RAIO-0717-54951

July 18, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 41 (eRAI No. 8844) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 41 (eRAI No. 8844)," dated May 26, 2017

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 8844:

- 15.04.06-2

The response to the remaining questions in the referenced RAI will be provided by September 14, 2017.

This letter and the enclosed response make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

Zackary W. Rad
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8844

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Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8844

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Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 8844
Date of RAI Issue: 05/26/2017

NRC Question No.: 15.04.06-2

In accordance with 10 CFR 50 Appendix A GDC 10, “Reactor design,” 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.

To meet the requirements of GDC 10, as they relate to an inadvertent boron dilution event challenging specified acceptable fuel design limits (SAFDLs), the analysis should be completed using suitably conservative parameters as specified in Standard Review Plan (SRP) Section 15.4.6, SRP Acceptance Criteria 5.

In FSAR Tier 2, Section 15.4.6.2, “Sequence of Events and Systems Operation,” the applicant states that below 50 percent power, two pump operation is not allowed; however, the applicant does not explain why two pump operation is not allowed below 50 percent power. The staff notes that having two makeup pumps supplying dilution flow to the RCS could result in more severe consequences. The staff could not find any technical specification control regarding makeup pump operation and could not determine from FSAR Tier 2, Section 9.3.4, “Chemical and Volume Control System,” any reason why two pump operation would not be allowed below 50 percent power. Based on the docketed information, the staff is unable to determine if the applicant’s analysis presented in FSAR Tier 2, Section 15.4.6 uses suitably conservative parameters. The staff requests the applicant to provide additional information justifying why two pump operation is not allowed below 50 percent power to support its current analysis. The staff further requests the applicant to modify the FSAR as necessary to address this question.

NuScale Response:

The boron dilution analyses in FSAR Tier 2, Section 15.4.6 assume that for initial power levels below 50% power, the flowrate from the Chemical and Volume Control System (CVCS) makeup pumps does not exceed 25 gpm. The text in FSAR Section 15.4.6 incorrectly states that below 50% power, only one CVCS makeup pump is allowed to operate. The 25 gpm limit is based on the maximum capacity of one makeup pump with an added uncertainty of 5 gpm. The text in FSAR Section 15.4.6 is revised to clarify that the dilution flow rate is restricted. The discussion

about the letdown and makeup flow rates was revised to add clarity.

Part 4, Technical Specifications, Section 3.1.9 and Section B 3.1.9 were also revised to include this limit on the CVCS makeup pumps demineralized water flow path flowrate.

Impact on DCA:

FSAR Section 15.4.6.2 and Part 4, Technical Specifications Section 3.1.9, B 3.1.9 have been revised as described in the response above and as shown in the markup provided in this response.

15.4.6 Inadvertent Decrease in Boron Concentration in the Reactor Coolant System

15.4.6.1 Identification of Causes and Accident Description

A malfunction in the chemical volume and control system (CVCS) or an operator error could result in unborated or diluted water being inadvertently added to the RCS. In the NuScale design, a boric acid blend system allows the operator to match or adjust the boron concentration of the reactor coolant makeup water during normal operation. Boron dilution can be either an automatic or a manual operation. In either case, the dilution is governed by administrative controls with procedures that establish the limits on the rate and duration of dilution. An unintended decrease in boron concentration increases the reactivity of the core and decreases the shutdown margin.

The module protection system (MPS) is designed to isolate the demineralized water source prior to the loss of a significant portion of the technical specification minimum shutdown margin. The MPS automatically isolates the demineralized water source on high subcritical multiplication, low RCS flow, and any reactor trip system (RTS) actuation. The CVCS is disconnected from the RCS during Mode 4 (transition) and Mode 5 (refueling), but the refueling mode is evaluated to make sure that it bounds the effects of other possible dilution sources present during the refueling process.

An inadvertent decrease in boron concentration in the RCS is expected to occur one or more times during the lifetime of the reactor, and is classified as an AOO.

