RAIO-0917-56336

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. 134 (eRAI No. 8934) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 134 (eRAI No. 8934)," 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 Enclosure to this letter contains NuScale's response to the following RAI Questions from NRC eRAI No. 8934:

- 03.07.02-13
- 03.07.02-14

The response to question 03.07.02-15 will be provided by December 21, 2017.

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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Enclsoure 1: NuScale Response to NRC Request for Addtional Information eRAI No. 8934

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8934

NUSCALE POWER™

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

eRAI No.: 8934
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.07.02-13

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.

a. On Page 3.7-28 of the FSAR, in the second paragraph, the applicant states, "The bottom nodes of the foundation are represented by COMBIN14 spring elements." The applicant is requested to describe how the spring constant for COMBIN14 elements was evaluated. Also, please clarify if the spring constant (1010 lbs/inch) used for the SAP2000 model described on Page 3.7-23 of the FSAR is used for the ANSYS model.
b. On Page 3.7-28 of the FSAR, in the second paragraph from the bottom, the applicant states, "Fixed base boundary conditions are utilized for the ANSYS model." However, on Page 3.7-28, in the second paragraph, the foundation bottom nodes are represented by spring elements. The applicant is requested to explain how fixed-base boundary conditions are realized by using spring elements.
c. Figure 3.7.2-34 in the FSAR shows a plan view of the wall segments used for fluid-structure interaction (FSI) analysis, and walls separating the refueling pool, spent fuel pool, and dry dock are indicated. However, ANSYS finite elements presented in Figure 3.7.2-33 do not show a wall segment separating the refueling pool and spent fuel pool and a segment separating the refueling pool and dry dock. The applicant is requested to clarify the discrepancy.
d. On Page 3.7-28 of the FSAR, in the second paragraph from the bottom, the applicant states, "The input to the ANSYS analysis is the CSDRS-compatible Capitola time history." In Section 8.0 of NuScale Technical Report, TR-0916-51502-P (NuScale Power Module Seismic Analysis), Rev 0, the applicant indicates that the time history input to NPM seismic analysis was obtained from RXB SASSI2010 analysis based on the CSDRS-compatible Capitola time history and Soil Type 7. The applicant is requested to justify the adequacy of the NPM seismic analysis based on a single CSDRS-based time-history and a single soil type while the seismic design of the RXB is based on analyses involving multiple time histories and soil types as discussed in FSAR Section 3.7.2.4.

NuScale Response:

Responses pertaining to the ANSYS model in FSAR Tier 2, Section 3.7.2 are provided as follows:

a. The spring elements at the base of the ANSYS model have very high stiffness values to represent a fixed-base condition, therefore, the spring constant for COMBIN14 elements was not evaluated. The bottom of the foundation basemat of the reactor building (RXB) ANSYS model has three COMBIN14 spring elements attached to each node with stiffness values of $1x10^8$lbf/in, $1x10^8$ lbf/in , and $1x10^8$ lbf/in for the E-W, N-S, and vertical directions, respectively. FSAR Tier 2, Section 3.7.2.1.2.4 is revised to provide additional details of these spring elements used in the ANSYS model.

b. Fixed base boundary conditions are utilized by connecting the nodes at the bottom of the base to boundary condition nodes using three orthogonal 0.1 inch-long COMBIN14 spring elements in X, Y, Z directions. These boundary condition nodes are fixed in translation in the direction of the attached spring element and free in all other degrees of freedom. For example, boundary condition nodes i, j, k attached to spring elements along X, Y, Z directions respectively, are fixed in translation X, Y, Z respectively. As the COMBIN14 spring elements have very high stiffness values, the assembly of the COMBIN14 spring element to a fixed boundary becomes a fixed boundary. FSAR Tier 2, Section 3.7.2.1.2.4 is revised to provide additional details of how the fixed-base boundary conditions are realized by using spring elements.

c. A wall segment separating the refueling pool and spent fuel pool and a segment separating the refueling pool and dry dock are included in the ANSYS model. They are hidden by the fluid elements shown in FSAR Tier 2, Figure 3.7.2-33. A new figure, Figure 3.7.2-34, will be added to FSAR Tier 2, Section 3.7.2 to show these details.

d. The analysis of the NuScale Power Module (NPM) based on the CSDRS-compatible Capitola time history and Soil Type 7 is adequate to demonstrate that the NPM design is acceptable and meets the requirements of 10 CFR Part 50, GDC 2, and 10 CFR Part 50, Appendix S at sites with characteristics consistent with these inputs. NuScale is seeking certification of the NPM design for this single time history and soil type. As noted in the above RAI, the RXB analysis described in FSAR Tier 2, Section 3.7.2 encompasses additional soil profiles.

