October 06, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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**SUBJECT:** NuScale Power, LLC Response to NRC Request for Additional Information No. 164 (eRAI No. 8935) on the NuScale Design Certification Application

**REFERENCE:** U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 164 (eRAI No. 8935)," dated August 11, 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. 8935:

- 03.07.02-24

The response schedule for the remaining questions of RAI No. 164, eRAI 8935 were provided in an email to NRC (Greg Cranston) dated September 12, 2017.

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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Enclosue 1: NuScale Response to NRC Request for Additional Information eRAI No. 8935

**Enclosure 1:**

NuScale Response to NRC Request for Additional Information eRAI No. 8935

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

**eRAI No.:** 8935
**Date of RAI Issue:** 08/11/2017

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**NRC Question No.:** 03.07.02-24

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.

On Page 3.7-37 of the FSAR, Rev 0, the staff notes that there are 540 SSI analysis cases with five CSDRS compatible time history inputs and 72 SSI analysis cases with one CSDRS-HF compatible time history input. Staff is not able to discern which of these analysis cases correspond with
which SSCs.
Please update the FSAR to include a table to summarize the above-mentioned analysis cases with the following breakdown based on these SSCs:

a. Analysis cases used to establish the seismic demands (loads and ISRS) for each of the seismic Category I buildings, RXB and CRB.
b. Analysis cases used to establish the seismic demands (loads and ISRS) for the NuScale Power Module, Bioshield, Reactor Building Crane, Fuel Handling Crane, Fuel Storage Rack, Reactor Flange Tool, and Containment Flange Tool.

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**NuScale Response:**

The primary NuScale design basis for all Seismic Category I SSC is the certified seismic design response spectra (CSDRS), as described in Tier 2, Section 3.7 and 3.7.1.1.1 of the FSAR. The design complies with General Design Criterion 2 and 10 CFR 50, Appendix S in that SSC are designed to withstand the effects of earthquakes without loss of the capability to perform their safety functions. This is consistent with the commitment made in Tier 1, Section 3.14.1 of the FSAR.

The design basis for Seismic Category I structures, reactor building (RXB) and control building (CRB), is expanded to also include a high frequency certified seismic design response spectra

(CSDRS-HF) in order to broaden the site applicability for these structures. Therefore, Tier 1, Section 5.0 of the FSAR identifies both spectra as NuScale design parameters. Additional clarification is added to Tier 2, Section 3.7.1.1.1 of the FSAR to specify when the CSDRS-HF is included in the design basis for the Seismic Category I structures. Appendix 3A provides the seismic analysis of the NuScale Power Module (NPM) and the specific design basis applied. These combined definitions identify the NuScale standard plant design.

In accordance with the COL Item 3.7-10 added in response to RAI-8936 question 03.07.02-8, a COL applicant is required to demonstrate that the site-specific configuration is bounded by the NuScale standard plant design:

*"A COL applicant that references the NuScale Power Plant design certification will perform a site-specific configuration analysis that includes the RXB with applicable configuration layout of the desired NPMs. The COL applicant will confirm the following are bounded by the corresponding design certified seismic demands:*

*1) The ISRS of the standard design at the foundation and roof*

*2) The maximum forces in the NPM lug restraints and skirts*

*3) The maximum forces and moments in the east and west wing walls and pool walls*

*If not, the standard design will be shown to have appropriate margin or should be appropriately modified to accommodate the site-specific demands."*

The statement in FSAR Tier 2, Section 3.7.2.4, "In the analysis using the SASSI2010 STRESS and MOTION modules, individual cases must be run for each combination of parameters. A total of 612 STRESS and MOTION cases can be produced…" refers to the summation of parameter combinations analyzed throughout the FSAR. There are no SSCs required or intended to be designed for all 612 cases.

