NuScaleDCRaisPEm Resource

From: Chowdhury, Prosanta
Sent: Friday, May 11, 2018 9:56 AM
To: Request for Additional Information
Cc: Lee, Samuel; Cranston, Gregory; Franovich, Rani; Karas, Rebecca; Burja, Alexandra; NuScaleDCRaisPEm Resource
Subject: Request for Additional Information No. 473 eRAI No. 9483 (15.01.01 - 15.01.04)
Attachments: Request for Additional Information No. 473 (eRAI No. 9483).pdf

Attached please find NRC staff's request for additional information (RAI) concerning review of the NuScale Design Certification Application.

The NRC Staff recognizes that NuScale has preliminarily identified that the response to one or more questions in this RAI is likely to require greater than 60 days. NuScale is expected to provide a schedule for the RAI response by email within 14 days.

If you have any questions, please contact me.

Thank you.

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Request for Additional Information No. 473 (eRAI No. 9483)

Issue Date: 05/11/2018
Application Title: NuScale Standard Design Certification - 52-048
Operating Company: NuScale Power, LLC
Docket No. 52-048
Review Section: 15.01.01 - 15.01.04 - Decrease in FW Temperature, Increase in FW Flow, Increase in Steam Flow, and Inadvertent Opening of a SG Relief or Safety Valve
Application Section:

QUESTIONS

15.01.01-2

General Design Criterion (GDC) 10, "Reactor design," in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits (SAFDLs) are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences (AOOs). Design-Specific Review Standard for NuScale small modular reactor (SMR) Design (DSRS) Section 15.1.1-15.1.4, "Decrease in Feedwater Temperature, Increase in Feedwater Flow, Increase in Steam Flow, and Inadvertent Opening of the Turbine Bypass System or Inadvertent Operation of the Decay Heat Removal System," provides guidance for meeting GDC 10 and states that mitigating systems should be assumed to be actuated in the analyses at setpoints with allowance for instrument inaccuracy in accordance with the guidance in Regulatory Guide 1.105, "Setpoints for Safety-Related Instrumentation."

Final Safety Analysis Report (FSAR) Tier 2, Sections 15.1.1, “Decrease in Feedwater Temperature,” 15.1.2, “Increase in Feedwater Flow,” 15.1.3, “Increase in Steam Flow,” and 15.1.5, “Steam Piping Failures Inside and Outside of Containment,” state that a 5 percent uncertainty is added to the high core power trip to account for a decalibration effect in the excore detectors caused by increased coolant density in the downcomer. The staff audited engineering calculation (EC)-0000-2017, Revision 0, “Decrease in Feedwater Temperature Analysis” (the calculation supporting FSAR Tier 2, Section 15.1.1) and notes that the 5 percent is based on **[[ ]]** .

To ensure that the analyses use conservative setpoints that will adequately protect SAFDLs, provide the basis for the 5 percent uncertainty in the high core power trip. In particular, provide **[[ ]]** .

15.01.01-3

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. To ensure compliance with GDC 10, the transient scenario having the most severe consequences for SAFDLs should be analyzed and presented in the FSAR.

FSAR Tier 2, Figure 15.1-1, "Feedwater Temperature (15.1.1 Decrease in Feedwater Temperature)," shows that the feedwater (FW) temperature at the top of the containment vessel starts at 310°F and decreases linearly to about 140°F, at which point it remains constant. However, the event description in FSAR Section 15.1.1.3.3 states that the limiting event initiates with a linear decrease in FW temperature to the minimum possible temperature of 100°F over 160 seconds. The staff acknowledges that the reason the temperature in Figure 15.1-1 does not decrease to 100°F may be because the FW isolation valves (FWIVs) close before 160 seconds. However, given the initial FW temperature of 310°F, the rate of temperature decrease becomes about 1.3°F/s. Therefore, the FW temperature should decrease by about 184°F over the 140 seconds (per FSAR Tier 2, Table 15.1.1, "Sequence of Events (15.1.1 Decrease in Feedwater Temperature)") prior to FWIV closure, leading to a final temperature of 126°F. To demonstrate that the results for the most limiting decrease in FW temperature scenario have been presented, explain why Figure 15.1-1 does not show a minimum value of 126°F. Update the FSAR as necessary.

