RAIO-1217-57467

December 04, 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. 204 (eRAI No. 9026) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 204 (eRAI No. 9026)," 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 Enclosures to this letter contain NuScale's response to the following RAI Question from NRC eRAI No. 9026:

- 09.01.02-17

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 204 (eRAI No. 9026). 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,

Zackary W. Rad
Director, Regulatory Affairs
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. 9026, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9026, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-1217-57468

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

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9026, proprietary

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

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9026, nonproprietary

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

eRAI No.: 9026
Date of RAI Issue: 09/01/2017

NRC Question No.: 09.01.02-17

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.

Based on its review of the Technical Report, the staff requests the applicant respond to the questions below, related to the Elastic-Plastic Material Property Modeling in the seismic analysis of the whole pool rack model and the single rack detailed model. The staff notes the following related sections and statements in the Technical Report that should be referred to in answering this question:

Section 3.1.4.2 "Fuel Storage Rack Element Properties." (p. 131) states, "{{

}}2(a),(c)

………..While it is not expected that the fuel storage racks will undergo plastic behavior, it is accounted for in the model."

Section 3.1.4.2 "Fuel Storage Rack Element Properties" (p. 132) states, "Uniform strain for {{ }}2(a),(c) is approximately estimated as 75 percent elongation at fracture from the stress-strain diagrams (shown in Figure SS.041, page 183, Reference 37). Hence, eu = 0.75 and elongation is 0.75 x 0.40 = 0.30."

Section 3.1.4.2 "Fuel Storage Rack Element Properties" (p. 132) also states, "{{

}}2(a),(c)"

Section 3.1.5.5 “Analysis, Evaluation, and Data” (p. 167) states, “Per Section NF-3121 and Section NF-3251, primary membrane and bending stresses are defined as normal stresses. For the plate-and-shell type supports evaluated in this calculation, maximum stress intensity is compared to the allowable stress values. The plastic analysis of linear type supports for Service Level D also uses stress intensity to evaluate stresses. Section NF-3212.1 defines stress intensity as twice the maximum shear stress, or the difference between the algebraically largest principal stress and the algebraically smallest principal stress at a given point.”

Section 3.1.5.5 “Analysis, Evaluation, and Data” (p. 169) states, “The fuel storage rack shell components (fuel tubes, baseplate, bottom grid, bottom horizontal bands, and top grid) are designed using the plate-and-shell type plastic analysis procedure requirements per Section F-1342 of ASME Section III, Appendices (Reference 13) for Level D. Corner angles and middle and top horizontal bands are designed using the linear-type plastic analysis procedure design requirements given in Section F-1344 for Level D. Welds and support legs are designed using the linear type elastic analysis procedure design requirements given in Section F-1334 for Level D.”

Based on the above statements, the staff requests the applicant to address the following:
(1) Since, as the applicant states, the fuel storage racks are not expected to undergo plastic behavior in the whole pool model analysis, the applicant should explain any impact to the results due to this modeling choice.

(2) The LS-DYNA material option, *mat_plastic_kinematic with isotropic hardening along with Von-Mises yield criteria, which was utilized in the rack analysis, allows the user to specify either isotropic strain hardening or kinematic strain hardening. For monotonic loading, isotropic strain hardening is acceptable. For cyclic loading, such as seismic, implementation of kinematic strain hardening is necessary in an elastic-plastic analysis. The applicant should provide the technical basis for specifying isotropic strain hardening for the whole pool seismic analysis.

(3) The description of the calculation of the engineering strain corresponding to tensile strength (eu) on p. 132 requires clarification. It appears that the applicant selected the elongation at fracture to be around 0.40 (40%), and to set eu at 75% of this value, i.e., 0.30. Please confirm or correct the staff’s interpretation. Based on the staff’s review of the applicant should explain why 0.40 was selected as the elongation at fracture. This appears to be inconsistent with Figure SS.041, page 183, Reference 37, which was cited in the description on p. 132.

