Response to SDAA Audit Question

Question Number: A-19.3-1

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Question:

The SDAA is missing an analysis (key inputs, assumptions, and results) for the period beyond 72 hours and up to 7 days, and supports the conclusion that nonsafety-related SSC are not relied on to perform a RTNSS B function for the period beginning 72 hours after a design-basis event and lasting the following 4 days to ensure long-term safety. SECY-96-128 requires the facility to be capable of sustaining all design-basis events with onsite equipment and resources for 7 days. The Chapter 15 safety analysis and supporting methods (e.g., extended passive cooling) only cover the first 72 hours of design-basis events, and the mission time for the PRA is also 72 hours.

Response:

The NuScale US460 standard design operates with the NuScale Power Modules partially immersed in the reactor pool which serves as the ultimate heat sink (UHS). The reactor pressure vessel (RPV) is housed in a steel containment vessel (CNV) that transfers decay heat through the CNV walls to the UHS, providing an effective passive heat sink for both the short term and long term.

Automatic actions ensure the passive safety systems maintain the core cooling and containment functions. Upon receipt of an actuation signal or loss of power, the containment isolation valves close, performing the function of containment isolation and maintaining reactor coolant system (RCS) inventory. Automatic actuation of the decay heat removal system (DHRS) valves to open establishes natural circulation flow and heat transfer through the DHRS heat exchangers to the UHS. The emergency core cooling system (ECCS) valves automatically open to establish natural circulation flow of the RCS between the RPV and the CNV, allowing heat transfer from the fuel to the UHS. During ECCS operation, temperature and pressure in the CNV are passively maintained at acceptable levels by heat transfer through the CNV wall to the UHS.

The passive safety-related functions described above are being performed prior to 72 hours following a design-basis event, and these functions are continually performed beyond 7 days. As described in FSAR Section 9.2.5, the UHS cooling capability extends beyond 7 days. As identified in FSAR Sections 6.2.2 and 6.3.2.2, with the UHS cooling capability, the ECCS and the CNV continue to transfer decay heat to the UHS for at least 7 days.

In response to discussions with NRC reviewers during follow up calls, NuScale has added text to FSAR Section 19.3 describing in more detail the determination of structures, systems, and components (SSC) that qualify as Regulatory Treatment of Nonsafety Systems (RTNSS) B. The reviewers also requested a written summary with further detail, which is provided below.

Demonstration of core cooling and containment integrity are addressed as follows for initiating events that result in cooling using the DHRS:

- The reactor remains subcritical during DHRS operation. The core reactivity balance depends on time in cycle and success of control rod insertion. The ECCS is automatically actuated after reactor trip to maintain subcriticality, but operators can bypass ECCS if subcriticality under cold conditions is confirmed.
- Maintaining coolable geometry in the long-term event progression requires ensuring that boron precipitation does not occur. The DHRS operation is non-limiting compared to ECCS operation for boron precipitation, which is discussed below.
- The DHRS transfers decay and residual heat to the reactor pool. Limiting conditions for heat removal occur within 72 hours of event initiation while the DHRS condensers remain covered. Assuming the reactor pool is initially at the minimum level (52 ft) and maximum temperature (120°F) allowed by technical specifications, six modules rejecting heat to the reactor pool, and ANSI/ANS 5.1 2014 standard decay heat, the pool level remains above the top of the DHRS condensers for more than 7 days. {{ }}$^{2(a),(c)}$, Revision 1, is available in the "SDAA Audit Chapter 9" eRR. Case A of this calculation addresses the initial conditions referenced above.
- During DHRS operation, there is no sustained mass and energy release into containment, and containment integrity is not challenged.

Demonstration of core cooling and containment integrity are addressed as follows for initiating events that result in cooling using ECCS and DHRS:

- The reactor remains subcritical during ECCS and DHRS operation. The initial core reactivity balance depends on time in cycle and success of control rod insertion. Results of the limiting Chapter 15 analyses demonstrate that the core boron concentration remains above the concentration required to demonstrate subcriticality, accounting for the highest worth control rod stuck out. These analyses demonstrate that the limiting time for subcriticality occurs in the first 72 hours of the event, due to xenon burnout and absence of a long-term boron loss mechanism. Therefore, the Chapter 15 analyses bound the 7-day evaluation conditions with respect to subcriticality.

- Maintaining coolable geometry requires assuring that boron precipitation does not occur. The Chapter 15 analyses demonstrate that the boron concentration in the RCS remains below the precipitation limit in the first 72 hours of these initiating events. {{ }}2(a),(c), Revision 1, is available in the "SDAA Audit Chapter 15" eRR. As identified in the boron transport analysis for precipitation, if all of the boron in the module was transferred to the RCS, boron concentrations would still remain below the solubility limits. The RCS temperature rise due to reactor pool heatup provides additional margin to the solubility limits during the 7-day period considered by RTNSS.
- The ECCS and DHRS transfer decay heat to the reactor pool. As described above, the DHRS condenser remains covered for more than 7 days. Section 15.0.5 presents an ECCS cooling analysis biased for maximum temperature. This maximum temperature analysis assumes pool temperature is close to boiling (210°F), and uses a bounding low reactor pool level (48 ft). These assumed conditions bound the 7-day pool boil off analysis described above.

