June 03, 2019

Docket No. 52-048

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

SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 202 (eRAI No. 8911) on the NuScale Design Certification Application

REFERENCES:

1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 202 (eRAI No. 8911)," dated August 25, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 202 (eRAI No.8911)," dated December 21, 2018
3. NuScale Power, LLC Supplemental Response to NRC "Request for Additional Information No. 202 (eRAI No. 8911)," dated April 9, 2019
4. NuScale Power, LLC Supplemental Response to NRC "Request for Additional Information No. 202 (eRAI No. 8911)," dated May 1, 2019

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

The Enclosures to this letter contain NuScale's supplemental response to the following RAI Question from NRC eRAI No. 8911:

- 03.09.02-18

Enclosure 1 is the proprietary version of the NuScale Supplemental Response to NRC RAI No. 202 (eRAI No. 8911). 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 Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

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

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8911, proprietary

Enclosure 2: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8911, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0619-65809

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8911, proprietary

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Enclosure 2:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8911, nonproprietary

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 8911
Date of RAI Issue: 08/25/2017

NRC Question No.: 03.09.02-18

10 CFR 52.47 requires the design certification applicant to include a description and analysis of the structures, systems, and components (SSCs) sufficient to permit understanding of the system designs. TR-0916-51502-P, Rev. 0, "NuScale Power Module Seismic Analysis" describes the methodologies and structural models that are used to analyze the dynamic structural response due to seismic loads acting on the NuScale Power Module (NPM). The description is insufficient for staff to reach a safety finding. Specifically, the report does not provide the seismic and LOCA stress results. Please provide the seismic analysis details and stress results under Service Level D condition for the following reactor internals components. Include the requested information in the NPM Seismic Report or in separate reports.

- core support assembly (core barrel, lower core plate, reflector, upper core plate, upper core support)
- lower riser assembly
- upper riser assembly (upper riser, upper riser hanger support)
- control rod assembly guide tube, control rod assembly guide tube support, control rod assembly card, control rod drive shaft, and control rod drive shaft support
- steam generator tubes and tube supports
- control rod assembly guide tubes

The component analysis should include a brief description of the component structure modelling, input motion (time history or in-structure response spectrum), major assumptions, acceptance criteria under Service Level D condition including stress and deflection limits, fluid modelling, mass distribution, damping values, gap considerations, dominant modes and frequencies, and seismic and LOCA stress results and ASME B&PV Code Section III stress evaluation under Service Level D condition.

NuScale Response:

The initial response to RAI 8911 Question 03.09.02-18 was submitted by NuScale letter RAIO-1218-63980, dated December 21, 2018. In a subsequent follow-up public meeting with NRC on January 22, 2019, additional questions were asked specific to the Reactor Vessel Internals (RVI) portion of this response. Responses to all of the additional RVI questions, with the exception of Question RVI 1, were provided by the supplemental response to RAI 8911 Question 03.09.02-18, dated May 1, 2019 (NuScale letter RAIO-0419-65386).

The following information further supplements the first supplemental response to RAI 8911 Q18, and addresses the followup question RVI 1.

<u>Question RVI 1</u> - ASME Section III Appendix F-1321.3 requires consideration of gaps between part of the structures. CRDS and CRAGT have diametric gap as below.

	CRDS	CRAGT
Diametric Gap (in)	{{	}}2(a),(c)

Data from {{

}}2(a),(c)

Describe the boundary conditions at the diametric gaps (fixed or free) of CRDS and CRAGT and provide justification for not considering the gaps.

NuScale response - The boundary conditions and justification for not considering the gaps for the control rod assembly guide tube (CRAGT) and control rod drive system (CRDS) are described separately below.

<u>CRAGT</u>

The CRAGT is one of the four components included in the control rod assembly (CRA) model, as shown in Figure 1. In the CRA analysis, the bottom pilot node is fixed in all 6 degrees of freedom (DOFs), because the CRA Lower Flange is bolted to the Upper Core Plate. The top pilot node is also fixed in 6 DOFs. Although there is a {{ }}2(a),(c) inch radial gap between the CRDS Alignment Cone and the CRA Guide Tube Support Plate (see Figure 2), the contact impact force is insignificant locally, because the gap size is small. Given that the sections in the nearby CRDS Alignment Cone and CRA Guide Tube Support Plate are large, the stress due to the contact impact force is negligible. Therefore, the gap was not modeled in the analysis.

