requirements of GDC 44. 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 FSAR, Section 5.4.3, and the staff's evaluation of the DHRS system is in Section 5.4.4 of this report.

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

The staff reviewed the FWS design to evaluate whether design provisions are provided for periodic inspections of components, as required by GDC 45 and periodic functional testing of the system and components, as required by GDC 46. Using the enhanced safety-focus review approach, the staff's review focused on the SSCs that are functionally part of the FWS that perform or support feedwater and containment isolation functions. The isolation functions are important to nuclear safety because FWS 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.

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

The FWS components that perform the isolation functions are the FWIV and the feedwater isolation check valves. These valves are considered CIVs and are discussed in FSAR section 6.2. The valves are located such that there is sufficient access to allow for inservice inspection; maintenance; repair; and 10 CFR Part 50, Appendix J, “Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors,” type C testing. These valves are included in the plant’s TS, and testing of the FWIV is also performed according to TS 3.7.2, “Feedwater Isolation.”

The staff confirmed that the FWS SSCs were included as part of the inservice testing program in Chapter 3, “Design of Systems, Structure, Components, and Equipment,” of the FSAR. FSAR Table 3.9-16, “Active Valve List,” 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 functions of the valves are feedwater isolation, containment isolation, and decay heat removal boundary. Since provisions permit periodic inservice inspection of the feedwater isolation and check valves, and they are included in the inservice test program, as indicated in FSAR table 3.9-16, the staff finds that the NuScale design provides for periodic inspection and testing and therefore satisfactorily addresses the requirements of GDC 45 and 46.

10.4.6.4.6 Compliance with 10 CFR 20.1406, “Minimization of Contamination”

The regulations in 10 CFR 20.1406 require, in part, that each SDA 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 minimize the generation of radioactive waste. Primary-to-secondary leakage through the SG tubes has the potential to introduce radioactive material into the FWS. The applicant stated, in FSAR section 10.4.6.3, that the FWS 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 FWS to evaluate whether the design complies with the requirements of 10 CFR 20.1406. In FSAR section 10.4.6.3, the applicant stated that main steam and condensate monitoring with MSS and FWS isolation capabilities minimizes the contamination and release to the environment, and that the FWS drains to the BPDS, which discharges to the radioactive waste drain system should the FWS become contaminated. The staff finds that the applicant has also addressed the FWS design features for compliance with RG 4.21 in FSAR Table 12.3-23, “Regulatory Guide 4.21 Features for Condensate and Feedwater System.” Section 12.3 of this SER includes the general review of NuScale compliance with RG 4.21.

Based on the above discussion, the staff concludes that the FWS, as described in the FSAR, complies with 10 CFR 20.1406.

10.4.6.5 Initial Test Program

Preoperational tests related to the FWS for standard design approval include the FWS tests (#25 and #28). These tests are performed by the COL holder in accordance with FSAR Table 14.2-25, “Test # 25 Condensate and Feedwater System,” and FSAR Table 14.2-28, “Test # 28 Feedwater Heater Vents and Drains System.” Section 14.2 of this SER documents the staff evaluation of the initial test program for the standard design approval review.

10.4.6.6 Conclusion

The staff finds the FWS 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.

10.4.7 Auxiliary Boiler System

10.4.7.1 Introduction

The staff reviewed FSAR Section 10.4.7, “Auxiliary Boiler System.” There is no specific SRP section applicable to 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 for this area of review. The ABS is designed to supply steam to systems where main steam is not available or not preferred.

10.4.7.2 Summary of Application

FSAR section 10.4.7 contains a general description of the ABS, as well as relevant information on the ABS design, including the design bases, instrumentation, and the inspection and testing program.

FSAR section 14.2 (Test # 06, “Auxiliary Boiler System”) provides information on initial testing of the ABS. There are no proposed ITAAC, or specific TS requirements associated with the ABS.

10.4.7.3 Regulatory Basis

There is no specific SRP section applicable to 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, requires, in part, that SSCs important to safety be 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, requires, in part, that SSCs important to safety 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 a pipe break or malfunction that could adversely affect essential systems or components necessary for safe shutdown or accident prevention or mitigation.

- GDC 5 requires, in part, that SSCs important to safety not be shared among the NPMs

- GDC 60, requires, in part, the ability of the auxiliary steam system design to control releases of radioactive materials to the environment.

