RAIO-0818-61403

August 16, 2018

Docket: PROJ0769

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. 9519 (eRAI No. 9519) on the NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9519 (eRAI No. 9519)," dated June 18, 2018
2. NuScale Topical Report, "Loss-of-Coolant Accident Evaluation Model," TR-0516-49422, Revision 0, dated December 2016

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. 9519:

- 15.06.05-20

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 9519 (eRAI No. 9519). NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The proprietary enclosures have been deemed to contain Export Controlled Information. This information must be protected from disclosure per the requirements of 10 CFR § 810. 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 Paul Infanger at 541-452-7351 or at pinfanger@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
Samuel Lee, NRC, OWFN-8G9A
Rani Franovich, NRC, OWFN-8G9A

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9519, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9519, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0818-61436

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. 9519, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9519, 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: PROJ0769

eRAI No.: 9519
Date of RAI Issue: 06/18/2018

NRC Question No.: 15.06.05-20
Title 10, Part 52, of the Code of Federal Regulations (10 CFR Part 52), "Licenses, Certifications, and Approvals for Nuclear Power Plants," Section 52.47, "Contents of Applications; Technical Information" (10 CFR 52.47), specifies that an application for certification of a nuclear power reactor design that uses simplified, inherent, passive, or other innovative means to accomplish its safety functions must meet the requirements of 10 CFR 50.43(e) (52 Part 52.47(c)(2)). 10 CFR 50.43(e) requires, in part, assessment of the analytical tools used for safety analyses over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences. Regulatory Guide 1.203 describes a process that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in developing and assessing evaluation models (EMs) that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant. Regulatory Guide 1.203 describes a process that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in developing and assessing evaluation models that may be used to analyze transient and accident behavior that is within the design basis of a nuclear power plant.
As stated in RG 1.203, an evaluation model (EM) is the calculational framework for evaluating the behavior of the reactor system during a postulated transient or design-basis accident. As such, the EM may include one or more computer programs, special models, and all other information needed to apply the calculational framework to a specific event, as illustrated by the following examples:

1. Procedures for treating the input and output information (particularly the code input arising from the plant geometry and the assumed plant state at transient initiation),
2. Specification of those portions of the analysis not included in the computer programs for which alternative approaches are used, and
3. All other information needed to specify the calculational procedure.

The entirety of an evaluation model (EM) ultimately determines whether the results are in compliance with applicable regulations. Therefore, the development, assessment, and review processes must consider the entire EM.
{{

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

NUSCALE
Power for all humankind

{{

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

NuScale Response:

The NRELAP5 assessment of the SIET TF-2 test data was updated to correct the pitch to diameter ratio input. The updated assessment was performed using NRELAP5 Version 1.4. Section 7.4.2 of Loss-of-Coolant Accident Evaluation Model Topical Report, TR-0516-49422-P, Rev. 0, has been revised to reflect the updated SIET TF-2 assessment as shown in the markup provided with this response. The updated pitch to diameter ratio input and the updated assessment calculation results and conclusions are discussed in this response.

<u>SIET TF-2 and NuScale Power Module Plant Steam Generator Primary Pitch to Diameter Ratio Input</u>

The updated values for the SIET TF-2 facility and the NuScale Power Module (NPM) plant steam generator primary pitch to diameter (P/D) ratio NRELAP5 input are provided in Table 1. The values are different than the values cited in the Request for Additional Information (RAI) due to the way the P/D ratio input is used in the NRELAP5 code.

In the NPM and SIET TF-2 NRELAP5 models, the primary side of the helical coil steam generator (HCSG) is {{

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

{{

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

Using this approach, the area ratios and P/D ratios were recalculated for both the NPM and the SIET TF-2 facility. The updated values are shown in the Table 1. The incorrect P/D input for the NPM and SIET TF-2 models was documented in the NuScale Corrective Action Program.

Table 1. HCSG Primary Side Area Ratio and Pitch to Diameter Ratio

{{

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

Updated SIET TF-2 NRELAP5 Assessment Results and Conclusions

The SIET TF-2 assessment was revised using the updated NRELAP5 base model with NRELAP5 Version 1.4. {{

}}2(a),(c),ECI These additional changes are discussed in the NuScale response to eRAI 9158, Question 15.00.02-5 (Letter RAIO-0818-61404).

