RAIO-0518-59882

May 07, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 134 (eRAI No. 8934) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 134 (eRAI No. 8934)," dated August 05, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 134 (eRAI No. 8934)," dated December 21, 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. 8934:

- 03.07.02-15

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

Enclosure 1:

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

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

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

NRC Question No.: 03.07.02-15

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 3.7-30 of the FSAR, Eq. 3.7-14 represents the conversion of ANSYS FSI-based hydrodynamic pressure to SASSI2010 equivalent static pressure. In this process, ANSYS used the CSDRS-compatible Capitola time history input on a fixed-base model and SASSI2010 used the CSDRS-compatible Capitola time history input for Soil Types 7, 8, and 11, respectively. The applicant is requested to explain why FSI correction factors for the case of CSDRS-HF-compatible time history input for Soil Type 9 (hard rock) are not considered. Since the boundary conditions for an ANSYS fixed-base model and a SASSI model with Soil Type 9 (hard rock) are similar, it appears that FSI- correction factors developed for Soil Type 9 may be more representative.
b. On Page 3.7-31 of the FSAR, the fourth paragraph, "The pressure at the bottom of the pool due to …", describes an approach the applicant took in taking into account the FSI effects on vertical water pressure estimation. The applicant is requested to provide a technical basis for the approach taken.

NuScale Response:

As discussed, in a meeting on March 6, 2018, a supplement to NuScale's original response to RAI 8934 03.07.02-15 is provided.

a. Please see FSAR changes attached that incorporates the summary of relevant portions of the RAI response.

b.

   1. An actual pressure profile is not applied to the RXB walls and floor. The SASSI2010 analysis with lumped water masses does not represent fluid-structure-interaction behavior, and, therefore, underestimates the hydrodynamic pressures on the RXB walls. In order to account for this, an ANSYS FSI analysis,

in which the water elements were explicitly modeled, was performed. It was determined that an additional 4.2 psi of hydrodynamic pressure on the walls should be included. This additional pressure was added to the SAP2000 model as an equivalent static load by amplifying the gravity load by a factor of 1.28. A schematic of the hydrostatic and "missing" hydrodynamic load is shown in FSAR Figure 3.7.2-129.

2. The total hydrodynamic load consists of the lumped-mass hydrodynamic load from the SASSI2010 analysis (which underestimates the hydrodynamic load) and the fluid-structure-interaction correction load from the ANSYS analysis. The effects of the lumped-mass-based hydrodynamic pressures on the pool walls and floor are included in the determination of forces on the walls and floor from the SSI analysis.These hydrodynamic effects from SASSI2010 are included in the E_{ss} term of the governing load combination. The "missing" hydrodynamic load is added to the hydrostatic load to determine the total fluid pressure on the RXB walls.

Impact on DCA:

FSAR Tier 2, Section 3.7.2 has been revised as described in the response above and as shown in the markup provided in this response.

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

$$P_{static} = \frac{\Sigma A}{\Sigma h} \qquad \text{Eq. 3.7-13}$$

Average equivalent static pressure from SASSI2010 for each soil type and each wall segment are presented in Table 3.7.2-3. The table also includes a weighted wall average based on the lengths of the walls.

Equivalent Static Pressure Estimation

The SASSI2010 (corrected) equivalent static pressure due to hydrodynamic effects is calculated as follows:

$$P_{addl} = P_{hd} \times \frac{a_{SASSI}}{a_{ANSYS}} \qquad \text{Eq. 3.7-14}$$

Where:

- P_{addl} = additional equivalent static pressure,
- P_{hd} = hydrodynamic pressure from ANSYS,
- a_{SASSI} = acceleration from SASSI2010 using either soil type 7, 8, or 11; and
- a_{ANSYS} = acceleration from ANSYS.

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The FSI analysis uses synthetic ground motions based on Capitola seed time histories. Based on the overall building base shear comparison in Table 3.8.5-3, these runs using soil types 7, 8, and 11, and the CSDRS spectrum are more controlling than the soil type 9, CSDRS-HF spectrum case. Therefore, the factors used to convert ANSYS FSI hydrodynamic pressures to equivalent static pressures for soil types 7, 8, and 11 adequately envelope soil type 9.

Once the factors between SASSI2010 and ANSYS acceleration are obtained, the additional equivalent hydrostatic pressure for SASSI2010 can be computed. Table 3.7.2-4 through Table 3.7.2-6 present the average values for each segment and soil type, and includes a weighted value for each wall.

Table 3.7.2-7 compares this equivalent static pressure with the original static pressures obtained from SASSI2010.

Development of Correction Factor

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The maximum static wall pressure differences between the ANSYS and SASSI2010 models are summarized in Table 3.7.2-7. ~~These maximum pressures were initially underestimated in the SASSI2010 analysis using lumped nodal~~

~~masses. The ANSYS RXB analysis provided a more accurate wall pressure due to Fluid-Structure Interaction effects.~~The SASSI2010 analysis with lumped water masses does not represent fluid-structure-interaction behavior, and, therefore, underestimates the hydrodynamic pressures on the RXB walls. In order to account for this, an ANSYS FSI analysis, in which the water elements were explicitly modeled, was performed. Based on these results, an average pressure of 4.20 psi was added as static pressure to the SAP2000 RXB model. This added pressure accounts for the missing 3D effects of fluid-impulsive pressure on the pool walls and foundation.

RAI 03.07.02-15S1

The pressure at the bottom of the pool due to gravity loading of the water is approximately 30 psi (62.4 lb/ft^3 * 69 ft depth *1/144 ft^2/in^2). Consequently, the average pressure on the wall is half this amount, or 15 psi. The pressure of 4.20 psi is 28 percent of the average pressure (4.20 psi/15 psi = 0.28). Therefore, a 1.28g vertical static loading was added to the SAP2000 model to ensure this additional pressure is accounted for in the design. See Figure 3.7.2-129. Increasing the downward acceleration by a factor of 1.28 corrects for the underestimated fluid pressure, due to mass lumping, in the SSI model.

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The total hydrodynamic load consists of the lumped-mass hydrodynamic load from the SASSI2010 analysis (which underestimates the hydrodynamic load) and the fluid-structure-interaction correction load from the ANSYS analysis. The effects of the lumped-mass-based hydrodynamic pressures on the pool walls and floor are included in the determination of forces on the walls and floor from the SSI analysis. These hydrodynamic effects from SASSI2010 are included in the E_{ss} term of the governing load combination. The "missing" hydrodynamic load is added to the hydrostatic load to determine the total fluid pressure on the RXB walls.

3.7.2.1.2.5 Control Building

A general discussion of the CRB and the major features and components is provided in Section 1.2.2.2. Architectural drawings, including plan and section views are provided in Figure 1.2-21 through Figure 1.2-27.

The CRB is located approximately 34 feet to the east of the RXB and its primary function is to house the Main Control Room and the Technical Support Center.

The CRB is a reinforced concrete building with an upper steel structure supporting the roof. The reinforced concrete portion of the building is Seismic Category I. The SSC on the top floor have no safety-related or risk-significant functions. The walls and roof above this floor are provided for weather protection/climate control. This part of the structure is not required to be Seismic Category I. However, to ensure it will not fail and affect the Seismic Category I portion of the building, or the Seismic Category I RXB, the steel portion of the building is classified and analyzed as a Seismic Category II structure.

RAI 03.07.02-15S1

Figure 3.7.2-129: Development of Average Static Pressure of 4.20 psi at Mid Height of Pool Water for SAP2000 Model to Account for 3D FSI Effects