- GDC 64, requires, in part, that provisions be 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, requires, in part, that the design features 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.

10.4.7.4 Technical Evaluation

The ABS is not safety related. The ABS is a non-seismic system designed to supply steam to systems where main steam is not available or not preferred. The primary functions of the ABS are to provide steam to the turbine gland seals, support the ACCS by supplying steam to the deaerator during startup, and support the condensate polishing resin regeneration system. The ABS is not credited for mitigation of a DBE and has no safe-shutdown functions.

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

Compliance with the requirements of GDC 2 is based on the fact 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. FSAR 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. In FSAR table 10.4-4, the seismic classification for the ABS is listed as Seismic Category III, and the location is the TGB. Since the ABS is not safety related, or risk significant, and the TGB does not contain any seismic Category I SSCs, the staff finds that the seismic Category III categorization of the ABS is appropriate, and the ABS complies with GDC 2.

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

The staff also reviewed the ABS design 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 as stated in 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. FSAR table 10.4-4 identifies the location of the ABS as the turbine building. Because there are no safety-related SSCs that can potentially be affected by the dynamic effects of an ABS failure, the staff finds that the design of the ABS meets the requirements of GDC 4.

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

Since the ABS serves all NPMs, the staff also reviewed the design of the ABS to evaluate 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 that an event in 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 FSAR section 10.4.7.3 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, finds that failure of this system would not significantly impair the ability of SSCs important to safety to perform their safety function. Therefore, the staff finds that the ABS design meets the requirements of GDC 5.

10.4.7.4.4 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 to evaluate whether the design complies 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 that the nuclear power unit design include provisions to monitor and suitably control 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.

FSAR figure 11.5-1b shows that effluent radiation monitoring is provided for the ABS. As stated in FSAR Section 11.5-4, "Effluent and Process Monitoring Off Normal Radiation Conditions," if high radiation is detected in the ABS skid vents, skid drains, or steam header drains, then the auxiliary boiler superheater skid outlet valve closes, auxiliary boiler skid to superheater skid valve closes, the module-specific main steam to auxiliary boiler header valves close, and the MCR receives an alarm.

Based on the above, the staff finds that the ABS complies with GDC 60 and 64.

10.4.7.4.5 10 CFR 20.1406, "Minimization of Contamination"

The staff also reviewed the design of the ABS to evaluate whether the design complies with the requirements of 10 CFR 20.1406 with respect to minimizing contamination of the facility and the environment. The staff finds that the ABS includes design features that address the provisions of RG 4.21, as described in FSAR Table 12.3-12, "Regulatory Guide 4.21 Design Features for Auxiliary Boiler System." Section 12.3 of this SER describes the general review of NuScale conformance with RG 4.21.

Based on its review, the staff concludes that the ABS design complies with 10 CFR 20.1406.

10.4.7.5 Initial Test Program

Preoperational tests related to the ABS for standard design approval include the test # 6. The test is performed by the COL holder in accordance with FSAR Table 14.2-6, "Test # 06, Auxiliary Boiler System." Section 14.2 of this SER documents the staff evaluation of the initial test program.

10.4.7.6 Conclusion

Based on its review of the ABS described above, the staff concludes that the design is acceptable because it meets the appropriate regulatory requirements as stated in section 10.4.7.3 of this SER.

10.4.8 Feedwater Treatment System

10.4.8.1 Introduction

The purpose of the feedwater treatment system (FWTS) is to maintain secondary water quality in combination with the condensate polisher skid (FSAR section 10.4.5) and process sampling system (FSAR section 9.3.2) by providing chemical addition and feedwater sampling. The FWTS provides chemical injection capability for maintaining feedwater pH and dissolved oxygen limits to meet the requirements of the Secondary Water Chemistry Control Program (FSAR section 10.3.5).