Therefore, the Chapter 15 analyses demonstrate that core cooling and containment integrity are maintained by safety-related SSC under conditions that could occur during the 7-day period considered by RTNSS B. Nonsafety-related SSC are not relied on to perform a RTNSS B function to ensure long-term safety.

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

Safety analyses, PRA insights, and sensitivity studies (discussed in Chapter 15, Section 19.1, and Section 19.2, respectively) provide reasonable assurance that core cooling and containment integrity is maintained during the time period beginning 72 hours after a design-basis event and lasting the following 4 days, with only safety-related SSC, consistent with SECY-96-128.

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The NuScale Power Modules are partially immersed in the reactor pool. The reactor pressure vessel is housed in a steel containment vessel that transfers sensible and core decay heat through the containment vessel walls and the decay heat removal system (DHRS) to the ultimate heat sink that provides a passive heat sink for both short and long-term heat removal. Safety-related SSC that operate automatically without operator action, fail-safe on a loss of power, and are passively maintained for extended periods following an accident perform the functions of core cooling and containment cooling.

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Demonstration of core cooling and containment integrity is addressed as follows for initiating events that result in cooling using DHRS:

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- The reactor remains subcritical during DHRS operation. The core reactivity balance depends on time in cycle and the success of control rod insertion. The emergency core cooling system (ECCS) actuates after a reactor trip to maintain subcriticality, but operators can bypass ECCS if subcriticality under cold conditions is confirmed.

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- Maintaining coolable geometry requires ensuring that boron precipitation does not occur. The DHRS operation is non-limiting compared to ECCS operation for boron precipitation.

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- The DHRS transfers decay and residual heat to the reactor pool. Limiting conditions for heat removal occur within 72 hours of event initiation while the DHRS condensers remain covered. A pool boil off analysis demonstrates that, assuming the ultimate heat sink is initially at the minimum level and maximum temperature allowed by technical specifications, and six modules are rejecting heat to the reactor pool, with realistic decay heat, the pool level remains above the top of the DHRS condensers for more than 7 days.

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- During DHRS operation, there is no sustained mass and energy release into containment, and containment integrity is not challenged.

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Demonstration of core cooling and containment integrity is addressed as follows for initiating events that result in cooling using ECCS and DHRS:

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- The reactor remains subcritical during ECCS and DHRS operation. The initial core reactivity balance depends on time in cycle and success of control rod insertion. Safety analyses, described in Section 15.0.5, Extended Passive Cooling for Decay and Residual Heat Removal, demonstrate that the core boron concentration remains above the concentration required to demonstrate subcriticality, accounting for the highest worth control rod stuck out. These analyses demonstrate that the limiting time for subcriticality occurs in the first 72 hours of the event. Therefore, the analyses bound the 7-day evaluation conditions with respect to subcriticality.

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- Maintaining coolable geometry requires ensuring that boron precipitation does not occur. Safety analyses biased for cold pool conditions, described in Section 15.0.5, demonstrate the boron concentration in the reactor coolant system remains below the precipitation limit in the first 72 hours of these initiating events. The reactor coolant system temperature rise due to reactor pool heatup provides additional margin to the solubility limits during the 7-day period considered by RTNSS.

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- The ECCS and DHRS transfer decay heat to the reactor pool. As described above, the DHRS condensers remain covered for more than 7 days. The ECCS cooldown analysis presented in Section 15.0.5 that is biased for maximum temperature assumes pool temperature is close to boiling, and uses a bounding low reactor pool level. These assumed conditions bound the 7-day pool boil off analysis described above.

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Therefore, analyses demonstrate core cooling and containment integrity are maintained, and nonsafety-related SSC are not relied on to perform a RTNSS B function for the period beginning 72 hours after a design-basis event and lasting the following 4 days to ensure long-term safety.

The RTNSS B evaluation process also considered if nonsafety-related SSC are candidates for additional regulatory oversight from seismic considerations.

As described in Section 19.1.5, the seismic margins analysis (SMA) models both active and passive nonsafety-related SSC as well as safety-related SSC. This analysis identifies few component failures that have the potential to contribute to seismic risk.

For passive nonsafety-related SSC, SMA evalution concludes that the design meets the regulatory requirement for a high confidence of low probability of failure value that is greater than 1.67 times the design-basis safe shutdown earthquake with safety functions being maintained utilizing only safety-related SSC. Thus, additional regulatory oversight for these components is not in the scope of the RTNSS program.

Therefore, no nonsafety-related SSC meet the RTNSS B criteria.

19.3.2.3 Regulatory Treatment of Nonsafety Systems C

Nonsafety-related SSC functions are evaluated to determine whether they are relied upon under power operating and shutdown conditions to meet the NRC