October 03, 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. 135 (eRAI No. 8928) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 135 (eRAI No. 8928)," dated August 05, 2017

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 Questions from NRC eRAI No. 8928:

- 03.07.03-1
- 03.07.03-2
- 03.07.03-3
- 03.07.03-4
- 03.07.03-5

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 135 (eRAI No. 8928). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The proprietary enclosures have been deemed to contain Export Controlled Information. This information must be protected from disclosure per the requirements of 10 CFR § 810. 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
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8928, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8928, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0917-56335

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8928, proprietary

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Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8928, nonproprietary

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

eRAI No.: 8928
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.03-1

Title 10 of the Code of Federal Regulations, Part 50, Appendix A, Criterion 2 and Appendix S to 10 CFR Part 50, provide the requirements to be met by SSC important to safety. DSRS Section 3.7.3 provides review guidance pertaining to the design of important to safety seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping; tunnels, and conduits; concrete dams; and atmospheric tanks. Consistent with DSRS Section 3.7.3, the staff reviewed the descriptive information, including plans and sections of each structure, to establish that there is sufficient information to define the structural aspects and elements relied upon for the substructure to perform the intended safety function.

Staff reviewed the FSAR sections related to the Reactor Building Crane (RBC). The Reactor Building Crane is described in FSAR Sections 3.7.2.1.2.3, “Reactor Building Crane,” and 3.7.3.3.1, “Reactor Building Crane.” In Section 3.7.2.1.2.3 it is stated that “for the analysis of the RXB, the RBC is unloaded (i.e., no suspended NPM) and located in the middle of the reactor pool area.” In the section 3.7.3.3.1, it is stated that “The RBC is then evaluated as a decoupled model using the ISRS [in-structure response spectra] developed from the building model. If significant changes are necessary to the RBC, the beam model is updated. If the structure is re-analyzed (due to any significant change in the model), new ISRS are generated. The new ISRS are compared to the ISRS used as input for the design of the RBC. If warranted, a new analysis of the RBC is performed.”

The staff requests the applicant to clarify whether or not: 1) the iterative process mentioned above has been completed and 2) the respective results are included in the DCD. Also, explain why the selected ISRS is based solely on the RBC located in the middle of the reactor pool area.

NuScale Response:

The iterative process has been completed for the design of the reactor building crane (RBC). The respective results were included in FSAR Tier 2, Section 3.7.3.3.1 but have been removed as DSRS Section 3.7.3 is not applicable to the crane seismic analysis (see RAI 8928

Q03.07.03-5). FSAR Tier 2, Section 3.7.2.1.2.3 is updated to delete the reference to Section 3.7.3.

The location of the RBC in-structure response spectra (ISRS) was selected to provide a conservative design input for the RBC, which will occur when it is located in the most flexible region of the pool walls.

Impact on DCA:

FSAR Tier 2, Section 3.7.2.1.2.3 has been revised as described in the response above and as shown in the markup provided with this response.

near the dry dock gate. In this position, the RBC is not above either the SFP or the NPMs. The RBC is described in Section 9.1.5.

Reactor Building Crane Model Included in the Reactor Building SASSI2010 Model

RAI 03.07.03-1

Figure 3.7.2-29 shows the beam and spring model used to represent the RBC. For the analysis of the RXB, the RBC is unloaded (i.e., no suspended NPM) and located in the middle of the reactor pool area as shown in Figure 3.7.2-24. The RXB analysis produces in-structure response spectra (ISRS) that are used as input to the RBC seismic analysis. ~~The seismic analysis of the RBC is discussed in Section 3.7.3.~~

3.7.2.1.2.4 Ultimate Heat Sink Pool

The UHS pool contributes a large amount of weight to the global mass of the RXB. This fluid impacts the dynamic characteristics of the building. Figure 3.7.2-30 provides a visualization of the hydrodynamic structural system (building and UHS pools). Figure 3.7.2-31 provides a similar view, but eliminates the structure and shows only the pool water. In the RXB SAP2000 model, the hydrodynamic load generated due to the pool water mass during a seismic event is addressed by assigning lumped masses on the pool walls and foundation nodes that are in contact with the pool water.

These lumped nodal masses are multiplied by the nodal accelerations during the dynamic analyses and introduce equivalent dynamic pressures on the walls and foundation as impulsive pressures. All of the pool water mass is assigned as lumped nodal masses in the two horizontal and vertical directions separately. Neither the SAP2000 nor SASSI2010 computer programs have an explicit fluid element formulation to accurately calculate the hydrodynamic effects due to all three directional components of earthquake input motions. To develop a correction factor, a fluid structure interaction (FSI) model was created in ANSYS and used to develop fluid loads. These results were compared to the SASSI2010 dynamic results and a correction factor established.

ANSYS Model

In the ANSYS model, the foundation was modeled with two layers of 3D SOLID185 finite elements. In the pool region, the foundation is raised by 1 foot to support the twelve NPMs. Therefore, a layer of 1 foot solid elements was added in the pool water region. This foundation modeling using the solid elements provides an accurate geometrical height for the pool water level and the support locations of the NPMs on the bay and pool walls. As in the SAP2000 model, the NPMs are vertically unrestrained and rest on the pool foundation. All the building exterior and interior walls are modeled using SHELL181 elements. The wall horizontal distance is defined at the neutral surface from the global coordinate system origin. All slabs are modeled using SHELL181 elements. The slab height or vertical distance is defined at the neutral surface

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eRAI No.: 8928
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.03-2

Title 10 of the Code of Federal Regulations, Part 50, Appendix A, Criterion 2 and Appendix S to 10 CFR Part 50, provide the requirements to be met by SSC important to safety. DSRS Section 3.7.3 provides review guidance pertaining to the design of important to safety seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping; tunnels, and conduits; concrete dams; and atmospheric tanks. Consistent with DSRS Section 3.7.3, the staff reviewed the descriptive information, including plans and sections of each structure, to establish that there is sufficient information to define the structural aspects and elements relied upon for the substructure to perform the intended safety function.

