RAIO-0719-66504

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July 31, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 483 (eRAI No. 9516) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 483 (eRAI No. 9516)," dated May 25, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 483 (eRAI No.9516)," dated December 21, 2018
3. NuScale Technical Report Long-Term Cooling Methodology, dated January 2017, TR-0916-51299

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

The Enclosures to this letter contain NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9516:

- 15-26

Enclosure 1 is the proprietary version of the NuScale Supplemental Response to NRC RAI No. 483 (eRAI No. 9516). 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 Matthew Presson at 541-452-7531 or at mpresson@nuscalepower.com.

Sincerely,

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

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9516, proprietary

Enclosure 2: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9516, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0719-66505

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9516, proprietary

Enclosure 2:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9516, nonproprietary

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

eRAI No.: 9516
Date of RAI Issue: 05/25/2018

NRC Question No.: 15-26

10 CFR 50 Appendix A, GDC 34, Residual heat removal, and NuScale's PDC 34, in FSAR Section 3.1.4.5, state,

"A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded."

The long term cooling technical report (LTC-TR), TR-0916-51299, supports FSAR Section 15.0.5, Long Term Decay and Residual Heat Removal, when the ECCS is used for long term decay heat removal following either a non-LOCA or LOCA event up to 72 hours. The primary acceptance criteria for the analysis are 1) Collapsed liquid level is maintained above the active fuel and 2) fuel cladding temperature is maintained at an acceptable level such that the SAFDLs are preserved.

RG 1.203 describes the EMDAP, and provides guidance, which the NRC staff considers acceptable for use in developing and accessing EMs used to analyze transient and accident behavior. RG 1.203 provides guidance regarding the content of assessment reports:

"With respect to a calculational device input model and the related sensitivity studies, assessment reports must achieve the following additional purposes:

(10) Provide a nodalization diagram, along with a discussion of the nodalization rationale.

(11) Specify and discuss the boundary and initial conditions, as well as the operational conditions for the calculations.

(13) Discuss modifications to the input model (nodalization, boundary, initial or operational conditions) resulting from sensitivity studies."

In LTC-TR Section 4.3, the Applicant describes the studies performed to assess the difference in the NRELAP5 nodalization for the LTC-EM and the NRELAP5 nodalization for the LOCA-EM, and stated that both nodalization schemes preserve the code validation pedigree. However, the LTC-TR did not explain what was different. LTC-TR Section 4.3 stated:

{{

}}2(a),(c)

In addition, the changes described in Section 4.1 of the LTC TR were included in the LOCA EM nodalization calculation. The background, bases, and justification for these changed conditions is not discussed in the LTC-TR. In Figure 4-18 through Figure 4-23 of The TR, the applicant describes the differences in the results between the calculations. However, there is no explanation relating the differences in the nodalization to the differences in the results. The applicant concluded that the {{

}}2(a),(c) Without a firm understanding of the reasons for the differences in the calculations, it is not clear how it may be concluded that the differences in the pressures and temperatures would not affect the flows through the RVVs, RRVs, flow within the RPV, the natural circulation of coolant flow within the CNV and the heat transfer response during the long- term cooling calculation.

Discuss the analysis differences between the LTC-EM nodalization of the letdown line break and the LOCA-EM nodalization of the letdown line break, including the basis and justification for the changes to the LOCA-EM model for the conditions noted. Describe how the differences between the model nodalization resulted in the differences between the calculated results. Alternately, the applicant may provide a detailed technical basis justifying the LTC EM nodalization based on adequately capturing the uncertainity assoicated with the high ranked phenomena identified by the PIRT.

NuScale Response:

The original response for this RAI (submitted in NuScale correspondence RAIO-1218-63931, dated December 18, 2018) is revised with this supplemental response, which addresses subsequent questions from the NRC. The following changes are made to the long-term cooling methodology report (TR-0916-51299, Rev. 0) as shown at the end of this response:

1. In Section 3.2, the figure of merit of CHFR discussion is changed to clarify that cladding temperature exhibit a "long-term decreasing trend" instead of "remain acceptably low" as part of the surrogate for MCHFR.
2. In Section 3.2, the figure of merit of Subcriticality is clarified as being applicable to a subcritical core configuration.
3. In Section 5.3.4, the text regarding the time period beyond the 72 hours evaluation period is removed.
4. In Section 5.6, a summary of the results of a comparison of state-point versus 72-hour calculation runs with NRELAP5 is presented to demonstrate the appropriate use of the state-point calculations in the long-term cooling evaluations.

