RAIO-0918-61810

Docket No. 52-048

September 14, 2018

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. 484 (eRAI No. 8930) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 484 (eRAI No. 8930)," dated May 29, 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 Question from NRC eRAI No. 8930:

- 15-27

Enclosure 1 is the proprietary version of the NuScale Response to NRC RAI No. 484 (eRAI No. 8930). 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 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. 8930, proprietary

Enclosure 2: NuScale Response to NRC Request for Additional Information eRAI No. 8930, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0918-61811

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvalis, Oregon 97330, Office: 541.360.0500, Fax: 541.207.3928
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Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8930, proprietary

NuScale Power, LLC
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Enclosure 2:

NuScale Response to NRC Request for Additional Information eRAI No. 8930, nonproprietary

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

eRAI No.: 8930
Date of RAI Issue: 05/29/2018

NRC Question No.: 15-27

Requirements:

Title 10 of the Code of Federal Regulations, Section 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors,” requires, in part, that after any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

10 CFR, Part 50, Appendix A, General Design Criterion (GDC) 28—*Reactivity limits* requires that the reactivity control systems be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that the effects of postulated reactivity accidents can neither (1) result in damage to the reactor coolant pressure boundary greater than limited local yielding nor (2) sufficiently disturb the core, its support structures or other reactor pressure vessel internals to impair significantly the capability to cool the core. These postulated reactivity accidents shall include consideration of rod ejection (unless prevented by positive means), rod dropout, steam line rupture, changes in reactor coolant temperature and pressure, and cold water addition. In addition, Generic Safety Issue (GSI) 185 (Control of Re-criticality Following small break (SB) loss of coolant accidents (LOCAs) addresses scenarios of potential return to criticality following a SB LOCA resulting from insertion of unborated water into a pressurized water reactor (PWR) core.

To meet the requirements mentioned above regarding long-term cooling, the results of the accident analysis should show that for the worst case boron dilution event the capability to cool the core is maintained.

Background:

Page 2 of the applicant's report, "Long-Term Cooling Methodology," TR-0916-51299-P, Revision 0, states that the criterion for the core remaining subcritical (Criterion #5) is "not applicable to the Long-Term Cooling (LTC) condition since no mechanism to push a large volume of diluted water into the core inlet exists, and therefore no credible mechanism for recriticality due to boron dilution exists." However, there are postulated events that could allow the addition of cooler water with diluted boron concentrations from containment to the reactor vessel via the RRVs during the long term cooling phase following any Chapter 15 scenario. For instance, diluted or unborated water can accumulate inside containment due to steaming from the reactor vent valves (RVVs) (which may concentrate boron in the area above the core) when the reactor is being cooled by emergency core cooling system (ECCS) recirculation. The diluted or unborated water accumulating inside containment can also further mix with secondary side unborated water that was introduced into containment after a pipe carrying unborated water ruptered inside containment (see RAI 8744, Question 15.02.08-3). The diluted or unborated water can then make its way back into the reactor pressure vessel, and ultimately, into the core via the RRV ECCS recirculation path. The diluted or unborated water can affect core criticality, potentially leading to recriticality, and thus present a challenge to acceptance criteria.

This RAI is being issued, in part, as a follow-up RAI to RAI 8744, Question 15.02.08-3 after determining that RAI 8744, Question 15.02.08-3 did not provide adequate information to resolve the issue. All together, this RAI will require the applicant to detail and define the methodology used for boron transport inside the reactor pressure vessel and containment vessel after ECCS actuates as well as to present the results in the FSAR of a long-term cooling analysis that show how a bounding boron dilution event affects the criticality and coolability of the core.

The staff asked RAI 8744, Question 15.02.08-3, to require the applicant to determine if core criticality is affected by the introduction of pure, secondary side water into the core after ECCS recirculation begins following a FWLB inside containment. The applicant's response to RAI 8744, Question 15.02.08-3 argues that void fraction due to "high" decay heat limits (or precludes) the return to power evaluated in the LTC analysis. This may be true, but sufficient detail regarding void reactivity vs. dilution reactivity (core generated dilution due to boiling and unborated water pipe break generated dilution) and how these values were determined should be provided. Analysis assumptions (e.g. dilution water volume) and plots of reactivity and, if necessary, core power vs. time are necessary to address this RAI.