Staff reviewed Section 3.7.3.3.2, “Bioshields,” the subsection entitled, “Reinforced Concrete Properties and Slab Capacity,” of the FSAR. The last paragraph on page 3.7-56 states, “The welded connections between the vertical and horizontal component of the bioshield are designed based on the provisions of Chapter J of AISC 360.” The applicant is requested to provide a technical justification for use of the AISC 360 code for the welded connections between the vertical and horizontal component of the seismic Category II bioshield. Page 16.1-2 of the AISC 360-10 code lists the requirements for nuclear applications, including the use of AISC N690. The applicant is also requested to clarify any additional provisions from AISC N690 regarding the design and weld inspection that are applicable to the bioshield.

NuScale Response:

The Bioshields are not safety related structures. Thus, the use of AISC N690, “Specification for Safety-Related Steel Structures for Nuclear Facilities,” is not required and all welded connections may be in accordance with AISC 360-10. Additionally, in accordance with DSRS 3.7.2.II.8.C, the non-Seismic Category I Bioshields have been analyzed and designed to prevent their failure under safe shutdown earthquake (SSE) conditions. Although page 16.1-2 of AISC 360-10 specifies the use of AISC N690 for “the design, fabrication and erection of nuclear structures,” AISC N690 applies to the design of safety-related steel nuclear structures, thus, there are no additional provisions from AISC N690 regarding the design and weld inspection that are applicable to the Bioshield.

Impact on DCA:

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

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eRAI No.: 8928
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.03-3

Title 10 of the Code of Federal Regulations, Part 50, Appendix A, Criterion 2 and Appendix S to 10 CFR Part 50, provide the requirements to be met by SSC important to safety. DSRS Section 3.7.3 provides review guidance pertaining to the design of important to safety seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping; tunnels, and conduits; concrete dams; and atmospheric tanks. Consistent with DSRS Section 3.7.3, the staff reviewed the descriptive information, including plans and sections of each structure, to establish that there is sufficient information to define the structural aspects and elements relied upon for the substructure to perform the intended safety function.

Staff reviewed Section 3.7.3.3.2, “Bioshields,” the subsection entitled, “Structural Steel Properties,” of the FSAR. The paragraph on page 3.7-56 states, in part, “The operation environment underneath the bioshield is expected to be higher than the ambient building temperature. Therefore, a yield strength of 21.4 ksi, corresponding to a temperature of 200 degrees F, is used.” The applicant is requested to provide a technical bases for using a design temperature of 200 degrees F for the bioshield components. Additionally, the applicant is requested to address the following:

a. If the bioshield vertical face is below the water surface, what would be the compartment pressure and temperature on the bioshield? This effect should be considered for the bio shield design. In this scenario, what will be the safety classification if the bio shield requires blow out?

b. It is not clear to the staff whether or not the vertical plate is vented. Provide the detail design basis temperature, pressure, and safety classification of the bioshield. Also, provide detailed design information for the bioshield design and description for the plate/tubing configuration including welded joints.

NuScale Response:

A design temperature of 200 degrees Fahrenheit, for the bioshield components, was chosen before environment qualification (EQ) profiles were generated as a conservative design temperature to steel strength reduction. Passive cooling calculations place the pool room around 200 degrees Fahrenheit. Top of module temperature conditions have been calculated to be {{ }}[2(a)(c)ECI] under normal operating conditions.

Additionally, responses pertaining to FSAR, Tier 2, Subsection 3.7.3.3.2, "Bioshields," are provided as follows:

a. The vertical portion of the Bioshield extends 1 ft below the water surface. Normal operating pressure is atmospheric. An HVAC vent in the vertical portion of the Bioshield and on the pool wall will draw air in from the pool area through the operating bay and into the reactor building (RXB) HVAC system. In emergency events, the Bioshield is designed with hinged blow off panels to release pressure generated in the operating bay. This pressure relief panel provides a passive ventilation path for emergency situations.

   The Bioshield normal compartment pressure and temperature are depicted in FSAR Tier 2, Appendix 3C, Table 3C-6, Line G. The classification of the Bioshield is listed in Table 3.2-1. The Bioshield is classified as B2 (non-safety), but has augmented quality requirements as specified in FSAR Tier 2, Table 3.2-1.

b. The vertical face of the Bioshield is vented to maintain the required {{ }}[2(a),(c)ECI] airflow requirement for the reactor building HVAC system (RBVS). The Bioshield is also designed with emergency hinged blow off panels that begin opening at pressures <0.005 psi to provide positive pressure ventilation out from under the operating bay. The design temperature for this emergency ventilation operation was taken to be 140° F, causing a reduction in the steel yield strength. The reduction in yield strength was then used for design of the vertical face.

   The Bioshield is a non-safety related, non-risk significant component that serves to provide protection from adverse environments that could result in preventing safety-related SSCs from performing required safety-related functions.

