NuScale Power

RAIO-0618-60652

June 28, 2018

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. 463 (eRAI No. 9486) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 463 (eRAI No. 9486)," dated May 03, 2018

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 Questions from NRC eRAI No. 9486:

- 20.01-17
- 20.01-18
- 20.01-19

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 463 (eRAI No. 9486). 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
Omid Tabatabai, 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. 9486, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 9486, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0618-60653

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9486, proprietary

Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 9486, 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.: 9486
Date of RAI Issue: 05/03/2018

NRC Question No.: 20.01-17

Regulatory Basis:

10 CFR 52.47(a)(2) requires that a standard design certification applicant provide a description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished. In SECY 12-0025, the staff provided the Commission with proposed orders requiring mitigation strategies for beyond-design-basis external events to be issued to all power reactor licensees and holders of construction permits. In the paper, the staff indicated that for New Reactors that are currently under active staff review, the staff plans to ensure that the Commission-approved Fukushima recommended actions are addressed prior to licensing. On March 12, 2012, the NRC issued Orders EA-12-049 requiring operating nuclear plants to develop and implement strategies that will allow them to cope without ac power for an indefinite amount of time. The strategies must ensure that the reactor core and spent fuel pool are adequately cooled, and containment function is maintained. Currently the NRC is using JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” which endorses NEI 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” as guidance for review of how a reactor design responds to an external beyond-design-basis event. The Commission is currently proposing to amend its regulations to establish regulatory requirements for nuclear power reactor applicants and licensees to mitigate beyond-design- basis events (FRN Vol. 80, No. 219 pages 70610-701647, dated November 13, 2015), and such rule would put the responsibility of addressing the plant response to a beyond-design-basis to the COL applicant. Because the rule is not yet final and there is not an SRP or DSRS section covering this chapter, the staff is using the JLD-ISG-2012-01 guidance to review this chapter.

Background:

During the Chapter 20.1 audit, the staff reviewed the station blackout transient analysis, which includes analytic results in support of the Extended Loss of AC Power (ELAP) conclusions in FSAR Chapter 20, and observed large fluctuations of the following parameters:

- Steam generator water level from 18 - 24 hours during DHRS operation and from 24 - 47 hours during ECCS operation,
- Energy transfer rates from 18 - 24 hours,
- ECCS flow rates from 24 - 72 hours,
- Core exit and lower riser void fractions form 18 – 24 hours during DHRS operation, and 24-72 hours during ECCS operation, and
- Core temperatures from 18 - 24 hours.
- DHRS flow rate from 18 - 24 hours.

Request:

The staff requests the applicant to:

1. Identify and describe in sufficient detail the mechanism(s) responsible for the large fluctuations during DHRS operation from 18 - 24 hours, and
2. Identify and describe in sufficient detail the mechanism(s) responsible for the large fluctuations during ECCS operation, after 24 hours, for the parameters identified above, and
3. Provide an explanation of the effects on the core parameters due to these fluctuations.

NuScale Response:

After many hours of coolant shrinkage due to cooling by the decay heat removal system (DHRS), the reactor pressure vessel (RPV) coolant liquid level has the potential to decrease below the top of the riser structure. This condition interrupts the single-phase liquid natural circulation flow loop, causing the net liquid mass flux in the primary flow loop to drop to zero. The NRELAP5 model used in the station blackout analysis analyzes the primary reactor coolant system using a simplified one-dimensional hydraulic model without consideration for the buoyancy-driven axial mixing that would occur in a quiescent body of water. This simplified treatment results in the calculation of stagnant coolant throughout the riser, core, and downcomer. The heating of the stagnant water column by the core causes fluctuations in vapor generation as the core coolant repeatedly transitions between subcooled and saturated conditions. This effect drives the fluctuations in the primary and secondary side water levels and heat transfer rates from 18 to 24 hours in the NuScale Extended Loss of AC Power (ELAP) results. At 24 hours, the module protection system actuates the emergency core cooling system (ECCS), causing the transition from this DHRS cooling mode.

During equilibrium ECCS operation, the water levels in the riser, downcomer, and containment vessel (CNV) are all closely coupled. The riser and downcomer exhibit manometer-like behavior, with small oscillations in respective collapsed water levels. Because the average downcomer liquid level is in equilibrium with the CNV water level, the oscillations in the downcomer level cause corresponding oscillations in the reactor recirculation valve (RRV) liquid flow rate with flow reversal. However, from the long term equilibrium liquid levels in the riser, downcomer, and CNV, it is clear that the total mass in each system is constant. Therefore, by conservation of mass, the integral RRV flow from the CNV to the RPV is equal to the integral reactor vent valve flow from the RPV to the CNV despite the fluctuations in flow rates. The result is that the core remains well covered with many feet of liquid coolant and that core cooling is maintained. During ECCS operation, the steam generators become uncovered on the primary side and heat transfer from the steam volume is significantly less than through the ECCS heat transfer mechanisms. Fluctuations in the steam generator level have a minimal impact on the steam generator heat removal rate, and do not affect relevant core parameters.

