RAIO-1218-63911

December 19, 2018

Docket: PROJ0769

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

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 9579 (eRAI No. 9579) 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. 9579 (eRAI No. 9579)," dated October 19, 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. 9579 :

- 15.09-12

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9579 (eRAI No. 9579). 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. 9579 , proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9579 , nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-1218-63912

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9579 , proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9579 , nonproprietary

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9579
Date of RAI Issue: 10/19/2018

NRC Question No.: 15.09-12

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 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, in RAI 9107, the NRC staff requested NuScale to provide an uncertainty analysis for PIM. The RAI 9107 response did not provide such an analysis, rather, argued that the uncertainty is likely less than 0.2 based on a combination of qualitative and quantitative arguments. In terms of quantitative results, there are time traces provided for a flow sensitivity study, but the applicant did not provide the DR values for the sensitivity calculations.

Therefore the staff requests NuScale to:

1. Provide the DR values from the flow sensitivity study,

2. Provide the flow range for each analyzed power level and explain how this flow range is sufficient to cover the uncertainty in the hydraulic modeling, and

3. DR, or adjust the PIM DR acceptance criterion from 0.8 above 5 percent rated power to 0.7 above 5 percent rated power.

NuScale Response:

The response to this request for information (RAI) first addresses the premise of the questions to provide clarification. Subsequently, responses to the itemized questions are provided.

Clarification:

The minimum power for which a decay ratio (DR) acceptance criterion in the NuScale topical report (TR), TR-0516-49417-P, Evaluation Methodology for Stability Analysis of the NuScale Power Module, has been originally assigned based on the power below which specified acceptable fuel design limits (SAFDLs) cannot be violated. This power value was given as 5% of rated power as a very conservative measure pending the completion of the methods used for the quantification of critical heat flux (CHF). Subsequently, the power limit for CHF at 20% was used and presented in responses to several RAIs.

The TR methodology seeks approval based on the demonstration of unconditional stability in the normal operating domain (as opposed to no SAFDL violation). Even outside the normal operating domain, where instabilities have been intentionally induced in the PIM simulations, by allowing the loss of riser inlet subcooling and vapor formation in the riser, the resulting oscillations were shown to be nonlinearly limited in magnitude and do not violate CHF limits.

NuScale maintains that the acceptance criterion should remain as a DR less than or equal to 0.8 at 5% of rated power. The basis for this determination is that DR is calculated for the entire power range at regular power intervals of 5%, which makes 5% power the lowest power level for the stability reload analysis. This point bounds the stability in the entire power range as DR has been shown to decrease with increasing power. An update to the TR has been made to clarify the basis of the acceptance criterion minimum power value of 5%.

Response to items 1 and 2:

NuScale performed new calculations to assess the DR uncertainty due to the change in the flow rate associated with the uncertainty of hydraulic characterization. These new calculations apply to a wider range than the originally cited calculations, and use a more up-to-date PIM code version and base input data. The best estimate set of calculations were performed at beginning of cycle (BOC) and end of cycle (EOC) exposures and used multiple power levels. The PIM code was updated to accept a user-specified multiplier of the friction losses as the parameter affected by the hydraulic characterization uncertainty. For a multiplier greater than unity, the flow rate is reduced accordingly, and vice versa. {{

}}2(a),(c)

The decay ratios requested in RAI item 1 are provided along with the mass flow rate values requested in item 2. The BOC results are provided in Table 1 and EOC results are provided in Table 2.

Table 1 Stability results at BOC with hydraulic characterization uncertainty

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}}2(a),(c)

Table 2 Stability results at EOC with hydraulic characterization uncertainty

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}}2(a),(c)

The results shown in Table 1 and Table 2 {{

}}2(a),(c)

Extraction of decay ratio from PIM output

DR and period calculations are performed internal to the PIM code, and are also performed outside PIM as a post processing step of its output. {{

}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

Response to item 3:

The DR acceptance criterion of 0.8 is commonly assigned to Boiling Water Reactor (BWR) stability codes and was proposed for PIM for historical continuity. The DR acceptance criterion of 0.8 is justified by the discussion provided below. The rationale for this is expounded on with further comparison between the Nuscale Power Module (NPM) and BWRs where the NPM is a simpler system:

