RAIO-0218-58796

February 21, 2018

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. 221 (eRAI No. 9114) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 221 (eRAI No. 9114)," dated September 12, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 221 (eRAI No.9114)," dated November 13, 2017

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 Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9114:

- 03.07.02-31

This letter and the enclosed response 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. 9114

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9114

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

eRAI No.: 9114
Date of RAI Issue: 09/12/2017

NRC Question No.: 03.07.02-31

10 CFR 52.47(a)(20) requires that an application for Design Certification must include the information necessary to demonstrate that the standard plant complies with the earthquake engineering criteria in 10 CFR 50, Appendix S. 10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake (SSE) through design, testing, or qualification methods.

FSAR Tier 2, Section 3A.1 states the seismic analysis of the NuScale Power Module (NPM) is provided in technical report, TR-0916-51502, "NuScale Power Module Seismic Analysis". In TR-0916-51502, Section 3.1, the applicant indicates that NPM simplified beam models developed in ANSYS are incorporated into the RXB system model used in SAP2000 and SASSI2010 analyses. In TR-0916-51502, Section 6.0, the applicant discusses how NPM simplified beam models were derived from the corresponding NPM detailed 3D models in ANSYS. However, the staff notes that the NPM beam models depicted in Figure 6- 1 (dry) and Figure 6-13 (wet) in TR-0916-51502 appear to be different than the model shown in FSAR Figure 3.7.2-28, which FSAR Section 3.7.2.1.2.2 states represents the SASSI2010 NPM beam model.

Therefore, the applicant is requested to explain how the NPM beam models included in the SAP2000/SASSI2010 RXB models were developed and validated (e.g., comparison of dynamic characteristics between the detailed and simplified models).

NuScale Response:

As discussed, in a public meeting on January 30, 2018, a supplement to NuScale's original response to RAI 9114 03.07.02-31 is provided as follows:

As the NRC has stated, the NuScale Power Module (NPM) beam models used in the soil-structure interaction (SSI) and load combinations for the building models in SASSI2010 and SAP2000, are different from those presented in the technical report, TR-0916-51502. The beam models from TR-0916-51502 are more refined models which better represent the dynamic

behavior of the detailed 3D model and are more appropriate for the NPM specific analyses.

The NPM beam model shown in FSAR Tier 2, Figure 3.7.2-28, and described in Section 3.7.2.1.2.2, was created to have similar dynamic characteristics as the 3D model and is used in the analysis of the SAP2000 and SASSI2010 RXB models. To validate the NPM beam model, a modal analysis in three directions was performed in order to tune the simplified model to match the detailed 3D model response. The frequencies for the most significant modes are presented in Table 1. The simplified beam model captures the overall dynamic behavior of the 3D NPM model required for the building response analyses used in the SASSI2010 and SAP2000 models.

Table 1: Major mode comparisons between simplified NPM beam model and 3D model.

Simplified Beam Model		**3D Model**
X-Freq.	**X-Eff. Mass**	**X-Freq.**
(Hz)	**($lbfs^2$/in)**	**(Hz)**
6.9	3999	5.83
12.85	2395	11.16
17.14	284	17.45
Simplified Beam Model		**3D Model**
Y-Freq.	**Y-Eff. Mass**	**Z-Freq.**
(Hz)	**($lbfs^2$/in)**	**(Hz)**
9.23	1989	8.89
14.29	3304	12.59
19.28	1399	15.12
Simplified Beam Model		**3D Model**
Z-Freq.	**Z-Eff. Mass**	**Y-Freq.**
(Hz)	**($lbfs^2$/in)**	**(Hz)**
14.18	2456	13.94
19.4	2227	16.41
42.67	191	42.9

Impact on DCA:

FSAR Tier 2, Section 3.7.2.1.2.2 and Table 3.7.2-38 have been revised as described in the response above and as shown in the markup provided in this response.

NuScale Power Module Model Included in the Reactor Building SASSI2010 Model

RAI 03.07.02-20, RAI 03.07.02-20S1, RAI 03.07.02-31S1

Within the SASSI2010 building model, the NPM is represented by a beam model as shown in Figure 3.7.2-28. The beam model was developed to have similar dynamic characteristics as a 3-D ANSYS model of a single NPM bay. To validate the NPM beam model, a modal analysis in three directions was performed in order to tune the simplified model to match the detailed 3-D model response, shown in Table 3.7.2-38. The skirt support at the base of the containment restricts horizontal and vertical movements but permits the NPM to twist about the vertical axis. Eight rigid beams arranged like the legs of a spider are modeled to connect the NPM model containment skirt to nodes in the building model located at the interface of the skirt and pool floor. Twist about the vertical axis is released at the base of the NPM model. The RXB analysis produces local acceleration time histories that are used as input to the NPM seismic analysis. The seismic analysis of the NPM is discussed in Appendix 3A. Table 3.7.2-36 and Table 3.7.2-37 outline the NPM beam model to RXB model interface boundary conditions for the SASSI2010 and ANSYS models, respectively.

3.7.2.1.2.3 Reactor Building Crane

The RBC is a bridge crane used to transport modules between the operating locations and the refueling and disassembly area and the drydock. The RBC travels on rails on the top of the reactor pool walls at EL. 145'-6". When not in use, the RBC is parked over the refueling pool with the trolley at the north end 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

RAI 03.07.02-31S1

Table 3.7.2-38: Major Mode Comparisons Between Simplified NuScale Power Module Beam Model and 3-D Model

Simplified Beam Model		3-D Model
X-Freq. (Hz)	X-Eff. Mass ($lb_f s^2$/in.)	X-Freq. (Hz)
6.9	3999	5.83
12.85	2395	11.16
17.14	284	17.45
Simplified Beam Model		**3-D Model**
Y-Freq. (Hz)	Y-Eff. Mass ($lb_f s^2$/in.)	Z-Freq. (Hz)
9.23	1989	8.89
14.29	3304	12.59
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Simplified Beam Model		**3-D Model**
Z-Freq. (Hz)	Z-Eff. Mass ($lb_f s^2$/in.)	Y-Freq. (Hz)
14.18	2456	13.94
19.4	2227	16.41
42.67	191	42.9