To clarify, Section 3.7.2.4, two tables referenced from RAI-8900 Question 03.07.01-1 are incorporated into FSAR Tier 2 as Tables 3.7.2-33 and 3.7.2-34. The seismic input used for the design of the SSCs varies based on different design requirements, locations and levels of conservatism for each SSC. The seismic parameters used can be summarized using eight “Seismic Analysis Codes”, defined in Table 3.7.2-33. Section 3.7.2.4.6 is revised to include the following codes used to identify the various seismic analyses described throughout Section 3.7 of the FSAR:

1. RXB Standalone Structural Response
2. RXB Triple Building Structural Response
3. RXB Standalone In-structure Response Spectra (ISRS)

4. RXB Triple Building ISRS
5. NPM ISRS
6. CRB Standalone ISRS
7. CRB Standalone Structural Response
8. CRB Triple Building Structural Response

Table 3.7.2-34 provides a list of the SSCs and notes the accompanying identification codes used for the seismic demand analyses. The tables will be added to the FSAR in Tier 2 Section 3.7.2.4 to provide an accessible location to reference the analysis cases for each SSC.

a. The structural response of the RXB has been designed in accordance with the seismic identification codes 1 and 2. These analysis cases include all seed time histories, soil types, cracked, uncracked conditions in both the standalone RXB model and the triple building model. For the ISRS within the RXB, the analysis follows the codes 3 and 4 to account for the operating basis earthquake (OBE) damping (4%) described in Section 1.2 of Regulatory Guide 1.61.

   For the CRB, the number of analysis cases considered is different between the standalone CRB model and the triple building model. The structural response follows the Seismic Analysis Codes 7 and 8. In general, the bounding soil case is Soil Type 7 for the CSDRS and Soil Type 9 for the CSDRS-HF for the triple building model.

   The ISRS for the CRB has been developed using only the standalone model. The seismic analysis for the ISRS of the CRB using the triple building model will be addressed in the response to RAI-8935 Question 03.07.02-26.

b. The analysis cases used to establish the seismic demands for the NuScale Power Module, Bioshield, Reactor Building Crane, Fuel Handling Crane, Fuel Storage Rack, Reactor Flange Tool, and Containment Flange Tool have been identified in Tables 3.7.2-33 and 3.7.2-34.

**Impact on DCA:**

FSAR Tier 2, Sections 3.7.1.1.1, 3.7.2.4.6, and FSAR Tier 2, Tables 3.7.2-33 and 3.7.2-34 have been revised as described in the response above and as shown in the markup provided in this response.

The GMRS, SSE, OBE and FIRS are site-specific. They are developed by the COL applicant. For the evaluation of the site-independent RXB and CRB, the certified seismic design response spectra (CSDRS) (described below) is used instead of the FIRS.

**Certified Seismic Design Response Spectra** are site-independent seismic design response spectra that have been developed for design of the Seismic Category I and II Structures. The NuScale CSDRS consists of two sets of spectra, identified as the CSDRS and the CSDRS-High Frequency (CSDRS-HF). The CSDRS are applied as an outcrop motion in the free-field at the foundation level of each building.

**Certified Seismic Design Response Spectra (CSDRS)** is a smooth broadband seismic design spectra developed to envelop the GMRS at most site and soil combinations. Development of the CSDRS is discussed in Section 3.7.1.1.1.1.

**High Frequency Certified Seismic Design Response Spectra (CSDRS-HF)** is a seismic design spectra developed to envelop the GMRS of most hard rock sites. The CSDRS-HF has less low frequency (below ~10 Hz) and more high frequency (above ~10 Hz) content than the CSDRS. Development of the CSDRS-HF is discussed in Section 3.7.1.1.1.2.

## 3.7.1 Seismic Design Parameters

### 3.7.1.1 Design Ground Motion

#### 3.7.1.1.1 Design Ground Motion Response Spectra

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~~Two spectra are used as the design ground motion response spectra.~~ The CSDRS is a broad spectra (similar to RG 1.60) which is intended to encompass the GMRS at most selected sites. The CSDRS is used as a design basis for all Seismic Category I SSC to withstand the effects of earthquakes without loss of the capability to perform their safety functions. However, the CSDRS will not bound hard rock sites in the central and eastern United States. To improve the range of acceptable locations, site-independent Seismic Category I ~~SSC~~structures, RXB and CRB, are also evaluated using a spectra that has more content above 10 Hz than the CSDRS. This spectra is identified as the CSDRS-HF. These spectra are described in more detail below.

