RAIO-0118-58173

January 15, 2018

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
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Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 9129 (eRAI No. 9129) on the NuScale Topical Report, "Subchannel Analysis Methodology," TR-0915-17564, Revision 1

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9129 (eRAI No. 9129)," dated November 17, 2017
2. NuScale Topical Report, "Subchannel Analysis Methodology," TR-0915-17564, Revision 1, dated February 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. 9129:

- 04.04-13

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. 9129

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9129

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9129
Date of RAI Issue: 11/17/2017

NRC Question No.: 04.04-13

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 using a subchannel analysis methodology for determining the thermal margin available for the NuScale design in steady-state and transient events, the applicant’s methodology should clearly define and justify the approach used for axial power assumptions in all steady state and transient events.

Part 1: In topical report section 3.10.9, the applicant states that "for the events involving control rod motion (SRP Section 15.4), an event-specific nuclear analysis is performed to determine control rod worth, radial power distribution, and axial power distribution." However, in the NuScale subchannel analysis methodology audit, the applicant stated that for all SRP Section 15.4 analyses, excluding the single rod withdrawal event, the axial power shape used is the CHF-limiting axial power shape from the generic axial power shape analysis, which is detailed in topical report Section 3.10.8. Furthermore, for the single rod withdrawal event, the applicant stated in the audit that the axial power shape used here is the post-rod movement axial shape as opposed to the more conservative initial condition power shape; the staff believes the use of the post-rod movement axial shape would be the conservative axial power shape choice. The staff asks the applicant to clarify in the topical report which axial power shape methodology is used for any and all 15.4 events (e.g. does the axial power shape come from an event specific nuclear analysis or is the axial power shape that which comes from the generic axial power shape analysis detailed in topical report section 3.10.8). The staff further asks the applicant to justify in the topical report why the specified axial power shape methodology for use in any and all 15.4 analyses is conservative.

Part 2: In topical report section 3.10.9, the applicant states that "if a permissible normal operation power swing results in the core-average axial power shape at the edges of the [axial offset] window, then once rods leave the core for an uncontrolled bank withdrawal or single rod withdrawal, the core-average axial power shape has the potential to go beyond the AO limits. The potential to exceed the AO limits is for a brief amount of time; however, this would be unanalyzed space from the axial power shapes analysis." The staff understands that there is potential for the AO window to be exceeded and that this would constitute unanalyzed space for performing a subchannel analysis that uses an axial power shape from the generic axial power shape analysis because the applicant did not originally consider axial power shapes outside of the AO window in the generic axial power shape analysis. The staff asks the applicant to identify all events for which the AO window could be exceeded and provide justification for why the chosen axial power shape is conservative.

NuScale Response:

Part 1:

Additional clarification and justification is provided in an attached markup of Section 3.10.9 of the topical report, which specifies the conservatism in the axial power shape for Section 15.4 analyses. The markup summarizes that a nuclear analysis is performed for each of the Standard Review Plan (SRP) 15.4 events that involve control rod motion. This nuclear analysis determines the post-event axial power shape and is the conservative axial power shape for analyzing the event. In some cases, the transients that have available margin can be analyzed with a bounding, even more limiting axial power shape. The event initiating power level axial power shape from the generic axial power shapes analysis is more conservative than the post-event axial power shape. In all cases, the flux shape used in the analysis is conservative for the event and is held constant throughout the transient.

Part 2:

Events that are characterized by control rod movement and have the potential to exceed the axial offset window are: Uncontrolled Control Rod Assembly Withdrawal from Subcritical (SRP 15.4.1), Uncontrolled Control Rod Assembly Withdrawal at Power (SRP 15.4.2), Control Rod Misoperation (SRP 15.4.3), and Rod Ejection (SRP 15.4.8). Rod Ejection (TR-0716-50350, Rod Ejection Accident Methodology) is outside of the scope of the subchannel analysis methodology topical report. The analysis of events that exceed the axial offset window is conservative for the reasons described in Part 1 of this response. Content is added to Section 3.10.9 and Section 4.8 of the topical report for clarification.

Impact on Topical Report:

Topical Report TR-0915-17564, Subchannel Analysis Methodology, has been revised as described in the response above and as shown in the markup provided in this response.

The CHF limiting axial power shape (based on core-average axial power) is sufficient to be used for most transient analyses. For the transients that are not characterized by control rod motion (non-SRP 15.4 events), the core-average axial power shape does not deviate significantly from the shapes already considered within the power shapes analysis, and therefore the subchannel limiting axial power shape is appropriate. The combination of the core-average axial power shape of initiating power level with the conservative radial power distribution and the system flow boundary conditions provides a conservative MCHFR calculation.

