RAIO-0818-61572

August 27, 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. 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
3. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 134 (eRAI No, 8934)" dated May 7, 2018
4. NuScale Power, LLC Supplemental Response to "NRC Request for Additional Information No. 134 (eRAI No. 8934)" dated June 29, 2018

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
NuScale Power, LLC

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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

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:

During a Public Meeting on July 24, 2018, the NRC requested NuScale submit a supplemental response to this RAI. Further, the NRC provided the following details concerning past submittals for this question and clarification needed in the new supplemental response:

In its 06/29/2018 response to RAI 8934, Question 03.07.02-15, the applicant provided an evaluation which shows that an additional gravity loading by a factor of 1.28g creates load demands in the pool walls and foundation that are equivalent to the demands from the 4.2 psi

average hydrostatic pressure. The applicant also provided FSAR markups to address staff's concerns communicated during the 05/29/2018 public meeting.

1) Staff reviewed Page 3.7-124 (FSAR Draft Revision 2) in the markup provided in the RAI response and the following is an excerpt from the first and second paragraphs on that page:

"….. 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.

The pressure at the bottom of the pool due to gravity loading of the water is approximately 30 psi (62.4 lb/ft3 * 69 ft depth *1/144 ft2/in2). 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. **Horizontal hydrostatic load is a function of fluid density and depth. Fluid density can be altered by changing the acceleration due to gravity. Increasing the vertical gravitational acceleration increases the horizontal hydrostatic pressure.**"

(a) It appears that the two underlined statements above conflict each other. The applicant should consider rewording and streamlining the affected paragraphs to avoid potential confusion and enhance clarity. As the applicant stated in the RAI response, it was determined that an average pressure of 4.2 psi must be applied to the walls to correct for the underestimated hydrodynamic pressure. Then, this additional pressure was added to the SAP2000 model by amplifying the gravity load by a factor of 1.28.

Response: The paragraphs have been reworded. See FSAR markup.

(b) The purpose of the last two sentences (bold faced) in the quoted paragraph above are not clear to the staff. Also, the phrase "Fluid density can be altered by changing..." does not appear to be a correct statement.

Response: The Staff had a question as to how increasing vertical acceleration could also increase lateral fluid pressure. The sentences were added in an attempt to explain the relationship between vertical acceleration and horizontal pressure. Because the sentences were not clear, they have been removed. See FSAR markup.

2) Clarify in the RAI response, whether the C_r, T_o, and R_o loads from ACI Equation 9-6 have been considered in establishing the design basis demands for the RXB or otherwise provide basis for not including these demands as applicable.

Response: Crane load, Ccr , is included explicitly in the load combination. Pipe and equipment reaction load, R_0 , is included where applicable. The effect of T_0 is not included, due to the self-relieving nature of thermal loads that results from concrete cracking; thermal effects are discussed in more detail as a part of eRAI 8971 question 03.08.04-13.

3) The applicant should include in the FSAR (preferably in FSAR Section 3.8.4.3.2), a statement that captures the applicant's response to staff' follow-up question #4 with respect to the hydrostatic pressure distribution being applied as a surface pressure to all wetted area elements in the SAP2000 model.

Response: Statement added to FSAR Section 3.8.4.3.2. See markup.

4) The applicant should include in the FSAR a statement saying that amplifying the gravity load by a factor of 1.28 generates more conservative load demands for the pool walls and foundation than the 4.2 psi average hydrostatic pressure, or to that effect.

Response: Statement added. See markup.

5) Staff notes that the RAI response references Figure 2-2 which is not identified in the document. Also in Section 2 of the discussion, the Figure numbers start at 2-5 (with 2-1 to 2-4 missing). Since RAI response is an official document docketed, the applicant should maintain correctness and acceptable styles of the document provided.

Response: Response provided to NRC on 06/29/2018 to RAI 8934, Question 03.07.02-15 has been reformatted to correct the inconsistencies noted above. The response was re-submitted separately.

Impact on DCA:

FSAR Section 3.7.2 and 3.8.4 have been revised as described in the response above and as shown in the markup provided in this response.

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

RAI 03.07.02-15S1, RAI 03.07.02-15S3

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 modelit was determined that an additional 4.2 psi needed to be included in 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, RAI 03.07.02-15S2, RAI 03.07.02-15S3

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. Analyses have been performed that confirm that the 1.28 x gravity load bounds a 4.2 psi pressure profile.

RAI 03.07.02-15S1, RAI 03.07.02-15S2

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 (see FSAR Section 3.8.4.3.16 for the definition of E_{SS}). The “missing” hydrodynamic load is added to the hydrostatic load to determine the total fluid pressure on the RXB walls and foundation.

3.8.4.3.1.11 Uniform Equivalent Dead Load

The uniform equivalent dead load for the RXB and CRB is used to account for pieces of equipment less than 1000 lbs in weight not accounted for in the equipment dead loads and for cable trays, piping and ducts. The RXB and CRB floors are designed using a uniform equivalent dead load of 50 psf. The equivalent dead load is 25 psf for the RXB roof and 20 psf for the CRB roof.

RAI 03.08.04-1

3.8.4.3.1.12 RFT Weight

RAI 03.08.04-1

The RFT stand weighs approximately 80,000 lbs. The RFT bolt tensioning tools weigh approximately 21,000 lbs. each, conservatively this was rounded to 25,000 pounds. Four bolt tensioning tools operate on the RFT, making the whole RFT weight 180,000 pounds. The lower reactor pressure vessel (RPV) weighs approximately 206,000 pounds.

3.8.4.3.2 Liquid Loads (F)

The liquid load consists of the water pressure exerted on the walls in the Reactor Pool, Refueling Pool, Spent Fuel Pool and Dry Dock during static and seismic conditions. As noted in Section 3.8.4.3.1.4, the water weight in the RXB is approximately 64,700 kips. This pool water weight is included in the dead load as described above. The CRB does not have liquid loads.

RAI 03.07.02-15S3

The hydrostatic load considers the water pressure exerted on the structural pool walls in contact with the water. The pressure distribution considers zero pressure at the normal water level of the pool and increasing water pressure with water depth. The hydrostatic pressure varies linearly from the pool surface to the bottom of the pool floor. The hydrostatic pressure distribution is applied as a surface pressure to all wetted area elements.

These hydrodynamic loads are due to the seismic response from the water in the pools, which exert a water pressure on the structural pool walls in contact with the water. The hydrodynamic load effect is taken into account by distributing the water mass on each affected structural wall in the pool. The entire pool water mass is considered to participate in the hydrodynamic response for the two horizontal and vertical directions. i.e., the water mass in the East-West (X) direction is applied as lumped masses on all wall surface nodes which would resist the fluid motion in the X direction.

Figure 3.8.4-13 shows the water mass regions that contribute to the hydrodynamic response in the longitudinal X-direction. Similarly, Figure 3.8.4-14 shows the water mass regions corresponding to the hydrodynamic response in the transverse Y-direction. The vertical hydrodynamic effect is simply attained by evenly distributing the entire water mass along the bottom of the pool floor.