Fluctuations in heat and mass transfer during DHRS and ECCS cooling affect some core thermal hydraulic parameters. In spite of these fluctuations, core temperatures show a general decreasing trend indicating sufficient decay heat removal.

Impact on DCA:

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

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

eRAI No.: 9486
Date of RAI Issue: 05/03/2018

NRC Question No.: 20.01-18

Regulatory Basis:

10 CFR 52.47(a)(2) requires that a standard design certification applicant provide a description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished. In SECY 12-0025, the staff provided the Commission with proposed orders requiring mitigation strategies for beyond-design-basis external events to be issued to all power reactor licensees and holders of construction permits. In the paper, the staff indicated that for New Reactors that are currently under active staff review, the staff plans to ensure that the Commission-approved Fukushima recommended actions are addressed prior to licensing. On March 12, 2012, the NRC issued Orders EA-12-049 requiring operating nuclear plants to develop and implement strategies that will allow them to cope without ac power for an indefinite amount of time. The strategies must ensure that the reactor core and spent fuel pool are adequately cooled, and containment function is maintained. Currently the NRC is using JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” which endorses NEI 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” as guidance for review of how a reactor design responds to an external beyond-design-basis event. The Commission is currently proposing to amend its regulations to establish regulatory requirements for nuclear power reactor applicants and licensees to mitigate beyond-design- basis events (FRN Vol. 80, No. 219 pages 70610-701647, dated November 13, 2015), and such rule would put the responsibility of addressing the plant response to a beyond-design-basis to the COL applicant. Because the rule is not yet final and there is not an SRP or DSRS section covering this chapter, the staff is using the JLD-ISG-2012-01 guidance to review this chapter.

Background:

During an audit, NRC staff identified that the station blackout analysis, which is referenced in the Extended Loss of AC Power calculation as forming the basis for multiple conclusions, uses assumed "nominal" design characteristics for the emergency core cooling system (ECCS) valves, and that verification of these assumed characteristics was not performed.

Additionally, based on statements made in the station blackout engineering calculation, the applicant does not intend to verify the assumed ECCS valve characteristics used in the station blackout analysis. This is causing NRC staff to question whether the modeling of the ECCS valves in the station blackout analysis is suitable.

Request:

NRC staff requests that the applicant provide evidence to demonstrate that the modeling of the ECCS valves in the station blackout analysis is consistent with design commitments made in the NuScale design certification application.

NuScale Response:

As noted in the NuScale Design Specific Review Standard (DSRS) Chapter 8.4 Section III Subsection 7 Paragraph B, the station blackout (SBO) analysis should assume initial conditions at normal operating ranges for reactor pressure, temperature, and water level, and should assume that plant equipment is either normally operating or available. This is supported by the NUMARC-87-00 industry guidelines report on SBO assessment, which is endorsed by RG 1.155. Therefore, nominal treatment of equipment is applied to the NuScale emergency core cooling system (ECCS) valve flow characteristics for the purposes of the SBO coping analysis used to demonstrate the adequacy of the design of the electrical systems.

The NuScale SBO transient consists of three distinct transient phases: the first is the loss of normal AC power followed by a cooldown with decay heat removal system, the second is the transition to ECCS cooling at 24 hours, and the third is the ECCS long term cooling. Each phase is either analyzed or well bounded by other analyses in FSAR Chapters 6 and 15 for relevant safety acceptance criteria. The first phase is analyzed for minimum critical heat flux ratio (MCHFR) and peak primary and secondary pressure with results presented in FSAR Section 15.2.6. The second phase of the SBO is well bounded by the analysis of MCHFR and peak containment vessel pressure generated by an inadvertent opening of an ECCS valve with results presented in FSAR Sections 15.6.6 and 6.2.1, respectively. The third phase of the SBO is well bounded by the ECCS performance analysis presented in FSAR Section 6.3.3. Each analysis supporting the safety conclusions presented in these FSAR sections was performed with appropriate modeling conservatisms, including treatment of the ECCS valve performance characteristics as committed to in FSAR Section 6.3.2. The nominal modeling of the ECCS valves in the SBO analysis is appropriate for the purposes of supporting FSAR Section 8.4, as this analysis is not principally intended to be a safety evaluation of the ECCS design.

