From:	Getachew Tesfaye
Sent:	Saturday, March 2, 2024 9:35 AM
To:	Request for Additional Information
Cc:	Stacy Joseph; Mahmoud -MJ- Jardaneh; Griffith, Thomas; Sfowler@nuscalepower.com; NuScale-SDA-720RAIsPEm Resource
Subject:	NuScale SDAA Section 15.4.6 - Request for Additional Information No. 018 (RAI-10142-R1)
Attachments:	SECTION 15.4.6 - RAI-10142-R1-FINAL.pdf

Attached please find NRC staff's request for additional information (RAI) concerning the review of NuScale Standard Design Approval Application for its US460 standard plant design (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23306A033).

Please submit your technically correct and complete response by the agreed upon date to the NRC Document Control Desk.

If you have any questions, please do not hesitate to contact me.

Thank you,

Getachew Tesfaye (He/Him)
Senior Project Manager
NRC/NRR/DNRL/NRLB
301-415-8013

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Options
Priority: Normal
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:

REQUEST FOR ADDITIONAL INFORMATION No. 018 (RAI-10142-R1)
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
NUSCALE STANDARD DESIGN APPROVAL APPLICATION
DOCKET NO. 05200050
CHAPTER 15, "TRANSIENT AND ACCIDENT ANALYSES"
SECTION 15.4.6, "INADVERTENT DECREASE IN BORON CONCENTRATION IN THE REACTOR COOLANT SYSTEM"
ISSUE DATE: 03/02/2024

Background

By letter dated October 31, 2023, NuScale Power, LLC (NuScale or the applicant), submitted Part 2, Final Safety Analysis Report, (FSAR), Chapter 15, "Transient and Accident Analysis," Revision 1 (Agencywide Documents Access and Management System Accession No. ML23304A365) of the NuScale Standard Design Approval Application (SDAA) for its US460 standard plant design. The applicant submitted the US460 plant SDAA in accordance with the requirements of Title 10 *Code of Federal Regulations* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Subpart E, "Standard Design Approvals." The NRC staff has reviewed the information on inadvertent decrease in boron concentration in the reactor coolant system (RCS) provided in Chapter 15, Section 15.4.6, of the FSAR and determined that additional information is required to complete its review.

Question 15.4.6-1

Regulatory Basis

10 CFR 52.137(a)(4) states a standard design application must include "[a]n analysis and evaluation of the design and performance of SSC with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of SSCs provided for the prevention of accidents and the mitigation of the consequences of accidents."

GDC 10, "Reactor Design," states 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 are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

GDC 13, "Instrumentation and Control," states that instrumentation shall be provided to monitor variables and systems over their anticipated ranges for anticipated operational occurrences as appropriate to assure adequate safety. It further states that appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

GDC 26, "Reactivity Control System Redundancy and Capability," states that a reactivity control system shall be provided that is capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with

appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded.

Issue

Malfunction of the NPM-20 chemical and volume control system or operator error could result in inadvertent addition of diluted or unborated water to the reactor coolant system (RCS). Such an addition will dilute boron in the RCS coolant and may result in a loss of shutdown margin, preventing the reactivity control system from performing its safety function and satisfying associated regulatory requirements such as General Design Criteria 10, 13, and 26.

FSAR Section 15.4.6 evaluates these inadvertent boron dilution transients. The at-power evaluation credits automatic isolation of the demineralized water system (DWS) via the module protection system to terminate the dilution. Supporting documents, examined by the staff via audit, indicate that the DWS is isolated by an assumed operator response which terminates inadvertent boron dilution transients initiated later in the cycle, but do not specify whether the module protection system would isolate the DWS to terminate these cases before shutdown margin is lost if the operator response is not assumed consistent with the automatic response of the current US460 design.

Guidance in SRP 15.4.6 describes supporting information and analysis typically provided by active operating reactors if operator action is relied upon to mitigate a boron dilution transient, such as redundant alarms that alert the operator to the unplanned boron dilution and the event sequence that provides operators the shortest time to isolate dilution sources. Additional information is needed to support credit for operator action as NuScale's NPM-20 passive design and its approach to design basis event mitigation differs significantly from operating reactors.