15.4.6.2 Sequence of Events and Systems Operation

An inadvertent decrease in boron concentration in the RCS is evaluated for Modes 1, 2, 3, and 5. Boron dilution causes an increase in reactivity, and the plant response to the event is similar to an uncontrolled CRA withdrawal, presented in Section 15.4.1 and Section 15.4.2. The limiting CVCS dilution source considered in this analysis is the demineralized water system (DWS) supply. To reduce the overall probability of boron dilution events, administrative controls are placed on the boron addition system supply to the CVCS makeup pumps, assuring that it is not a dilution source for the RCS or the refueling pool.

Unless specified in this section, the RCS boron dilution evaluation assumes the plant control systems and engineered safety features perform as designed, with allowances for instrument inaccuracy. No operator action is credited to mitigate the effects of an RCS boron dilution event.

RAI 15.04.06-2

The CVCS has two variable speed positive displacement makeup pumps that supply the RCS with makeup coolant and change RCS boron concentration by supplying blended makeup water. Each makeup pump has a maximum capacity of 20 gpm. Normally one pump is operated at a time and the other is provided for redundancy. In most cases, normal power operations require no more than 20 gpm but it is possible to run both makeup pumps at the same time above 50 percent power. ~~Below 50 percent power, two pump operation is not allowed.~~ Therefore, the maximum possible CVCS makeup flow rate is supplied by running two makeup pumps with a maximum capacity

of 40 gpm. For conservatism, the analysis applies an additional 5 gpm uncertainty to the makeup flow rates for each pump (25 gpm/pump). Below 50 percent power, the demineralized water flowrate from the CVCS makeup is limited to 25 gpm. To prevent reactor trip on high pressurizer pressure or level, the ~~maximum~~ CVCS letdown mass flow rate is ~~assumed to be~~ maintained equal to the ~~maximum~~ makeup flow rate.

The regulating CRA bank is not credited with mitigating the reactivity insertion associated with a boron dilution of the RCS. Each of the two regulating bank groups is assumed to be at their respective PDIL so that rods do not insert automatically as a result of the reactivity addition of an RCS boron dilution.

To preclude the possibility of boron dilution when a CRA is stuck out during Modes 2 and 3, administrative controls require the isolation of the DWS supply valves until the stuck CRA has been fully inserted.

A boron dilution event could occur during refueling operation (Mode 5) if unborated water is unexpectedly introduced to the reactor building pool. Table 15.4-9 provides possible reactor building internal flooding sources with estimated water volumes that could introduce unborated water to the pool. It is assumed that the flooding source immediately enters the pool and mixes perfectly and instantaneously to provide the maximum boron dilution rate.

A loss of normal power is considered during Modes 1 and 5. The loss of alternating current (AC) power during Mode 5 results in the loss of the reactor pool cooling and recirculation system. To accommodate the loss of pool cooling circulation, the initial minimum pool mixing volume assumed in the analysis is further reduced for conservatism. In Mode 1 operation, the loss of power scenarios are non-limiting.

- Loss of normal AC - In this scenario, MPS remains powered so none of the safety systems are automatically actuated. The feedwater pumps, pressurizer heaters, the turbine stop valve, and CVCS pumps (recirculation and makeup) are assumed to fail. By securing CVCS, the dilution event is terminated and ends the event earlier than if the pumps were allowed to continue to operate.
- Loss of normal direct current (DC) power system and loss of normal AC - Power to the reactor trip breakers is provided by the normal DC power system so this scenario is the same as a loss of normal AC scenario with the addition of the reactor trip at the time at which power is lost. For the boron dilution event, this scenario is non-limiting for the reasons listed above.
- Loss of highly reliable DC power system, normal DC power system, and loss of normal AC - Power to the MPS is provided via the highly reliable DC power system so this scenario results in an actuation of a reactor trip and all of the engineered safety functions. In terms of boron dilution event, this scenario is non-limiting for the reasons discussed above. Also, the CVCS demineralized water supply isolation valves are normally held open with instrument air. Upon loss of instrument air or power, the valve returns to a closed state by a passive force. The closed position is the safe position for the demineralized water isolation valves since it isolates the dilution path.