<u>State-point convergence</u>

During state-point convergence, heat transfer to the reactor pool (via DHRS and/or ECCS) is initially greater than decay heat since excess RCS stored energy is being removed. Due to lowering temperatures, thus lowering the thermal driving force, heat removal slows and eventually converges to equal decay heat. At this point, system temperatures and pressures are converged as well. Relative to the transient case, final state-point temperature and pressure is a function of decay heat at 72 hours only. A larger delta between the 12.5 hour transient temperature and 72 hour state point temperature would only increase the calculation execution time needed to remove excess thermal energy and reach converged results. For example, a state-point evaluation at 25% power decay heat after 72 hours will converge to the same system temperatures and pressures regardless if the analysis uses initial conditions from a transient case at 100% initial power or 25% initial power.

To confirm, the maximum temperature 100% injection line break transient is evaluated for 72 hours and compared to results using the state-point method. This initiating event is selected as it is the limiting break for LTC analysis. The maximum temperature scenario is selected as this case was previously demonstrated in the original transient calculation set to reliably execute for the full 72 hour LTC period. This event is sufficient to support the above discussion that the state-point results will converge to the same transient results at 72 hours, which occurs regardless of the biasing applied. Two scenarios are considered to address differing initial conditions at the beginning of the state-point convergence calculation. The first compares results from a 72 hour transient to the state-point results at 100% initial power. The second compares results at 25% initial power; however two state-point cases are performed, one beginning from the 25% power transient initial conditions and the second beginning from the 100% power transient initial conditions.

Results in Table 1 verify that the state-point analysis estimate of the quasi-steady cooldown is appropriate by showing the predicted conditions at 72 hours is within 1 psi for system pressures, 1 degree F for system temperatures, and within 0.1 feet for the collapsed liquid level above the core compared to the corresponding transient results. The 25% power scenario confirms that the state-point results converge to the transient 72 hour solution regardless of differing initial conditions.

Table 1. Maximum temperature 100% IL break transient and state-point results at 72 hours

Case	Core Inlet T (°F)	Lower RPV P (psia)	Collapsed Riser Level (ft)	CNV T. at RRV (°F)	Lower CNV P (psia)
100% power transient	270	50	9.0	264	51
100% power state-point	271	51	9.0	264	52
25% power transient	245	37	9.9	244	37
25% power state-point (initial conditions from 25% power transient)	245	37	9.9	245	37
25% power state-point (initial conditions from 100% power transient)	245	37	9.8	245	37

Impact on DCA:

Technical Report TR-0916-51299, Long-Term Cooling Methodology, has been revised as described in the response above and as shown in the markup provided in this response.

3.0 Phenomena Identification and Ranking Table

3.1 Phenomena Identification and Ranking Table Process

The purpose of the NuScale LTC PIRT is to provide an assessment of the relative importance of phenomena and processes that may occur in the NuScale module during LTC in relation to specified FOMs. This assessment is part of the process prescribed by Regulatory Guide 1.203 (Reference 8.2.6).

The current NuScale LTC PIRT has been developed by a panel of experts for the NPM and is built upon the state-of-knowledge at the time of its development. A comprehensive, integrated PIRT was performed for LTC based on the full event progression. The PIRT panel considered the NPM design to identify systems, components, and subcomponents of the design for which phenomena were assessed. The panel then followed the PIRT process. Phenomena were identified and ranked considering their level of importance relative to identified figures-of-merit (FOM) for LTC.

The panel established a knowledge ranking for each of the phenomena. The knowledge level is on a 1 to 4 scale; 4 represents well-known and easily modeled phenomena, while 1 represents a parameter that is not understood and can be difficult to sufficiently model.

3.2 Figures of Merit

During post-LOCA long-term cooling, there are three identified FOMs to which the identified phenomena are compared.

- CHFR: The ratio of the heat flux needed to cause CHF phenomena to the actual local heat flux of a fuel rod. Since the core remains covered with water throughout the event, clad does not significantly heat up. Therefore collapsed liquid level with a long-term decreasing trend in fuel cladding temperature is identified as the surrogate FOM for demonstrating acceptable cladding integrity.~~As discussed in Section 2.3, during long-term cooling, maintaining a collapsed liquid level in the riser above the core and demonstrating cladding temperatures remain acceptably low indicate that minimum CHFR is not challenged.~~

- Coolant collapsed level: The coolant level that results if all voids in the vapor-phase coolant are collapsed. If the core remains covered, significant clad heatup is avoided and it is evident that 10 CFR 50.46 criteria of adequate LTC is established.