Information Requested

Provide the analysis of the Mode 1 boron dilution event(s) which demonstrates that the module protection system isolates DWS before shutdown margin is lost without reliance on operator intervention. Operator intervention at any time within the 72 hours following the initiating event would constitute a reliance on that operator action to mitigate the event. This analysis should ensure that limiting times-in-cycle are evaluated with consideration of whether loss of shutdown margin occurs before DWS isolation by the module protection system.

Alternately, to enable staff review of the adequacy of the current Mode 1 analysis documented in FSAR 15.4.6 and staff assessment of the use of operator actions, provide the following information in the FSAR: 1) identification and description of redundant instrumentation and control room alarms that alert the operators of an unplanned boron dilution, 2) a listing of the specific operator actions necessary to terminate the event and the total time required (the event duration is considered to include the time from the initiating event through the following 72 hours), and 3) the event sequence and timing with the smallest elapsed time from the signal generated and control room alarm detecting the dilution event to the time a loss of shutdown margin would occur.

The Mode 1 analysis should ensure that limiting (with respect to available time for operator action) times-in-cycle are evaluated. Revise the FSAR with pertinent portions of the analysis and supporting information, including revisions to protection system signals and setpoints, description of control room alarms and indications, and discussions of assumed operator

response during the 72 hours following the initiating event in FSAR Chapters such as 7, 15, 18, and 19.

Question 15.4.6-2

Regulatory Basis

10 CFR 52.137(a)(4) states a standard design application must include "[a]n analysis and evaluation of the design and performance of SSC with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of SSCs provided for the prevention of accidents and the mitigation of the consequences of accidents."

GDC 10, "Reactor Design," states 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 are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

GDC 13, "Instrumentation and Control," states that instrumentation shall be provided to monitor variables and systems over their anticipated ranges for anticipated operational occurrences as appropriate to assure adequate safety. It further states that appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

Issue

The NPM-20 design relies on boron concentration limits in the US460 reactor building pool to ensure the reactor core remains subcritical during refueling. Internal flooding could result in the inadvertent addition of diluted or unborated water to the pool. Such an addition will reduce the pool boron concentration and may lead to inadvertent criticality, challenging specified acceptable fuel design limits described in General Design Criteria 10. In the refueling configuration, the reactor pressure vessel and containment vessel are disassembled and do not serve as fission product barriers.

FSAR Section 15.4.6 evaluates inadvertent boron dilution during refueling (Mode 5) conditions. The evaluation considers whether internal flooding sources add quantities of diluted or unborated water that induce criticality. The volume of diluted or unborated water added by each internal flooding source is assessed in the internal flooding analysis described in FSAR Chapter 3, which indicates that internal flooding sources are isolated by an assumed operator response. NRC staff examined this analysis via audit and determined that margin to acceptance criteria is highly sensitive to the timing of operator action. However, the FSAR Chapter 15 safety analysis does not allow credit for operator action in the first 72 hours of design basis events as the US460 is a passive plant design.

Information Requested

Provide an analysis of the Mode 5 boron dilution transient which demonstrates that subcriticality is maintained for the limiting source of unborated water without reliance on operator intervention. Operator intervention at any time within the 72 hours following the initiating event would constitute a reliance on that operator action to mitigate the event. Revise the FSAR with pertinent portions of the analysis, such as the limiting internal flood volume, flood sources

evaluated, alternate flooding analysis assumptions, design features and SSCs credited in lieu of operator response to isolate the flood source, and assumptions pertinent to event timing and boron mixing throughout regions of the pool.

Alternately, to enable staff assessment of the use of operator actions, provide the following information in the FSAR: 1) identification and description of redundant instrumentation and control room alarms that alert the operators of an unplanned boron dilution, 2) for each flood source requiring operator intervention, a listing of the specific operator actions necessary to terminate the flooding events or otherwise maintain subcriticality, and the total time required (the event duration is considered to include the time from the initiating event through the following 72 hours), and 3) the event sequence and timing with the smallest elapsed time from the signal generated and control room alarm detecting the dilution event to the time inadvertent criticality would occur. Revise pertinent FSAR Chapters, such as 7, 15, 18, and 19, to include relevant details for control room indication and alarms, and assumed operator response during the 72 hours following the initiating event for the analysis of inadvertent boron dilution during refueling (Mode 5) conditions.