##### 3.7.1.1.1.1 Certified Seismic Design Response Spectra

Response spectra were developed to envelope most sites except for the highly seismic west coast sites and the central and eastern United States hard rock sites subject to higher frequency earthquakes. The response spectra are smooth broadband geometric mean spectra that were developed based upon expert panel recommendations and comparison to available industry data providing SSEs at existing and proposed reactor sites. The vertical component was developed independently of the horizontal component, i.e., the vertical component is not a ratio of the horizontal component. The CSDRS bounds the RG 1.60 spectra anchored at 0.1g.

These stresses are then combined as described in Section 3.7.2.4.1. Steps 2 and 3 of this process are illustrated in Table 3.7.2-25 for an example solid element.

#### 3.7.2.4.5 Relative Displacements at Selected Locations

Multiple locations on both the RXB and CRB have been selected for presentation of relative displacement. The node numbers and their global coordinates of the selected locations are shown in Table 3.7.2-26 for the RXB and Table 3.7.2-27 for the CRB. These locations can be seen in Figure 3.7.2-94 for the RXB and in Figure 3.7.2-95 for the CRB.

The relative displacement results from the different cases are post-processed using the steps described in Section 3.7.2.4.1.

The relative displacements calculated for the selected locations in both the standalone models and the triple building model are presented in Table 3.7.2-28 and Table 3.7.2-29. The displacements are in the global directions.

#### 3.7.2.4.6 Design Approach

The initial structural analysis of the RXB was performed with the entire suite of analysis cases as described above. The CRB analysis did not include all the triple building model cases. For the triple building model, Soil Type 7 was evaluated with the CSDRS and Soil Type 9 was evaluated with the CSDRS-HF. The cases are selected because they represent controlling conditions. In general, Soil Type 7 with the CSDRS is controlling for both the RXB and the CRB.

~~When new information (such as an update to the NPM beam model) requires the analysis to be revisited, a limited set of cases are run. The cases are selected because they represent controlling conditions. In general, Soil Type 7 with the CSDRS is controlling for both the RXB and the CRB.~~

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The analysis cases used to determine the seismic demand for Seismic Category I SSC can be labeled using eight identification codes:

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1) RXB Standalone Structural Response

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2) RXB Triple Building Structural Response

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3) RXB Standalone ISRS

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4) RXB Triple Building ISRS

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5) NPM ISRS

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6) CRB Standalone ISRS

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7) CRB Standalone Structural Response

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8) CRB Triple Building Structural Response

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Each code represents a different combination of the 540 CSDRS cases and 72 CSDRS-HF cases listed in Section 3.7.2.4. Table 3.7.2-33 provides the tabulated seismic parameter combinations for the eight identification codes to identify: seed input time history, soil type, direction, building model, concrete condition and damping. Table 3.7.2-34 provides a list of the SC-I SSCs and associated identification codes for the analysis used to calculate the seismic demands.

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The methodology for combining the results of these seismic analysis cases is described in Section 3.7.2.4.1.

The results for the selected cases are compared to the existing design envelop at: The reactor pool floor, The NPM lug restraints, the ground floor, the RBC crane rails, and the roof of the RXB and the main control room floor and the ground floor of the CRB. If the results are bounded by the current design envelope, they are not incorporated and the full suite of cases are not run. When forces, moments, or accelerations produced by the focused analyses are not bounded, that information is incorporated into the design envelope for all affected locations. The full suite of cases are not re-performed. However, the change is incorporated into the models so that any subsequent re-analysis of any soil-earthquake combination will include the change.

### 3.7.2.5 Development of In-Structure Floor Response Spectra

Development of ISRS follows the guidance in RG 1.122, "Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components" Rev. 1. The SASSI2010 MOTION module is used to produce accelerations for ISRS development. A 4 percent structural damping is used for both cracked and uncracked concrete.