3.1 REACTIVITY CONTROL SYSTEMS

3.1.9 Boron Dilution Control

LCO 3.1.9 Two CVCS demineralized water isolation valves shall be OPERABLE.

AND

Boric Acid Storage Tank boron concentration shall be within the limits specified in the COLR.

AND

Maximum CVCS makeup pump demineralized water flow path flowrate is within the limits specified in the COLR.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One CVCS demineralized water isolation valve inoperable.	A.1 Restore CVCS demineralized water isolation valves to OPERABLE status.	72 hours
B. Required Action and associated Completion Time not met. OR Two CVCS demineralized water isolation valves inoperable. OR	B.1 ----------NOTE---------- Flow path(s) may be unisolated intermittently under administrative controls. ---------- Isolate dilution source flow paths in the CVCS makeup line by use of at least one closed manual or one closed and de-activated automatic valve.	1 hour

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. (continued) Boric Acid Storage Tank not within limits. OR CVCS makeup pump demineralized water flow path not configured to ensure maximum flowrate is within limits.		

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.9.1	Verify that CVCS makeup pump demineralized water flow path is configured to ensure that it remains within the limits specified in the COLR.	In accordance with the Surveillance Frequency Control Program
SR 3.1.9.2~~1~~	Verify each CVCS demineralized water isolation valve that is not locked, sealed, or otherwise secured in the isolated position, actuates to the isolated position on an actual or simulated signal.	In accordance with the Surveillance Frequency Control Program
SR 3.1.9.3~~2~~	Verify Boric Acid Storage Tank boron concentration to be within the limits specified in the COLR.	In accordance with the Surveillance Frequency Control Program
SR 3.1.9.4	Verify each CVCS makeup pump maximum flowrate is ≤ 25 gpm.	In accordance with the Surveillance Frequency Control Program

BASES

APPLICABLE SAFETY ANALYSES (continued)

The RTS actuation initiates a signal to isolate the demineralized water isolation valves to support a reactor trip. The demineralized water isolation valves prevent the only designed source of dilution water from contributing to events when these conditions exist. The analysis for an inadvertent boron dilution event assumes that the diluting flow is from the demineralized water source, however the boric acid storage tank also supplies flow to the CVCS. Controlling the boron concentration in the boric acid storage tank ensures that it is not a source of dilution water. Thus the boric acid storage tank boron concentration is an assumption of the boron dilution accident.

Another initial assumption of the inadvertent boron dilution event (Ref. 1) is that the maximum CVCS dilution flow is limited at reduced power levels. The lowest maximum acceptable demineralized water flow rate is that provided by one CVCS makeup pump. And the maximum acceptable demineralized water flow rate varies with core design and boron concentration in the RCS. The initial safety analysis assumption limits maximum flow to that provided by a single makeup pump, however analyses may be performed consistent with approved methodologies listed in TS 5.6.3, "Core Operating Limits Report" to permit adjustments to the maximum demineralized water flow limit as a function of core design and boron concentration in the RCS.

CVCS demineralized water isolation valves satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii). The boron concentration in the boric acid storage tank satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

The requirement that two demineralized water isolation valves be OPERABLE assures that there will be redundant means available to terminate an inadvertent boron dilution event. The requirement that the boron concentration of the boric acid storage tank be maintained within the limits specified in the COLR ensures that the tank is not a source to the CVCS that could result in an inadvertent boron dilution event.

The limits on maximum CVCS makeup pump demineralized water flow path flowrate are established by restricting the flow that can be provided during system operation to within the limits in the COLR. The restrictions may be implemented by use of at least one closed manual or one closed and de-activated automatic valve, or by removing the power supply from one CVCS makeup pump.

BASES

APPLICABILITY

The requirement that two demineralized water isolation valves be OPERABLE, and that the boric acid storage tank boron concentration and maximum CVCS makeup pump demineralized water flow path flowrate is within the limits specified in the COLR is applicable in MODES 1, 2, and 3. In these MODES, a boron dilution event is considered possible, and the automatic closure of these valves is assumed in the safety analysis. The boron concentration of the boric acid storage tank is not assumed to be capable of causing a dilution event by the boron dilution event analysis. The maximum CVCS makeup pump demineralized water flow path flowrate is an assumption of the boron dilution event.

