November 20, 2017

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 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) on the NuScale Design Certfication Application, date October 24 , 2017 (ML17297B950)

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. 8911:

- 03.09.02-24

A majority of the responses to RAI No. 202, eRAI No. 8911, questions were previously provided in Reference 2. The schedule for questions 03.09.02-18, 03.09.02-43 and 03.09.02-46 was provided in an email to NRC (Greg Cranston) dated September 12, 2017. The response to question 03.09.02-45 will be provided by February 28, 2018.

The technical report TR-0916-51502, "NuScale Power Module Seismic Analysis" contained export controlled information. The markup pages in the enclosed RAI response for TR-0916-51502 are therefore labeled "Export Controlled," although these markup pages do not contain any export controlled information.

Enclosure 1 is the proprietary version of the NuScale 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

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Marieliz Vera, NRC, OWFN-8G9A

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

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

Enclosure 3: Affidavit of Zackary W. Rad, AF-1117-57296

Enclosure 1:

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

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Enclosure 2:

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

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

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

NRC Question No.: 03.09.02-24

10 CFR 50, Appendix A, GDC 4 requires structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. The Standard Review Plan (SRP) establishes criteria that the NRC considers acceptable to use in implementing the agency's regulations. SRP 3.9.2, Revision 3 states that the number of element is adequate when additional degrees of freedom do not result in more than a 10-percent increase in responses. TR-0916-51502-P, Rev. 0, Section 4.1.3.1 states that the lower RVI submodel geometry is based on the lower riser and core support drawings. The computer-aided design model used to generate the drawings was defeatured and simplified in order to reduce the element count of the mesh. The lower RVI is meshed using 8- node solid shell elements and 8-node solid elements. The reflector is modeled as a separate part as is the rest of the lower RVI. This avoids requiring a conformal mesh between the two parts. A cutaway view of the lower RVI mesh is shown in Figure 4-5. The description is insufficient for staff to reach a safety finding. The applicant is requested to provide the following information:

1. Provide a discussion of how the SRP provision regarding adequate number of element is addressed considering the reduced element count of the mesh.
2. List all the sub components that are modelled in the lower RVI submodel and the corresponding element types.
3. Explain the meaning of "defeatured" and what simplifications were made in creating the lower RVI submodel.
4. In Figure 4-5, indicating the location of the 8-node shell elements and 8-node solid elements by using two different colors and provide element type of the 8-node shell element and 8-node solid element.
5. Is the reflector modelled by 8-nodes shell elements or 8-node solid elements?
6. How are the upper and lower core plates modelled? Provide FE mesh figures for the upper and lower core plates with element and nodal numbers.
7. The upper part of the lower RVI submodel shown in Fig. 4-5 appears to be a complicated structure. Provide a detailed description of the structure and its modelling.

Include the requested information in the NPM Seismic Report or in separate reports.

NuScale Response:

Subquestion 1:

The requirements of SRP 3.9.2, Revision 3 have been addressed by conducting a mesh sensitivity study for the model, as documented in Section 4.0 of TR-0916-51502. The mesh was increased from approximately {{ }}2(a),(c) elements. A modal analysis analysis was conducted using the refined model. The mesh of the refined model compared to the coarse model for the CNV is provided in Figure 1. Other structures had similar levels of refinement. {{

}}2(a),(c)

Figure 1 CNV Coarse Mesh (Left) and Refined Mesh (Right)

For the major components, the modal response of the structure with the refined mesh is within 10% of the response of the coarse mesh, with the exception of the course mesh mode at

{{ }}2(a),(c). This upper riser internals mode is not as significant for the refined model, as this mode has separated into four modes {{ }}2(a),(c) of lesser significance. The mass participation for the {{ }}2(a),(c) mode was {{ }}2(a),(c) while the sum of the mass participation for the four separated modes is {{ }}2(a),(c). The modal responses of the coarse model and the refined model are provided in Table 1. Only modes with significant mass participation and major fuel beam modes are provided.

