RAIO-1217-57932

December 29, 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 Supplemental Response to NRC Request for Additional Information No. 151 (eRAI No. 8974) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 151 (eRAI No. 8974)," dated August 05, 2017
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 151 (eRAI No.8974)," dated October 03, 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. 8974:

- 03.08.04-21

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,

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8974

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8974

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

eRAI No.: 8974
Date of RAI Issue: 08/05/2017

NRC Question No.: 03.08.04-21

10 CFR 50, Appendix A, GDC 1, 2, and 4, provide requirements to be met by SSC important to safety. In accordance with these requirements, DSRS Section 3.8.4 provides review guidance pertaining to the design of seismic Category I structures, other than the containment. Consistent with DSRS Section 3.8.4, the staff reviews, in part, loads and loading combinations.

Section 3B.2.7.4, “Nuclear Power Module Lug Restraint,” states that “a separate local SAP2000 model is used to analyze the support system for increased demand.” Further, this section states that “the load is distributed as point loads to one of the lugs.” Figures 3B-58 and 3B-59 show the distribution of the point loads. Section 3B.2.7.4 also describes that the load used to evaluate the lug components is 3500 kip (which is consistent with the distributed loads shown in Figures 3B-58 and 3B-59). Clarify whether the aforementioned “increased demand” refers to the 3500 kip load. If not, define the “increased demand.” Additionally, provide the basis for the 3500 kips including a description of the analysis cases from which this demand is obtained.

In addition to the above, FSAR Table 3B-27 provides the SASSI maximum lug reactions for RXB cracked model using Soil Type 7 (CSDRS) and Soil Type 9 (CSDRS-HF). Further, as stated in Section 3B.2.7.4.2, “since these maximum lug reactions are below the lug support design capacity of 3,500 kips, the design is acceptable.” Justify the use of the aforementioned SASSI cases only and not the envelope of all SASSI cases, in comparing with the design capacity of 3,500 kips.

NuScale Response:

Based on a public meeting with the NRC Staff on November 29, 2017, NuScale is supplementing the original response to RAI Question 03.08.04-21 to clarify that the capacity of the lugs is 4500 kips. FSAR Tier 2, Section 3B.2.7.4 has been revised accordingly. The lugs were designed for 3500 kips, but due to margin in the design (maximum demand/capacity of 0.7777 in the lug design), the actual capacity is 3500 kips/0.7777 = 4500 kips, which is higher than the maximum demand of 3726 kips.

Impact on DCA:

FSAR Tier 2, Section 3B.2.7.4 been revised as described in the response above and as shown in the markup provided in this response.

~~There is a potential for buckling of ½" thick pool floor liner plate while resisting the lateral load. However, the pool is filled with water from EL. 25'-0" to EL. 94' -0" for water column height of 69 feet. The water pressure at the pool floor is approximately 30 psi. This water pressure is always present and acts on the liner plate compressing against concrete base mat. Hence the notion of potential buckling of liner plate while resisting later load is not credible.~~

3B.2.7.4 Nuscale Power Module Lug Restraint

The NPM lug restraint design consists of a stainless steel bumper comprised of 2" thick plates with 2" thick stiffener plates. The bumpers are welded to 2" thick stainless steel liner plates. On the inside of the liner plate there are 3" thick, 5" wide (48" depth) steel shear lugs to transfer the lateral shear loads into the wall. Finally, the two bumpers on either side of the lug on the pool walls are bolted together with ~~2" in diameter~~ through-bolts to withstand tensile loads due to moments from the eccentric lateral shear loads. The design layout for the support system for the NPM lug restraints is shown in Figure 3B-51.

The bumpers are Stainless Steel Type 630 - H1150, with a yield strength of 100.8 ksi, and an ultimate strength of 135 ksi. The shear lugs are carbon steel ASTM A572 GR 50, with a yield strength of 50 ksi, and an ultimate strength of 65 ksi. The through-bolts are ASTM A193 GR B7, with a yield strength of 105 ksi, and an ultimate strength of 125 ksi.

