Response to SDAA Audit Question

Question Number: A-10.3-1

Receipt Date: 04/10/2023

Question:

GDC 4 requires structures systems and components important to safety be protected against the consequences of hydraulic instabilities such as steam/water - hammer events. Steam or water hammer in the main steam or main feedwatersystem has the potential to impact the MSIVS, FWIVs, steam generators, and the connected safety-related decay heat removal system (DHRS). In its review of the main steam and the condensate and feedwater systems the staff reviews the plant design features and operational methods relied on to minimize or prevent water hammer in these systems. Sections 10.3.3 and 10.4.6.2.4 of the SDAA refererences SDAA secrtion 3.6.3 for the information on the design and layout of the MSS and FWS, which includes provisions to minimize potential for water hammer and other flow instabilites. The staff could not find the referenced information in SDAA section 3.6.3.

NuScale is requested to provide the information that referred to when it referenced SDAA Section 3.6.3, including all information used to support its conclusion that the main steam and main feedwater system design meets the requirements of GDC 4 with respect to steam hammer events in the main steam system, and water hammer event in the main feedwater systems.

Response:

In response to Audit Question A-10.3-1 NuScale has added text to sections 10.3.3 and 10.4.6 to address the dynamic effects of steam and water hammer.

Markups of the affected changes, as described in the response, are provided below:

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General Design Criterion 4 is considered in the design and arrangement of main steam components located in the RXB. The MSS satisfies GDC 4 in that nonsafety-related with augmented requirement components (e.g., secondary MSIVs and secondary MSIBVs) are protected from dynamic effects. The dynamic loads such as those caused by MSIV closure or turbine stop valve closure due to water hammer and steam hammer, and relief valve discharge loads are evaluated in the design and analysis of the MSS piping. The design utilizes drain pots, line sloping, and drain valves to minimize the effects of dynamic loads and water hammer. Section 3.12 describes the design of piping systems and piping supports used in Seismic Category I, Seismic Category II, and non-seismic systems. Analysis of a postulated high-energy line break is provided in Section 3.6.1 and Section 3.6.2. ~~The design and layout of the MSS include provisions to minimize potential for water hammer and other flow instabilities (Section 3.6.3).~~

General Design Criterion 5 is considered in the design of the MSS. There are no safety-related components in the MSS shared among NPMs, and therefore the MSS does not impair the ability of other NPMs to perform their safety functions.

The decay and residual heat removal safety function per PDC 34 is performed by the DHRS flowpath, and the containment isolation function of the containment system is performed by the MSIVs and the feedwater isolation valves. Secondary system isolation is provided to protect the SG inventory without an unnecessary cooldown. Consistent with PDC 34, the nonsafety-related secondary MSIVs downstream of the MSIVs are credited as backup isolation components in the event that an MSIV fails to close. Although not safety-related, the secondary MSIVs are designed to close under postulated worst-case conditions and are included in technical specification surveillance requirements to ensure their reliability and operability. Thus, consistent with the position established in NUREG-0138, Issue Number 1, the secondary MSIVs ensure that blowdown is limited if a steamline were to break upstream of the MSIV. Conformance with PDC 34 is further discussed in Section 5.4.

The requirements of 10 CFR 20.1101(b) and 10 CFR 20.1406 are considered in the design of the MSS. Section 12.3 provides further discussion of the facility design features to protect against contamination.

Consistent with 10 CFR 50.63, the nonsafety-related portion of the MSS is not relied upon to operate in response to a station blackout (SBO). Rather, the DHRS operates in conjunction with the ultimate heat sink to fulfill the core cooling function in the event of an SBO. Successful operation of the DHRS relies on the MSIVs, which form part of the DHRS flowpath and pressure boundary. Secondary MSIVs provide backup to the MSIVs and thus are required to fail closed during an SBO. This functionality is ensured with or without electrical power. Conformance with 10 CFR 50.63 is discussed in Section 8.4.

10.3.4 Inspections and Tests

Section 14.2 describes the Initial Test Program used to test and inspect MSS components. Nonsafety-related MSS piping and components are inspected and through testing to demonstrate the valve actuates as expected at operating conditions.