Table 1 Major Modes of the Coarse and Refined Models

Coarse X-Freq. (Hz)	Refined X-Freq. (Hz)	Major NPM subcomponent responding at frequency	Type of mode	Percentage of Coarse Model Frequency
{{		Fuel Beam	Bending	100%
		Entire RXM	Bending	96%
		Entire RXM	Bending	97%
		RVP+LRVI+URVI+CRDM	Bending	98%
		RVP+LRVI+URVI+CRDM	Bending	97%
		CRDM+CNV	Torsion	97%
		CNV+RPV	Shell/Torsion	96%
	}}2(a),(c)	RPV+LRVI+URVI+CRDM	Bending	99%

Coarse Y-Freq. (Hz)	Refined Y-Freq. (Hz)	Major NPM subcomponent responding at frequency	Type of mode	Percentage of Coarse Model Frequency
{{		Entire RXM	Axial	96%
		CNV+TAMAS+CRAGT Support Plate	Axial	98%
	}}2(a),(c)	CNV+TAMAS	Axial	100%

Coarse Z-Freq. (Hz)	Refined Z-Freq. (Hz)	Major NPM subcomponent responding at frequency	Type of mode	Percentage of Coarse Model Frequency
{{		Fuel Beam	Bending	100%
		Entire RXM	Bending	99%
		RPV+Fuel+URVI+CRDM	Bending	94%
		URVI	Torsion	94%
		RPV+Fuel+URVI+CRDM	Bending	94%
		RPV+URVI+CRDM	Bending	106%
		RPV+LRVI+URVI+CRDM	Bending	98%
		CNV+LRVI+URVI+CRDM	Bending	97%
	}}2(a),(c)	RPV+LRVI+CNV+CRDM	Shell/Torsion	101%

Corresponding clarification has been included in Section 4.1 of TR-0916-51502.

Subquestion 2:

The following is a list of the components that are modeled within the lower RVI submodel, and their corresponding element types:

- Lower riser: SOLSH190
- Upper core plate: SOLID185
- Upper CRDS support: SOLID185
- CRA guide tube support plate: SOLID185
- Core barrel: SOLSH190
- Lower core plate: SOLID185
- Reflector blocks (upper, intermediate, and lower): SOLID185
- Upper support blocks: SOLID185
- Belleville washers: COMBIN14

Subquestion 3:

The model is “defeatured” by removing components or features of the structure that do not significantly affect the global dynamic response. The following are examples of features that were removed from and/or simplified for the lower RVI model:

- Small flow holes were removed from the reflector blocks
- Filleted corners on the lower core plate were modeled as sharp corners
- The effects of the Belleville washers were captured by modeling the assembly as spring elements
- The holes in the ISI guide tube support were removed

As part of the defeaturing, certain components were not modeled, as not modeling did not affect the overall stiffness of the structure. Their mass is accounted for by increasing the density of the structures to which they attach. The following components are not modeled:

- CRA guide tube assemblies
- ICI guide tubes and bottom flags
- Lower riser trunnions
- Fuel pins
- Lock plate assemblies

Subquestion 4:

See Figure 2 below. 8-node SOLSH190 shell elements are shown in red. 8-node SOLID185 solid elements are shown in purple. The mesh views have been updated in Figure 4-6 of TR-0916-51502, and corresponding description added to Section 4.1.3.1.

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}}2(a),(c)

Figure 2 Lower Internals Solid Shell / Solid Elements

Subquestion 5:

The response to this question is provided in Subquestion 2.

Subquestion 6:

The upper and lower core plates are modeled with SOLID185 elements. The mesh of the upper and lower core plates are provided below in Figure 3 and Figure 4.

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}}2(a),(c)

Figure 3 Upper Core Plate Mesh, approximately 500 nodes and 200 elements

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}}2(a),(c)

Figure 4 Lower Core Plate Mesh , approximately 700 nodes and 400 elements

Direct element and node numbers are not used in this model. Element and nodal selections are done based on components selections within ANSYS. Therefore element and node numbers are not provided. Remote points are scoped to the bottom of the upper core plate and to the top of the lower core plate, in order to provide attachment points for the fuel assembly beam in Figure 4-7 of TR-0916-51502. These remote points are also selected based on component selections.

Subquestion 7:

The upper portion of the lower RVI submodel is the lower riser assembly. This assembly contains the lower riser shell, lower riser transition, upper core plate, CRA guide tube support plate, and the upper CRDS support.

The CRA guide tubes, ICI guide tubes, and lower riser trunnion are not modeled. None of these structures would contribute significant stiffness to the lower RVI assembly, therefore it is not necessary to model their stiffness. The mass of these components is accounted for in the total mass of the structure.

The mesh of the upper riser shell is shown in Figure 4-14 of TR-0916-51502. For clarity, the mesh of the CRA guide tube support plate and the upper CRDS support are shown in Figures 5 and 6 .

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

Figure 5: CRA Guide Tube Support Plate

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}}2(a),(c)

Figure 6: Upper CRDS Support

Impact on DCA:

The technical report TR-0916-51502 has been revised as described in the response above and as shown in the markup provided with this response.

are connected by constraint equations, contact elements, or coupled degrees of freedom. ANSYS also uses the term "submodeling" to describe a finite element technique that can be used to obtain more accurate results in a particular region of a model, by using a more refined model of the particular region. This use of the term "submodel" is not the meaning intended in this report. In the ANSYS documentation, substructuring refers to procedures that condense a group of finite elements into one element represented by a single mass, stiffness and damping matrix. The single-matrix element is called a "superelement." The ANSYS substructuring technique, ANSYS superelements, and the concept of master nodes are not used in this report.