3.10.9 Standard Review Plan Section 15.4 Analyses

For the events involving control rod motion (SRP Section 15.4), an event-specific nuclear analysis is performed to determine control rod worth, radial power distribution ($F_{\Delta H}$ augmentation factor), and axial power distribution. The initial conditions for control rod motion transients start from the edges of the AO window as the edge of the window is a permissible condition prior to an event actuation. If a permissible normal operation power swing results in the core-average axial power shape at the edges of the window, then once rods leave the core for an uncontrolled bank withdrawal (UCBW) or single rod withdrawal, the core-average axial power shape has the potential to go beyond the AO limits. The potential to exceed the AO limits is for a brief amount of time; however, this would be unanalyzed space from the axial power shapes analysis. This is the reason for the necessity ofAn event-specific nuclear analysesanalysis to provides axial power shapes for the post-transient rod position condition in addition to radial peaking augmentation (if applicable) and control rod worth information for specific transients.

The specific design basis events in SRP sections 15.4.1, 15.4.2, 15.4.3, and 15.4.8 are control rod reactivity movement events which have an event-specific nuclear analysis that determines the post-event axial power shape.

For the control rod movement events (e.g. SRP 15.4.1, 15.4.2, 15.4.3, and 15.4.8) that have significant margin, the generic axial power shape (discussed in Section 3.10.8) for the initiating power level may be used for conservatism. As shown in Figure 3-8, the example NuScale axial offset window gets wider as power decreases, allowing higher magnitude axial peaking; thus the limiting generic axial power shape for the pre-event power level applied throughout the event is more limiting than the axial power shape after the event.

DetailMore specific detail is provided in Sections 4.7 to 4.10 as to what axial power shape is assumed for control rod reactivity design-basis events.

3.11 Numerical Solution

As discussed further in Section 5.1.2, VIPRE-01 has three solution schemes that are available for use: direct solution, iterative solution, or the RECIRC solution. The direct and iterative schemes require the flow to always be positive (upward), while the more robust RECIRC solution can accommodate localized reverse flow. The RECIRC solution

The key result of the misload subchannel analysis is the maximum allowed radial peaking augmentation factor. Each cycle-specific nuclear analysis confirms that the maximum augmentation factor calculated is not violated.

4.8 Uncontrolled Bank Withdrawal at Power (SRP Section 15.4.2)

The UCBW transient is characterized as an increase in power from the positive reactivity addition by the control rod withdrawal. The core power increase and the mismatch with the steam demand results in an increase in core temperature and MCHFR is challenged.

The transient analysis considers a spectrum of reactivity insertion rates for the positive reactivity addition by the control rods. The power range neutron excore detectors provide high power and high flux rate core protection. For cases in which the reactivity insertion is sufficiently slow, the high pressurizer pressure and level setpoints are credited in the analysis.

A spectrum of insertion rates are evaluated with maximum and minimum reactivity feedbacks because the reactor trips and timing of the trips that mitigate the event are different. Different power levels are also evaluated to ensure the adequacy of the trip logic availability to prevent MCHFR.

For NuScale subchannel analysis, the $F_{\Delta H}$ power distribution used for the control bank withdrawal is symmetric, meaning that the power distribution developed in the basemodel is applicable. For the UCBW events that are initiated at a partial power, an augmentation factor for the increased allowable $F_{\Delta H}$ radial peaking is applied. This is performed as discussed in Section 3.10.90 using Eq. 3-6 and Eq. 3-7. The default axial power shape used is the initial core average shape at the initiating power level, however, a post-event core average limiting axial power shape may be used to reduce excessive conservatism present in the initial condition shape from the initial (lower) power level. As discussed in Section 3.10.9, the event specific nuclear analysis determines the axial power shape after rod movement.

4.9 Uncontrolled Bank Withdrawal at Subcritical or Low Power (SRP Section 15.4.1)

The uncontrolled bank withdrawal at subcritical (UCBWS) or low power event is similar to UCBW at power, except the event can result in a rapid insertion of positive reactivity. This event is characterized as a fast transient as it is limited in power excursion due to Doppler feedback. This feedback limits the power of the event enough that even with delays in the module protection system, the transient is terminated by a reactor trip.

The radial power distribution is symmetric for the bank withdrawal event, meaning that an augmentation factor for power asymmetry is not necessary. However, because the operating limit $F_{\Delta H}$ peaking factor for HZP is larger than the HFP value, the power distribution must be adjusted. Additionally, at zero power, the PDIL-ARO augmentation factor is larger than at full power. Because the peak-to-average ratio used in setting the $F_{\Delta H}$ power distribution remains valid for the low power cases, a simple multiplier is used