NUSCALE POWER™

RAIO-0318-59255

March 22, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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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
3. NuScale Power, LLC Supplemental Response to NRC "Request for Additional Information No. 151 (eRAI No. 8974)," dated December 29, 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,

Zackary W. Rad
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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:

As discussed, in a public meeting on February 20, 2018, a supplement to NuScale's original response to RAI 8974 03.08.04-21 is provided.

A separate SAP2000 model is created for the local analysis of the RXM lug support system. This lug restraint model is a comprehensive finite element model of half of a single NPM wing wall. 2.5' of the wall thickness with two lugs on one face of the wall are included in the model. The load is distributed as point loads to one of the lugs. The wing wall is modeled with solid elements. The liner plate, the stainless steel lug, and the bumper built up section are modeled with shell elements. The through bolts are not explicitly modeled, however, the axial tension of the shear lugs are used to determine the tension force in the through bolts. Since the shear lugs transfer the shear loads from the bumper to concrete, the through bolts are considered to be under tension only. All welds along the load path are CJP welds. This includes; the bumper built up section, bumper to liner plate, and liner plate to the shear lugs.

In this local model, an assumed horizontal load of 3500 kips is applied to determine the stresses in different components of the support. Different modes of failure for different lugs components are checked including; tensile capacity of through-bolts, punching shear and concrete bearing, and bending stresses on the liner plate. The most controlling mode of failure is bearing against concrete with a D/C=0.777. Since this D/C occurs for an applied load of 3500 kips, the true capacity of the lug assembly, where D/C would reach a value of 1.0, occurs for a load of 3500 kips/0.777=4500 kips.

To check the adequacy of the lugs, the maximum seismic reaction on a lug from the NPM seismic analysis model, is compared against the lug capacity calculated from the local lug model. The maximum demand reactions in the global RXB model 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 maximum lug reaction from the NPM seismic analysis model is provided in Table 8-6 of TR-0916-51502, NuScale Power Module Seismic Analysis, and is less than the lug capacity of 4500 kips. This shows that the lugs are structurally qualified.

Impact on DCA:

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

RAI 03.08.04-21S2, RAI 03.08.02-6, RAI 13.05.02.01-1S2

Table 1.6-2: NuScale Referenced Technical Reports

Report Number	Title	FSAR Section
TR-0116-20781	Fluence Calculation Methodology and Results	4.3, 5.3
TR-0316-22048	Nuclear Steam Supply System Advanced Sensor Technical Report	7.1, 7.2
TR-0416-48929	NuScale Design of Physical Security Systems	9.5, 13.6, 14.2, 14.3
TR-0516-49084	Containment Analysis Methodology	6.2
TR-0616-49121	NuScale Instrument Setpoint Methodology Technical Report	7.0, 7.2
TR-0716-50424	Combustible Gas Control	3.8, 6.2
TR-0716-50439	Comprehensive Vibration Assessment Program (CVAP) Technical Report TR-0716-50439	3.9, 14.2
TR-0816-49833	Fuel Storage Rack Analysis	3.7, 3.8, 9.1
TR-0816-50796	Loss of Large Areas Due to Explosions and Fires Assessment	20.2
TR-0816-50797	Mitigation Strategies for Extended Loss of AC Power (ELAP) Event	20.1
TR-0816-51127	NuFuel HTP2 Fuel and Control Rod Assembly Designs	4.2
TR-0916-51299	Long-Term Cooling Methodology	5.4, 6.2, 6.3, 15.0
TR-0916-51502	NuScale Power Module Seismic Analysis	3.7, 3.12, 3B
TR-1015-18177	Pressure and Temperature Limits Methodology	5.3
TR-1016-51669	NuScale Power Module Short-Term Transient Analysis	3.8
TR-1116-51962	NuScale Containment Leakage Integrity Assurance	6.2
TR-1116-52065	Effluent Release Methodology Technical Report	11.1, 11.2, 11.3
RP-0215-10815	Concept of Operations	18.7
RP-0316-17614	Human Factors Engineering Operating Experience Review Results Summary Report	18.2
RP-0316-17615	Human Factors Engineering Functional Requirements Analysis and Function Allocation Results Summary Report	18.3
RP-0316-17616	Human Factors Engineering Task Analysis Results Summary Report	18.4
RP-0316-17617	Human Factors Engineering Staffing and Qualifications Results Summary Report	18.5
RP-0316-17618	Human Factors Engineering Treatment of Important Human Actions Results Summary Report	18.6
RP-0316-17619	Human Factors Engineering Human-System Interface Design Results Summary Report	18.7
RP-0516-49116	Control Room Staffing Plan Validation Results	18.5
RP-0914-8534	Human Factors Engineering Program management Plan	18.1
RP-0914-8543	Human Factors Verification and Validation Implementation Plan	18.1
RP-0914-8544	Human Factors Engineering Design Implementation Implementation Plan	18.11
RP-1215-20253	Control Room Staffing Plan Validation Methodology	18.5
TR-1117-57216	NuScale Generic Technical Guidelines	13.5
TR-0917-56119	CNV Ultimate Pressure Integrity	3.8