(4) Based on the results of the whole pool model analyses, the applicant should describe the extent of plastic behavior in the racks. Identify locations and magnitudes of plastic strain.

(5) Describe the elastic-plastic material model implemented in the detailed rack model analyses.

(6) Based on the results of the detailed rack model analyses, what is the extent of plastic behavior in the rack? Identify locations and magnitudes of plastic strain.F

NuScale Response:

Response to 09.01.02-17 (1):

The fuel storage racks are designed to be stiff structures having an aspect ratio of {{

}}[2(a),(c)] was anticipated to move within the spent fuel pool via rigid body movement rather than local flexibility and swaying in the motion of the surrounding fluid. This rigid body motion was, therefore, expected to result in forces dominated by the pressures of the fluid, which would result in elastic stresses due to the equalization of water pressures on the inside of the rack and fuel tubes. However, it was recognized that rigid body motion could result in large rack-to-rack or rack-to-wall impact. A sharp impact could result in small, local, permanent deformations (dents). To capture this deflection, {{

}}[2(a),(c)] were defined, as stated in the technical report (TR-0816-49833).

Response to 09.01.02-17 (2):

Kinematic strain hardening is appropriate for cyclic loading. Cyclic loading typically means full-reversing load cycles, where compression and tension loads are equal, or nearly equal, in magnitude and exceed the elastic limit. The fuel storage racks in the spent fuel pool were found not to experience full-reversing load cycles. {{

}}[2(a),(c)]

Response to 09.01.02-17 (3):

The curves in Figure SS.401 of Reference 37 (of the technical report) are developed from testing and research of actual metals. The fuel storage rack design follows DSRS Section 3.8.4, Appendix D guidance to use ASME Section II, Part D, which provides minimum material properties. Since the experimental data of Reference 37 may be higher than the code minimums, the figures of Reference 37 are only used to establish that the maximum uniform strain of {{

}}[2(a),(c)]

NUSCALE POWER™

Response to 09.01.02-17 (4):

The table below lists the maximum plastic strains recorded in the shell elements of the whole pool analysis:

Maximum Plastic Strain in Fuel Tubes, Upper Grid, and Lower Grid

{{

}}2(a), (c)

{{

}}2(a), (c)

Load cases with maximum strain were found in TH1-low friction (fuel tube on exterior face) and LF2-low friction (fuel tube on interior face). The plots below show the strain locations and magnitudes of the shell elements of TH1 and LF2. For clarification, Von-Mises stress for the baseplates from TH1 is also shown below. The baseplate is {{

}}2(a), (c).

See the response to RAI 9011 Question 09.01.02-21 for the description of modifications made to reduce run times. As a result, the baseplate is modeled with {{

}}2(a), (c) Since the baseplate is connected to the lower grid and fuel tubes, the combined section is very rigid, similar to the corner posts described above. Only plastic deformations in local areas would then be expected and elastic-plastic material properties would result in lower-than-expected impact loads at the baseplate level. To confirm the baseplate state, the baseplate is checked for stresses. The baseplate stresses were only locally observed to exceed 10% of the yield strength (modified yield strength). The maximum baseplate stress is {{ }}2(a), (c) This corresponds to instances of baseplate-to-baseplate impact. The plot of the Von-Mises stresses for all baseplates at 17.175 seconds shows that peak stresses are local in nature. {{

}}2(a), (c)

{{

}}2(a),(c)

TH1 Analysis with Friction 0.2 - Rack 7 Fuel Tubes, Upper and Lower Grid Plastic Strain at t=48 Seconds

{{

}}2(a),(c)

TH1 Analysis with Friction 0.2 - Rack 8 Fuel Tubes, Upper and Lower Grid Plastic Strain at t=48 Seconds

{{

}}2(a),(c)

TH1 Analysis with Friction 0.2 - All Racks Fuel Tubes, Upper and Lower Grid Plastic Strain at t=48 Seconds

{{

}}[2(a),(c)]

TH1 Analysis with Friction 0.2 - All Racks Fuel Tubes and Lower Grid (Upper Grids removed for clarity) Plastic Strain at t=48 Seconds