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A separate local SAP2000 model is used to analyze the support system for an assumed demand of 3500 kips. ~~increased demand.~~ The NPM lug restraint model is a comprehensive finite element model of half of a single NPM wing wall. The wall is 2.5' thick and has one support lug for analysis. The load is distributed as point loads to one of the lugs. The wing wall is modeled with solid elements, the liner plate and the stainless steel lug are modeled with shell elements. The stiffeners are also modeled with shell elements.

The NPM bay walls and location of the NPM lugs is shown in Figure 3B-52. The NPM lug restraint model is shown in Figure 3B-53 and Figure 3B-54. The liner plate and shear lugs are modeled as shell elements and are shown in Figure 3B-55 and Figure 3B-56. In Figure 3B-57, the outside of the bumper is removed in order to display the stiffener plates inside.

RAI 03.08.04-21, RAI 03.08.04-21S1

The demand reactions are based on two cases of Soil Type 7 (CSDRS) and Soil Type 9 (CSDRS-HF). These two cases, in general provide the highest structural responses. The capacity is based on the assumed value of 3500 kips, that the lugs are designed for, however, due to the extra margin in the design, the actual strength is 4500 kips which is higher than the maximum demand of 3726 kips. The demand to capacity ratios in calculations for the lug components ~~are based on a NPM reaction of 3500 kips~~are derived and shown to be less than one, which shows the lugs are qualified.~~.~~ ~~The original design has been modified by increasing the diameter of the through~~

~~bolts in the wing wall and pool wall from 2 inches in diameter to 2.5 inches. This increases the capacity of the restraint.~~

Section cuts were used to extract forces and moments for design of the NPM lug support. Table 3B-26 displays the forces and moments for the two 3500 kip load cases: W-Lug-PY+ (shown in Figure 3B-58) and W-Lug-PY+ (shown in Figure 3B-59). Figure 3B-60 shows the liner plate section cuts at the intersection of the inside face of the bumper to the liner plate. These cuts are used to find the design moment (M1) due to design loading. Figure 3B-61 shows the shear lug section cuts (fins) that occur between the liner plate and shear lugs. The shear (F2) from these cuts is summed to verify that the total 3500 kip load is being transferred to the wall as shown in Table 3B-26. Finally, maximum tension load of 804 kips occurs on the shear lug directly below the 2" plate and the maximum shear of 790 kips occurs in the shear lug at X=88.20 inches. The sign of the F1 force for the fin at X=16.25" is negative but the deflected shape of the lug support system clearly shows this is a tension force (Figure 3B-62). These values are utilized in the shear lug evaluation.

3B.2.7.4.1 Shear Lug Evaluation

Shear lugs comprising of steel bar fins are used for the transfer of the NPM lug restraint l loads to the concrete walls by shear. The shear lugs are rectangular shaped fins having dimensions 3" wide x 5" bar and 4 feet long embedded in the concrete.

The shear lugs are made of carbon steel (ASTM A572 Gr. 50) having a yield strength of 50 ksi and ultimate strength of 70 ksi. The 28 day strength of concrete in the walls is 5000 psi.

In addition to the shear there will be tensile load on the fins. This is because the NPM lug load is applied with an eccentricity causing moment that results in a tensile load on some of the fins. The tensile loads are design to be resisted by through-bolts made of ASTM A193 Gr B7 material having a yield strength of 105 ksi and an ultimate strength of 125 ksi.

~~Figure 3B-63~~Figure 3B-51 shows a layout of the shear lugs and the through-bolts. There are 32 through-bolts that correspond to each lug of the NPM as shown in ~~Figure 3B-63~~Figure 3B-51. The through-bolt is 2.5" in diameter and fabricated from ASTM A193 GR B7 Steel~~.~~, F_y=105 ksi. The total shear capacity of the through-bolts is 5573 kips. This results in a D/C ratio (assuming a design load of 3500 kips) of 0.63.

The tensile capacity of the through bolts is the smaller of the bolt steel strength and the concrete strength. ~~Figure 3B-64 below show a schematic detail of shear lugs and through bolts.~~

The through-bolt is 2.5" in diameter and fabricated from ASTM A193 GR B7 Steel. The through-bolt tensile D/C ratio (assuming a design load of 3500 kips) is 0.51. This D/C ratio is from the most highly stressed fin in tension. Therefore the through-bolts are acceptable and will exhibit ductile behavior.