Response to SDAA Audit Question

Question Number: A-3.9.2-8

Receipt Date: 03/31/2023

Question:

TR-121515-P, Rev. 0, “US460 NuScale Power Module Seismic Analysis” describes the methodologies and structural models that are used to analyze the dynamic structural response due to seismic loads acting on the SDAA version of the NuScale Power Module (NPM). The description is insufficient for staff to reach a safety finding. In particular, no stress analyses for ASME Service Level D conditions were provided (and in fact do not appear to be part of the scope of TR-121515-P). Also, the linkage between cases evaluated in FSAR chapter 3.7.2 and those described in TR-121515 is unclear. Finally, the seismic analysis methodology has changed substantially since those reported in the DCA application, and the changes are not fully described. NuScale should make available the following for audit:

1. Details on the seismic evaluations: a. Internal NuScale reports which more thoroughly describe the analysis models and approach, particularly how all fluid-structure interaction effects, including sloshing, is addressed.

b. A clear linkage between the conditions evaluated in TR-121515-P and those described in the reactor building seismic analyses in FSAR Chapter 3.7.2. What cases described in 3.7.2 were analyzed in TR121515-P? What cases were not and why? How were the varying damping levels, different SSE input profiles, effects of cracked vs. uncracked concrete, incoherent vs. coherent loading at multiple mounting locations, and any other effects assessed in 3.7.2 addressed in the NPM seismic evaluations?

c. The DCA seismic analysis included an uncertainty assessment. Explain how uncertainty is addressed in the SDAA seismic analysis. Is the uncertainty bounded by {{ }}$^{2(a),(c)}$ described in the report?

d. A summary of major differences in analysis methodology between the DCA and SDAA submissions.

e. Details on how the lower seismic restraint is modeled .

2. Stress calculations under ASME Service Level D conditions for the five most limiting structures, systems, and components (SSCs) for each load case. Include a brief description of the SSC modelling, applied input motion (time history or in-structure response spectrum, coherent vs. incoherent loading at different mounting locations), major assumptions, acceptance criteria under Service Level D condition including stress and deflection limits, fluid modelling, mass distribution, damping value(s), gap considerations and potential contact with adjacent components and/or walls, dominant modes of vibration and frequencies (show images of the mode shapes), stress convergence studies, stress concentration factors, weld factors (if welds are at or near a limiting location), seismic and LOCA stress results, and ASME B&PV Code Section III stress evaluation under Service Level D condition.

3. Calculations for radial deflections of the CRDS and ICIGT and assessments of the effects of impacts (if any) between the CRDS and ICIGT and the adjacent holes within the various plates along the height of the NPM RPV.

4. Calculations of the relative motion and corresponding stresses and separation distances (if separation occurs) at and around the “bellows” connecting the upper and lower RPV sections.

Response:

NuScale provided responses for Audit Question A-3.9.2-8 on May 24, 2023. On June 2, 2023 NRC staff requested clarification and additional details to supplement the NuScale responses. This supplemental response to Audit Question A-3.9.2-8 provides clarification and additional details in the requested areas.

Item 1(b)

The building seismic analysis cases described in FSAR Chapter 3.7.2 are summarized in Table 1, below.

In total,{{

}}2(a),(c),ECI

In the NuScale Power Module (NPM) time history analysis described in {{

}}2(a),(c),ECI

In-structure acceleration time history from the four analysis cases shown in Table 1 are applied as input motion to the NPM time history analyses. In agreement with previous analysis (i.e., DCA application), in-structure acceleration responses from {{

}}2(a),(c),ECI Final NPM responses documented in {{

}}2(a),(c),ECI

{{

}}2(a),(c),ECI

Table 1 {{

}}2(a),(c),ECI

Item 1(d)

The following summarizes the methodology differences between US600 and US460 seismic methodology. Information in this summary is not intended to replace or supplement content in the US600 design application.

The US460, as compared to US600, uses modern {{

}}2(a),(c),ECI

Methodology of the Entire Pool Model and Application of Boundary Conditions

In the US600 design, {{

}}2(a),(c),ECI

Inputs to the Seismic Model

In both the US600 and US460, input time history acceleration loads are obtained from the RXB models. The time histories are based on solutions of the RXB. In the US600 design, {{

}}2(a),(c),ECI

Modeling of Connections

The US460 design {{

}}2(a),(c),ECI

Meshing

In the US600 design, {{

}}2(a),(c),ECI For the US460 design, modern technology is utilized to {{

}}2(a),(c),ECI

Modeling of Seismic Restraints

When modeling seismic restraints for US600, the {{

}}2(a),(c),ECI In the US460, the design {{

}}2(a),(c),ECI

Reflector Blocks

The US460 reflector blocks are {{ }}2(a),(c) where the US600 model {{

}}2(a),(c)

Modeling of the Bellows

The US600 {{

}}2(a),(c),ECI The geometry of the US460 bellows {{

}}2(a),(c),ECI

Item 2

Stress calculations under ASME Service Level D conditions for the five most limiting structures, systems, and components (SSCs) for each load case are not included in the scope of TR-121515. These calculations are performed as a part of the US460 design finalization. As discussed in NuScale letter LO-1020-72203, October 22, 2020 ASME evaluations are finalized as part of the ASME Design Report process confirmed by ITAAC closure. EQ-100342, {{

}}2(a),(c),ECI

EQ-100342 is provided in the eRR.

Item 3

The CRDS and ICIGT are not within the scope of this TR-121515. Stress and fatigue resulting from deflections and potential impacts are evaluated in accordance with ASME Code, Section III. These calculations are performed as a part of the US460 design finalization. As discussed in NuScale letter LO-1020-72203, October 22, 2020 ASME evaluations are finalized as part of the ASME Design Report process confirmed by ITAAC closure.

Item 4

EC-107251, {{

}}2(a),(c),ECI

{{

}}2(a),(c),ECI

Figure 1{{

}}2(a),(c),ECI

No changes to the SDAA are necessary.