   The vertical portion of the bioshield is a 4" x 4" x 1/2" square tube steel welded frame (approximately 21' x 30') with both the vertical and horizontal members spaced approximately 2 feet on center. The members are in the same plane. Hinges for the panels are welded to the square tube steel on the side facing the center of the pool. These hinges solely support the blow off panels. The panels consist of a 1/4" steel plate with the other part of the hinges and stiffener ribs welded to the back. Eight pressure relief panels cover the area from the top of the square tube steel frame to approximately 6'-6" from the bottom of the square tube steel frame. Approximately 2'-6" from the bottom of the square tube steel frame, and on both the left and right hand side, there is a framed section (approximately 4 square ft) to accommodate the HVAC vent. In between these vents exists another pressure relief panel. The bottom 2'-6" of the square tube steel frame is covered with a steel plate.

Impact on DCA:

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

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Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.03-4

Title 10 of the Code of Federal Regulations, Part 50, Appendix A, Criterion 2 and Appendix S to 10 CFR Part 50, provide the requirements to be met by SSC important to safety. DSRS Section 3.7.3 provides review guidance pertaining to the design of important to safety seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping; tunnels, and conduits; concrete dams; and atmospheric tanks. Consistent with DSRS Section 3.7.3, the staff reviewed the descriptive information, including plans and sections of each structure, to establish that there is sufficient information to define the structural aspects and elements relied upon for the substructure to perform the intended safety function.

Staff reviewed Section 3.7.3.3.2.1, “Evaluation,” of the FSAR. The last paragraph on page 3.7-57 states, in part, “the capacity of the anchor bolt is checked. The anchor bolt material is ASTM A193 Grade B7 due to its temperature and corrosion resistance.” The bioshield has a seismic Category II categorization. In evaluating the slab and anchor bolts for the bioshield, the staff noticed that the safety classification of the anchor bolt was not provided. The staff believes that the bolts used for anchoring the bioshield to the slab should be safety related. Therefore, the applicant is requested to provide the following:

a. The safety classification of the bolts.
b. The anchor bolts pattern (spacing) for the bioshield mounting as stated in the application that, “The bioshield slab is anchored to the NPM bay walls with four 1.5-in. vertical bolts on each wall and to the NPM pool wall with eight 1.5-in. bolts in the horizontal direction.”
c. A description as to how the horizontal direction bolts are installed.

NuScale Response:

The following responses pertain to the bolts used for anchoring the bioshield:

a. The bolts for the bioshield are non-safety related, Seismic Category II. In accordance with DSRS 3.7.3.II.8, an attached Non-Seismic Category I subsystem, up to the first anchor beyond the interface, should also be designed in such a manner that during an earthquake of SSE intensity it will not cause a failure of the Seismic Category I SSCs. The bolts for the bioshield have been designed to resist the safe shutdown earthquake, and remain functional. In addition, the analysis of the proposed bolt layout has shown the demand to capacity ratio for the bolts to be relatively low. Lastly, it should be noted that the horizontal and vertical bolts were analyzed separately with the full loads of the bioshield applied for conservatism.

b. The bioshield has 8 vertically placed bolts, 4 along the eastern edge and 4 along the western edge, of the reinforced concrete section of the bioshield down into the operating bay walls. It also has 8 equally spaced, horizontally placed bolts connecting a plate on the bioshield to the pool wall.

c. The bioshield is put into place with the reactor building crane (RBC). The horizontal bolts are manually placed and tightened. There are 8 1-1/2” diameter horizontal bolts connecting the bioshield to the reactor building (RXB) pool wall via steel plate to the reinforced concrete wall.

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

NuScale Power

Response to Request for Additional Information
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eRAI No.: 8928
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.03-5

Title 10 of the Code of Federal Regulations, Part 50, Appendix A, Criterion 2 and Appendix S to 10 CFR Part 50, provide the requirements to be met by SSC important to safety. DSRS Section 3.7.3 provides review guidance pertaining to the design of important to safety seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping; tunnels, and conduits; concrete dams; and atmospheric tanks. Consistent with DSRS Section 3.7.3, the staff reviews the descriptive information, including plans and sections of each structure, to establish that there is sufficient information to define the structural aspects and elements relied upon for the substructure to perform the intended safety function.

The staff reviewed Section 3.7.3.3.1, “Reactor Building Crane,” of the FSAR and noted that additional information is needed to complete the safety review of the RBC. Thus, the staff is requesting the applicant to augment Section 3.7.3.3.1 to include the finite element model of the crane and its characteristics, the dynamic properties, along with the seismic responses at the critical locations.

NuScale Response:

FSAR Tier 2, Section 3.7.3.3.1 and Tables 3.7.3-1 through 3.7.3-7 have been deleted. DSRS Section 3.7.3 is not applicable to the reactor building crane (RBC) seismic analysis. FSAR Tier 2, Section 9.1.5 contains the safety evaluation and design for the RBC. Seismic analysis methodology is prescribed by ASME NOG-1. Cranes designed to meet ASME NOG-1 have been accepted by the NRC as meeting requirements for NUREG-0554 and General Design Criteria 2. The discussion of the reactor building (RXB) seismic analysis is provided in FSAR Tier 2, Section 3.7.2.

Impact on DCA:

FSAR Tier 2, Section 3.7.3, Section 3.8.4.1.13 andFSAR Tier 2, Tables 3.7.3-1 through 3.7.3-7 have been revised as described in the response above and as shown in the markup provided with this response.