Impact on DCA:

FSAR Tier 2, Section 3.7.2.1.2.4 and FSAR Tier 2, Figure 3.7.2-34 have been revised as described in the response above and as shown in the markup provided in this response.

from the global coordinate system origin. The exterior and interior roofs are modeled using the SHELL181 elements. The roof height or vertical distance is defined at the neutral surface from the global coordinate system origin.

In order to capture the interaction of pool water with the NPMs and analyze hydrodynamic effects, the Containment Vessel (CNV) of each NPM is modeled with SHELL181 elements as a cylindrical shell with the proper outer diameter. The Reactor Pressure Vessel inside the CNV is modeled with BEAM188 elements. This model matches the dynamic characteristics (e.g., natural frequency) of the NPM beam model. The bottom nodes of the CNV and the pool foundation surfaces are modeled by CONTA173 and TARGE170 elements to allow potential uplifting of the NPM. The CONTA173 element is used to represent contact and sliding between 3-D "target" surfaces (TARGE170) and a deformable surface, defined by this element. This element has three degrees of freedom at each node: translations in the nodal x, y, and z directions. This element is located on the surfaces of 3-D solid or shell elements without mid-side nodes (SHELL181) and has the same geometric characteristics as the shell element face with which it is connected.

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The concrete T-beams underneath the slabs and concrete pilasters are modeled with BEAM188 elements. All water mass regions are modeled by FLUID80 fluid finite elements. This fluid element is defined by eight nodes having three degrees of freedom at each node: translation in the nodal x, y, and z directions. This element is used to model fluids contained within vessels having no net flow rate and is well suited for calculating hydrostatic pressures and fluid/solid interactions. The bottom nodes of the foundation are represented by COMBIN14 spring elements. The bottom of the foundation basemat of the RXB ANSYS model has three COMBIN14 spring elements attached to each node with stiffness values of 1×10^8 lbf/in, 1×10^8 lbf/in and 1×10^8 lbf/in in the E-W, N-S and vertical directions, respectively.

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The ANSYS model used for this evaluation is shown in ~~Figure 3.7.2-32 and Figure 3.7.2-33~~Figure 3.7.2-32, Figure 3.7.2-33 and Figure 3.7.2-34. ~~For the ANSYS model, the z ordinate is at the top of the pool water, instead of the base of the foundation, which is used for the building analyses in SAP2000 and SASSI2010.~~For the ANSYS model, the z ordinate is at the top of the pool water, in order to define the location of the free water surface in the FSI analysis, instead of at the base of the foundation, which is used for the building analyses in SAP2000 and SASSI2010.

The locations of the RXB pool walls are modeled at the neutral planes and the pool walls are 5 foot thick. Therefore, in modeling the fluid as three dimensional fluid elements, the fluid mass will be greater than it actually is due to 2.5 foot less wall thickness because of the locations of the neutral planes. Thus, the fluid mass density is reduced to compensate for the extra water mass created inside the pool area in the ANSYS FSI analysis model. The extra fluid volume is estimated to be ~ 24.4 percent. This is the reduction factor applied to the water mass density in the dynamic analysis. In the SAP2000 model, the location of the RXB pool walls at the neutral planes has no effect when the pool water is modeled as lumped masses, since the lumped masses are calculated separately.

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~~Fixed base boundary conditions are utilized for the ANSYS model~~Fixed base boundary conditions are utilized by connecting the nodes at the bottom of the base to boundary condition nodes using three orthogonal 0.1 inch-long COMBIN14 spring elements in the X, Y, Z directions. These boundary condition nodes are fixed in translation in the direction of the attached spring element and free in all other degrees of freedom. For example, boundary condition nodes i, j, k attached to spring elements along X, Y, Z directions respectively, are fixed in translation, X,Y, Z respectively. The input to the ANSYS analysis is the CSDRS-compatible Capitola time history.

