RAIO-1218-63997

December 31, 2018

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 9580 (eRAI No. 9580) on the NuScale Topical Report, "Evaluation Methodology for Stability Analysis of the NuScale Power Module," TR-0516-49417, Revision 0

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9580 (eRAI No. 9580)," dated October 31, 2018
2. NuScale Topical Report, "Evaluation Methodology for Stability Analysis of the NuScale Power Module," TR-0516-49417, Revision 0, dated July 2016

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

The Enclosures to this letter contain NuScale's response to the following RAI Question from NRC eRAI No. 9580:

- 15.09-15

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9580 (eRAI No. 9580). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

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

If you have any questions on this response, please contact Paul Infanger at 541-452-7351 or at pinfanger@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9580, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9580, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-1218-63998

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9580, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9580, nonproprietary

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9580
Date of RAI Issue: 10/31/2018

NRC Question No.: 15.09-15

Title 10 of the Code of Federal Regulations (10CFR), Part 50, Appendix A, General Design Criterion (GDC) for Nuclear Power Plants - Criterion 12—Suppression of reactor power oscillations requires that oscillations be either not possible or reliably detected and suppressed. The Design-Specific Review Standard (DSRS), 15.9.A, "Design-Specific Review Standard for NuScale SMR Design, Thermal Hydraulic Stability Review Responsibilities," indicates that the applicant's analyses should correctly and accurately identify all factors that could potentially cause instabilities and their consequences. The analyses should also demonstrate that design features that are implemented prevent unacceptable consequences to the fuel. The Standard Review Plan (SRP) 15.0.2 acceptance criteria with respect to accident scenario identification states that the process must include evaluation of physical phenomena to identify those that are important in determining the figure of merit for the scenario.

In section 4.4, "Phenomena Identification and Ranking Table (PIRT)," of the topical report (TR), TR-0516-49417-P, the TR states, under the Table 4.1 {{

}}2(a),(c) However, the applicant's response to RAI 9093 Question 01-39, indicates that secondary side instability is not precluded by design {{ }}2(a),(c). The original response to RAI 9093, states "The maximum acceptable level of secondary flow oscillation magnitude (OM) is limited to 10% about the mean value as determined by the mass flow rate at the SG tube inlet". Similarly, the response to RAI 9158 states {{

}}2(a),(c) In contrast, the revised (final) response to RAI 9093 removed the {{ }}2(a),(c) and does not provide an alternative quantification for "maximum acceptable level of secondary flow oscillation magnitude," nor defines "acceptable limit."

RAI 9158 indicates that {{

}}2(a),(c). RAI 9158 also states {{

}}2(a),(c) However, if the secondary side can become unstable without limits on the secondary side oscillation magnitude, the secondary side can be expected to become unstable during conditions of normal operation, and for oscillations that occur during the instability to grow beyond the linear range into the non-linear range. As these unstable secondary side oscillations grow beyond the linear range, the non-linear characteristics can result in changes in the time-average heat removal characteristics of the secondary side – leading to the potential for dramatic fluctuations in the primary side temperature, flow and power. The consequences of such flow oscillations must be evaluated to ensure that thermal margin is maintained and the staff's requirements with respect to GDC 12 are met.

In order to make an affirmative finding associated with the above regulatory requirement important to safety, NRC staff requests NuScale to:

1. Define the acceptable limit of secondary flow oscillation by providing a quantitative envelope. If the acceptable limit is not defined in terms of oscillation magnitude, the staff requests that NuScale provide this limit and explain how the limit relates to the flow oscillation magnitude.

2. The final response to RAI 9093 Question 01-39 describes a maximum acceptable level of secondary flow oscillation that appears to be a condition for approval of the long term stability solution. Update the topical report, TR-0516-49417-P, to clarify that whether or not the applicability is conditional to any COL applicant or licensee confirming that the maximum level of secondary flow fluctuation is within the acceptable limit(s) described in the response to this RAI.