3.7.3 Seismic Subsystem Analysis

Seismic subsystems are structures, systems, and components (SSC) for which the seismic forces are transmitted through the building structure as opposed to being imparted through the soil. The following are considered subsystems:

- structures, such as floor slabs, walls, miscellaneous steel platforms and framing
- equipment modules consisting of components, piping, supports, and structural frames
- equipment including vessels, tanks, heat exchanges, valves, and instrumentation
- distributive systems including piping and supports, electrical cable trays and supports, heating ventilation and air conditioning ductwork and supports, instrumentation tubing and supports, and conduits and supports. These distributed systems are predominantly Seismic Category II

In general, subsystems are evaluated as part of the detailed design using the analysis methodology described herein. Piping systems and their supports are further described in Section 3.12.

There are four seismic subsystems that are included in the certified design and specifically evaluated.

Each NuScale Power Module (NPM) is a subsystem. The seismic analysis of the NPMs is provided in Appendix 3A. The NPMs are included in the Reactor Building seismic model as beam elements as discussed in Section 3.7.2.

The fuel storage racks are a subsystem. The design of the racks is discussed in Section 9.1.2 and the details of the seismic analysis are provided in technical report TR-0816-49833 (Reference 3.7.3-1). The fuel storage racks are included in the seismic analysis of the building as a weight only.

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The Reactor Building crane (RBC) is a subsystem. The design of the RBC is discussed in Section 9.1.5. The RBC is included in the Reactor Building seismic analysis as a beam and spring model as discussed in Section 3.7.2. ~~The seismic analysis of the RBC is discussed in Section 3.7.3.3.1.~~

The bioshields are subsystems. The bioshields are included in the building model as weights only. The bioshield design and analysis is discussed in Section 3.7.3.3.2.

3.7.3.1 Seismic Analysis Methods

Subsystems are generally evaluated using response spectrum analysis. Simple substructures may be evaluated using the equivalent static load method. These methods are described below. The NPMs and fuel storage racks were evaluated using time histories as described in Appendix 3A and technical report TR-0816-49833 (Reference 3.7.3-1), respectively.

for the standard plant are normally composed of two SSE events, with 10 maximum stress-cycles each, for a total of 20 full cycles. This is considered equivalent to the cyclic load basis of one SSE and five OBEs.

Alternatively, the number of fractional vibratory cycles equivalent to that of 20 full SSE vibratory cycles with an amplitude not less than one-third of the maximum SSE amplitude may be used when derived in accordance with IEEE 344 (Reference 3.7.3-8).

3.7.3.3 Procedures Used for Analytical Modeling

For the decoupling of the subsystem and the supporting system, the following criteria are used:

- if $R_m < 0.01$, decoupling can be done for any R_f
- if $0.01 \le R_m \le 0.1$, decoupling can be done if $0.8 \ge R_f \ge 1.25$
- if $R_m > 0.1$, a subsystem model should be included in the primary system model

where,

$$R_m = \frac{\text{total mass of supported subsystem}}{\text{total mass of supporting subsystem}}$$

$$R_f = \frac{\text{fundamental frequency of supported subsystem}}{\text{dominant frequency of support motion}}$$

The Reactor Building (RXB) structural weight is greater than 500,000 kips (see Table 3.7.2-13). As such, a subsystem can be decoupled if the weight is less 5000 kips. The larger subsystems, the NPM and the RBC, have weights on the order of 2000 kips and could be uncoupled. However, they are both coupled in the RXB model. The fuel storage racks have a loaded weight less than 2000 kips, and each bioshield is less than 200 kips. Therefore these SSC are decoupled.

Distributed systems (cable trays, piping, heating ventilation and air conditioning) and individual components will not have significant weights that would challenge the $R_m < 0.01$ criterion.

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3.7.3.3.1 ~~Reactor Building Crane~~

~~The RBC is nonsafety-related, risk-significant and Seismic Category I. The RBC is normally parked over the refueling pool with the north end near the dry dock gate. In this position, the RBC is not above either the spent fuel pool or the NPMs. The RBC is discussed in Section 9.1.5. A simplified beam and spring model of the RBC is coupled in the RXB model and ISRS developed at the rails. These ISRS are shown in Figure 3.7.2-114. The RBC is then evaluated as a decoupled model using the ISRS developed from the building model. If significant changes are necessary to the RBC, the beam model is updated. If the structure is re-analyzed (due to any significant~~

~~change in the model), new ISRS are generated. The new ISRS are compared to the ISRS used as input for the design of the RBC. If warranted, a new analysis of the RBC is performed. Due to this iterative nature of the design process, the ISRS used for the analysis of the RBC lag the building. The seismic analysis of the RBC is completed per ASME NOG-1 (Reference 3.7.3-3).~~

RAI 03.07.03-5

~~To evaluate the RBC, a detailed finite element model representing the bridge and the trolley was developed in ANSYS 14.0 (Reference 3.7.3-2) and used to evaluate the crane as per the load combinations given in Section 4140 of ASME NOG-1 (Reference 3.7.3-3). The bridge and trolley structural members are modeled using BEAM 188 elements with user defined cross sections that represent the actual cross section of the component. Miscellaneous item weights are included in the finite element model by adjusting the density of the component they are attached in order to represent the total dead weight. Rated load and bottom block weight are represented by using MASS21 elements. To capture the pendulum effect, ropes are modeled by using COMBIN14 spring elements.~~