ANSYS Results

The ANSYS model was used to run X, Y, and Z input motion time histories separately and evaluate the results. The results are split based on sections created from the eastern wall (X1 to X3) and northern wall (Y1 to Y5), as shown in Figure 3.7.2-35. The maximum accelerations using the ANSYS model due to the three separate input time history motions and the combined resultant obtained using square root-of-the-sum of the squares (SRSS) methodology accelerations are plotted in Figure 3.7.2-36 and Figure 3.7.2-37.

The average ANSYS hydrodynamic pressure is calculated in the following fashion:

- Calculate the SRSS hydrodynamic pressure due to three separate input motions
- Find the height difference between elevations (element height)
- Create trapezoidal pressure areas from this height by the difference in pressures, i.e.:

$$A = h \times \frac{P_{above} + P_{below}}{2} \quad \text{Eq. 3.7-8}$$

- The average pressure is the sum of pressures over heights, i.e.:

$$P_{hd} = \frac{\Sigma A}{\Sigma h} \quad \text{Eq. 3.7-9}$$

The SRSS hydrodynamic pressure results for all wall sections are plotted in Figure 3.7.2-38 and Figure 3.7.2-39, and the average values are provided in Table 3.7.2-2.

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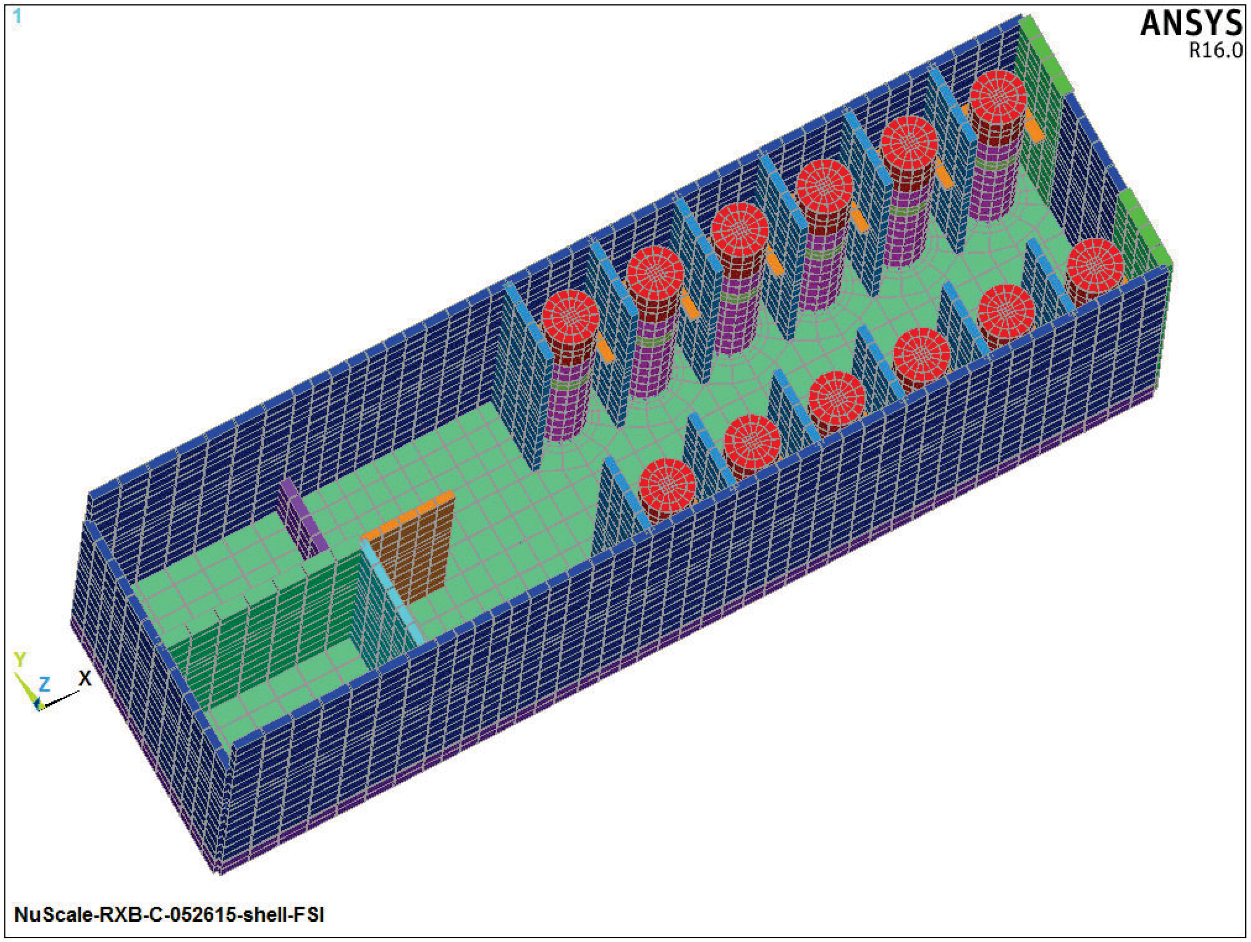
Figure 3.7.2-34: 3D View of Pool without Water with 12 RXMs