10.4.8.2 Summary of Application

FSAR section 10.4.8 contains the system design basis and a general description of the system equipment and operation. FSAR Section 10.4.8.1, "Design Bases," states that the FWTS serves no safety-related functions, is not risk-significant, is not credited for mitigation of a DBA, and has no safe-shutdown functions. The FWTS provides for chemical injection to support water chemistry and the condensate polisher skid and resin regeneration system, which are discussed in FSAR sections 10.3.5 and 10.4.5, respectively. FSAR section 9.3.2 describes collection of representative samples of the secondary water. Section 10.4.8 includes COL Item 10.4-1, which requires a COL applicant to provide a secondary water chemistry analysis showing that FWTS size, materials, and capacities satisfy the requirements of the Secondary Water Chemistry Control Program described in section 10.3.5 and that the system is compatible with the chemicals used.

FSAR figure 10.1-1 shows the location of the FWTS chemical injection, as well as the condensate polisher skid and CPS.

FSAR section 14.2, Test # 26, "Feedwater Treatment System," and Test # 72, provide information on initial testing.

10.4.8.3 Regulatory Basis

The relevant regulatory requirement for this area of review is GDC 14. FSAR sections 10.3.5 and 10.4.5 describe how the secondary water chemistry control supports compliance with GDC 14. The FWTS supports secondary water chemistry by enabling chemical injection.

GDC 14, "Reactor coolant pressure boundary," 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.

10.4.8.4 Technical Evaluation

The purpose of the FWTS is to control corrosion and erosion of feedwater system components by providing for chemical injection to maintain feedwater pH and dissolved oxygen concentration. The staff reviewed the information in FSAR section 10.4.8, in conjunction with the information in FSAR sections 10.3.5 and 10.4.5, with respect to the requirements of GDC 14. GDC 14 is applicable to the FWTS since the system is designed to perform chemical injection to help maintain secondary water chemistry. Secondary water chemistry is controlled, in part, to prevent corrosion-induced failure of the RCPB, specifically the SG tubing. The FWTS was reviewed in conjunction with the secondary water chemistry and condensate polisher skid sections of the FSAR because these systems and programs work together to maintain secondary water chemistry and to help prevent corrosion-induced failure of the RCPB.

The staff's review of FSAR section 10.4.8 focused on the ability of the FWTS to provide the appropriate chemical injection that allows for the control of certain secondary water chemistry parameters. FSAR sections 10.3.5 and 10.4.5 describe how maintaining acceptable secondary water chemistry will demonstrate compliance with GDC 14 with respect to corrosion-induced failure of the RCPB.

FSAR section 10.4.8.2, "System Description," states that chemical injection points are provided downstream of the FWS condensate pumps, and there is separate equipment for pH control and oxygen scavenger injection. Figure 10.1-1 shows the FWTS injection location schematically. FSAR section 10.4.8.3, "System Operation," states that the Process Sampling System (PSS) monitors the feedwater, and the FWTS makes chemical additions to keep feedwater chemistry within limits. The FWTS chemical addition pumps use the PSS readings to determine the chemical injection requirements, which are controlled by the plant control system and module control system. These chemical injections are available for normal operation and for cleanup modes during startup. The staff finds this design acceptable based on having provisions and equipment for monitoring the feedwater chemistry and injecting chemicals for pH and dissolved oxygen control.

FSAR section 10.4.8 includes COL Item 10.4-1, which makes a COL applicant responsible for providing a secondary water chemistry analysis that must show that the size, materials, and capacity of the FWTS equipment and components satisfy the water quality requirements of the Secondary Water Chemistry Control Program described in FSAR section 10.3.5, and that the system is compatible with the feedwater chemicals. The staff finds it acceptable for the COL applicant to be responsible for the details of the FWTS because the design will be required to meet the requirements of the Secondary Water Chemistry Control Program described in section 10.3.5, while allowing the COL applicant flexibility in the choice of chemicals and equipment to meet those requirements. The flexibility to customize the design is acceptable because the EPRI Guidelines that form the basis for the Secondary Water Chemistry Control Program allow for more than one way to maintain pH and dissolved oxygen limits.

10.4.8.5 Initial Test Program

Section 14.2 of this SER contains the evaluation of preoperational test # 26 in FSAR section 14.2, Table 14.2-26, "Test # 26 Feedwater Treatment System," and preoperational test # 72 in FSAR section 14.2, table 14.2-72. These preoperational tests are performed by the COL holder.

10.4.8.6 Conclusion

Based on its review of the FWTS described above, the staff concludes that the design is acceptable because it meets the requirements of GDC 14.