Request:

The staff requests the applicant to specify and describe in sufficient detail in the FSAR a methodology used to calculate boron transport during long-term cooling following ECCS actuation after any Chapter 15 event. As part of the description of the methodology, the applicant should appropriately justify the methods, assumptions, and techniques using acceptable validation bases. Furthermore, the staff requests the applicant to provide the results of a long-term cooling analysis that show how a bounding boron dilution event affects the core criticality and coolability. These results should include the quantitative distribution of boron throughout the RCS and containment vessels as a function of time following ECCS actuation. The analysis should consider the most limiting boron dilution volume (e.g. condensate in containment from steaming through the RVVs and from any additional un-borated water already inside containment from breaks in piping carrying un-borated water inside containment). Similarly, the response should include the analysis assumptions and plots of various reactivity effects that determine reactor power to confirm that the core is sub-critical.

NuScale Response:

2Overview

As requested by eRAI 8930, a systematic analysis approach has been developed for addressing possible boron transport phenomena in order to address and disposition the temporal aspects of boron distribution during ECCS cooling modes. As previously addressed in eRAI 8744 15.02.08-3 (Letter RAIO-0617-54560, dated June 21, 2017), this bounding transport analysis concludes that bulk boron dilution is not possible because if there is any boron initially in the RCS, it will tend to accumulate in the core region. During initial stages of ECCS operation, relatively pure water leaves the reactor pressure vessel (RPV) through the reactor vent valves (RVVs), leaving the boron in the core region. Due to the unique aspects of the NuScale module ECCS design, it is not susceptible to large pure water injections similar to a loop seal clearing in a traditional PWR. Regardless of the initial liquid level in the containment prior to ECCS actuation, recirculation of liquid through the reactor recirculation valves (RRVs) does not occur until pressure equalization between the containment vessel (CNV) and the RPV, at which point the recirculation rate is driven by the RCS boil off rate. Consequently, the boron mass transport balance will tend toward accumulation of boron in the core region. Therefore, the conservative time in cycle to evaluate a loss of shutdown margin due to moderator overcooling is end of cycle, as previously concluded in response to RAI 8744 and presented in FSAR section 15.0.6.

Methodology

The following analysis approach was used to develop a conservative evaluation model to address time dependent boron transport for ECCS mode core cooling in the NuScale module.

- The processes and phenomena identified in the long-term cooling (LTC) phenomena identification and ranking table (PIRT) involved in the boron transport and distribution in the reactor coolant system (RCS) and the CNV of the NuScale Power Module (NPM) with high importance and large uncertainty were evaluated.
- The conservation equations governing the boron transport in the RCS and CNV of the NPM are formulated based on a control volume analysis approach considering possible boron transport paths for design-basis loss-of-coolant accident (LOCA) and non-LOCA initiating events followed by the emergency core cooling system (ECCS) actuation.
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}}2(a),(c)

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}}2(a),(c)

Table 1. Justification of conservatism of {{

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

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

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

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}}2(a),(c)

Transient Results

As previously identified in the response to eRAI 8744 15.02.08-3, the limiting containment flooding event from the standpoint of pure water addition to the system was identified as the control rod drive cooling line break, which allows for low temperature pure water accumulation in the CNV. If DC power is assumed unavailable, the ECCS valves will open once the system has depressurized to the point of the inadvertent actuation block release pressure. This transient was simulated in NRELAP5 to provide time dependent mass distribution and transport as input to the three volume model with conservative assumptions as previously described.

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}}2(a),(c)

{{

}}2(a),(c)

Figure 1 {{ }}2(a),(c) RCS Results

The conservative {{

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

{{

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

Figure 2 Conservative {{ }}[2(a),(c)] Results

Simple Reactivity Balance Evaluation of Blowdown

While the boron concentration drop during the blowdown phase is not physically possible, the reactivity evaluation of this concentration drop is simple to disposition. {{

}}2(a),(c)

Conclusion

- Per the NRC request, a conservative transient boron distribution and transport methodology has been developed for the purposes of quantifying the ECCS mode boron distribution.
- This methodology confirms the previous response to eRAI 8744 15.02.08-3 as demonstrated in Figures 1 and 2.
- A reactivity balance is performed to show that even with a nonphysical conservative short-term drop in boron concentration, the overall void feedback and rod insertion worth provide sufficient negative reactivity to compensate for this boron concentration drop.
- Further evaluation of ECCS boron distribution from a dilution perspective is not necessary as this bounding methodology demonstrates that ECCS mode core cooling will concentrate boron in the core region for all cases with a non-zero boron concentration. An overcooling shutdown coping analyses was performed at EOC where this boron concentration effect does not occur, which demonstrated acceptable results.

Impact on DCA:

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

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0918-61811

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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 develops its long term cooling 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 No. 484, eRAI 8930. 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 September 14, 2018.

Zackary W. Rad