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~~Constraint equations (rigid regions) are used to connect the drum to the trolley and coupled sets are used to connect the trolley to the bridge. Coupled sets are also used to provide rotational release at the pinned connections.~~

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~~The analysis is performed with the trolley located at three different positions on the bridge (end, quarter and middle) with the hook at lowest and highest elevations with a load of the rated capacity. The "No load" condition is also analyzed for all three trolley positions.~~

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~~Modal Analysis~~

~~Modal analysis was carried out prior to response spectrum analysis. The first 150 modes of the model were extracted in the modal analysis through the Block Lanczos method (up to 100Hz). The fundamental frequencies for the crane at various trolley, hook and load configurations are given in Table 3.7.3-1. Mass participation values given in the table represents the fundamental mode's participating mass in comparison with the overall mass of the system.The number of modes extracted was kept high to ensure that the mass participation in the modal analysis is at least 90 percent, meeting the requirements of Section 4153.9 of NOG-1. Table 3.7.3-2 summarizes the mass participation in the modal analysis and the least mass participation in each direction is highlighted. Except for the no load condition, mass participation was close to 95 percent. This, along with choosing a very low significance factor of 1E-6 for the modal combination in the spectrum analysis results in capturing a large modal contribution in the response computation.~~

RAI 03.07.03-5

~~**Response Spectrum Analysis**~~

~~Response Spectrum analysis is carried out for vertical, north-south and east-west directional spectrum. During the response spectrum analysis, the grouping method is used to combine the modal responses for closely spaced modes and the square-root-of-the-sum-of-the-squares (SRSS) method is used for combination of not closely spaced modes as per Section 4153.10 of NOG-1. After the spectrum analysis, component stress values of each of the analysis results are summed based on the SRSS rule to get the combined stress due to three excitations. This combined stress is added with the static analysis results in an absolute sense to get the "seismic + static" result for each component stress. Adding the absolute values of responses address both addition and subtraction of seismic response with the static results. The formula below shows the combination of responses. Normal and shear stress values are compared with the allowable stress for all the configurations.~~

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$$\boxed{R_{sum} = |R_{sta}| + \sqrt{R_{sew}^2 + R_{sns}^2 + R_{sud}^2}} \qquad \text{Eq. 3.7-18}$$

~~where,~~

~~R_{sew} = stresses from seismic loading on east-west direction,~~

~~R_{sns} = stresses from seismic loading north-south direction,~~

~~R_{sud} = stresses from seismic loading on vertical direction, and~~

~~R_{sta} = stresses from 1g static loading with the load on the hook.~~

RAI 03.07.03-5

~~The static solution is performed for 1g loading in the vertical direction. Inertial loads and impact loads are not present in the static analysis as described in Section 4140 of NOG-1.~~

RAI 03.07.03-5

~~There are two SSE load cases:~~

~~$PC_{10} = P_{db} + P_{dt} + P_{cs} + P'_e + P_{wo}$~~

~~$PC_{11} = P_{db} + P_{dt} + P'_e + P_{wo}$~~

~~where,~~

~~P_{db} = dead weight of the bridge,~~

~~P_{dt}=dead weight of the trolley,~~

~~P_{cs} = credible critical load,~~

~~P'_e = CSDRS or CSDRS-HF loads, and~~

~~P_{wo} = operating wind load (not applicable).~~

RAI 03.07.03-5

~~Structural crane components are constructed with ASTM A572 Grade 50 material or better. Allowable stress for the ASTM A572 Grade 50 material used in the trolley and bridge are given in Table 3.7.3-3 for extreme environmental conditions.~~

RAI 03.07.03-5

~~Table 3.7.3-4 through Table 3.7.3-7 show the summary of combined stresses in the bridge and trolley for all configurations based on the CSDRS and CSDRS-HF. Maximum normal stress and shear stress are highlighted in the tables. The maximums are less than the allowable given in Table 3.7.3-3.~~

3.7.3.3.2 Bioshields

The bioshields are nonsafety-related, not risk-significant, Seismic Category II components that are placed on top of each module bay at the 125' elevation to provide an additional radiological barrier to reduce dose rates in the RXB and support personnel access. Bioshields are removed while a NPM is being detached and refueled. During that time, the removed bioshield is placed on top of an in-place bioshield.

Each bioshield is comprised of a horizontal slab supported by the bay walls and a hanging vertical face plate attached to the horizontal slab. The horizontal slab consists of 21.5-in. thick reinforced 5000 psi concrete with a 2-in. layer of high-density polyethylene on the top. The concrete and high-density polyethylene are encapsulated in 1/4-in. steel plates for a total thickness of two feet. The vertical plate is constructed of a stainless steel tube framing system and stainless steel face plates. The vertical plate is vented for heat removal during normal operation and heat and pressure mitigation in the event of a high energy line break and slow leak, high temperature event above the NPM. A solid design is used as a representative weight for the structural analysis.

The bioshields are attached to the bay walls and outer pool wall using 1.5-in. diameter removable anchor bolts. Figure 3.7.3-1 shows six installed bioshields and Figure 3.7.3-2 shows a vertical faceplate.

Reinforced Concrete Properties and Slab Capacity

Table 3.7.3-8 contains the section dimensions used for the design of the bioshield. Table 3.7.3-9 shows the concrete and reinforcement design values used for capacity calculations. The values are obtained from ACI 349 (Reference 3.7.3-4). The minimum concrete cover for cast-in-place members is based on Section 7.7.1 of ACI 349.