3. Provide an evaluation of both in-phase and out-of-phase flow oscillations that considers oscillatory behavior in the non-linear regime and quantify the impact on reactor coolant system flow from large amplitude, non-linear secondary side oscillations of sufficient limit-cycle oscillation magnitude to cover the range of operation allowed by the acceptable limits described in the response to this RAI. It is acceptable to the staff for the applicant to provide the results of calculations using PIM that show the magnitude of the primary side flow oscillation where a bounding secondary oscillation is imposed as a boundary condition

so long as the bounding boundary condition is consistent with, or conservative with respect to, the acceptable limits as defined by the response to this RAI.

The response to RAI 9093 Question 01-39 does not address the staff's original question posed in that RAI. The original question requested NuScale to describe the process for demonstrating compliance with the applicant's previous requirement, which was that SG tubes are designed with sufficiently tight inlet orifices to preclude density wave instability. The final RAI response to RAI 9093 changes the current TR and DCD requirement that "instability is precluded" to a new unspecific requirement that, "flow fluctuations are maintained within acceptable limits."

According to the applicant's final response to RAI 9093 Question 01-39, flow oscillations on the secondary side of the steam generator (SG) will be allowed, rather than excluded. The applicant states that oscillations will be confined to acceptable limits that are yet to be determined. If the SG tubes are no longer inherently stable, it is conceivable that a secondary side system design could further destabilize the secondary side; which would allow in-phase flow oscillation and for these oscillations to achieve a greater oscillation magnitude when compared to that achieved by individual tubes.

4. Describe how compliance with the acceptable limits is demonstrated or maintained. The staff has identified four compliance options organized around different principles: 1.) passive design features, 2.) active design features, 3.) analytical demonstration, and 4.) experimental demonstration. The NRC staff requests NuScale to explain how any one of these principles is used demonstrate or maintain compliance within the acceptable limits and update the TR:

4-1. If NuScale intends to maintain compliance using passive design features, then the staff requests NuScale to:

1. Provide a description of those specific design features of the secondary side that ensure that the in-phase flow fluctuation is limited within acceptable limits as defined in response to this RAI and update the TR and DCD to includedescriptions of any design features relied on.

a. If the flow fluctuations are limited by the SG tube inlet orifices, then describe the

process for demonstrating that the SG tubes are designed with sufficiently tight inlet orifices to limit flow fluctuations within the acceptable limits that are to be provided in response to this RAI. Provide an ITAAC item that addresses the demonstration.

b. If the flow fluctuations are not limited by the orifices, but rather through a different aspect of the thermal-hydraulic design, the NRC staff requests NuScale to describe those aspects of the design that limit flow fluctuations to remain within acceptable limits.

c. Address how secondary side design and control system design impact secondary side instability characteristics (e.g., how steam line pressure controlled throttling valves may effect total steam generator pressure drop).

2. Alternatively, if the applicant intends to disposition this issue under the COL item described by the response to RAI 9218, the staff requests that NuScale explicitly describe that aspect of the COL item in the response to this request; and revise the COL item in the RAI 9218 response and DCD to explicitly describe the associated aspect(s).

4-2. If NuScale intends to maintain compliance using active design features, then the staff requests NuScale to:

1. Clarify whether active means are part of the long term stability solution strategy with respect to managing the influence of secondary side instability on primary side response

2. If active means are part of the long term stability solution strategy, describe any additional, active means proposed to limit the secondary side in-phase flow oscillation magnitude (e.g., a trip function) and update the Stability Topical Report (TR-0516-49417-P) and the DCD to include a description of any of these additional active means as part of the description of the long term stability solution.

4-3. If NuScale intends to demonstrate compliance through analysis, then the staff

requests NuScale to:

1. Provide an analysis that demonstrates compliance with the acceptable limits of flow fluctuation as defined in the response to this RAI and provide a submittal for NRC review that includes: (1) a description of the evaluation model, (2) a validation report, (3) an uncertainty analysis, and (4) the associated analytical results.

2. Alternatively, the applicant can respond to this request by including a COL item to provide essentially the same information requested under above under 4- 3 Part 1.

