RAIO-0918-61838

September 18, 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. 9476 (eRAI No. 9476) on the NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9476 (eRAI No. 9476)," dated May 08, 2018
2. NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0, dated December 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. 9476:

- 15.06.05-13

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9476 (eRAI No. 9476). 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
Samuel Lee, NRC, OWFN-8G9A
Rani Franovich, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9476, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9476, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0918-61839

NuScale Power, LLC
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Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9476, proprietary

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Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9476, nonproprietary

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Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9476
Date of RAI Issue: 05/08/2018

NRC Question No.: 15.06.05-13

Title 10, Part 52, of the *Code of Federal Regulations* (10 CFR Part 52), "Licenses, Certifications, and Approvals for Nuclear Power Plants," Section 52.47, "Contents of Applications; Technical Information" (10 CFR 52.47), specifies that an application for certification of a nuclear power reactor design that uses simplified, inherent, passive, or other innovative means to accomplish its safety functions must meet the requirements of 10 CFR 50.43(e) (52 Part 52.47(c)(2)). 10 CFR 50.43(e) requires, in part, assessment of the analytical tools used for safety analyses over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences. Regulatory Guide (RG) 1.203 describes a process that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in developing and assessing evaluation models (EMs) that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant.

As stated in RG 1.203, an EM is the calculational framework for evaluating the behavior of the reactor system during a postulated transient or design-basis accident. As such, the EM may include one or more computer programs, special models, and all other information needed to apply the calculational framework to a specific event, as illustrated by the following examples:

(1) Procedures for treating the input and output information (particularly the code input arising from the plant geometry and the assumed plant state at transient initiation)

(2) Specification of those portions of the analysis not included in the computer programs for which alternative approaches are used

(3) All other information needed to specify the calculational procedure

The entirety of an EM ultimately determines whether the results are in compliance with

applicable regulations. Therefore, the development, assessment, and review processes must consider the entire EM.

The RELAP5 code geometry fixes the length of a junction fluid column joining two cells so that if a simple manometer is modeled, the inertia of the fluid column is determined by the geometry, not the length of the fluid column in the U-tube. Thus, the inertia of the fluid column in RELAP5 momentum formulation can be inconsistent with the junction geometry since this is fixed by the input. Comparisons of the NRELAP5 code with a simple oscillating manometer, with and without friction, shows that very quickly, RELAP5 predicts an incorrect period that is completely out of phase with the correct solution. Such behavior is attributable to the improper fluid inertia specified by the RELAP5 geometric formulation. If this fundamental numerical deficiency exists, the code capability to accurately calculate the natural circulation flow during steady state and transient becomes questionable. Thus, the calculated two-phase water level above the core during a loss of coolant accident (LOCA), which is the figure of merit of the analysis, may not be conservative.

- Please discuss the impact of this modeling feature on the NRELAP5 prediction of fluid level and flow behavior in a manometer with and without friction and the impact on the predictive capabilities of heterogeneous fluid behavior in the vessel in the NuScale primary system under transient LOCA conditions.
- For the manometer input test problem (with and without friction) and solutions provided to NuScale by the staff, please provide the comparisons of NRELAP5 to the manometer solutions with and without friction, showing the flow rates and levels vs time.
- Please also discuss the impact of any conclusions from these comparisons to the ability of NRELAP5 to predict emergency core cooling system response in the small modular reactor following the limiting small break LOCA.

NuScale Response:

Using large or lengthy hydrodynamic volumes to model a component, and volume mean void fractions in the numeric solution as employed by NRELAP5, leads to inaccurate calculation of pressure gradients across a junction if a distinct level exists in a control volume above the junction. This, in addition to the semi-implicit solution scheme, leads to diffusive behavior in prediction of an oscillating manometer without friction. Consequently, NRELAP5 would not be able to exactly predict the amplitude and period of manometric oscillations under frictionless conditions without using special models. In the presence of friction, the use of mean void

fractions and fixed geometry based momentum cell length within a control volume is less impactful to level prediction due to the presence of physical diffusion. In addition, using smaller hydrodynamic volumes improves resolution of a large change in void fraction, such as associated with a liquid level in an oscillating manometer, and results in less numerical diffusion if appropriate time steps are taken near the Courant limit. NRELAP5, as applied in the Loss-of-Coolant Accident Evaluation Model (LOCA EM), {{