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Table 3.7.3-1: ~~Reactor Building Crane Fundamental Frequencies~~

~~Configuration~~			~~Fundamental Frequency (Hz)~~			~~Mass Participation~~		
~~Trolley~~	~~Hook~~	~~Load~~	~~X (NS)~~	~~Y (EW)~~	~~Z (V)~~	~~X (NS)~~	~~Y (EW)~~	~~Z (V)~~
~~End~~	~~Down~~	~~Yes~~	~~8.13~~	~~1.83~~	~~3.18~~	~~31.62%~~	~~33.83%~~	~~61.82%~~
~~End~~	~~Up~~	~~Yes~~	~~8.69~~	~~1.87~~	~~4.27~~	~~46.96%~~	~~30.81%~~	~~71.20%~~
~~End~~	~~Up~~	~~No~~	~~7.24~~	~~1.89~~	~~7.24~~	~~26.34%~~	~~29.21%~~	~~38.92%~~
~~Mid~~	~~Down~~	~~Yes~~	~~11.14~~	~~1.70~~	~~2.84~~	~~29.04%~~	~~36.40%~~	~~69.12%~~
~~Mid~~	~~Up~~	~~Yes~~	~~10.91~~	~~1.75~~	~~3.48~~	~~52.21%~~	~~32.83%~~	~~76.68%~~
~~Mid~~	~~Up~~	~~No~~	~~10.94~~	~~1.77~~	~~6.24~~	~~29.08%~~	~~30.57%~~	~~59.04%~~
~~Quarter~~	~~Down~~	~~Yes~~	~~8.52~~	~~1.76~~	~~2.99~~	~~28.59%~~	~~35.45%~~	~~66.39%~~
~~Quarter~~	~~Up~~	~~Yes~~	~~9.81~~	~~1.81~~	~~3.78~~	~~48.28%~~	~~32.13%~~	~~74.74%~~
~~Quarter~~	~~Up~~	~~No~~	~~10.84~~	~~1.82~~	~~6.69~~	~~25.33%~~	~~30.20%~~	~~51.05%~~

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Table 3.7.3-2: ~~Reactor Building Crane Mass Participation In Modal Analysis~~

~~Configuration~~			~~Mass Participation~~		
~~Trolley~~	~~Hook~~	~~Load~~	~~X (NS)~~	~~Y (EW)~~	~~Z (V)~~
~~End~~	~~Down~~	~~Yes~~	~~96.95%~~	~~99.78%~~	~~94.98%~~
~~End~~	~~Up~~	~~Yes~~	~~96.95%~~	~~99.78%~~	~~94.98%~~
~~End~~	~~Up~~	~~No~~	~~94.36%~~	~~99.59%~~	~~90.71%~~
~~Mid~~	~~Down~~	~~Yes~~	~~96.93%~~	~~99.78%~~	~~94.94%~~
~~Mid~~	~~Up~~	~~Yes~~	~~96.93%~~	~~99.78%~~	~~94.94%~~
~~Mid~~	~~Up~~	~~No~~	~~94.32%~~	~~99.59%~~	~~90.76%~~
~~Quarter~~	~~Down~~	~~Yes~~	~~96.98%~~	~~99.78%~~	~~94.94%~~
~~Quarter~~	~~Up~~	~~Yes~~	~~96.98%~~	~~99.78%~~	~~94.94%~~
~~Quarter~~	~~Up~~	~~No~~	~~94.42%~~	~~99.59%~~	~~90.64%~~

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Table 3.7.3-3: ~~Reactor Building Crane Allowable Stress - Extreme Environmental Conditions (Per NOG-1)~~

~~Material~~	~~Yield Strength (ksi)~~	~~Allowable Compression Stress (ksi)~~	~~Allowable Tension Stress (ksi)~~	~~Allowable Shear Stress (ksi)~~
~~ASTM A572 Gr. 50~~	~~50~~	~~45~~	~~45~~	~~25~~

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Table 3.7.3-4: ~~Reactor Building Crane Bridge Combined Seismic Response (CSDRS)~~

~~Configuration~~			~~COMBINED RESPONSES (ksi)~~								
			~~Girders~~			~~End Truck Assembly~~			~~End Tie and Link Assembly~~		
			~~Normal~~	~~Shear~~		~~Normal~~	~~Shear~~		~~Normal~~	~~Shear~~	
~~Trolley~~	~~Hook~~	~~Load~~	~~SX~~	~~SXY~~	~~SXZ~~	~~SX~~	~~SXY~~	~~SXZ~~	~~SX~~	~~SXY~~	~~SXZ~~
~~Mid~~	~~Up~~	~~Yes~~	**~~33.7~~**	~~9.1~~	~~14.9~~	~~24.3~~	~~5.1~~	~~9.0~~	~~25.6~~	~~3.8~~	~~11.0~~
~~Mid~~	~~Down~~	~~Yes~~	~~29.9~~	~~9.6~~	~~14.6~~	~~26.4~~	~~5.0~~	~~8.6~~	~~26.1~~	~~3.3~~	~~11.2~~
~~Mid~~	~~Up~~	~~No~~	~~23.7~~	~~9.8~~	~~13.2~~	~~25.0~~	~~5.4~~	~~7.0~~	~~27.1~~	~~3.6~~	~~12.1~~
~~Quarter~~	~~Up~~	~~Yes~~	~~32.9~~	~~9.6~~	~~18.3~~	~~28.3~~	~~6.2~~	~~11.2~~	~~26.7~~	~~3.3~~	~~11.5~~
~~Quarter~~	~~Down~~	~~Yes~~	~~32.0~~	~~9.7~~	~~16.5~~	~~26.4~~	~~5.8~~	~~10.4~~	~~27.0~~	~~2.5~~	~~11.5~~
~~Quarter~~	~~Up~~	~~No~~	~~27.4~~	~~11.2~~	~~15.1~~	~~27.6~~	~~6.2~~	~~8.5~~	**~~30.9~~**	~~3.0~~	**~~14.1~~**
~~End~~	~~Up~~	~~Yes~~	~~30.6~~	~~9.2~~	**~~19.3~~**	**~~31.7~~**	~~7.0~~	**~~12.7~~**	~~27.9~~	~~6.4~~	~~12.2~~
~~End~~	~~Down~~	~~Yes~~	~~31.0~~	~~9.9~~	~~17.9~~	~~28.5~~	~~6.2~~	~~11.3~~	~~28.6~~	~~2.3~~	~~11.9~~
~~End~~	~~Up~~	~~No~~	~~26.1~~	~~8.7~~	~~14.3~~	~~24.7~~	~~5.2~~	~~8.9~~	~~26.7~~	~~2.8~~	~~11.9~~
~~Allowable Values~~			~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~

