

## NuScaleDCRaisPEm Resource

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**Sent:** Friday, August 18, 2017 8:37 AM  
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**Subject:** Request for Additional Information No. 185, RAI 8963 (3.8.5)  
**Attachments:** Request for Additional Information No. 185 (eRAI No. 8963).pdf

Attached please find NRC staff's request for additional information concerning review of the NuScale Design Certification Application.

Please submit your technically correct and complete response within 60 days of the date of this RAI to the NRC Document Control Desk.

If you have any questions, please contact me.

Thank you.

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## Request for Additional Information No. 185 (eRAI No. 8963)

Issue Date: 08/18/2017

Application Title: NuScale Standard Design Certification - 52-048

Operating Company: NuScale Power, LLC

Docket No. 52-048

Review Section: 03.08.05 - Foundations

Application Section: 3.8.5

### QUESTIONS

#### 03.08.05-5

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the loads on foundations.

FSAR Tier 2, Section 3.8.5.6.5, "Thermal Loads," states that "An explicit analysis considering these loads (Thermal Loads) has not been performed, as thermal loads are a minor consideration." While, Section 3.8.4.4.1, "Reactor Building Analysis," states that "..., a fixed base model was created in ANSYS to evaluate the effects of thermal loads on the structure." Therefore, address this discrepancy.

#### 03.08.05-6

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the design and analysis procedures of foundations.

In FSAR Tier 2, Section 3.8.4.1, "Description of Foundations," the applicant describes the basemat reinforcement pattern of the foundation of RXB, and in Tier 2, Appendix 3B "Design Reports and Critical Section Details." However, the applicant did not provide sufficient information for the design assessments, boundary conditions for each foundation model, settlement evaluation and associated figures. Based on the review, the staff was not able to find sufficient information in the FSAR to make a safety assessment for the design of RXB basemat. Therefore, provide the following information for the RXB basemat:

- design assessments-should include: the capacity of sections, forces & moments at critical locations, design checks, etc.
- boundary conditions for each foundation model -should include: stiffness types and parameter throughout the embedded portion of the RXB for each type of model (standalone and combined) – SASSI2010, SAP2000, and ANSYS -- it should also be noted that, DSRs Section 3.8.5.II.4.N states "In the case of gravity loads and basemat foundations, the soil stiffness parameters should be consistent with: (a) dishing or Boussinesq effects (if uncoupled distributed springs are used then it may be necessary for the stiffness to be increased at the edges and reduced at the center of the basemat footprint); (b) basemat size (subgrade modulus could be highly dependent on basemat dimensions); (c) time scale of the loads (i.e., short term construction loads vs. long term loads present throughout the life of the structure); and (d) soil type (i.e., granular vs. cohesive soils)."
- settlement evaluations and figures showing reinforcement patterns for (a) the entire RXB basemat, (b) intersections between walls & the RXB basemat, and (c) intersections between pilasters & the RXB basemat. Settlement evaluation should include following types of

settlements: (1) Maximum vertical settlements, (2) tilt settlement, (3) differential settlement between structures and (4) angular distortion.

#### 03.08.05-7

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the design of foundations.

The applicant uses a surcharge pressure of 0.25 ksf in FSAR Tier 2, Section 3.8.5.3.1, "Lateral Soil Pressure and Seismic Loads," and tabulates it in Table 3.8.5-1, "RXB Stability Evaluation Input Parameters," and Table 3.8.5-9, "CRB Stability Evaluation Input Parameters," and it was applied throughout the perimeters of the RXB and CRB embedded walls. Explain the basis for the surcharge pressure of 0.25 ksf, and why it was applied uniformly around the perimeter of the RXB and CRB embedded walls.

#### 03.08.05-8

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the stability on foundations.

FSAR Tier 2, Tables 3.8.5-1, "RXB Stability Evaluation Input Parameters," tabulates the coefficient of friction (CoF) between walls and soil and between basemat bottom surface and soil. However, the applicant did not tabulate these CoF values in Table 3.8.5-9, "CRB Stability Evaluation Input Parameters." Provide the CRB CoF values between walls and soil and between basemat bottom surface and soil in Table 3.8.5-9.

