October 31, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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11555 Rockville Pike
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SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 213 (eRAI No. 8890) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 213 (eRAI No. 8890)," dated September 01, 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 Question from NRC eRAI No. 8890:

- 3.10-1

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 Response to NRC Request for Additional Information eRAI No. 8890

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8890

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

eRAI No.: 8890
Date of RAI Issue: 09/01/2017

NRC Question No.: 3.10-1

10 CFR 52.47(a)(9) requires applicants for light-water-cooled nuclear power plants to evaluate the standard plant design against the Standard Review Plan (SRP) in effect 6 months before the docket date of the application. The evaluation required is to include an identification and description of all differences in design features, analytical techniques, and procedural measures proposed for the design and those corresponding features, techniques, and measures given in the SRP acceptance criteria.

For the NuScale application, the SRP revision in effect 6 months before the docket date of the application was revision 3.
DCD Tier 2, 3.10.2.1, Qualification by Testing, states "The test input motions are applied to two perpendicular horizontal axes or a vertical and a horizontal axis for the seismic and dynamic part of the load unless it can be shown that the sensitivity of the equipment response to vibratory motion in the horizontal direction is insignificant. To avoid an exclusively rectilinear input motion, the time phasing of the inputs in each direction are chosen carefully. Alternatively, the test may be conducted with the horizontal and vertical inputs in-phase and then the test is repeated, after rotating the equipment 90 degrees horizontally with the horizontal and vertical inputs 180 degrees out-of-phase."
The alternative statement is not in agreement with SRP 3.10, which states that an acceptable alternative is to test with vertical and horizontal inputs in phase, and then repeat the test with inputs 180 degrees out of phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally. In the SRP, 4 tests (in-phase/out-phase, rotate 90 deg. then in-phase/out-phase) are described. However, DCD Tier 2, 3.10.2.1 only has 2 tests (in-phase, rotate 90 deg. then out-phase).
Additionally, SRP 3.10 states:

For the seismic and dynamic portion of the loads, the test input motion should be applied to one vertical axis and one principal horizontal axis (or two orthogonal horizontal axes) simultaneously, unless it can be demonstrated that the equipment response in the vertical direction is not sensitive to the vibratory motion in the horizontal direction, and vice versa.
DCD Tier 2, 3.10.2.1 states;

The test input motions are applied to two perpendicular horizontal axes or a vertical and a horizontal axis for the seismic and dynamic part of the load unless it can be shown that the sensitivity of the equipment response to vibratory motion in the horizontal direction is insignificant.

Justify these deviations or revise the DCD to include:

- Testing in phase and out of phase, then rotate equipment and test in phase and out of phase in accordance with the SRP criteria.
- Testing in the horizontal direction and vice versa.

NuScale Response:

FSAR Tier 2, Section 3.10.2.1, is revised to include testing in phase and out of phase, then rotate equipment in phase and out of phase in accordance with SRP 3.10 criteria, and testing in the horizontal direction and vice versa.

For the seismic and dynamic portion of the loads, the test input motion should be applied to one vertical axis and one principal horizontal axis (or two orthogonal horizontal axes) simultaneously, unless it can be demonstrated that the equipment response in the vertical direction is not sensitive to the vibratory motion in the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear resultant input is avoided. An acceptable alternative is to test with vertical and horizontal inputs in-phase, and then repeat the test with inputs 180 degrees out-of phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.

Impact on DCA:

FSAR Tier 2, Section 3.10.2.1 has been revised as described in the response above and as shown in the markup provided in this response.

3.10.2.1 Qualification by Testing

Seismic qualification of mechanical and electrical equipment by testing is performed in accordance with the requirements of IEEE 344-2004 (Reference 3.10-1). For equipment qualified by testing, the test simulates normal loadings, such as thermal and flow-induced loads, concurrently with the seismic and other dynamic loadings. The loads include forces imposed by piping onto the equipment. The survival and operability of the equipment is verified during and after the testing.

The seismic testing consists of subjecting the equipment to vibratory motion that simulates the vibratory motion postulated to occur at the equipment mounting location. The testing conservatively considers the multi-dimensional effects of the postulated earthquake.