~~Note: Maximum normal and shear forces are highlighted.~~

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Table 3.7.3-5: ~~Reactor Building Crane Trolley Combined Seismic Response (CSDRS)~~

~~Configuration~~			~~COMBINED RESPONSES (ksi)~~					
			~~Trolley End Truck~~			~~Trolley Frame~~		
			~~Normal~~	~~Shear~~		~~Normal~~	~~Shear~~	
~~Trolley~~	~~Hook~~	~~Load~~	~~SX~~	~~SXY~~	~~SXZ~~	~~SX~~	~~SXY~~	~~SXZ~~
~~Mid~~	~~Up~~	~~Yes~~	~~21.8~~	~~2.4~~	~~12.9~~	~~32.5~~	~~11.9~~	~~18.5~~
~~Mid~~	~~Down~~	~~Yes~~	~~18.9~~	~~2.2~~	~~11.6~~	~~27.9~~	~~16.0~~	~~15.7~~
~~Mid~~	~~Up~~	~~No~~	~~18.1~~	~~1.8~~	~~9.2~~	~~16.7~~	~~15.5~~	~~12.5~~
~~Quarter~~	~~Up~~	~~Yes~~	~~25.1~~	~~2.6~~	~~14.1~~	~~35.8~~	~~13.0~~	~~20.4~~
~~Quarter~~	~~Down~~	~~Yes~~	~~20.4~~	~~2.3~~	~~12.6~~	~~29.8~~	~~16.1~~	~~16.9~~
~~Quarter~~	~~Up~~	~~No~~	~~16.9~~	~~1.8~~	~~9.8~~	~~15.4~~	~~13.9~~	~~11.2~~
~~End~~	~~Up~~	~~Yes~~	**~~27.6~~**	~~2.7~~	**~~14.9~~**	**~~37.6~~**	~~13.0~~	**~~21.3~~**
~~End~~	~~Down~~	~~Yes~~	~~25.4~~	~~2.7~~	~~14.9~~	~~28.7~~	~~16.3~~	~~16.4~~
~~End~~	~~Up~~	~~No~~	~~19.9~~	~~2.2~~	~~12.1~~	~~13.8~~	~~13.7~~	~~11.1~~
~~Allowable Values~~			~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~

~~Note: Maximum normal and shear forces are highlighted.~~

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Table 3.7.3-6: ~~Reactor Building Crane Bridge Combined Seismic Response (CSDRS-HF)~~

~~**Configuration**~~			~~**COMBINED RESPONSES (ksi)**~~								
			~~**Girders**~~			~~**End Truck Assembly**~~			~~**End Tie and Link Assembly**~~		
			~~**Normal**~~	~~**Shear**~~		~~**Normal**~~	~~**Shear**~~		~~**Normal**~~	~~**Shear**~~	
~~**Trolley**~~	~~**Hook**~~	~~**Load**~~	~~**SX**~~	~~**SXY**~~	~~**SXZ**~~	~~**SX**~~	~~**SXY**~~	~~**SXZ**~~	~~**SX**~~	~~**SXY**~~	~~**SXZ**~~
~~Mid~~	~~Up~~	~~Yes~~	~~26.5~~	~~9.9~~	~~14.5~~	~~25.8~~	~~5.2~~	~~8.3~~	~~25.6~~	~~6.0~~	~~10.9~~
~~Mid~~	~~Down~~	~~Yes~~	~~24.0~~	~~10.5~~	~~15.0~~	~~**28.3**~~	~~5.1~~	~~8.5~~	~~26.4~~	~~5.1~~	~~11.0~~
~~Mid~~	~~Up~~	~~No~~	~~20.7~~	~~9.8~~	~~12.8~~	~~25.4~~	~~5.3~~	~~7.2~~	~~26.2~~	~~5.5~~	~~11.9~~
~~Quarter~~	~~Up~~	~~Yes~~	~~27.4~~	~~10.1~~	~~16.2~~	~~24.1~~	~~5.4~~	~~9.4~~	~~25.8~~	~~5.1~~	~~11.8~~
~~Quarter~~	~~Down~~	~~Yes~~	~~29.0~~	~~10.5~~	~~15.9~~	~~26.2~~	~~5.5~~	~~9.6~~	~~26.3~~	~~3.5~~	~~11.5~~
~~Quarter~~	~~Up~~	~~No~~	~~25.7~~	~~11.3~~	~~14.8~~	~~27.9~~	~~6.2~~	~~8.6~~	~~**29.9**~~	~~4.2~~	~~**13.6**~~
~~End~~	~~Up~~	~~Yes~~	~~27.9~~	~~9.7~~	~~16.9~~	~~26.5~~	~~5.9~~	~~10.4~~	~~27.0~~	~~10.4~~	~~13.5~~
~~End~~	~~Down~~	~~Yes~~	~~**30.2**~~	~~10.7~~	~~**17.1**~~	~~26.5~~	~~5.9~~	~~**10.4**~~	~~28.4~~	~~3.1~~	~~12.0~~
~~End~~	~~Up~~	~~No~~	~~25.6~~	~~9.3~~	~~15.2~~	~~26.0~~	~~5.5~~	~~9.4~~	~~27.1~~	~~4.1~~	~~12.2~~
~~Allowable Values~~			~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~