The CRDM support frame and CRDM submodel described in this report are generated by the ANSYS computer code. The ANSYS CRDM submodel is translated from a CRDM stress analysis model developed by the CRDM vendor using their proprietary structural computer code. Modal analyses were performed to verify the equivalence of the ANSYS to the CRDM vendor models.

The piping, valves, manways, instruments, PZR heaters, and other small internal components such as bolts are not explicitly modeled. These minor features do not affect the gross structural behavior of the model and removing them allows for simplified meshing techniques to be used. The piping is flexible relative to the vessels, so it does not drive the response of the CNV or RPV.

A mesh sensitivity study for the model described in the following sections was conducted. The mesh was increased from approximately {{ }}2(a),(c) elements. A modal analysis and a harmonic analysis were conducted using the refined model.

For the major components, the modal response of the structure with the refined mesh is within 10% of the response of the coarse mesh, with the exception of the coarse mesh mode at {{ }}2(a),(c). This upper riser internals mode is not as significant for the refined model, as this mode has separated into four modes {{ }}2(a),(c) of lesser significance. The mass participation for the {{ }}2(a),(c) mode was {{ }}2(a),(c) while the sum of the mass participation for the four separated modes is {{ }}2(a),(c).

The sum of the responses of the four separated modes is similar to the single mode response in magnitude and these modes are within 10% of the single mode. Therefore, the mesh used for the NPM seismic model as described in the following sections is acceptable.

Potential uplift of the NPM is captured through nonlinear contact with the rigid floor surface.

ledges in the circumferential direction, the connection is effectively modeled. Likewise, the bolted connection at each of the four CNV ledges generates the need to couple the pilot nodes associated with the slots of the RPV supports and the holes of the CNV ledges in the vertical direction (i.e., there is no uplift).

The CRDM support frame is modeled with beam elements as shown in Figure 4-20. The cross-sections of these beam elements are either a rectangle (representation of the support plates) or hollow rectangles (other beams in the CRDM support frame). An actual representation of the seismic support plates in Figure C-8 is not needed at the level of detail of the NPM seismic model. The connection to the RPV head is facilitated by six degree of freedom (DOF) target/contact pairs (bonded) to the proximal surfaces of the RPV head solid elements.

4.1.2.3 Reactor Pressure Vessel Materials

The RPV is assigned material properties of SA-508 Grade 3 Class 2 steel, except for the upper RPV support, which is SA-533 Grade B Class 2. The elastic modulus values are taken at the average reactor coolant system (RCS) temperature of 550 degrees F. The density is taken at the as-built temperature of 70 degrees F because the model is built with room temperature nominal dimensions.

4.1.3 Lower Reactor Vessel Internals Submodel

4.1.3.1 Lower Reactor Vessel Internals Geometry, Mesh and Mass

The lower RVI geometry is based on the lower riser and core support drawings. The computer-aided design model used to generate the drawings was defeatured and simplified in order to reduce the element count of the mesh. Figure 4-6 shows the simplified lower RVI geometry. Items shown in purple are SOLID185 elements and items shown in red are SOLSH190 elements.

The lower RVI is meshed using 8-node solid shell elements and 8-node solid elements. The solid shell elements are used at any shell section where there is one element through the thickness. The solid elements are used at intersection regions of shells and where there is more than one element through the thickness. The reflector is modeled as a separate part as is the rest of the lower RVI. This avoids requiring a conformal mesh between the two parts. A cutaway view of the lower RVI mesh is shown in Figure 4-6 (fuel assembly beam elements not shown).

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}}2(a),(c)

Figure 4-6 Lower reactor vessel internals geometry and mesh

The lower RVI has its mass adjusted in a similar manner as the vessels. The lower RVI mass adjustment summary is shown in Table 4-7. The core support mass is the sum of the following three RVI components: the Core Support, Surveillance Capsules, and Core Entrance Flow Plate. The negative mass adjustment associated with the core support was incorporated by reducing the density of the reflector material as shown in Table 4-8. The meshed mass is higher than the actual mass because the cooling channels in the reflector are not modeled (they are filled in) in the ANSYS model.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1117-57296

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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 and analyses by which NuScale develops its power module seismic analysis .

    NuScale has performed significant research and evaluation to develop a basis for this method and analyses 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 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 11/20/2017.

Zackary W. Rad