Single-frequency and multi-frequency tests are used for seismic qualification. The in-structure floor response spectra damping values provide the seismic and dynamic test inputs. The purpose of multi-frequency testing is to provide a broadband test motion that can produce a simultaneous response from multiple modes of a multi-degree-of-freedom system, the malfunction of which can be caused by modal interactions. It is preferable to perform multi-frequency testing rather than single-frequency testing because of the usually broad frequency content of the seismic and dynamic load excitation.

However, single-frequency testing, such as sine beats, may be used in the following situations:

- when seismic ground motion is filtered due to a single predominant structural mode
- when it can be shown that the anticipated response of the equipment is sufficiently represented by a single mode
- when the input has enough duration and intensity to cause the excitation of the applicable modes to the required magnitude, causing the TRS to bound the corresponding spectra
- when the resultant floor motion consists of a single predominant frequency

RAI 3.10-1

~~The test input motions are applied to two perpendicular horizontal axes or a vertical and a horizontal axis for the seismic and dynamic part of the load unless it can be shown that the sensitivity of the equipment response to vibratory motion in the horizontal direction is insignificant. To avoid an exclusively rectilinear input motion, the time phasing of the inputs in each direction are chosen carefully. Alternatively, the test may be conducted with the horizontal and vertical inputs in-phase and then the test is repeated, after rotating the equipment 90 degrees horizontally with the horizontal and vertical inputs 180 degrees out-of-phase.~~For the seismic and dynamic portion of the loads, the test input motion should be applied to one vertical axis and one principal horizontal axis (or two orthogonal horizontal axes) simultaneously, unless it can be demonstrated that the equipment response in the vertical direction is not sensitive to the vibratory motion in the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear resultant input is avoided. An acceptable alternative is to test with vertical and horizontal inputs in-phase, and then repeat the test with inputs 180 degrees out-of-phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.

The equipment mounting in the test setup simulates the equipment mounting in service and does not cause nonrepresentative dynamic coupling of the equipment to its mounting fixture. The test simulates the dynamic coupling effects of cable, conduit, instrument lines, electrical connects, and other interfaces, unless adequate justification is provided. The testing also simulates the effects of aging, such as the fatigue effects of five OBEs plus the loadings associated with normal operation for the design life of the equipment prior to simulating the effects of an SSE, which is equivalent to two SSEs, with 10 stress cycles each, per Section 3.10.1.1.

3.10.2.2 Qualification by Analysis

Qualification by analysis is performed on equipment that is only required to maintain its structural integrity to perform its safety function. IEEE 344-2004 (Reference 3.10-1) describes a methodology for calculating the fatigue associated with aging and OBEs. The methods of qualification by analysis are dynamic analysis and static coefficient analysis. The analysis accounts for the complexity of the equipment and accurately represents the response of the equipment to seismic excitation. The two methods of analysis are described below. The analysis shows that the fatigue-inducing effects of the OBEs in combination with other normal, fatigue-inducing operational loads followed by an SSE do not cause the failure of the analyzed equipment to perform its safety function.

For analyses in which multi-module and multi-directional responses are combined, the analyses use the guidance of RG 1.92 Revision 3 "Combining Modal Responses and Spatial Components in Seismic Response Analysis."

Dynamic Analysis

The mass distribution and stiffness characteristics of the equipment and equipment supports are represented by an appropriate model. To determine whether the equipment is rigid or flexible, a modal analysis is performed. If the model has no resonances in the frequency range below the cutoff frequency of the RRS, the equipment is considered rigid and may be analyzed statically. For flexible equipment, a response spectrum analysis or a time history analysis is used to analyze the model.

Static Coefficient Analysis

The static coefficient analysis method is an alternative to dynamic analysis and includes more conservatism. Natural frequencies do not need to be determined to perform static coefficient analysis. The equipment's acceleration response is assumed to be the maximum acceleration in the amplified region peak of the RRS at a conservative and justifiable value of damping. The effects of multi-frequency excitation and multi-mode response for linear frame-type structures that can be represented by a simple model, such as members like beams and columns, are approximated by a static coefficient of