RAIO-1117-57127

November 10, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 189 (eRAI No. 9025) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 189 (eRAI No. 9025)," dated August 19, 2017
2. NuScale Power, LLC Response to NRC Request for Additional Information No. 189 (eRAI No. 9025) on the NuScale Design Certfication Application, date October 18, 2017 (ML17291B314)

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosures to this letter contain NuScale's response to the following RAI Question from NRC eRAI No. 9025:

- 09.01.02-15

The response to RAI Questions 09.01.02-14 and 09.01.02-16 were previously provided in Reference 2. This completes all responses to eRAI No. 9025.

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 189 (eRAI No. 9025). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 is the nonproprietary version of the NuScale response.

This letter and the enclosed responses make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Carrie Fosaaen at 541-452-7126 or at cfosaaen@nuscalepower.com.

Sincerely,

Jennie Wike
Manager, Licensing
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Anthony Markley, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9025, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9025, nonproprietary

Enclosure 3: Affidavit of Thomas A. Bergman, AF-1117-57128

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9025, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9025, nonproprietary

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

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

eRAI No.: 9025
Date of RAI Issue: 08/19/2017

NRC Question No.: 09.01.02-15

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. SRP Sections 9.1.2 and DSRS Sections 3.8.4 Appendix D describe the specific SRP acceptance criteria for the review of the fuel racks to meet the requirements of the Commission's regulations identified above.

The staff reviewed the shallow-drop and deep-drop analysis provided on Pages 119 through 128 of TR- 0816-49833-P. The applicant should provide additional information on the following descriptions related to the load drop analysis.

a. On page 123 of the TR, in Section 3.1.3.6.2, the applicant states, "Thus, the model of the bottom of the rack includes the bottom inner grid, bottom outer grid, bottom outer plate, baseplate, and a small section of the corner posts. The nodes at the locations of the foot assemblies are constrained." The applicant should explain the difference between the outer grid and the inner grid, including a figure if applicable; and whether the nodes at the locations of the foot assemblies are constrained only in the vertical direction.

b. On page 123 of the TR, in Section 3.1.3.6.2, the applicant describes the deep-drop analysis on the center of the baseplate. The applicant should clarify or correct the first sentence in the second paragraph to refer to the deep-drop analysis. The sentence reads, "The geometry for the shallow-drop analysis is based on the ANSYS model discussed in Section 3.1.1 and shown in Figure 3-121."

c. For the deep-drop analysis (Figures 3-121, 3-122, and 3-123), the applicant should explain why other FAs (or their equivalent dead load) are not included in the model which would impose additional load on the baseplate, or provide justification for not considering all other fuel assemblies in place when a fuel assembly drops through an empty cell.

d. On page 121 of the TR, Section 3.1.3.3, Item 1 describes the configuration for the shallow drop analysis. Figure 3-120 shows the FEM for the shallow drop which appears to show only 6 fuel tubes (with reduced lengths) in the model. In terms of mass loading on the racks during this shallow drop, the applicant should explain why only a set of 6 fuel tubes with reduced lengths are considered and not all of the fuel tubes and poison plates.

e. For all of the shallow drop evaluations, provide figures that clearly show the path of the dropped fuel assembly as it impacts the lead-ins, top grid, corner posts, and fuel tubes.

f. In the load drop analysis described in TR-0816-49833-P, Section 3.1.3, the applicant did not include a shallow drop on the corner of the fuel storage rack. On page 121, assumption 2 states that a shallow drop onto the center of the rack envelopes a shallow drop onto the corner post, because the corner of the rack is stiffer than the center of the rack. The staff requests the applicant provide additional justification that a shallow drop onto the corner post is bounded by a shallow drop onto the center of the rack. The applicant should confirm that the corner post does not buckle.

g. For all of the fuel drop accident analyses described in Section 3.1.3, explain if any sensitivity analyses were performed to verify the mesh size discretization of the finite elements or explain why these analyses were not performed. Also, describe if the adequacy of the drop analyses were checked by plotting the hourglass energy together with the kinetic energy, internal energy, and total energy throughout the time history to ensure that the hourglass energy is sufficiently small.