In MODE 1 less than 15% RTP, the detection and mitigation of a boron dilution event would be signaled by a High Source or Intermediate Range Log Power Rate or a High Source Range Count Rate.

In MODE 1 greater than≥ 15% RTP, the detection and mitigation of a boron dilution event would be signaled by a High Power Range Rate or High Power Range Linear Power.In MODES 2 and 3, the detection and mitigation of a boron dilution event would be signaled by a Source Range High Count Rate trip, a trip on Source Range High Log Power Rate, or a trip on High Subcritical Multiplication, or low RCS flow.

In MODES 4 and 5, a dilution event is precluded because the CVCS flow path is not connected to the normal CVCS, thus eliminating the possibility of a boron dilution event. Pool volume is sufficient to minimize the potential for boron dilution during MODE 5 within the surveillance intervals provided by LCO Ultimate Heat Sink, 3.5.3.

ACTIONS

A.1

If one CVCS demineralized water isolation valve is inoperable, the valve must be restored to OPERABLE status in 72 hours. The allowed Completion Time is considered acceptable because the safety function of automatically isolating the dilution source can be accomplished by the redundant isolation valve.

BASES

ACTIONS (continued)

B.1

If the Required Action and associated Completion Time is not met, or if both CVCS demineralized water isolation valves are not OPERABLE (i.e., not able to be closed automatically), then the demineralized water supply flow path to the RCS must be isolated to preclude a boron dilution event. Isolation can be accomplished by manually isolating the CVCS demineralized water isolation valve(s) or by positioning the manual 3-way combining valve to only take suction from the boric acid tank. Alternatively, the dilution path may be isolated by closing appropriate isolation valve(s) in the flow path(s) from the demineralized water storage tank to the RCS.

If the boric acid concentration in the boric acid storage tank ~~is~~or if the CVCS makeup pump demineralized water flow path flowrate are not within the limits specified in the COLR, then the flow path to the RCS must be isolated to preclude a boron dilution event.

The Required Action is modified by a Note allowing either flow path to be unisolated intermittently under administrative controls. These administrative controls consist of stationing a dedicated operator at the valve controls, who is in continuous communication with the main control room. In this way, the flow path can be rapidly isolated when a need for isolation is indicated.

SURVEILLANCE REQUIREMENTS

SR 3.1.9.1

This Surveillance verifies that CVCS makeup pump demineralized water flow path is configured to ensure that the maximum dilution flow rate that can exist during makeup pump operation remains within the limits specified in the COLR. The Surveillance accomplishes this by assuring that when the maximum demineralized water flowrate is restricted to that of a single CVCS makeup pump, at least one closed manual or one closed and de-activated automatic valve is correctly configured, or verifying that the power supply has been removed from one CVCS makeup pump. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.1.9.2~~1~~

This Surveillance demonstrates that each automatic CVCS demineralized water isolation valve actuates to the isolated position on an actual or simulated actuation signal. This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the isolated position under administrative controls. The actuation logic is tested as part of Engineered Safety Features Actuation System Actuation and Logic testing, and valve performance is monitored as part of the INSERVICE TESTING PROGRAM.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.1.9.3~~2~~

This Surveillance ensures that the boric acid storage tank is not a potential source of dilution water.

Boron concentration in the tank is verified to be within the limits specified in the COLR by periodic measurement.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.1.9.4

This Surveillance verifies that CVCS makeup pump maximum flowrate is ≤ 25 gpm. The lowest maximum makeup pump demineralized water flowrate that can be used while in operation is that of one CVCS makeup pump as assumed in the boron dilution analysis. The Surveillance verifies the maximum flowrate of each CVCS makeup pump is consistent with the analysis assumptions. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

REFERENCES

1. FSAR Chapter 15, “Transient and Accident Analysis.”