RAIO-0318-59362

March 30, 2018

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 9107 (eRAI No. 9107) 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. 9107 (eRAI No. 9107)," dated September 12, 2017
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. 9107:

- 01-42

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9107 (eRAI No. 9107). 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 Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

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

Distribution: Samuel Lee, NRC, OWFN-8G9A
Prosanta Chowdhury NRC, OWFN-8G9A
Bruce Bavol, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9107, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9107, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0318-59363

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9107, proprietary

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9107, nonproprietary

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9107
Date of RAI Issue: 09/12/2017

NRC Question No.: 01-42

Title 10 of the Code of Federal Regulations (CFR), Part 50, Appendix A, General. Design Criterion (GDC) 12, "Suppression of reactor power oscillations," requires that oscillations be either not possible or reliably detected and suppressed. The Standard Review Plan (SRP) 15.0.2 acceptance criteria with respect to evaluation models specifies that the chosen mathematical models and the numerical solution of those models must be able to predict the important physical phenomena reasonably well from both qualitative and quantitative points of view.

In Section 10.2, "General Stability Characteristics," of the topical report (TR), TR-0516-49417-P, Figure 10-1 provides an illustration of allowable and forbidden NPM operation, in terms of the decay ratio (DR) band versus riser subcooling, and including a proposed region of safety margin. Bullet 2 in section 10.2 of the TR addresses the decay ratio acceptance criterion of 0.8 (or less). The DR acceptance criterion must be defined with sufficient margin to account for biases, including those introduced by numerical diffusion and uncertainty.

In order to make an affirmative finding NRC staff requests NuScale to:
1) Provide an uncertainty analysis for PIM.
- One option might be to provide an analysis based on parametric sensitivity results whereby the models associated with highly important phenomena are perturbed by the magnitude of their respective uncertainty as determined by SET or IET validation.
- Where applicable, provide results of SET or IET validation used to support the uncertainty analysis.
2) Quantify any biases in PIM DR prediction associated with numerical diffusion.
3) Compare the PIM uncertainty and bias to the margin afforded by the DR acceptance criterion of 0.8 and justify the acceptance criterion.

NuScale Response:

Item 1:

The uncertainty analysis for PIM is based on the assessment of the effects of the important

design and operational parameters on the calculated decay ratio. These parameters have been narrowed down to: power, reactivity feedback, riser inlet subcooling, hydraulic characterization (flow), and nodalization. The effect of the uncertainty of each of these parameters is discussed below.

Power: The effect of power has been studied and reported extensively in TR-0516-49417-P. It was shown that {{

}}$^{2(a),(c)}$. At powers below {{ }}$^{2(a),(c)}$ of rated, there is no possibility of violating specified acceptable fuel design limits (SAFDL). With regards to DR uncertainty due to power measurement uncertainty, the plant instrumentation is capable of measuring power with small uncertainty which has a negligible effect on the decay ratio estimation.

Reactivity Feedback: The uncertainty in the reactivity feedback is covered by running PIM at the exposure conditions of BOC and EOC. It has been shown that large margin to instability is maintained even at the least favorable stability performance associated with the BOC conditions where the moderator temperature coefficient is least negative.

Riser Inlet Subcooling: The effect of riser inlet subcooling on DR is not continuous, rather it has no effect on stability provided that riser voiding is prevented. The loss of riser inlet subcooling is protected by the MPS trip on loss of sub-cooled margin.

Flow: The mass flow rate in the natural circulation loop is dependent on power. However, flow at a given power level is also affected by the estimates of flow resistance in different parts of the primary loop. Unlike the case for boiling water reactors, the effect of flow resistance in the NPM is not affected by its location; therefore, no detailed sensitivity of individual pressure loss components is needed. The collective effect of uncertainty in pressure loss components is represented by uncertainty in the flow itself. Two extreme cases of the highest and lowest flow at rated power cover the hydraulic characterization uncertainty. These values are {{

}}$^{2(a),(c)}$ respectively. Transient calculations were performed to produce the time trace of the reactor coolant flow rate starting from a perturbed initial steady state, where the hydraulic resistances are at the lowest and highest estimated value respectively. The following results demonstrate that the effect of hydraulic characterization uncertainty on the decay ratio is small.

{{

}}$^{2(a),(c)}$

Nodalization: As mentioned in the response to RAI 8801, the nodalization of the NPM model in PIM has been set up with sufficiently large number of nodes which minimizes the numerical diffusion effect. Moreover, the time step size has been selected that is dependent on the flow rate such that Courant number value is 0.8~0.9. The decay ratio uncertainty because of the nodalization and Courant number is estimated to be within {{ }}$^{2(a),(c)}$

The PIM results quantifying the effect of realistic riser heat transfer are presented in Table 1 and plotted in Figure 9 as function of relative power at both BOC and EOC conditions.

Item 2:

The bias of the DR in PIM is estimated to be less than {{ }}$^{2(a),(c)}$ However, the real system is diffusive because of physical processes such as turbulence, heat conduction, and heat exchange with solid structures. In the particular geometry of the NPM, the main source of physical diffusion is the heat exchange across the riser wall. It is estimated that the physical diffusion due to the heat exchange across the riser wall is similar if not larger than the numerical diffusion, therefore the PIM code predicts conservative decay ratio when the adiabatic riser option is selected.

The PIM results quantifying the effect of realistic riser heat transfer are presented in Table 1 and plotted in Figure 9 as function of relative power at both BOC and EOC conditions.

Item 3:

The bias due to numerical diffusion in the PIM modeling of the NPM is judged to be small and well compensated for by the physical diffusive processes. Therefore no net bias is justifiable for the calculated decay ratios. Uncertainties in operating conditions and hydraulic characterization were analyzed and the effect has been found to be small compared with the 0.2 decay ratio margin. It must be noted that the highest calculated decay ratio is {{ }}$^{2(a),(c)}$ which is within the decay ratio margin and also at very low power where no SAFDL violation is possible. The lowest power where SAFDL violation is considered credible is {{ }}$^{2(a),(c)}$ at which the highest calculated decay ratio is {{ }}$^{2(a),(c)}$ which indicates a high degree of stability well within the acceptance criterion.

NuScale considers that the decay ratio margin of 0.2 is an overestimation of the needed conservatism for PIM calculations of the NuScale module stability. This decay ratio margin has been chosen, rather arbitrarily, to reflect historical continuity based on BWR experience.

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}}2(a),(c)

Figure 1 Time trace of reactor coolant flow at rated power assuming low flow

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}}2(a),(c)

Figure 2 Time trace of reactor coolant flow at rated power assuming high flow

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

Figure 3 Time trace of reactor coolant flow at 50% of rated power assuming low flow

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

Figure 4 Time trace of reactor coolant flow at 50% of rated power assuming high flow

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

Figure 5 Time trace of reactor coolant flow at 20% of rated power assuming low flow

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

Figure 6 Time trace of reactor coolant flow at 20% of rated power assuming high flow

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

Figure 7 Time trace of reactor coolant flow at 1% of rated power assuming low flow

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

Figure 8 Time trace of reactor coolant flow at 1% of rated power assuming high flow

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}}2(a),(c)

Figure 9 Riser heat transfer impacts on decay ratio as a function of core power and burnup conditions

Table 1 Tabulated Decay Ratios for Riser Heat Transfer Impact

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}}2(a),(c)

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-0318-59363

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

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 methods by which NuScale develops its stability analysis of the NuScale power module.

    NuScale has performed significant research and evaluation to develop a basis for these methods 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 RAI No. 9107, eRAI No. 9107. 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 3/29/2018.

Zackary W. Rad