November 13, 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. 221 (eRAI No. 9114) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 221 (eRAI No. 9114)," dated September 12, 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 Enclosure to this letter contains NuScale's response to the following RAI Questions from NRC eRAI No. 9114:

- 03.07.02-31
- 03.07.02-32

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
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9114

Enclosure 1:

NuScale 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 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 updated models which better represent the dynamic behavior of the detailed 3D model and are more appropriate for the NPM specific analyses. The updated NPM beam models were imported into the SASSI2010 building model and run through a RXB

SSI analysis for three study cases using the Capitola input time history. A critical design check was formed in the NPM support walls to demonstrate that the RXB design is robust and D/C ratios are acceptable. In addition, the maximum lug support forces are within the acceptable range of the lug support capacity. Therefore, the updated NPM beam models documented in TR-0916-51502 were shown to have minimal impact on the RXB building response, and the simplified models documented in Section 3.7.2.1.2.2 of the FSAR Tier 2 provide adequate dynamics responses for the design of the building structure.

The simplified beam models used in SASSI2010 and SAP2000 have been verified using an alternate approach to the one described in TR-0916-51502. 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. This beam model can be used in the reactor building (RXB) model to capture the RXB-NPM interactions, or to get approximate results of the full 3D model, but with a faster run time.

The NPM beam model consists of linear beam, spring/damper, and lumped mass elements only. The reactor pressure vessel (RPV), containment vessel (CNV), CNV support skirt, platform frame and control rod drive mechanisms (CRDMs) are all represented by massless hollow cylindrical beam elements. The equivalent inner and outer diameters of RPV and CNV head and shell sections are calculated matching cross-section areas and moments of inertia. Lumped masses are included to represent the mass of the CNV platform and the 16 CRDMs. These are attached to the CNV and RPV head, respectively, using very stiff beam elements. The modes from these two components are not expected to have a significant impact on the overall NPM response. The lower bumper connection between the RPV and CNV is represented by linear springs. Beam elements attach the CNV centerline to the RXB wall at the lateral support lug elevation. It is assumed that the effective connection between the lug and pool wall is at the geometric center of the lug, and the beam is sized accordingly to be 101 inches from the center of the NPM to the connection. The lugs are designed to carry shear loads only and thus are constrained in one degree of freedom.

The CNV skirt is pinned to the pool floor using stiff springs in the X, Y, and Z axes. Additionally, rotational springs are applied to capture the rotational stiffness of the skirt with respect to the floor.

The wet beam model was developed to include added mass effects from being immersed in the NPM pool. The beam model was constructed such that the horizontal response is decoupled from the vertical motion. The added mass in the horizontal directions (X and Y) is included as point masses on the CNV nodes. The amount of added mass was determined by trial and error until the effective masses of the major modes roughly matched those of the 3D model. The stiffness of the CNV shear lugs and RPV-CNV bumper springs were also adjusted to match frequencies of the 3D model. The vertical response is captured by a set of tuned point masses and springs that comprise the three primary vertical modes. All springs and masses are tuned to the 3D model frequencies and effective masses. To get the proper frequency (f), the equation f = 1/(2*pi)*sqrt(k/m) was used to solve for each spring stiffness (k). Each mass (m) is assumed to be the effective mass of the 3D model (with respect to each the three major modes).

To validate the NPM beam model, a modal analysis was performed in order to tune the simplified beam model to match the detailed 3D model response. The analysis was conducted for the wet condition (NPM immersed in the reactor pool). The frequencies and effective masses for the most significant modes are compared to validate the dynamic characteristics of the beam model.

Impact on DCA:

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

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eRAI No.: 9114
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NRC Question No.: 03.07.02-32

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 references NuScale technical report, TR-0916-51502, which provides details about the seismic analysis of the NuScale Power Module (NPM) and the models used. Additionally, in FSAR Section 3.7.2.1.2.4, the applicant indicates that the NPM model used in the ANSYS fluid-structure interaction (FSI) analysis consists of cylindrical shell elements representing the containment vessel (CNV) and beam elements representing the reactor pressure vessel (RPV), which is different from the NPM models discussed in TR-0916-51502. Therefore, the applicant is requested to explain how the NPM model used in ANSYS FSI analysis discussed in FSAR Section 3.7.2.1.2.4 were developed and validated (e.g., comparison of dynamic characteristics between the detailed and simplified models).

NuScale Response:

The NuScale Power Module (NPM) model used in the ANSYS FSI analysis discussed in FSAR Section 3.7.2.1.2.4 is similar to the NPM beam model used in the SAP2000/SASSI2010 building models described in FSAR Section 3.7.2.1.2.2 and in the response to RAI 9114, question 03.07.04-31 .

To validate the NPM beam model, a modal analysis was performed in order to tune the simplified beam model to match the detailed 3D model response. The analysis was conducted for the wet condition (NPM immersed in reactor pool). The frequencies and effective masses for the most significant modes are compared to validate the dynamic characteristics of the beam model.

In order to properly capture the interaction of pool water with twelve NPMs and analyze hydrodynamic effects, the Containment Vessel (CNV) of each NPM is modeled as a cylindrical shell with the proper CNV outer diameter. The Reactor Pressure Vessel (RPV) inside the CNV is modeled with BEAM188 elements. Additionally, all water mass regions are modeled by FLUID80 fluid finite element models. The NPM model with the CNV modeled as SHELL181 elements matches the dynamic characteristics of the NPM beam model.

Impact on DCA:

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