4-4. If NuScale intends to demonstrate compliance through experimental demonstration, then the staff requests NuScale to:

1. If the applicant intends to reference the SIET-TF2 experimental results, provide rationale for the applicability of SIET-TF2 results to the NPM. Specifically:

a. Justify the SIET-TF2 experimental results applicability in light of the fact that the {{ }}2(a),(c).

b. Justify the applicability given that the oscillation magnitude of the NuScale SG tubes may be greater than the range covered by the conditions explored in the SIET-TF2 series of tests.

c. Justify the applicability of the results given that the SIET-TF2 tests do not address in-phase flow oscillation.

d. Justify the applicability given other aspects of the SEIT-TF2 test thermal-hydraulic conditions, {{ }}2(a),(c), which do not generally seem to correlate with the expected thermal-hydraulic conditions of normal operation.

2. If the applicant intends to demonstrate compliance through a different experiment:

a. Describe how the thermal-hydraulic conditions of this experiment would cover the anticipated range of operating conditions on the secondary side for all conditions of normal operation.

b. Describe how the SG inlet is or will be instrumented in the experiment.

c. Describe any COL item associated with the conduct of such an experiment (e.g., how the COL applicant will supply the experimental data and verification to the NRC to confirm compliance with the acceptable limit described in the response to this RAI).

NuScale Response:

Response to Item 1:

Secondary flow oscillations in individual steam generator (SG) tubes that are out-of-phase pose no limit with regards to the driving flow and power oscillations of the primary side. Additionally, in-phase secondary side instability and oscillations are excluded as the net flow is dominated by the feedwater pumps with head that far exceeds pressure drop in SG tubes due to density waves. Therefore, this response focuses on the potential for induced feedwater oscillations that may arise from cycling feedwater or steam line valves or the feedwater pump speed controls.

The response to feedwater flow oscillations at different frequencies on the primary flow was provided to the NRC in TR-0516-49417, Evaluation Methodology for Stability Analysis of the NuScale Power Module, (called herein the topical report (TR)). Additional details, specifically exploring possible resonances in the NuScale Power Module (NPM), were provided in response to NRC request for additional information (RAI) 9444 (RAIO-0818-61457, ML18229A337).

In the RAI 9444 response, the results of additional PIM code calculations were provided. In these calculations the feedwater flow oscillation periods that resulted in maximum (peak) primary flow response were selected where the oscillation amplitude was increased to the maximum possible value (+/-100%). Beginning of Cycle (BOC) and End of Cycle (EOC) conditions were analyzed so that the least stable configuration of the reactor flow (occurred at BOC), and

the maximum core power response (occurred at EOC) due to its large (negative) moderator temperature reactivity coefficient could be accounted for. Reactor powers of 20% and 100% were analyzed to span the possible impact on critical heat flux. This parametric study did not reveal any critical heat flux (CHF) limit violations using the PIM built-in EPRI CHF correlation. With large calculated CHFR margins, this result is generically valid and no fuel-specific CHF confirmation calculations are needed. The results are shown in Figures 1 through Figure 24 provided below. It should also be noted that, even though the critical heat flux limit is not violated, the reactor protection system would trip the reactor in these conditions in the case of loss of steam superheat or large changes in reactor power. The PIM calculation input data and results are summarized in Table 1 and Table 2, respectively.

Based on the above, no limits are needed for feedwater flow oscillations as the maximum possible oscillation magnitude taken at the worst possible frequencies does not challenge critical heat flux limits, and would result in reactor trip particularly for high power operation.