Response to Request for Additional Information
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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.

a. On Page 3.7-28 of the FSAR, in the first paragraph, the applicant describes modeling of "contact" between the bottom nodes of the Containment Vessel (CNV) and pool foundation surface. The applicant is requested to clarify whether friction is considered between the contacting surfaces and provide the coefficient of friction, if considered.
b. In Figure 3.7.2-32 in the FSAR, backfill soil elements are included in the ANSYS analysis model. The applicant is requested to describe the boundary conditions on the exterior sides of the backfill soil elements and describe whether they are modeled as a stress-free surface?
c. Figure 3.7.2-35 in the FSAR indicates perfect matching between accelerations for X1 and X3 wall sections; whereas, Figure 3.7.2-37 indicates slight difference between pressures for X1 and X3. The applicant is requested to explain the difference in pressure between X1 and X3 while their accelerations are shown to match perfectly.
d. Figures 3.7.2-37 and 3.7.2-38 in the FSAR indicate a non-zero pressure at the top of the curve, which appears to indicate that the top end point of the curve does not correspond to the free water surface of the pool top. The applicant is requested to clarify and explain why the curves do not cover the elevations all the way up to the free water surface.

NuScale Response:

Responses pertaining to the ANSYS model in FSAR Tier 2, Section 3.7.2.1.2.4, Ultimate Heat Sink Pool, are provided as follows:

a. Modeling of contact between the bottom nodes of the Containment Vessel (CNV) and pool foundation surface is described in FSAR Tier 2, Section 3.7.2.1.2.4. Friction is not considered between the bottom nodes of the Containment Vessel and pool foundation surface. It should be noted, in TR-0916-51502, NuScale Power Module Seismic Analysis, a non-linear dynamic analysis was performed to include the effects of friction and impact on the design loads for which the CNV skirt support is designed.

b. Boundary conditions on the exterior sides of backfill soil elements are set up such that the backfill soil is free around the perimeter (i.e. stress-free surface at four vertical sides) and fixed at the bottom. Each node at the bottom surface of the backfill soil is attached to three orthogonal COMBIN14 elements with a length and spring stiffness of 0.1 inch and 1.E8 lb/in, respectively.

c. The difference in pressure between wall sections X1 and X3 in FSAR Tier 2, Figure 3.7.2-35 is due to asymmetric geometry of the pool. The hydrodynamic pressure, calculated from 3D fluid structure interaction (FSI) analysis, is dependent on both seismic input (i.e., acceleration) and geometry of the pool. Therefore, any difference in geometry would result in a different hydrodynamic pressure on wall sections.

d. The hydrodynamic pressure plots, in FSAR Tier 2, Figures 3.7.2-37 and 3.7.2-38, are based on the pressure values at the centroid of each water element of the model. These values were then assigned at the top coordinate of the element height, meaning the centroidal pressure values are used over the full element height. This assigns the free surface to the pool a pressure as seen in the plots. This method of modeling produces the horizontal shift seen in the figures.

Impact on DCA:

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