Section 3.9.6 describes inservice testing requirements for the FWRV. The valve position is classified as a Type D accident monitoring variable in accordance with IEEE 497-2002, as endorsed by RG 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants" (Reference 10.4-4).

10.4.6.2.3 Backup Feedwater Check Valves

Figure 10.1-1 shows nonsafety-related backup feedwater check valves are installed in each feedwater line downstream of the FWRV. These backup feedwater check valves serve as backup isolation devices to the safety-related feedwater integral check valve for isolation of the DHRS when reverse flow is experienced during a break in the FWS piping and are designed to withstand the forces of closing after a FWS line rupture.

Section 6.2 discusses the safety-related check valve upstream of the FWIV. The nonsafety-related backup check valve is downstream of the FWRV for backup backflow prevention.

Section 15.0.0 describes the nonsafety-related backup feedwater check valves used for event mitigation as backup protection for the safety-related FWIV integral check valves. The nonsafety-related backup FW check valve is a commercially available valve that uses a proven design and demonstrates reliable operation based on operating experience in water systems. A design with no previous operating experience may be proven through testing to demonstrate the valve actuates as expected at operating conditions.

Section 3.9.6 describes the inservice testing requirements for the nonsafety-related backup feedwater check valve.

10.4.6.2.4 Condensate and Feedwater Piping

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The FWS piping layout among components is shown in Figure 10.1-1. The FWS and SG design include features that minimize potential for water hammer and subsequent effects. ~~Section 3.6.3 provides additional detail.~~

The FWS piping meets ASME B31.1 (Reference 10.4-3) requirements. Section 10.3.6 describes FWS piping materials and Section 3.6 provides descriptions of piping and support design.

The FWS incorporates considerations to prevent erosion and corrosion. These considerations include material selection, limits on flow velocity, inspection programs, and limits on water chemistry to reduce FAC, erosion, and corrosion of piping and piping components. Section 10.3.6 discusses FAC.

Sudden loss of FWS flow at power causes SG heat removal rates to decrease, which causes reactor coolant temperature to increase. Section 15.2.7 discusses a loss of feedwater flow.

10.4.6.3 Safety Evaluation

Section 6.2 describes the portion of the feedwater piping from the SG feedwater nozzles to the outermost FWIV flange, designed to ensure feedwater system isolation in accident situations and containment isolation in cases in which the feedwater system could potentially become a containment bypass pathway.

The design of the FWS follows GDC 2. The FWS SSC that are nonsafety-related with augmented requirements (i.e., FWRVs, backup feedwater check valves, and piping inside the RXB) are Seismic Category I and are located in the Seismic Category I portions of the RXB, which protects them from the effects of natural phenomena. Adequacy of the structural design of the RXB is described in Section 3.3 for wind and tornadoes, Section 3.4 for flooding, Section 3.5 for missile protection, and Section 3.7 for earthquakes. These backup portions of FWS are designed to remain functional during and after a safe shutdown earthquake and meet the guidelines of RG 1.29.

The design of FWS SSC and piping inside the RXB ensures protection against environmental and dynamic effects associated with normal operation, maintenance, testing, and postulated accidents in accordance with GDC 4. The FWS SSC that are nonsafety-related with augmented requirements (i.e., FWRVs, backup feedwater check valves) are located in the Seismic Category I portions of the RXB, which protects them from the effects of natural phenomena. The design of FWS piping and SSC inside the RXB ensures protection against dynamic effects such as water hammer. Section 3.12 describes the design of piping systems and piping supports used in Seismic Category I, Seismic Category II, and non-seismic systems. Section 3.6 provides the analysis of a postulated high-energy line failure.

Isolation backup portions of the FWS located within the RXB are protected from effects of missiles generated by plant equipment failures outside the RXB.

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~~Section 3.6 describes SG design features implemented to prevent fluid flow water hammer.~~ 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 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 FWS piping arrangement and valve characteristics ensure water hammer loads are below SG design limits.

The design of the FWS follows GDC 5 because the components in the FWS are not shared among NPMs; therefore, failure of the FWS does not impair the ability of other NPMs to perform their safety functions.