CRDS

For the control rod drive (CRD) shafts in the upper riser assembly (URA) analysis, the tops are constrained in 6 DOFs and the steam plenum elevations are constrained in 4 DOFs (no vertical translational or torsional DOFs). Figure 3 shows one of the 16 CRD shafts taken from the upper riser assembly (URA) analysis. The boundary conditions for the 16 CRD shafts are identical. The CRD shafts are also coupled to the CRDS supports (the five grids) in the horizontal translational DOFs.

To investigate the gap effects, an additional analysis was performed. This analysis used two models (one linear and the other nonlinear) similar to the CRD shaft-CRDS support components in the URA analysis. The linear model (L) and the nonlinear model (NL) only include one CRD shaft and related supports. The L model is similar to the model in Figure 3 by coupling lateral translational DOFs. The NL model includes contact pairs at the radial gaps. Transient analyses are performed on these two models, and then their reaction forces, moments, and stresses at limiting locations are compared. If the stresses from the NL model are bounded by those from the L model, using the linear model in the URA analysis is acceptable.

The only difference between the L and NL models is whether the shaft is coupled to the supports. Both models are assigned “Standard” contact in ANSYS, but the L model is additionally assigned CP commands to couple lateral translational DOFs (Ux and Uz) of the shaft to the supports. A diagram of the model used in this evaluation is shown in Figure 4. This diagram shows the element connectivity between keypoints. It also lists the section number for each line, which correlates to a given cross-section geometry for the beam elements. Real constants for each line are listed which indicate the contact-target element pairing between the CRD shaft and the supports. The CRDS supports 1 through 5 are defined as locations 4 through 8 in the FEM, to be consistent with the naming system used in the URA analysis. Locations 1 through 3 are the RPV head, steam plenum, and hanger ring, respectively.

The CRD shaft, guides and supports are meshed with 2-node BEAM188 elements, using the quadratic shape function. The maximum element length is set to 1.75 inch. CONTA176 elements are overlaid on the CRD shaft elements that pair with TARGE170 elements on the guides and supports. The contact-target pairs are indicated in Figure 4. Due to the slenderness of the model, a single view of the model mesh does not show sufficient detail. Instead, different sections of the mesh are shown in Figure 5.

Stainless steel material properties are assigned to the model with mass correction to account for the simplification of the model. Global Rayleigh damping is used in the transient analysis. The alpha and beta damping multipliers are calculated based on {{ }}[2(a),(c)] system damping ratio in the frequency range of {{ }}[2(a),(c)] Hz. This frequency range, determined from modal analysis, covers the major modes of the shaft.

The time history inputs used in transient analysis are from the case S7CS_CAP_CR_RXM1_NomiK in the NPM Seismic Analysis technical report TR-0916-51502 Section 8.0. This loading case is the limiting case for the model in terms of locations and applicable frequencies. Displacement time histories are applied to the top of the shaft and supports. The keypoints 715, 716, and 208 are above the RPV head in the NPM and therefore are applied with the same displacements as those used on the Shaft top (location 1) in Figure 3. The integral steam plenum (keypoint 714) and upper riser hanger ring (keypoint 713) are connected, so they are both applied with the same displacements as those used on the location 2 in Figure 3. The five CRDS supports are applied with displacements as those used on locations 4 through 8, respectively.

Reaction forces and moments are extracted at eight bounding locations. These locations are illustrated in Figure 6. In addition, the Pm and Pm+Pb stresses are calculated at these locations. Displacement data at supports and corresponding shaft locations, as well as their contact status are also extracted. The resultant displacement data showed that the maximum relative displacement between supports and corresponding shaft locations in the NL model is about {{ }}[2(a),(c)] inch, demonstrating that the contact elements work correctly.