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}}2(a),(c)

- {{

}}2(a),(c)

Uncertainty Analysis

The NuScale approach to achieving accurate determination of the NPM stability is an integral one based on combining first principles, reduced order modeling, simulation code, and experimental benchmarks. This process has been discussed in the responses to several RAIs including eRAIs 8801, 9105, and 9106. The underlying engineering supporting those responses demonstrates that the behavior of the reactor is understood under different operating conditions, a process that informed a focused assessment of the uncertainty:

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}}2(a),(c)

- {{

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

The uncertainty calculus accounts for the components of numerical methods (numerical as compared with physical diffusion), characterization of hydraulic resistance, and biasing relative to experimental data. A best-estimate engineering judgment evaluation of the net decay ratio uncertainty is provided along with a conservative estimate.

In conclusion, the theoretical and numerical and experimental studies confirm that the stability results using the PIM code for the NPM, using the prescribed nodalization and time step, and applying the modeling conservative assumption of adiabatic riser flow, is accurately and conservatively calculated. The NPM was found to be unconditionally stable in the normal operating range defined by maintaining riser subcooling and moderator reactivity confined to the condition of negative power reactivity coefficient.

Uncertainty, by its inherent nature, cannot be quantified precisely. Empirical data remain the most reliable measure of uncertainty. {{

}}[2(a),(c)] However, as a ratio, the PIM decay ratio values are nearly double the measured values. It is therefore conservative to assign a stability acceptance criterion of DR=0.9. However, NuScale is only requesting approval of the lower acceptance criterion of DR=0.8 to offer a higher level of confidence in the stability margin.

Impact on Topical Report:

Topical Report TR-0516-49417, Evaluation Methodology for Stability Analysis of the NuScale Power Module, has been revised as described in the response above and as shown in the markup provided in this response.

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- Core Power. The system is highly stable (i.e., decay ratio is less than 0.5) for high power operation. {{

}}2(a),(c)

From the above discussion, two parameters are identified as controlling the stability of the reactor. The proposed stability analysis methodology considers these parameters as follows.

- Riser Subcooling. The loss of riser subcooling is identified as the condition for which instability is possible and likely. For this reason, riser subcooling is to be protected by a technical specification value with margin, where the margin is sufficiently large to cover instrumentation uncertainty and measurement delay. The riser subcooling margin is independent of the core design and burnup state and therefore is generically specified for the methodology and is not on a cycle-specific basis.

- Moderator Reactivity Coefficient. An analysis that utilizes the methodology described in this report is required to demonstrate that the decay ratio is at or below 0.8 for power at five percent of rated or above under the BOC conditions with subcooled riser, which places a limit on the MTC maximum positive value. A conservative positive MTC is used for the initial generic analysis, and therefore, a revision to the stability analysis would be needed only if this conservative value is exceeded in subsequent cycles.

~~}}2(a),(c),ECI~~

10.3 Stability Protection Solution

There are two stability protection types, which emerged from a long history of licensing the operation of BWRs. These types are detect and suppress and regional exclusion. The main features of these two types are presented below with the rationale for adopting the regional exclusion type in this methodology.

- Detect and suppress stability solution. This is an automated solution in which in-core instrumentation signals are processed and oscillation detection algorithms are applied continuously to identify the onset of unstable oscillations. The system is functioning over a wide operational domain defined on a two-dimensional power-flow operating map. Reactor trip set points are based on statistical methods with assumed distributions of oscillation frequency and decay ratios, taking into account reactor trip delays. The system is sufficiently sensitive that it can respond to global and regional mode instabilities and suppress them before thermal limits are violated. The detect and suppress solution is used by most BWR utilities because it can efficiently protect the fuel automatically without reliance on operator action. The advantages for BWRs include the system's ability to detect regional out-of-phase oscillations that are not manifest in the average neutron flux signals, and doing so on a short time scale that

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1218-63912

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 methodology for stability 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. 9579, eRAI 9579. 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 19, 2018.

Zackary W. Rad