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

In the case of the NuScale primary system during LOCA transient conditions, {{

}}[2(a),(c)] , not as a result of gravity driven oscillations in liquid levels between the two vessels. The plant response will be physically damped due to friction and form losses throughout the system. LOCA transients do not exhibit oscillations as seen in a manometer. This is further substantiated by NuScale integral test data as presented in the LOCA topical report (TR-0516-49422-P) Section 7.5.6.5, Section 7.5.6.6 and Section 7.5.7.5 for simulated LOCA transients. NRELAP5 comparisons show reasonable to excellent agreement in collapsed level prediction during simulated LOCA transients.

As requested, NRELAP5 has been assessed against the theorized oscillating manometer test problem, provided by the NRC staff. In this test problem, the levels are equalized at a non-equilibrium condition and with an initial velocity of zero. The case is analyzed with and without friction. An analytic solution is developed for the case without friction and the case with friction is solved with a numeric solution utilizing a fifth order Runge-Kutta method. A constant friction factor of 0.5 was used for the case with friction. In addition, the problem was modified to use {{

}}[2(a),(c)] The problem was analyzed using inputs as similar as possible to that of the LOCA EM for consistency, while keeping the same nodalization as the original problem. For instance, the volume flags and

timestep cards were modified to be more consistent with the LOCA EM. {{ }}2(a),(c)

Due to the numerical scheme implemented by NRELAP5, it is expected that some dampening of the oscillations within the manometer case will occur. The magnitude of the numerical diffusion is dictated by the Courant number and it is ideal to have the Courant number as close to one as possible to minimize numerical diffusion. In addition, the {{

}}2(a),(c)

Due to numerical scheme dependencies on the Courant number (i.e., dependencies on nodal size and timestep size), a sensitivity for the oscillating manometer case was performed considering a wide range of Courant numbers for cases with and without friction. The level and mass flowrate prediction in the left leg of the manometer are shown in Figures 1 and 2 for the case without friction present, and in Figures 3 and 4 for the case with friction present. Solutions were obtained over the a range of max Courant numbers between 0.0005 and 0.925. The velocity and mass flow rate starts at zero as expected and decreases in the negative direction due to liquid moving from the right leg to the left leg and the orientation of the junction being positive from left to right.

The results of the case without friction show NRELAP5 predicts more damping compared to the analytical solution without friction.

As expected, running at larger time steps and therefore {{

}}2(a),(c)

Thus, as long as NRELAP5 is run {{ }}2(a),(c) It is noted that for all cases the first peaks and troughs are well predicted demonstrating that the initial transient response is captured. The accuracy of the solution degrades with time in the no-friction case. {{

}}2(a),(c)

{{

}}2(a),(c)

Figure 1. Oscillating manometer level without friction using different timesteps

{{

}}2(a),(c)

Figure 2. Oscillating manometer mass flowrate without friction.

{{

}}2(a),(c)

Figure 3. Oscillating manometer level with friction using different timesteps.

{{

}}2(a),(c)

Figure 4. Oscillating manometer mass flowrate with friction.

For the NPM the following conclusions are made with respect to the prediction of the limiting LOCA analyses:

1. {{

}}2(a),(c)

In addition, the NPM configuration does not give way to a response like the manometer case. This is due to {{

}}2(a),(c)

Impact on Topical Report:

There are no impacts to the Topical Report TR-0516-49422, Loss-of-Coolant Accident Evaluation Model, as a result of this response.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0918-61839

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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 performs its loss-of-coolant accident analysis.

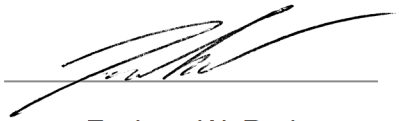
    NuScale has performed significant research and evaluation to develop a basis for this method and has invested significant resources, including the expenditure of a considerable sum of money

    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. 9476, eRAI No. 9476. 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 September 18, 2018.



Zackary W. Rad