15.01.01-4

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 13 requires the provision of instrumentation to monitor variables and systems over their anticipated ranges of normal operation, and of appropriate controls to maintain listed variables and systems within prescribed operating ranges. DSRS Section 15.1.1-15.1.4 provides guidance for meeting GDC 10 and 13 and guides the reviewer to review the sequence of events from initiation until a stabilized condition is reached. The sequence of events should be justified based upon the expected values of the relevant monitored parameters and instrument indications.

FSAR Tier 2, Table 15.1-1, lists most of the key events for the decrease in FW temperature event. However, it does not list the time of minimum critical heat flux ratio (MCHFR), despite the fact that MCHFR is the key acceptance criterion for the event. The staff also notes that Table 15.1-1 shows the reactor trips at 133 seconds, which is well beyond the time scale of FSAR Figure 15.1-9, "Critical Heat Flux Ratio (15.1.1 Decrease in Feedwater Temperature)." In order for the staff to assess the event response, add the timing of MCHFR to FSAR Table 15.1-1. In addition, add the timing of MCHFR to the sequence of events tables for other FSAR Chapter 15 events that seek to identify the limiting MCHFR, if not already present.

15.01.01-5

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. One of the specific acceptance criteria in DSRS Section 15.1.1-15.1.4 to meet this requirement is that the values of the parameters used in the analytical model should be suitably conservative.

FSAR Tier 2, Table 15.1-2, "Decrease in Feedwater Temperature - Inputs (Limiting Minimum Critical Heat Flux Ratio Case)," lists inputs and initial conditions for the decrease in FW temperature event. However, the table does not include values for initial pressurizer level or steam generator (SG) heat transfer. Tables 15.1-4, "Increase in Feedwater Flow - Inputs (Limiting Minimum Critical Heat Flux Ratio Case)," and 15.1-6, "Increase in Steam Flow - Inputs (Limiting Minimum Critical Heat Flux Ratio Case)," are also missing these values, as well as the initial feedwater temperature. The staff notes that the values chosen for these parameters and their biases influence MCHFR. To demonstrate the use of suitably conservative values for these parameters, add the parameter values and biases for initial pressurizer level and SG heat transfer to Tables 15.1-2, 15.1-4, and 15.1-6, and add the value and bias for initial FW temperature to Tables 15.1-4 and 15.1-6.

15.01.01-6

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 13 requires the provision of instrumentation to monitor variables and systems over their anticipated ranges of normal operation, and of appropriate controls to maintain listed variables and systems within prescribed operating ranges. DSRS Section 15.1.1-15.1.4 provides guidance for meeting GDC 10 and 13 and guides the reviewer to review the extent to which plant and reactor protection systems are required to function.

FSAR Section 15.1.2.2, "Sequence of Events and Systems Operation," states that, for the increase in feedwater flow event, the high RCS pressure trip provides protection for cases that do not reach the high power setpoint. However, the staff notes that the initial part of the transient depressurizes the RCS, so it is unclear why the low steam superheat or high steam pressure reactor trips would not occur before a high RCS pressure trip should a trip not occur on high power. To further illustrate this point, FSAR Figure 15.1-16, "Reactor Coolant System Pressure (15.1.2 Increase in Feedwater Flow)," shows that RCS pressure is about 1920 psia, well under the 2000 psia high RCS pressure trip setpoint, by the time of reactor trip. However, FSAR Table 15.1-3, "Sequence of Events (15.1.2 Increase in Feedwater Flow)," shows that the low steam superheat limit is reached one second before the high reactor power limit, and FSAR Figure 15.1-18, "Main Steam System Pressure (15.1.2 Increase in Feedwater Flow)," shows a rapid increase in steam pressure at the beginning of the transient. Furthermore, the list of credited MPS signals in FSAR Section 15.1.2.2 does not include the high RCS pressure trip. Explain the statement in the FSAR regarding the high RCS pressure trip, and update the FSAR as necessary.

15.01.01-7

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 15, "Reactor coolant system design," requires that the RCS and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary (RCPB) are not exceeded during any condition of normal operation, including AOOs. One of the specific acceptance criteria in DSRS Section 15.1.1-15.1.4 necessary to meet the requirements of GDC 10 and 15 for incidents of moderate frequency is that the event should not generate a more serious plant condition without other faults occurring independently.