- The D/C ratio of the bolts in shear and tension is 0.68.

RAI 03.07.02-20, RAI 03.08.04-31

- The maximum D/C ratio for concrete bearing due to lateral load transferred from the bearing plate is 0.71.

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 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.

RAI 03.08.04-21S2

A separate SAP2000 model is created for the local analysis of the RXB lug support system. This lug restraint model is a comprehensive, finite-element model of half of a single NPM wing wall. Therefore, 2.5' of the wall thickness, with two lugs on one face of the wall, are included in the model. The load is distributed as point loads to one of the lugs. The wing wall is modeled with solid elements. The liner plate, the stainless steel lug, and the bumper built-up section are modeled with shell elements. The through bolts are not modeled explicitly; however, the axial tension of the shear lugs is used to determine the tension force in the through bolts. Because the shear lugs transfer the shear loads from the bumper to concrete, the through bolts are considered to be under tension only. All welds along the load path are CJP welds. This includes the bumper built-up section, the bumper to the liner plate, and liner plate to the shear lugs.

RAI 03.08.04-21S2

In this local model, an assumed horizontal load of 3500 kips is applied to determine the stresses in different components of the support. Different modes of failure for different lug components are checked, including tensile capacity of through-bolts, punching shear and concrete bearing, and bending stresses on the liner plate. The most controlling mode of failure is bearing against concrete with a D/C=0.777. Because this D/C occurs for an applied load of 3500 kips, the true capacity of the lug assembly, where D/C would reach a value of 1.0, occurs for a load of 3500 kips/0.777=4500 kips.

RAI 03.08.04-21S2

To check the adequacy of the lugs, the maximum seismic reaction on a lug from the NPM Seismic Analysis model is compared against the lug capacity calculated from the local lug model. The maximum demand reactions in the global RXB model 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 maximum lug reaction from the NPM Seismic Analysis model is provided in Table 8-6 of TR-0916-51502, NuScale Power Module Seismic Analysis (Reference 3B-6), and is less than the lug capacity of 4500 kips. This shows that the lugs are structurally qualified.

RAI 03.08.04-21,

A separate local SAP2000 model is used to analyze the support system for an assumed demand of 3500 kips. 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, RAI 03.08.04-21S2

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 derived and shown to be less than one, which shows the lugs are qualified.

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.

A summary table of the design check results for the beams at elevation 120'-0" is presented in Table 3B-49. This summary table shows the maximum D/C ratios within each design check zone. As shown in Table 3B-49, all design check zones have D/C ratios that are less than 1.0; therefore the T-Beams at elevation 120'-0" are all acceptable.

3B.4 References

3B-1 SAP2000 Advanced Version 17.1.1, 2015, Computers and Structures, Inc., Walnut Creek, California.

3B-2 SASSI2010 Version 1.0, May 2012, Berkeley, California.

3B-3 American Concrete Institute, ACI 349-06, "Code Requirements for Nuclear Safety-Related Concrete Structures & Commentary," American Concrete Institute, Farmington Hills, MI.

3B-4 American National Standards Institute/American Institute of Steel Construction, N690-12, "Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities", American Institute of Steel Construction, 2012.

3B-5 ANSI/AISC 360-10, "Specification for Structural Steel Buildings", American Institute of Steel Construction, 2010.

RAI 03.08.04-21S2

3B-6 NuScale Power Module Analysis Technical Report TR-0916-51502.