#### 03.08.05-9

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the design of foundations.

FSAR Tier 2, 3.8.5.4.1.2, "RXB Basemat Analysis Model Description," states "A pressure of 36.92 psi was applied to the bottom of the basemat to account for the effect of buoyancy force of 279,445 kips ..." The staff performed an independent calculation, and the staff's result was 30.064 psi. Please explain how the 36.92 psi was obtained to determining the RXB buoyancy pressure.

#### 03.08.05-10

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the modeling of foundations.

FSAR Tier 2, 3.8.5.4.1.2, "RXB Basemat Analysis Model Description," page 3.8-60, the 4th paragraph, states that a pressure of 36.92 psi was used to account for buoyancy effects, while the 9th paragraph states that the analysis was done without the presence of buoyancy force. Therefore, address this inconsistency.

#### 03.08.05-11

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the design of foundations.

FSAR Tier 2, 3.8.5.4.1.2 (Page 3.8-58), "*RXB Basemat Analysis Model Description*," states "*The SAP2000 model was created modeling the RXB basemat with solid elements in order to calculate forces and moments in the basemat.*" Contrary to that statement, page 3.8-59 states "Figure 3.8.5-1 shows the SAP2000 model. The area elements shown in light red tinge are shell elements representing the base slab." Address this inconsistency. State what type of elements (solid or shell) were used in the SASSI 2010 model to calculate forces and moments in the basemat.

#### 03.08.05-12

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to representing the dynamic characteristics of foundations.

FSAR Tier 2, 3.8.5.4.1.2, "RXB Basemat Analysis Model Description," states "*The static forces and moments in the basemat are calculated with both the standalone and the combined building SAP2000 models.*" Additionally, this section states "*The seismic forces, moments and stresses in all structural elements such as walls, pilasters, and basemat were calculated using the standalone and combined SASSI 2010 models. The enveloped base pressures were applied to the solid foundation model to evaluate the responses. To be consistent with the SASSI 2010 analysis, absolute values of all responses obtained by applying base pressures from SASSI2010 were used together with the fixed end forces and moments from walls and pilasters to arrive at the seismic demands.*" It is not clear to the staff which structures or portions of the structures are included in the standalone and the combined building SAP2000 and SASSI2010 models, and whether there is a standalone basemat model. Therefore, describe each of the different models used for the basemat design.

#### 03.08.05-13

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to representing the settlement of foundations.

FSAR Tier 2, Section 3.8.5.5.5, "Settlement Approach," the applicant states "..., the soil stiffnesses are further reduced by 50 percent to amplify the effect of differential movements or settlements. The size of the soil included in the model is so large that the static displacements induced by the static loads of the structures become negligible on the edges of the free field soil model." It is not clear to the staff whether the reduced soil stiffnesses are extended to the size of the triple building (RWB+RXB+CRB) basemats or

extended for the entire soil model shown in Figure 3.8.5-41, "SAP2000 Model for Settlement." Clarify the boundary of soils with the reduced stiffness.

#### 03.08.05-14

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to maximizing the bending moments used in the design of foundations.

Based on the staff's review of FSAR Section 3.8.5.4, "Design and Analysis Procedures," the applicant did not provide any discussion related to "*stiff and soft spots*" in the foundation soil. Therefore, describe how the "*stiff and soft spots*" are to be considered in the basemat evaluations of seismic Category I structures.

#### 03.08.05-15

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to the stability of foundations.

FSAR Tier 2, Section 3.8.5.6.1 "RXB Stability," page 3.8-68, 4th paragraph, states "reinforcing pattern described above." However, the staff could not find any description of reinforcement in the previous text. Therefore, provide/address reinforcing pattern as referenced.

#### 03.08.05-16

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.1.1.1, "Dynamic RXB Uplift Ratio," refers to vertical seismic reaction time histories used in the dynamic uplift evaluation. However, the applicant did not discuss if the horizontal components of the input ground motions would impact the RXB uplift ratio. Provide a discussion on impact of horizontal component of the ground motion and its contribution to the uplift ratio (if any).