FSAR Section 15.1.2, "Increase in Feedwater Flow," evaluates the potential overfilling of a steam generator (SG) due to the increasing feedwater supply. Overfilling of a SG could result in loss of a decay heat removal system (DHRS) train, degrading decay heat removal capability. FSAR Section 15.1.2 concludes that the SG will not overfill, and DHRS capability is maintained. However, the staff audited the SG overfill case in Attachment 5 to engineering calculation (EC)-0000-2016, "Increase in Feedwater Flow Analysis," which supports FSAR Section 15.1.2, and noted two potential issues.

First, the peak pressures and levels for SG trains 1 and 2 are identical, despite the fact that a single failure of a FWIV is assumed. The staff would expect peak pressure and level in the train with the failed FWIV to be higher than in the train with the fully functional FWIV.

Second, a **[[ ]]** is used for the overfilling case. However, the staff notes that the maximum transient SG level is higher for the baseline cases, which were not biased to achieve **[[ ]]** cases. Thus, it appears that the approximately 80-percent level in both SG trains could potentially increase if a different initialization were used.

Furthermore, as stated in FSAR Section 15.0.0.6.6, the non-safety-related FW regulating valve (FWRV) is relied upon for backup to the failed FWIV. The FWRVs must be capable of closing under the conditions expected during the increase in feedwater flow event. The staff notes that the supplemental response to RAI 8888, Question 06.02.04-6, dated August 16, 2017, states that the FWRV meets the same flow requirements as the FWIVs; however, neither the FSAR nor the attached FSAR markup contains such information regarding the capability of the FWRVs.

Considering these observations, the staff is concerned about degraded heat removal capability via the DHRS should the level in both SG trains grow due to a more limiting initialization and/or a FWRV that may not close under the particular event conditions. Provide additional justification, such as sensitivity studies, that the SGs do not overfill and impede DHRS heat removal capability under the worst case conditions, and update the FSAR as necessary. In addition, add a statement to the FSAR such as the one provided in the supplemental response to RAI 8888, Question 06.02.04-6, mentioned above, that confirms the flow requirements for the FWRVs are equivalent to requirements for the FWIVs.

15.01.01-8

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 13 requires the provision of instrumentation to monitor variables and systems over their anticipated ranges of normal operation, and of appropriate controls to maintain listed variables and systems within prescribed operating ranges. GDC 15 requires that the RCS and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including AOOs. DSRS Section 15.1.1-15.1.4 provides the guidance for meeting GDC 10, 13, and 15, and directs the reviewer to review the sequence of events to determine the extent to which plant and reactor protection systems are required to function and the operation of engineered safety systems that is required, including time delays for actuation. In addition, the DSRS directs the reviewer to ensure a stabilized condition is reached.

The events in FSAR Sections 15.1.1-15.1.3 all result in DHRS actuation for post-trip core cooling, but some key assumptions related to DHRS cooling are not included in the FSAR. First, it is unclear when the DHRS valves open for these events relative to the actuation signal. In addition, the assumed reactor pool temperature and DHRS heat transfer bias (if any) are not provided. The staff notes that conditions that maximize heat removal by the DHRS would be the most consequential in terms of reaching a stabilized condition following reactor trip and DHRS actuation. Clarify the timing of the DHRS valve opening for FSAR Sections 15.1.1-15.1.3, and provide the reactor pool temperature and DHRS heat transfer bias assumed for the events. Update the FSAR to include these values.

15.01.01-9

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to ensure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 13 requires the provision of instrumentation to monitor variables and systems over their anticipated ranges of normal operation, and of appropriate controls to maintain listed variables and systems within prescribed operating ranges. GDC 15 requires that the RCS and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including AOOs. DSRS Section 15.1.1-15.1.4 provides the guidance for meeting GDC 10, 13, and 15, and directs the reviewer to review the sequence of events from initiation until a stabilized condition is reached as well as time-related variations of parameters such as coolant conditions and RCS pressure.