NuScale Response:

Response to 09.01.02-15(a):

The inner grids are made of interlocking plates. The outer grid plates surround the inner grid interlocking plates to capture the ends. To help illustrate, additional figures depicting outer/inner grids, outer plates, baseplate and how they are assembled are added to the technical report (TR) as Figure 1-1a through 1-1e, as shown in the markups at the end of this response.

For the fuel assembly drop analyses, the foot assemblies are not modeled explicitly and are analyzed separately.

The following boundary conditions are applied:

1. For shallow vertical drop (center strike), a portion of the rack is modeled (see Figure 3-120 of TR 816-49833-P). The fuel tubes and corner posts are modeled as half the actual heights. The nodes at the bottom of the corner posts and fuel tubes are constrained in all 6 degrees of freedom. The deflections and plastic strain under impact are highly localized and away from the applied boundary conditions.
2. For the deep vertical drops (center, corner and outside strikes), nodes at the periphery of each square hole at a support leg attachment location (see the figure below) are constrained in all 6 degrees of freedom.

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}}2(a),(c)

Deep Drop - Boundary Conditions (Constrained Nodes Shown in Orange)

Response to 09.01.02-15(b):

The sentence in Section 3.1.3.6.2, “The geometry for the shallow-drop analysis is based on ANSYS model discussed in Section 3.1.1 and shown in Figure 3-121.” contains a typo and has been corrected. The correct statement is:

> The geometry for the deep-drop analysis is based on the ANSYS model discussed in Section 3.1.1 and shown in Figure 3-121.

Response to 09.01.02-15(c):

Since the impact analysis is a local phenomenon with localized plastic deformation, the shallow and deep drop analyses considered only a portion of the model (thereby reducing the number of elements) to reduce the solution time. Presence of other fuel assemblies will impose only a minor additional elastic strain. The drop of fuel assembly will introduce very large elastic-plastic strains. Compared to the elastic strains under the weight of fuel assemblies, plastic strains under impact will be orders of magnitude higher. Therefore, consideration of other fuel assemblies will not alter the results and conclusion.

Response to 09.01.02-15(d):

The shallow vertical drop is analyzed with a partial spent fuel storage rack model with six tubes with shorter length. For the analysis, nodes at the bottom of the corner posts and fuel tubes are constrained in all 6 degrees of freedom. Since the impact analysis is a local phenomenon with localized plastic deformation, the shallow drop analysis considered a portion of the model (thereby reducing number of elements) to reduce the solution time. However, the analyses under impact showed that the deformation of the spent fuel storage model is sufficiently far away from the boundary of the model. The figure below shows the maximum shear stress under impact from the fuel assembly. This validates the adequacy of the reduced model for shallow vertical drop analysis of fuel assemblies.

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}}2(a),(c)

Shallow Drop: Shear Stress in Fuel Tubes

Response to 09.01.02-15(e):

Four (4) figures have been added to TR-0816-49833-P as Figures 3-120a through 3-120d to illustrate the path of the fuel assemblies analyzed for shallow drop cases.

Response to 09.01.02-15(f):

The spent fuel storage rack has four corner posts {{ }}$^{2(a),(c)}$ with welded outer top braces {{ }}$^{2(a),(c)}$, outer side plates {{ }}$^{2(a),(c)}$ at mid-height and bottom outer side plate {{ }}$^{2(a),(c)}$. Due to the connected outer plates, the unbraced length of the corner posts is small enough for buckling not to be a concern for a shallow drop onto the corner posts. The plates of the top grid are supported by outer braces by beam action without support from the bottom. The corner posts along with outer braces and plates provide additional rigidity at the corners compared to center of the grids. Also, due to the limitations of the fuel handling crane, only inside corners may be impacted, meaning a corner impact would likely impact additional spent fuel storage rack corners as well.

A calculation was performed, as depicted in the following figure, which represents a corner impact on a single spent fuel storage rack. The results showed highly localized stresses at the top of the corner angles. Stresses decrease significantly below the top grid; therefore, buckling is not a concern. Additionally, the high local stresses are caused by the rigid fuel assembly model in contact with the shell edge. In reality, some deformation of the fuel assembly will occur; thus, reducing stresses.