An example of reaction force comparison (at location 1b) from the two models is shown in Figure 7. The moment comparison is shown in Figure 8. Note that the “My” is not shown in Figure 8 because there is no torsional moment on the shaft. The stress comparison is shown in Figure 9. The minimum (negative value) and maximum (positive value) reactions summarized from all eight locations are listed in Table 1 and Table 2 for the NL and L models, respectively. The corresponding locations are also listed in these two tables.

From Figure 7, the reaction forces are generally higher in the NL model. The reaction frequency of the two models is similar, but the impact force due to the contact causes higher reaction forces in the NL model. From Figure 8, moment magnitudes are comparable in the two models. Figure 9 shows that the highest stresses are also comparable in the two models. This is because the peak moment loads are the main contributors to stresses in the shafts, and thus the higher peak reaction forces in the NL model do not significantly affect resultant stresses.

By comparing the global max values of Pm and Pm+Pb in Table 1 to those in Table 2, it is observed that the stresses are higher in the L model than in the NL model. In location 2, the maximum reaction forces and moments are much higher in the L model than in the NL model (see Figure 10 and Figure 11). This is because in the L model the vibration near the location 2 at peak load time points are close to the first major mode, and thus the resonance causes large reactions. For example, Figure 12 shows the time near the peak Fx in Figure 10. It is found that a cycle of the response is from {{ }}[2(a),(c)] seconds, as shown in Figure 12. This corresponds to a frequency of {{ }}[2(a),(c)], which is very close to the first major frequency {{ }}[2(a),(c)] Hz. On the other hand, the NL model vibrates at a higher frequency compared to the L model, and therefore the NL model reactions are lower. This is due to the nonlinear contact in the NL model changing the major frequencies of the shaft to be away from the transient load frequencies, so that resonance does not occur. Although there are impact forces between the contact surfaces, the impact forces are not significant because the gap size is small.

In conclusion, because the stresses from the nonlinear model are bounded by those from the linear model, using the linear model in the URA analysis (not considering the gap) is acceptable.

Table 1. NL results

(a) Minimum value

Location	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)
Loc1b	{{					
LocMid12						
Loc2						
Loc4b						
Loc5b						
Loc6b						
Loc7b						
Loc8b						
Global min value						
Global min location						}}2(a),(c)

(b) Maximum value

Location	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)	Pm (psi)	PmPb (psi)
Loc1b	{{							
LocMid12								
Loc2								
Loc4b								
Loc5b								
Loc6b								
Loc7b								
Loc8b								
Global max value								
Global max location								}}2(a),(c)

Table 2. L results

(a) Minimum value

Location	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)
Loc1b	{{					
LocMid12						
Loc2						
Loc4b						
Loc5b						
Loc6b						
Loc7b						
Loc8b						
Global min value						
Global min location						}}2(a),(c)

(b) Maximum value

Location	Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)	Pm (psi)	PmPb (psi)
Loc1b	{{							
LocMid12								
Loc2								
Loc4b								
Loc5b								
Loc6b								
Loc7b								
Loc8b								
Global max value								
Global max location								}}2(a),(c)

{{

}}2(a),(c)

Figure 1. CRA model components and boundary conditions

{{

}}2(a),(c)

Figure 2. Gap between the CRDS Alignment Cone and CRA Guide Tube Support Plate

{{

}}2(a),(c)

Figure 3. CRD Shaft boundary conditions in the URA analysis

{{

}}2(a),(c)

Figure 4. Diagram of the CRD shaft model (elements are collinear, but are shown offset for clarity; not to scale)

{{

}}2(a),(c)

Figure 5. Mesh of sections of the L and NL models

{{

}}2(a),(c)

Figure 6. Post-processing locations

{{

}}2(a),(c)

Figure 7. Reaction forces at location 1b

{{

}}2(a),(c)

Figure 8. Reaction moments at location 1b

{{

}}2(a),(c)

Figure 9. Resultant stresses at location 1b

{{

}}2(a),(c)

Figure 10. Reaction forces at location 2

{{

}}2(a),(c)

Figure 11. Reaction moments at location 2

{{

}}2(a),(c)

Figure 12. Resultant Fx at location 2 near highest peaks

Impact on DCA:

There are no impacts to the DCA as a result of this response.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0619-65809

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 power module seismic 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. 202, eRAI No. 8911. 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 June 3, 2019.

Zackary W. Rad