~~Note: Maximum normal and shear forces are highlighted.~~

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Table 3.7.3-7: ~~Reactor Building Crane Trolley Combined Seismic Response (CSDRS-HF)~~

~~Configuration~~			~~COMBINED RESPONSES (ksi)~~					
			~~Trolley End Truck~~			~~Trolley Frame~~		
			~~Normal~~	~~Shear~~		~~Normal~~	~~Shear~~	
~~Trolley~~	~~Hook~~	~~Load~~	~~SX~~	~~SXY~~	~~SXZ~~	~~SX~~	~~SXY~~	~~SXZ~~
~~Mid~~	~~Up~~	~~Yes~~	~~23.8~~	~~2.4~~	~~12.8~~	~~22.9~~	~~14.3~~	~~13.4~~
~~Mid~~	~~Down~~	~~Yes~~	~~21.0~~	~~2.2~~	~~11.9~~	~~21.7~~	~~18.0~~	~~14.5~~
~~Mid~~	~~Up~~	~~No~~	~~19.7~~	~~2.1~~	~~9.7~~	~~17.8~~	~~18.1~~	~~14.6~~
~~Quarter~~	~~Up~~	~~Yes~~	~~25.7~~	~~2.4~~	~~13.2~~	~~25.5~~	~~15.7~~	~~15.0~~
~~Quarter~~	~~Down~~	~~Yes~~	~~21.5~~	~~2.3~~	~~12.2~~	~~20.0~~	~~18.9~~	~~15.2~~
~~Quarter~~	~~Up~~	~~No~~	~~18.2~~	~~1.9~~	~~10.0~~	~~16.7~~	~~16.4~~	~~13.2~~
~~End~~	~~Up~~	~~Yes~~	**~~27.9~~**	~~2.5~~	~~13.7~~	**~~27.0~~**	~~15.8~~	~~15.7~~
~~End~~	~~Down~~	~~Yes~~	~~26.0~~	~~2.7~~	**~~14.5~~**	~~18.6~~	**~~19.7~~**	~~15.9~~
~~End~~	~~Up~~	~~No~~	~~20.7~~	~~2.3~~	~~12.1~~	~~14.8~~	~~17.2~~	~~13.9~~
~~Allowable Values~~			~~45~~	~~25~~	~~25~~	~~45~~	~~25~~	~~25~~

~~Note: Maximum normal and shear forces are highlighted.~~

3.8.4.1.9 Buried Conduit and Duct Banks

The design does not include any buried safety related pipes or pipe ducts.

3.8.4.1.10 Buried Pipe and Pipe Ducts

The design does not include any buried safety related pipes or pipe ducts.

3.8.4.1.11 Masonry Walls

Masonry walls are not used in the Reactor Building or in the Control Building.

3.8.4.1.12 Modular Construction

The design of the Seismic Category I RXB and CRB structural walls does not include steel-concrete (SC) modular subsystems. Modular construction techniques (including sacrificial steel) that do not alter the design, normal construction techniques, or analysis may be employed.

3.8.4.1.13 Reactor Building Crane

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The Reactor Building crane (RBC) is a bridge crane that rides on rails anchored to the RXB at EL 145' 6". The RBC is part of the Overhead Heavy Load Handling System and is discussed in Section 9.1.5. For analysis of the RXB, the RBC is included as a beam and spring model as described in Section 3.7.2.1.2.3. ~~The seismic analysis of the RBC is described in Section 3.7.3.3.1.~~

3.8.4.2 Applicable Codes, Standards, and Specifications

The following codes and standards are applicable for the design and construction of Seismic Category I structures and basemats. For the ASTM standards, which are applicable to construction, the code year is not specified. For these standards, the latest endorsed version at the time of construction is used.

3.8.4.2.1 Design Codes and Standards

ACI 207.1R	2005	Guide to Mass Concrete
ACI 211.1	1991	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 301	2010	Specification for Structural Concrete for Buildings.
ACI 304R	2000	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI 305.1	2014	Specification for Hot-Weather Concreting.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0917-56335

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

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 methodology by which NuScale develops its reactor building HVAC system and environmental qualification of equipment important to safety.

    NuScale has performed significant research and evaluation to develop a basis for this methodology 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. 135, eRAI No. 8928. 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 10/3/2017.

Zackary W. Rad