#### 3.7.2.5.1 Averaging and Combining Analysis Cases

**Step 1.** At each selected nodal location, the three co-directional ISRS from a single soil, time history, and stiffness are combined using SRSS.

**Step 2.** Step 1 is repeated for each of the cases that were analyzed.

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**Table 3.7.2-33: Definition of Seismic Analysis Identification Codes**

| Identification Code | CSDRS Input | | | | | CSDRS Soil Type | | | CSDRS-HF Input | CSDRS-HF Soil Type | | Damping | | Concrete Condition | | Building Model | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yermo | Capitola | Chi-Chi | Izmit | El Centro | 7 | 8 | 11 | Lucerne | 7 | 9 | OBE 4% | SSE 7% | Cracked | Uncracked | RXB | CRB | Triple |
| 1 | X | X | X | X | X | X | X | X | X | X | X | - | X | X | X | X | - | - |
| 2 | X | X | X | X | X | X | X | X | X | X | X | - | X | X | X | - | - | X |
| 3 | X | X | X | X | X | X | X | X | X | X | X | X | - | X | X | X | - | - |
| 4 | X | X | X | X | X | X | X | X | X | X | X | X | - | X | X | - | - | X |
| 5 | - | X | - | - | - | X | - | - | - | - | - | X | - | X | X | X | - | - |
| 6 | X | X | X | X | X | X | X | X | X | X | X | X | - | X | X | - | X | - |
| 7 | X | X | X | X | X | X | X | X | X | X | X | - | X | X | X | - | X | - |
| 8 | X | X | X | X | X | X | - | - | X | - | X | - | X | X | X | - | - | X |

Note: All seismic analysis codes include runs in the three primary directions (i.e. East-West, North-South, and Vertical).

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## Table 3.7.2-34: SSC Seismic Analysis Identification Code Assignments

| SSC | Description | Identification Code |
|---|---|---|
| CNTS | Containment System | 5 |
| SGS | Steam Generator System | 5 |
| RXC | Reactor Core System | 5 |
| CRDS | Control Rod Drive System | 5 |
| CRA | Control Rod Assembly | 5 |
| NSA | Neutron Source Assembly | 5 |
| RCS | Reactor Coolant System | 5 |
| CVCS | Chemical and Volume Control System | 5 |
| ECCS | Emergency Core Cooling System | 5 |
| DHRS | Decay Heat Removal System | 5 |
| CRHS | Control Room Habitability System | 6 |
| CRVS | Normal Control Room HVAC | 6 |
| MAEB | Module Assembly Equipment - Bolting | 3, 4 |
| FHE | Fuel Handling Equipment | 3 |
| SFSS | Spent Fuel Storage System | 3 |
| RPCS | Reactor Pool Cooling System | 3, 4 |
| UHS | Ultimate Heat Sink | 3, 4 |
| CES | Containment Evacuation System | 5 |
| MSS | Main Steam System | 5 |
| FWS | Condensate and Feedwater System | 5 |
| EDSS | Highly Reliable DC Power System | 3[1], 4[1], 6[2] |
| MPS | Module Protection System | 3[1], 4[1], 6[2] |
| NMS | Neutron Monitoring System | 3, 4 |
| SDIS | Safety Display and Indication System | 6 |
| ICIS | In-Core Instrumentation System | 5 |
| PPS | Plant Protection System | 3[1], 4[1], 6[2] |
| RMS | Radiation Monitoring System | 3[1], 4[1], 6[2] |
| RXB | Reactor Building | 1, 2 |
| RBC | Reactor Building Cranes | 3 |
| RBCM | Reactor Building Components - Pool Liner | 1, 2 |
| RBCM | Reactor Building Components - Bioshield | 3, 4 |
| CRB | Control Building | 7, 8 |
| SMS | Seismic Monitoring System | 3[1], 4[1], 6[2] |

[1] Design for SSCs located in the Reactor Building

[2] Design for SSCs located in the Control Building