- Subcriticality: The condition of a nuclear reactor system, in which nuclear fuel no longer sustains a fission chain reaction (that is, the reaction fails to initiate its own repetition, as it would in a reactor's normal operating condition). A reactor becomes subcritical when its fission events fail to release a sufficient number of neutrons to sustain an ongoing series of reactions, possibly as a result of increased neutron leakage or poisons. The scope of this report is limited to the evaluation of fission product decay heat loads (i.e. subcritical core configuration). Evaluation of extended cooldown loss of shutdown condition is not within the scope of this report.~~Note that for long-term cooling, the core heat source is decay heat.~~

5.3.3 Multi-module Consideration

In the NuScale plant design, up to twelve modules may be operating. The safety systems credited for mitigation of the design basis events are module-specific except for the shared reactor pool portion of the UHS. Long term cooling analysis evaluated a single module response to demonstrate that the acceptance criteria are met. The LTC analyses considered a range of reactor pool boundary conditions to sufficiently address the effects of one or more modules, up to all twelve modules, transferring decay heat into the reactor pool.

5.3.4 Long Term Cooling Evaluation Period

LTC analysis is limited to three days. This timeframe is considered acceptable because: (1) the most severe conditions will have been captured within the 72 hour window analyzed, and any conditions that could reasonably be expected to occur beyond this time period are thus bounded by the 72 hour calculation, and (2) after 72 hours, operator actions can be credited.

5.4 Initial Conditions and Biases

As stated in Section 5.1, three scenarios are defined to evaluate LTC acceptance criteria: minimum level, minimum temperature, and maximum temperature. Specific key conditions for these scenarios are defined in Table 5-1. Some cases feature minor variations from these conditions (defined on a case specific basis in the following sections) to evaluate parameter sensitivity.

Table 5-1 Default scenario initial conditions and biases

Scenario	Reactor Power (%)[(1)]	Decay Heat (multiplier)	RCS Avg. T. (°F)	RCS P. (psia)	PZR Level (%)	Pool T. (°F)	Pool Level (ft)	Non-condensable Gas (lbm)	ECCS Capacity (Area and Cv)	Expansion Factor (Y)	Single Failures	DHRS Enabled for LOCA[(2)]
Minimum Level	102	1.2 (LOCA) 1.0 (nonLOCA)	555	1780	52	65	69	0	minimum	0.7	RVV/ RRV	false
Minimum Temperature	102	0.8	535	1780	68	65	69	0	maximum	1.0	none	true
Maximum Temperature	102	1.2 (LOCA) 1.0 (nonLOCA)	555	1920	52	210	55	~131	minimum	0.7	RVV/ RRV	false

(1) Lower power, down to 13% initial power, is considered as a separate sensitivity for the minimum temperature cases.
(2) DHRS is always enabled for all non-LOCA events.

~~5.2~~5.5 Sensitivity Considerations

The parameters considered as part of the sensitivity analysis are based on the findings in the PIRT from Section 3.0 and are conservatively applied in Section 5.6 depending on the requirements of the specific scenario. These parameters are as follows:

over the long term. System pressures and temperatures also follow a continually decreasing trend with decay heat over time. Since transient minimum collapsed level has been captured and there are no mechanisms to change the cooldown trajectory, explicit transient calculations past 12.5 hours are not required.

Instead, a following state-point analysis is performed to save calculation time. This is done by taking module conditions at the end of 12.5 hours, setting core power to a constant value corresponding to decay heat levels at 72 hours, and then allowing system conditions to converge to equilibrium. The state-point analysis results provide final module conditions without needing to explicitly model the quasi-equilibrium, long term response as decay heat slowly decreases to the 72 hour value. The primary purpose of these calculations is to find the limiting minimum core inlet temperature which occurs at 72 hours for boron precipitation analysis. Long term maximum cladding temperature and collapsed level are also evaluated to confirm that acceptance criteria remain satisfied.

Table 5-2, below verifies that the state-point analysis estimating the quasi-steady cooldown is appropriate by showing that the predicted conditions at 72 hours for the state-point approximation is within 1 psi for system pressures, 1 degree F for system temperatures, and within 0.1 feet for the collapsed liquid level above the core for the 25% and 100% injection line break cases. The 25% power scenario results confirm that the state-point results converge to the transient 72 hour solution regardless of differing initial conditions. Final module conditions at 72 hours are discussed in Section 5.6.5. These calculations demonstrate the trend in both the RCS temperatures (including fuel cladding temperatures) and collapsed liquid level in the riser.

Table 5-2 Maximum temperature 100% injection line break transient and state-point results at 72 hours

Case	**Core Inlet T (°F)**	**Lower RPV P (psia)**	**Collapsed Riser Level (ft)**	**CNV T at RRV (°F)**	**Lower CNV P (psia)**
100% power transient	270	50	9.0	264	51
100% power state point	271	51	9.0	264	52
25% power transient	245	37	9.9	244	37
25% power state point (initial conditions from 25% power transient)	245	37	9.9	245	37
25% power state point (initial conditions from 100% power transient)	245	37	9.8	245	37

~~Combined effect cases were evaluated to determine the limiting conditions that could develop during the LTC phase. These cases are as follows:~~

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0719-66505

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. 483, eRAI No. 9516. 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 July 31, 2019.

Zackary W. Rad