Impact on DCA:

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

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

eRAI No.: 9486
Date of RAI Issue: 05/03/2018

NRC Question No.: 20.01-19

Regulatory Basis:

10 CFR 52.47(a)(2) requires that a standard design certification applicant provide a description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished. In SECY 12-0025, the staff provided the Commission with proposed orders requiring mitigation strategies for beyond-design-basis external events to be issued to all power reactor licensees and holders of construction permits. In the paper, the staff indicated that for New Reactors that are currently under active staff review, the staff plans to ensure that the Commission-approved Fukushima recommended actions are addressed prior to licensing. On March 12, 2012, the NRC issued Orders EA-12-049 requiring operating nuclear plants to develop and implement strategies that will allow them to cope without ac power for an indefinite amount of time. The strategies must ensure that the reactor core and spent fuel pool are adequately cooled, and containment function is maintained. Currently the NRC is using JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” which endorses NEI 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” as guidance for review of how a reactor design responds to an external beyond-design-basis event. The Commission is currently proposing to amend its regulations to establish regulatory requirements for nuclear power reactor applicants and licensees to mitigate beyond-design- basis events (FRN Vol. 80, No. 219 pages 70610-701647, dated November 13, 2015), and such rule would put the responsibility of addressing the plant response to a beyond-design-basis to the COL applicant. Because the rule is not yet final and there is not an SRP or DSRS section covering this chapter, the staff is using the JLD-ISG-2012-01 guidance to review this chapter.

Background:

In the station blackout transient analysis, Table A-5, Parameter Extreme Values and Timing Summary for Case: EDSS Available, the total final value of mass flow rate through the RRVs is approximately 5 times greater than the total mass flow rate through the RVVs. This indicates that the RPV level is increasing above the core, which is conservative for reactor core protection. However, if this mass flow rate imbalance continues beyond 72 hours, there is a potential for vortexing through the RRVs where eventually mostly steam is flowing through RRVs. In this case, the ECCS heat transfer function is impacted, which may have an adverse effect on core parameters, particularly the fuel temperature.

Request:

The staff requests the applicant to

1. provide an explanation for the difference between the mass flow rates at and beyond 72 hours,
2. demonstrate that vortexing does not occur beyond 72 hours and include the design elevation of the RRVs and the analytical CNV water level,
3. provide the elevation difference between the CNV water level and RRV intake centerline at 72 hours, and
4. discuss, if vortexing is occurring, the impact it has on ECCS heat transfer capability, effects on core parameters, boron dilution and precipitation.

NuScale Response:

Question 20.01-19 Part 1 Response:

As noted in the response to RAI 9486 Question 20.01-17 related to emergency core cooling system (ECCS) thermal-hydraulic conditions, the apparent fluctuations in ECCS valve flow rates in the station blackout (SBO) analysis are not representative of an integral change in coolant inventory between the reactor pressure vessel (RPV) and the containment vessel (CNV). This is apparent in the long term equilibrium liquid levels in the riser, downcomer, and CNV, which have reached an equilibrium condition well before 72 hours. By conservation of mass, the integral reactor recirculation valve (RRV) flow from the CNV to the RPV is equal to the integral reactor vent valve (RVV) flow from the RPV to the CNV despite the fluctuations in instantaneous flow rates. The result is that the core remains well covered by liquid coolant, supporting the conclusion that core cooling is maintained.

Question 20.01-19 Part 2 Response:

As described in the response to RAI 9518 Question 15.06.05-7 (NuScale letter RAIO-60666 dated June 28, 2018), the RRVs are not susceptible to vortex shedding lock-in and do not experience significant forces due to vortex shedding because they do not have susceptible geometries in the flow path.

The design elevation of the RRV penetration centerline is {{

}}$^{2(a),(c)}$ relative to the floor of the ultimate heat sink (UHS). The analytical CNV water level based on the case presented in Table A-5 of the station blackout (SBO) transient analysis is approximately {{ }}2(a),(c) relative to the floor of the UHS.

Question 20.01-19 Part 3 Response:

Based on the relative elevations provided in response to RAI 9486 Question 20.01-19 Part 2 above, the collapsed CNV water level is approximately {{ }}2(a),(c) above the RRV penetration centerline at 72 hours.

Question 20.01-19 Part 4 Response:

As discussed in the response to RAI 9518 Question 15.06.05-7 and the response to RAI 9486 Question 20.01-19 Part 2 above, the RRV geometry and thermal-hydraulic conditions are not susceptible to vortexing and therefore cannot impact ECCS heat transfer capability, important core parameters, or boron dilution and precipitation.

Impact on DCA:

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

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0618-60653

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 configuration by which NuScale develops its power module.

   NuScale has performed significant research and evaluation to develop a basis for this configuration 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. 463, eRAI 9486. 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 June 28, 2018.

Zackary W. Rad