{{

}}2(a),(c)

LF2 Analysis with Friction 0.2 - Rack 8 Fuel Tubes (Outer surfaces, upper grid, and lower grid removed for clarity) Plastic Strain at t=32 Second

{{

}}2(a),(c)

LF2 Analysis with Friction 0.2 - All Racks Fuel Tubes, Upper and Lower Grid Plastic Strain at t=31.95 Seconds

{{

}}2(a),(c)

LF2 Analysis with Friction 0.2 - All Racks Fuel Tubes and Lower Grid (Upper Grid removed for clarity) Plastic Strain at t=31.95 Seconds

{{

}}2(a),(c)

TH1 Analysis with Friction 0.2 - All Racks Baseplates VM Stress at t=17.175 Seconds

Response to 09.01.02-17 (5):

The detailed stress model is performed using ANSYS. {{

}}2(a),(c)

Response to 09.01.02-17 (6):

The table below shows a summary of the percentage of shell and beam elements exhibiting plastic behavior for each of the multiple time history analyses. The figures that follow present the locations of plastic strain.

Plasticity Summary

{{

}}2(a),(c)

Based on the table above, there is a very small amount of plastic strain for all cases {{

}}2(a),(c)

For all cases, the "narrow strip" (weak elements created to prevent ALE element intrusion between the small gaps in the fuel tubes, see TR-0816-49833, Section 3.1.1.2 modeling simplifications for simplified model number 4) elements that occur in the upper and lower grid areas are expected to produce higher stresses and strains due to being modeled with lower stiffness in the whole-pool LS-DYNA simulations and to being only one element wide. These "narrow strip" elements are not actual components of the rack and are the locations of the highest plastic strains in all cases.

The table above breaks down the accumulated equivalent plastic strain into two categories. Note that plastic strain presented here is the total strain with elastic strain removed. {{

}}2(a),(c)

{{

}}2(a),(c)

Accumulated Equivalent Plastic Strain in Rack 9 - Fuel Tubes, Grids, and Baseplate (STH)

{{

}}2(a),(c)

Accumulated Equivalent Plastic Strain in Rack 9 - Corner Posts and Outer Bands (STH)

{{

}}2(a),(c

Accumulated Equivalent Plastic Strain in Rack 10 - Fuel Tubes, Grids, and Baseplate (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 10 - Corner Posts and Outer Bands (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Fuel Tubes, Grids, and Baseplate (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Corner Posts and Outer Bands (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 14 - Fuel Tubes, Grids, and Baseplate (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 14 - Corner Posts and Outer Bands (STH)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 3 - Fuel Tubes, Grids, and Baseplate (LF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 3 - Corner Posts and Outer Bands (LF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 8 - Fuel Tubes, Grids, and Baseplate (LF3low)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 8 - Corner Posts and Outer Bands (LF3low)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 10 - Fuel Tubes, Grids, and Baseplate (HF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 10 - Corner Posts and Outer Bands (HF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Fuel Tubes, Grids, and Baseplate (HF1high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Corner Posts and Outer Bands (HF1high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Fuel Tubes, Grids, and Baseplate (HF2low)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 13 - Corner Posts and Outer Bands (HF2low)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 15 - Fuel Tubes, Grids, and Baseplate (HF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 15 - Corner Posts and Outer Bands (HF2high)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 15 - Fuel Tubes, Grids, and Baseplate (LF3low)

{{

}}2(a), (c)

Accumulated Equivalent Plastic Strain in Rack 15 - Corner Posts and Outer Bands (LF3low)

Impact on DCA:

There are no impacts to the DCA as a result of this response.

Enclosure 3:

Affidavit of Zackary W. Rad, AF-1217-57468

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 Zackary W. Rad

I, Zackary W. Rad, state as follows:

1. I am the Director, 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 methods by which NuScale develops its fuel storage racks.

    NuScale has performed significant research and evaluation to develop a basis for these methods 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. 204, eRAI No. 9026. 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 12/4/2017.

Zackary W. Rad