The updated SIET TF-2 assessment showed that NRELAP5 {{

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

{{

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

The conclusions of the updated SIET TF-2 analysis results are the same as the conclusions drawn from the analysis originally summarized in TR-0516-49422-P, Rev. 0. The updated SIET TF-2 analysis results have no impact on calculation of the initial steady state flow rate or in-vessel coolant temperature distribution in NPM plant calculations.

Impact on Topical Report:

Topical Report TR-0516-49422, Loss-of-Coolant Accident Evaluation Model, has been revised as described in the response above and as shown in the markup provided in this response.

{{

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

Figure 7-66. SIET electrically-heated test wall temperature for all coil 1 diabatic tests

7.4.2 SIET Fluid-Heated Test

The SIET fluid-heated tests were performed in support of the NuScale design development, with particular emphasis on providing experimental data for validation of NRELAP5 for prediction of helical coil SG primary and secondary heat transfer, primary side pressure drop, and secondary side dryout. and pressure drop.

7.4.2.1 Facility Description

The SIET TF-2 facility consists of a 252 helical coil tube bundle installed inside a pressure vessel. The tube bundle consists of 5 tube banks, simulating the {{

}}2(a),(b),(c),ECI All five tube bundles are placed in an annulus, formed by two cylindrical barrels, installed axially within the pressure vessel. The helical coils are wrapped around the inner barrel and kept in position by four supports,

7.4.2.3 Experimental Procedure

Target boundary conditions are obtained for the diabatic tests. The duration of the data recording for each test was a minimum 300 seconds for the pre-steady state and 150 seconds for the steady state.

7.4.2.4 Special Analysis Techniques

This benchmark assesses {{

}}2(a),(c)

7.4.2.5 Assessment Results

In general, NRELAP5 predicted the experimental data with reasonable-to-excellent agreement with few exceptions, as identified below. The following specific conclusions were drawn from the assessment:

- {{

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

7.4.2.5.1 Assessment of Adiabatic Experiment Data

Adiabatic experimental data from TF-2 testing is used to assess the modeling of primary side friction and form losses. The primary side pressure drop was measured at {{ }}2(a),(b),(c),ECI Figure 7-67 shows the comparison of predicted and measured

primary side pressure drop at all axial elevations for all adiabatic tests. The error bands represent the uncertainty in measurement of pressure drops. Excellent agreement between NRELAP5 predictions and measured test data exists with primary side pressure drop predicted within the measurement uncertainty. Similar results are obtained for other primary side pressure drop measurement elevations.{{

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

{{

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

Figure 7-67. SIET fluid-heated test adiabatic primary differential pressure

7.4.2.5.2 Primary Side Pressure Drop and Fluid Temperatures of Diabatic Experiments

{{

}}

{{

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

{{

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

Figure 7-68. SIET fluid-heated test diabatic test primary differential pressure

{{

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

Figure 7-69. SIET fluid-heated test diabatic test primary temperature

7.4.2.5.3 Steam Generator Tube Wall Temperature of Diabatic Experiments

{{

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

{{

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

Figure 7-70. Comparison of wall temperatures in TD0001 (Case 1A)

{{

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

Figure 7-71. Comparison of wall temperatures in TD00057 (Case 1A)

{{

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

Figure 7-72. Comparison of wall temperatures in TD0015TD0002 (Case 1A)

7.4.2.5.4 Secondary Side Fluid Temperature of Diabatic Experiments

Figure 7-73 and Figure 7-74 show the comparison of predicted and measured secondary side fluid temperatures at all elevations in Row 3 for selected tests. The figures also show the predicted and measured primary fluid temperatures.Most secondary side fluid temperatures are predicted reasonably well by NRELAP5, as shown in Figure 7-73. {{

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

{{

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

Figure 7-73. Comparison of primary and secondary side fluid temperatures Row 3in TD0001 (Case 1A)

{{

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

Figure 7-74. Comparison of primary and secondary side fluid temperatures in TD0005TD0002 (Case 1A)

7.5 NuScale NIST-1 Test Assessment Cases

A scaled facility of the NPM was constructed at Oregon State University, referred to as the NIST-1 facility, to assist in validation of the NRELAP5 system thermal-hydraulic code. The facility is designed to perform various tests, including LOCA tests. The NIST-1 facility consists of the major components in the NPM. These components include: an RPV, helical coil SG system with DHRS, CNV, and cooling pool vessel (CPV) representing the reactor pool. The NIST-1 ECCS connects the RPV to the CNV and consists of two RVVs and two RRVs, each on separate lines. Breaks can be simulated for the RCS lines that connect the RPV to the CNV to simulate piping breaks within the CNV. This system consists of a RCS discharge line, a RCS injection line, and a pressurizer spray supply line. The CVCS is not functional in the NIST-1 facility and is used only for simulation of CVCS line break LOCAs.