The staff notes that the figures of core inlet and core outlet temperatures provided in FSAR Sections 15.1.1-15.1.3 show coolant conditions increasing rather than stabilizing because of the time scale of the figures. Furthermore, FSAR Section 15.0.4 states, "Safety analyses of design basis events are performed from event initiation until a safe, stabilized condition is reached. A safe, stabilized condition is reached when the initiating event is mitigated, the acceptance criteria are met and system parameters (for example inventory levels, temperatures and pressures) are trending in the favorable direction. For events that involve a reactor trip, system parameters continue changing slowly as decay and residual heat are removed and the RCS continues to cool down. No operator action is required to reach or maintain a safe, stabilized condition." To allow the staff to make a finding with regard to conditions stabilizing for the events in FSAR Sections 15.1.1-15.1.3, provide the following figures on time scales sufficient to show the design reaches and maintains a stable condition, including any return to power from this specific event, and update the FSAR to include them:

- All core outlet temperature figures for FSAR Sections 15.1.1-15.1.3 (Figures 15.1-7, 15.1-17, and 15.1-28); alternatively, a figure of core average temperature for each event
- All total core reactivity figures for FSAR Sections 15.1.1-15.1.3 (Figures 15.1-4, 15.1-14, and 15.1-25)
- Reactor coolant system pressure for FSAR Section 15.1.3 (Figure 15.1-27)

In addition, the staff notes that FSAR Sections 15.1.2 and 15.1.3 refer to FSAR Section 15.0.6, "Evaluation of a Return to Power," for discussion on possible return to power scenarios. Because the return to power scenario is presented for a bounding cooldown event in 15.0.6, including ECCS actuation, and could result from various scenarios of power availability for the cooldown events in FSAR Section 15.1, add a reference in FSAR Section 15.1.1 to FSAR Section 15.0.6, similar to the ones in FSAR Sections 15.1.2 and 15.1.3.

15.01.01-10

GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded during any condition of normal operation, including the effects of AOOs. GDC 13 requires the provision of instrumentation to monitor variables and systems over their anticipated ranges of normal operation, and of appropriate controls to maintain listed variables and systems within prescribed operating ranges. GDC 15 requires that the RCS and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including AOOs.

The staff notes that FSAR Tier 2, Sections 15.1.1-15.1.3 contain several apparent typographical errors that affect technical meaning or details. These errors are listed below:

- FSAR Tier 2, Section 15.1.1.2 states that the steam outlet boundary is modeled as a constant mass flow. However, based on the staff's audit of engineering calculation (EC)-0000-2017, "Decrease in Feedwater Temperature Analysis" (the analysis supporting FSAR Section 15.1.1), the limiting case uses a constant steam pressure boundary.
- FSAR Tier 2, Section 15.1.1.2 discusses a decrease in FW event in the first sentence of the fourth full paragraph on Page 15.1-2 instead of a decrease in FW temperature event.
- FSAR Tier 2, Section 15.1.1.2 refers to steam flow events rather than a decrease in FW temperature event on Page 15.1-3.
- FSAR Tier 2, Section 15.1.1.3.3 states that the maximum secondary pressure is reached "just after" main steam and FW isolation, which seems inconsistent with FSAR Tier 2, Table 15.1-1, which shows that the maximum secondary pressure is actually reached 41 seconds after main steam and FW isolation.
- FSAR Tier 2, Section 15.1.2.3.3 states that SG pressure does not change significantly during the initial phase of the transient. However, based on FSAR Tier 2, Figure 15.1-18, the SG pressure increases rapidly prior to DHRS actuation.
- FSAR Tier 2, Section 15.1.3.3.3 states that reactor power reaches a peak at approximately 58 seconds for the increase in steam flow event. However, FSAR Tier 2, Table 15.1-5 shows that the peak reactor power is reached at 55 seconds.
- FSAR Tier 2, Table 15.1-5, "Sequence of Events (15.1.3 Increase in Steam Flow)," shows that the reactor trips on high hot leg temperature instantaneously instead of after the 8-second actuation delay specified in FSAR Tier 2, Table 15.0-7.
- FSAR Tier 2, Table 15.1-6, "Increase in Steam Flow - Inputs (Limiting Minimum Critical Heat Flux Ratio Case)," lists SG temperature as a parameter, when it appears it should be SG pressure.
- Figure 15.1-22, "Steam Flow (15.1.2 Increase in Steam Flow)," appears to be mistitled since the increase in steam flow event is described in FSAR Section 15.1.3.
- FSAR Tier 2, Figure 15.1-26 appears to be mistitled, as it shows reactor power but is titled "Total Core Reactivity."

The information in the design certification application that supports meeting the regulations (as cited above) needs to be precise and consistent so the staff is able to make a reasonable assurance finding. Please address the above items by either (1) updating the FSAR to correct them or (2) justifying why the information is correct.