NuScale Power™

LO-1216-52161

December 3, 2016

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 Submittal of NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-P (NRC Project No. 0769)

REFERENCES:

1. Letter from NuScale Power, LLC to U.S. Nuclear Regulatory Commission, "Evaluation Methodology for Stability Analysis of the NuScale Power Module," LO-0716-50371, dated July 31, 2016 (ML16250A851).
2. NuScale Topical Report, "Evaluation Methodology for Stability Analysis of the NuScale Power Module," TR-0516-49417-P, Revision 0, dated July 2016 (ML16250A851).
3. Letter from U.S. Nuclear Regulatory Commission to NuScale Power, LLC, "Request for the Review of NuScale Power, LLC, Power Topical Report TR-0516-49417-P, 'Evaluation Methodology for Stability Analysis of the NuScale Power Module,'" dated October 19, 2016 (ML16271A307).

In a letter dated July 31, 2016 (Reference 1), NuScale Power, LLC (NuScale) submitted the topical report entitled "Evaluation Methodology for Stability Analysis of the NuScale Power Module" (Reference 2). In Reference 3, the NRC requested NuScale to provide supplemental information by December 3, 2016 in order to enable the NRC staff to complete its acceptance review of the report. NuScale's response to the NRC's request for supplemental information is provided in this letter.

Enclosure 1 provides a proprietary version of the requested information. Enclosure 2 is the nonproprietary version of the requested information.

Enclosure 3 provides a revised page to be inserted into Reference 2. The revised page corrects a minor editorial error in the report. Enclosure 4 provides a nonproprietary version of the page replacement. NuScale plans to include the revised page in the approved version of the proprietary and nonproprietary report, which will be issued following NRC approval of the topical report.

NuScale requests that the proprietary enclosures be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 5) supports this request.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

Please feel free to contact Jennie Wike at (541) 360-0539 or at jwike@nuscalepower.com if you have any questions.

Sincerely,

Thomas A. Bergman
Vice President, Regulatory Affairs
NuScale Power, LLC

Distribution: Frank Akstulewicz, NRC, TWFN-6C20
Greg Cranston, NRC, TWFN-6E7
Rani Franovich, NRC, TWFN-6E7
Mark Tonacci, NRC, TWFN-6E7

Enclosure 1: NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-P, Revision 0, proprietary version
Enclosure 2: NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-NP, Revision 0, nonproprietary version
Enclosure 3: Replacement Page for TR-0516-49417-P, Revision 0, proprietary version
Enclosure 4: Replacement Page for TR-0516-49417-NP, Revision 0, nonproprietary version
Enclosure 5: Affidavit, AF-1216-52162

Enclosure 1:

NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-P, Revision 0, proprietary version

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

Enclosure 2:

NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-NP, Revision 0, nonproprietary version

NRC Request for Supplemental Information (Reference 1):

Because secondary side instability could appreciably affect stability of the primary side, please provide the technical basis, including analyses and experimental/testing information that supports your position. Your supplemental information should:

- *Contain sufficient technical information to support the NuScale position related to secondary side individual tube stability.*
- *Present and support the NuScale position related to the potential for feedback from the secondary side controllers to erode in-phase mode stability margin on the secondary side.*
- *Present and support the NuScale position related to the potential for density wave instabilities between steam generator tubes connected by common headers, and its effect on secondary side stability and should consider potential mechanisms for communication on the primary side (shell side) between tubes and its potential effect on steam generator stability.*
- *Discuss the potential for flow oscillation including the potential for in-phase heat transfer oscillation and coupled modes.*
- *Consider the potential for feedback mechanisms arising from interaction between the primary and secondary side due to integrated secondary side behavior (such as control system operation).*

The above mechanisms are complicated by the different lengths of steam generator tubes with slightly different natural frequencies. The effect of different tube lengths on secondary side stability also needs to be discussed.

NuScale Response:

The purpose of this supplement is to provide a focused presentation on the role the steam generator (SG) has on stability of the NuScale Power Module (NPM) primary flow. The information presented herein elaborates on and strengthens the presentation of the physics described in the topical report (Reference 2). The important role the SG plays as a heat sink in determining the stability of the natural circulation flow is demonstrated, while emphasizing the special feature of this effect being a one-way effect. There is no closed-loop feedback process between the SG and the primary flow that can influence the stability of the latter; rather there is an open-loop where the dynamic two-way coupling is broken. The purpose of this supplement is to respond to the NRC's concerns summarized in the requests for supplemental information (Reference 1), and demonstrate by first principles and new test data how the level of detail in the PIM code is adequate for the stability analysis methodology described in the topical report, and that no phenomena of significance were neglected in its modeling.