#### 03.08.05-17

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.1.1.1, "Dynamic RXB Uplift Ratio," page 3.8-69, 2nd paragraph, describes the uplift analysis of the RXB by using the total weight of 471,487 kips without reducing that dead weight by upward buoyancy force. Therefore, address the reason(s) for not considering the buoyancy force.

#### 03.08.05-18

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.1.2, "RXB Sliding," states "..., a nonlinear sliding analysis has been performed to show that sliding is insignificant." Describe the method, and results of basemat movement (in inches), of the nonlinear analysis, and justify why the results of horizontal sliding are insignificant.

#### 03.08.05-19

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.2.1.1, "Dynamic CRB Uplift Ratio," page 3.8-71, 2nd paragraph, describes the uplift analysis of the CRB by using the total weight of 48,680 kips without reducing the dead weight by upward buoyancy force. Therefore, address the reason(s) for not considering the buoyancy force.

#### 03.08.05-20

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.2.2, "Control Building Sliding," page 3.8-72, refers to Table 3.8.5-15, "Seismic Vertical CRB Base Reactions and DW," for the summary of results of CRB sliding analyses. However, Table 3.8.5-15 provides only reactions for the CRB. Therefore, provide a table tabulating the factor of safety results of flotation, sliding, and overturning for the CRB basemat to evaluate the stability of the CRB.

#### 03.08.05-21

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRS Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.2.3, "Control Building Overturning," states "The results provided in Table 3.8.5-13 results show that the embedded Control Building experiences less than 1/10" of overturning horizontal displacement and less than 1/64" of total vertical uplift displacement." The staff is requesting the applicant to describe what is meant by "overturning horizontal displacements," condition.

#### 03.08.05-22

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to stability of foundations.

FSAR Tier 2, Section 3.8.5.6.3, "Bearing Pressure," page 3.8-72, provides static bearing pressures of 10.1 ksf and 6.42 ksf for the RXB and CRB basemats, respectively. The applicant also provides dynamic bearing pressures of 4.6 ksf and 5.32 ksf for the RXB and CRB basemats, respectively. Furthermore, the applicant refers to Figure 3.8.5-3, "Seismic Base Pressure Contours from SASSI 2010 Analysis," to obtain seismic bearing pressure contour for the RXB basemat. It is not clear to the staff how the applicant determined 4.6 ksf from Figure 3.8.5-3. Therefore, address the following:

- a) describe the reason(s) why the dynamic bearing pressures of CRB is larger than the dynamic bearing pressures of RXB.
- b) explain how the applicant determined 4.6 ksf from Figure 3.8.5-3 for the dynamic bearing pressures of RXB basemat.
- c) address and provide figures of static and seismic basemat pressure contours for the CRB and CRB Tunnel.

03.08.05-23

10 CFR Part 50, Appendix A, GDC 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to the design and analysis procedures of foundations.

FSAR Tier 2, Section 3.8.5.6.8, "Leak Detection," states "A leak chase system is provided in the RXB basemat to detect any leakage from the reactor pool." However, the applicant did not describe the leak chase system in detail. Describe the leak chase system in detail; e.g., safety categorization of the systems, provide location of the leak chase system collection room/collection tank, and its associated piping from the RXB basemat and design requirements, etc.

03.08.05-24

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. DSRs Section 3.8.5 provides review guidance pertaining to mathematical modeling of foundations.

FSAR Tier 2, Table 3.8.5-11, "CRB SAP2000, SASSI2010, and ANSYS Model Summary," summaries SAP2000, SASSI, ANSYS for the CRB basemat models. However, the applicant did not reference Table 3.8.5-11 in the body of the FSAR. Therefore, the staff is requesting the applicant to reference Table 3.8.5-11 in the body of Chapter 3 of the FSAR. Furthermore, the applicant provides the RXB ANSYS model summary in Table 3.8.5-6, but did not provide SAP2000 and SASSI2010 summary of RXB basemat models in Table 3.8.5-6. Therefore, provide a table(s) summarizing the SAP2000 and SASSI2010 RXB basemat models in the FSAR.