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}}2(a),(c)

Shallow Drop (Corner Strike) - ISO View

Response to 09.01.02-15(g):

For all the fuel assembly load drop scenarios, mesh discretization studies were performed to determine the adequacy of the mesh used in the analyses. The initial size of the shell elements were selected based on element thickness, number of elements between the inner grids, and the location of the impacts. This study was performed by gradually increasing the mesh density in steps and comparing each critical parameter. The final mesh for analysis is chosen when results of the critical parameters see little to no change with increased mesh density. This mesh discretization study is performed as follows:

1. Shallow Vertical Drop analysis: For this impact scenario, the analyzed mesh is shown in in the following figure. The mesh size of the elements at the impact location was further reduced to one half of the mesh size used in the analysis. With the more refined mesh, the maximum vertical deflection of the top grid {{ }}2(a),(c) and the maximum shear stress {{ }}2(a),(c). The distribution of shear stress demonstrates good agreement between original and refined model results.
2. Deep Center Drop analysis: The mesh size of the elements at the impact location was reduced to one half of the mesh size used in the analysis. With the more refined mesh, the maximum vertical deflection {{ }}2(a),(c) and the

maximum shear stress increased from {{ }}[2(a),(c)]. The maximum effective plastic strain in the baseplate {{ }}[2(a),(c)]. The distribution of shear stress demonstrates good agreement between original and refined model results.

3. Deep Corner Drop analysis: The mesh size of the elements at the impact location was reduced to one half of the mesh size used in the analysis. With the more refined mesh, the maximum vertical deflection, maximum shear stress and effective plastic strain remained unchanged. The distribution of shear stress demonstrates good agreement between original and refined model mesh results.

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}}2(a),(c)

Shallow Drop - Local Mesh Sizing of Lead-Ins

The validity of each fuel assembly drop analysis was checked by comparing hourglass, internal, kinetic, and total energy against time. For each analysis, this comparison demonstrated that:

- the hourglass energy is small for the period of analysis,
- the total energy is always equal to the summation of kinetic, internal, and hourglass energy,
- the total energy remained nearly flat for the analysis period of time.
- The following figures demonstrate the variation of different energies with time for the different load drop scenarios.

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}}2(a),(c)

Energy Profile of Shallow Drop Analysis

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}}2(a),(c)

Energy Profile of Deep Center Drop Analysis

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}}2(a),(c)

Energy Profile of Deep Corner Drop Analysis

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Energy Profile of Deep Outside Drop Analysis

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}}2(a),(c)

Energy Profile of Shallow Drop on Corner Analysis

Impact on DCA:

Technical Report TR-0816-49833, Fuel Storage Rack Analysis, has been revised as described in the response above and as shown in the markup provided in this response.

The rack design presented in this report can be used to store either unirradiated (new) or irradiated (spent) FAs. Unirradiated assemblies and irradiated assemblies with a maximum enrichment of 5 wt% U-235 and {{ }}$^{2(a),(c)}$ average assembly burnup are stored in the SFP. The fuel design is derived from AREVA's 17x17 pressurized water reactor design for Westinghouse-type reactors. Many of the design features are common to the Advanced W17 HTP™ fuel design currently in operation, but the length is scaled down to meet the NuScale design. The overall length of the FA from the outside shoulders of the end fittings is 94 inches and has an active fuel length of 78.74 inches. The size of the FA is 8.426 x 8.426 inches and weighs 830 pounds.

The fuel storage design consists of fourteen 11x11 free-standing modules within the SFP with a 121 usable storage spaces divided into arrays of {{ }}$^{2(a),(c)}$ inner dimension square tubes arranged on an 11.22" pitch providing a flux trap to store and maintain criticality control of the new and spent FAs (see Figure 1—1, Figure 1—3, and Figure 1—4). Expanded views of the rack assemblies are provided in Figure 1—1a through Figure 1—1e to supplement Figure 1—1.