Instrumentation is included in the facility to capture the response of the system under steady-state and transient situations. The instrumentation includes pressure, differential pressure, water level, mass flow rate, heat flux, and temperature measurements.

{{

}}2(a),(c)

{{

}}2(a),(c)

8.2.19 {{ }}2(a),(c)

8.2.19.1 Background

{{

}}

77. Jeandey, C., et al., "Auto Vaporisation D'Ecoulements Eau/Vapeur, Departement des Reacteurs a Eau Service des Transferts Thermiques (Centre D'Etudes Nucleaires de Grenoble)," Report T.T. No. 163, July 1981.
78. U.S. Nuclear Regulatroy Commission, "Assessment of Two-Phase Critical Flow Models Performance in RELAP5 and TRACE against Marviken Critical Flow Tests," NUREG/IA-0401, February 2012.
79. Elias, E., and G. S. Lellouche, "Two-Phase Critical Flow," *International Journal of Multiphase Flow*, (1994): Vol. 20, No. 91-168.
80. US Nuclear Regulatory Commission, “TRACE V5.0 Theory Manual – Volume 1: Field Equations, Solution Methods, and Physical Models,” June 2008, Agencywide Document Access and Management System (ADAMS) Accession No. ML120060218.
81. RELAP5 MOD3.3 Code Manual, Volume IV: Models and Correlations, October 2010.
82. {{

}}2(a),(c) Reserved.
83. Lee, K.W., H.C. No, and C.H. Song, "Onset of Water Accumulation in the Upper Plenum with a Perforated Plate," *Nuclear Engineering and Design*, (2007): 237:1088-1095.
84. Wallis, G.B., *One-dimensional Two-Phase Flow*, McGraw-Hill, New York, NY, 1969.
85. Ilic, V., S. Banerjee, and S. Behling, ”Qualified Database for the Critical Flow of Water, Final Report”, EPRI-NP-4556, May 1986.
86. Zuber, N., and J. A. Findlay, “Average Volumetric Concentrations in Two-Phase Flow Systems”, *Transactions of the ASME, Journal of Heat Transfer*, (1965): 87:453-568.
87. The RELAP5-3D Code Development Team, "RELAP5-3D Code Manual, Volume III: Developmental Assessment", INEEL-EXT-98-00834, Revision 4.1, October 2013.
88. McAdams, W.H., *Heat Transmission*, 3rd Edition, McGraw-Hill, New York, NY, 1954.
89. Minkowycz, W.J., and E. M., Sparrow, “Local Nonsimilar Solutions for Natural Convection on a Vertical Cylinder,” *Journal of Heat Transfer*, (1974): 96(2), 178-183.
90. Plesset, M.S., and S. A. Zwick, "The Growth of Vapor Bubbles in Superheated Liquids", *Journal of Applied Physics*, (1954): 25, 493.
91. Lee, K., and D. J. Ryley, "The Evaporation of Water Droplets in Superheated Steam", *Transactions of the ASME, Journal of Heat Transfer*, (1968): pp. 445-451.
92. Aumiller, D.L., “The Effect of Nodalization on the Accuracy of the Finite-Difference Solution of the Transient Conduction Equation”, *2000 RELAP5 International Users Seminar*, Jackson Hole, Wyoming, September 12-14, 2000.
93. Electric Power Research Institute, "The Chexal-Lellouche Void Fraction Correlation for Generalized Applications," NSAC-139, April 1991.
94. Inayatov, A.Y., "Correlation of Data on Heat Transfer Flow Parallel to Tube Bundles at Relative Pitches of 1.1 < s/d < 1.6," *Heat Transfer-Soviet Research*, (1975): 7, 3, pp. 84-88.
95. {{

}}2(a),(c)

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0818-61436

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 method by which NuScale performs its loss of coolant accident analysis.

   NuScale has performed significant research and evaluation to develop a basis for this method 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 RAI No. 9519, eRAI No. 9519. 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 August 16, 2018.

Zackary W. Rad