Stability of the NuScale Power Module as a Natural Circulation Loop – An Overview

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Figure 1. Reduced order model results for 100-percent of rated power showing stable primary flow

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Figure 2. Reduced order model results for 30-percent of rated power showing less stable primary flow compared with rated conditions

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Figure 3. Reduced order model results for 10-percent power operating showing reduced stability compared with higher power

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Figure 4. Reduced order model results showing decay ratio decreasing with increasing power and minimal impact due to numerical diffusion

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Figure 5. Reduced order model results showing oscillation period decreasing with increasing power and minimal impact due to numerical diffusion

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Figure 6. Results of a SIET-TF2 steam generator stability tests

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The Role of the Control System

The topical report did not include the design of the module control system, as the topical report provides a methodology for stability analysis. The stability analysis methodology presented in the topical report is valid without consideration of a specific control system design provided the design of the module control system satisfies the following requirement:

> Any closed-loop control systems are designed and examined with respect to their impact on reactor stability by ensuring the respective control parameters (e.g., gain and time constants) are set to avoid any destabilizing effects.

The design of the module control system is expected to ensure it is stable and provides the required steady-state and transient response for all operating conditions. By not including the control system in the analysis presented in the topical report, the stabilizing effect of the control system is not credited.

Additional Considerations Supporting the Unimportance of Primary-Secondary Flow Coupling

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Conclusions

This response provides justification that the feedback loop between the primary flow and the heat transfer through the SG tubes is broken in the sense that secondary flow oscillations of any mode or magnitude cannot reinforce a primary flow perturbation and destabilize it. The important coupling between the primary and secondary sides is adequately captured by the models programmed in the PIM code where no self-excited flow response in the SG tubes is considered and no momentum conservation equation for the SG tubes is needed. A summary of how the NRC's requests for supplemental information were addressed in this response is provided below.

- *Contain sufficient technical information to support the NuScale position related to secondary side individual tube stability.*
    - This supplement presented an additional evaluation with a reduced-order model that confirms the adequacy of the SG model implemented in the PIM code for the purposes of primary flow and power stability evaluation.
    - In addition, the supplement presented design-specific test data obtained at the full-scale, hydraulically heated, and prototypical helical-coil SG SIET facility that corroborates the negligible impacts to primary side thermal-hydraulics from secondary side flow instabilities.
- *Present and support the NuScale position related to the potential for feedback from the secondary side controllers to erode in-phase mode stability margin on the secondary side.*
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    - The stability analysis methodology presented in the topical report is valid without consideration of a specific control system design since the module control system contains appropriate functional specifications to preclude unstable operation as related to GDC 12. The methodology demonstrated negligible impacts to primary side thermal-hydraulics from secondary side flow instabilities.
- *Present and support the NuScale position related to the potential for density wave instabilities between steam generator tubes connected by common headers, and its effect on secondary side stability and should consider potential mechanisms for communication on the primary side (shell side) between tubes and its potential effect on steam generator stability.*
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- *Discuss the potential for flow oscillation including the potential for in-phase heat transfer oscillation and coupled modes.*
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- *Consider the potential for feedback mechanisms arising from interaction between the primary and secondary side due to integrated secondary side behavior (such as control system operation).*
    - As described above, the stability analysis methodology presented in the topical report is valid without consideration of a specific control system design since the module control system contains appropriate functional specifications to preclude unstable operation as related to GDC 12. The methodology demonstrated negligible impacts to primary side thermal-hydraulics from secondary side flow instabilities.

References

1. U.S. Nuclear Regulatory Commission, "Request for the review of NuScale Power, LLC, Power Topical Report, TR-0516-49417-P, 'Evaluation Methodology for Stability Analysis of the NuScale Power Module'," October 19, 2016 (ML16271A307).
2. NuScale Topical Report, "Evaluation Methodology for Stability Analysis of the NuScale Power Module," TR-0516-49417-P, Revision 0, dated July 2016 (ML16250A850).
3. Farawila, Y. M., et al., "Analytical Stability Analogue for a Single-Phase Natural Circulation Loop," *Nuclear Science and Engineering*, Vol. 184, No. 3, November 2016.
4. S. Singh, A. K., et al., "Experimental Investigation on Characteristics of Boiling Two-Phase-Flow Instability in a Parallel-Multichannel Natural-Circulation System," *Nuclear Science and Engineering*, Vol. 184, 263-279, October 2016.
5. *U.S. Code of Federal Regulations*, "Suppression of Reactor Power Oscillations," General Design Criterion 12, Part 50, Chapter I, Title 10, "Energy," (10 CFR 50 Appendix A).

Enclosure 3:

Replacement Page for TR-0516-49417-P, Revision 0, proprietary version

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

Enclosure 4:

Replacement Page for TR-0516-49417-NP, Revision 0, nonproprietary version

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
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8.2.7 Effect of Oscillating Feedwater Flow

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Figure 8-50. Time trace of primary coolant flow response to feedwater flow oscillation with a defined period and end-of-cycle conditions

Enclosure 5:

Affidavit, AF-1216-52162

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

NuScale Power, LLC

AFFIDAVIT of Thomas A. Bergman

I, Thomas A. Bergman , state as follows:

(1) I am the Vice President of 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 response reveals distinguishing aspects about the method by which NuScale develops its methodology for the 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 entitled "NuScale Power, LLC Submittal of NuScale Response to NRC Request for Supplemental Information to TR-0516-49417-P."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 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 3, 2016.

Thomas A. Bergman