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}}$^{2(a),(c)}$

The principal structural load-carrying material used in the design is {{ }}$^{2(a),(c)}$ stainless steel fabricated from a mixture of sheet steel, bar, and rolled steel stock of standard and readily available sizes. The {{ }}$^{2(a),(c)}$ stainless steel meets the corrosion requirements {{ }}$^{2(a),(c)}$ while providing the minimum mechanical properties {{ }}$^{2(a),(c)}$. The individual tubes surrounding the FAs are fabricated from the same {{ }}$^{2(a),(c)}$ stainless steel and include a beveled "lead-in" to aid in the placement of FAs. The lead-in is designed to allow identification markers to be embossed for tracking FAs. The lead-ins are welded along the edges, but remain open at the intersection of four adjacent cells. The bottom of the rack is constructed of a thick baseplate ({{ }}$^{2(a),(c)}$) providing structural rigidity and support against FA drop scenarios.

The rack modules are used in wet conditions to allow the receipt and storage of new fuel and freshly discharged FAs in the SFP.

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}}2(a),(c)

Figure 1—1a Bottom Grid

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}}2(a),(c)

Figure 1—1b Bottom Grid, Cross Bars, Outer Grid Lower Bands, and Corner Posts

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}}2(a),(c)

Figure 1—1c Top Inner Grid

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}}2(a),(c)

Figure 1—1d Top Inner Grid

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}}2(a),(c)

Figure 1—1e Top Outer Grid

3.1.3.6 Analysis, Evaluation, and Data

3.1.3.6.1 Shallow-Drop Analysis

In the shallow-drop analysis, the FA plus CRA are considered to drop vertically and hit the top of the fuel storage rack in the center. This evaluation focuses explicitly on the fuel storage rack. The fuel storage rack is under water and all drops would be slowed by water.

The geometry for the shallow-drop analysis is based on the ANSYS model discussed in Section 3.1.1 and shown in ~~Figure 3—120~~Figure 3—120 through Figure 3—120d.

The summary of the shallow-drop analysis results is shown in Table 3-7.

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}}2(a),(c)

Figure 3—120 Shallow drop – finite element model

3.1.3.6.2 Deep Drop on Center Analysis (Case 2A)

For the deep drop on center analysis, the FA plus CRA are considered to drop vertically through a fuel cell and strike the baseplate in the center, providing the maximum deflection and stress in the baseplate.

The geometry for the shallowdeep-drop analysis is based on the ANSYS model discussed in Section 3.1.1 and shown in Figure 3—121. Components above the bottom outer plates are deleted. Any plates that are directly welded to the baseplate are included in the model in order to accurately account for the overall stiffness of the baseplate. Thus, the model of the bottom of the rack includes the bottom inner grid, bottom outer grid, bottom outer plate, baseplate, and a small section of the corner posts. The nodes at the locations of the foot assemblies are constrained.

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}}2(a),(c)

Figure 3—120a Shallow Drop (Center Strike) – ISO View

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}}2(a),(c)

Figure 3—120b Shallow Drop (Center Strike) – Top View

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Figure 3—120c Shallow Drop (Horizontal Strike) – ISO View

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}}2(a),(c)

Figure 3—120d Shallow Drop (Horizontal Strike) – Top View

Enclosure 3:

Affidavit of Thomas A. Bergman, AF-1117-57128

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
www.nuscalepower.com

NuScale Power, LLC

AFFIDAVIT of Thomas A. Bergman

I, Thomas A. Bergman, state as follows:

1. I am the Vice President, Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.
2. I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:
    a. The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.
    b. The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.
    c. Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.
    d. The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.
    e. The information requested to be withheld consists of patentable ideas.
3. Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying Request for Additional Information response reveals distinguishing aspects about the structure by which NuScale develops its spent fuel racks.

    NuScale has performed significant research and evaluation to develop a basis for this structure and has invested significant resources, including the expenditure of a considerable sum of money.

    The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

    If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

4. The information sought to be withheld is in the enclosed response to NRC Request for Additional Information No. 189, eRAI No. 9025. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.
5. The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC § 552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).
6. Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:
    a. The information sought to be withheld is owned and has been held in confidence by NuScale.
    b. The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.
    c. The information is being transmitted to and received by the NRC in confidence.
    d. No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.
    e. Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 11/10/2017.

Thomas A. Bergman