Table 1 Input Conditions for Oscillating Feedwater Flow PIM Cases

{{

}}2(a),(c)

Table 2 Summary Results for the Table 1 PIM Cases

{{

}}2(a),(c)

{{

}}2(a),(c)

Figure 1 Core and SG power and core flow for Case 1

{{

}}2(a),(c)

Figure 2   SG exit steam superheat and Feedwater flow for Case 1

{{

}}2(a),(c)

Figure 3   Critical heat flux ratio for Case 1

{{

}}2(a),(c)

Figure 4 Core and SG power and core flow for Case 2

{{

}}2(a),(c)

Figure 5 SG exit steam superheat and Feedwater flow for Case 2

{{

}}[2(a),(c)]

Figure 6   Critical heat flux ratio for Case 2

{{

}}2(a),(c)

Figure 7 Core and SG power and core flow for Case 3

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}}2(a),(c)

Figure 8   SG exit steam superheat and Feedwater flow for Case 3

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}}2(a),(c)

Figure 9 Critical heat flux ratio for Case 3

{{

}}2(a),(c)

Figure 10   Core and SG power and core flow for Case 4

{{

}}2(a),(c)

Figure 11 SG exit steam superheat and Feedwater flow for Case 4

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}}[2(a),(c)]

Figure 12 Critical heat flux ratio for Case 4

{{

}}2(a),(c)

Figure 13 Core and SG power and core flow for Case 5

{{

}}2(a),(c)

Figure 14 SG exit steam superheat and Feedwater flow for Case 5

{{

}}2(a),(c)

Figure 15 Critical heat flux ratio for Case 5

{{

}}2(a),(c)

Figure 16 Core and SG power and core flow for Case 6

{{

}}2(a),(c)

Figure 17   SG exit steam superheat and Feedwater flow for Case 6

{{

}}2(a),(c)

Figure 18   Critical heat flux ratio for Case 6

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}}2(a),(c)

Figure 19 Core and SG power and core flow for Case 7

{{

}}2(a),(c)

Figure 20 SG exit steam superheat and Feedwater flow for Case 7

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}}2(a),(c)

Figure 21 Critical heat flux ratio for Case 7

{{

}}2(a),(c)

Figure 22 Core and SG power and core flow for Case 8

{{

}}2(a),(c)

Figure 23 SG exit steam superheat and Feedwater flow for Case 8

{{

}}2(a),(c)

Figure 24 Critical heat flux ratio for Case 8

Response to Item 2:

The TR has been revised in previous RAI responses to remove any reliance on the magnitude of SG oscillations to the implementation of the long term stability solution. The TR states that the SG oscillations which are out-of-phase do not impact the primary side regardless of magnitude. The response to item 1 of above demonstrates that no limits are needed for in-phase oscillations, i.e. feedwater flow oscillations, which may arise due to external controls. The limits

on flow oscillations in SG tubes are not related to reactor stability, but to thermal and mechanical performance optimization, which is outside the scope of this TR.

Response to Item 3:

The requested PIM code analysis has been performed and presented in the response to item 1 above. The analysis covers the in-phase oscillations in the SG tubes which are equivalent to the net feedwater flow oscillations. The out-of-phase oscillations are bounded by the in-phase oscillation analysis, as their effects cancel out.

Response to Item 4:

As stated in the response to Item 1, no oscillation limits are needed on SG tubes individually as they may oscillate out-of-phase or collectively where the flow in the SG tubes oscillates with the net feedwater flow. The out-of-phase oscillations in the SG tubes cancel out at any magnitude. The in-phase oscillations that may arise from cycling feedwater or steam line valves or feedwater pump speed were examined and the results presented in this response demonstrate that no limits need to be imposed on feedwater flow oscillations as the primary side response remain sufficiently small that no critical heat flux violations result regardless of the feedwater oscillation amplitude.

Impact on Topical Report:

There are no impacts to the Topical Report TR-0516-49417, Evaluation Methodology for Stability Analysis of the NuScale Power Module, as a result of this response.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1218-63998

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NuScale Power, LLC

AFFIDAVIT of Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the method by which NuScale develops its stability analysis of the NuScale power module.

    NuScale has performed significant research and evaluation to develop a basis for this method and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed response to NRC Request for Additional Information No. 9580, eRAI No. 9580. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
   a. The information sought to be withheld is owned and has been held in confidence by NuScale.
   b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
   c. The information is being transmitted to and received by the NRC in confidence.
   d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
   e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 31, 2018.

Zackary W. Rad