January 11, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 457 (eRAI No. 9501) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 457 (eRAI No. 9501)," dated May 02, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 457 (eRAI No.9501)," dated June 12, 2018

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 Enclosure to this letter contains NuScale's supplemental response to the following RAI Question from NRC eRAI No. 9501:

- 15-12

This letter and the enclosed response 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

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9501

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9501

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

eRAI No.: 9501

Date of RAI Issue: 05/02/2018

NRC Question No.: 15-12

10 CFR 52.47(a)(11) requires an applicant for design certification to provide proposed technical specifications prepared in accordance with the requirements of 10 CFR 50.36. 10 CFR 50.36(c)(2)(ii)(B) requires that a technical specification limiting condition for operation (LCO) be established for a "process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier." The initial condition ranges assumed in the evaluation of design basis events is provided in Table 15.0-6 of the Final Safety Analysis Report (FSAR). This table includes the range of reactor coolant system (RCS) average temperatures and pressures assumed to bound the RCS average temperature and pressure ranges during planned normal operation, including startup. These are listed in Table 15.0-6 as the Tavg and pressurizer pressure parameter ranges, which form the analytical bounds for planned power operation.

NuScale generic technical specifications (GTS) do not include an LCO for the Tavg parameter directly. However, the staff noted that LCO 3.4.1 includes a LCO for RCS pressure, flow, and cold leg temperature (Tcold), with TS bases that state, "The limits placed on RCS pressure and temperature ensure that the minimum critical heat flux ratio (MCHFR) will be met for each of the transients analyzed." In their response to RAI 8772, Question 4.03-1, NuScale clarified that the RCS cold temperature is based on preserving thermal margin to critical heat flux.

The staff interprets FSAR Table 15.0-6 as providing the analysis initial condition ranges that are used in the Chapter 15 transient and accident analysis (LOCA and non-LOCA), to determine the appropriate acceptance criteria are met. Further, the NuScale Containment Response Analysis Methodology Technical Report, TR-0516-49084, incorporated by reference into the FSAR, provides the methodology for selection of the initial conditions of the analyses, but not in all cases the numerical values, such as Tavg.

1. The staff is seeking clarification of whether NuScale intends that LCO 3.4.1 protects the initial average RCS temperature and pressure ranges assumed in Table 15.0-6 for all of the design basis events listed above (LOCA and non-LOCA), as well as the initial conditions for the peak containment pressure analysis. If LCO 3.4.1 is only intended to ensure CHFR is met for "each of the transients analyzed," please specify the TS LCO that is intended to ensure CHFR is met for the LOCA analysis and peak containment pressure is met for FSAR Section 6.2.1 analyses. If LCO 3.4.1 is intended for the LOCA and peak containment pressure analyses, please update the Technical Specification Bases for LCO 3.4.1, and also include the methodology for the containment pressure analyses in Technical Specification Section 5.6.3.

2. In addition, the staff is seeking clarification regarding FSAR Figure 4.4-9," Analytical Operating Limits". FSAR Section 4.4.3.2, "Operating Restrictions", states that, "Figure 4.4-9 provides the operating map indicating the permissible operating range that is constrained by each of the following considerations." The staff interprets Figure 4.4-9 as defining the transient operating space (i.e., upset conditions a reactor enters during an AOO) as determined by the trip setpoints and not the initial permissible operating range for planned normal operation, which would be governed by Technical Specification LCOs. The staff is requesting that NuScale provide additional information regarding Figure 4.4-9 and revise the FSAR, if necessary, to clarify its intent.

NuScale Response:

This supplemental response is made to address comments received during the public meeting held on December 12, 2018 with the NRC staff.

FSAR Tier 2, Section 4.4.3.2 and Figure 4.4-9 have been modified to better reflect the operating and analytical design restrictions. Additionally, the Applicable Safety Analyses section of the bases of technical specification LCO 3.4.1 have been modified to better reflect the safety analyses related to the limits in this LCO.

Impact on DCA:

The FSAR and Technical Specifications have been been revised as described in the response above and as shown in the markup provided in this response.

The following flow paths allow flow to bypass the core and reduce flow through the fuel assemblies:

- reflector block cooling channels
- fuel assembly guide tubes and instrument tubes

Best-estimate flow, maximum flow, and minimum flow are calculated for the applicable design considerations. These calculations account for the uncertainties in the component flow resistances and the thermal head.

4.4.3.1.1.1 Reflector Cooling Channel Bypass

The reflector blocks surrounding the core have several cooling channels that allow flow to pass through the reflector blocks. A conservative value for the reflector cooling channel bypass fraction for steady-state and transients is provided in Reference 4.4-3.

4.4.3.1.1.2 Guide Tube and Instrument Tube Bypass

The maximum amount of bypass flow for the guide tubes and instrument tubes for the fuel assemblies is provided in Reference 4.4-3.

The total bypass flow used in the subchannel analysis is 8.5 percent. Below 20 percent power, the bypass flow is 9 percent.

RAI 15-12

4.4.3.2 Analytical Design Operating Restrictions

RAI 15-12S1, RAI 16-44S1

~~Figure 4.4-9 provides the operating map indicating the permissible operating range that is constrained by each of the following considerations:~~Figure 4.4-9 provides the operating map showing analytical and normal operating conditions. The green dotted line with T_{cold}, T_{avg}, and T_{hot} identified represent nominal full power operating conditions. T_{avg} remains fixed above 15 percent rated thermal power (RTP); T_{cold} and T_{hot} vary along the green dotted line as power is increased or decreased. The solid blue and black dotted lines illustrate the normal T_{avg} and RCS pressure operating ranges, excluding the T_{avg} during startup with the reactor at less than 15 percent RTP.

RAI 15-12S1, RAI 16-44S1

The analytical limits on the operating range that are illustrated as the outer box (red on three sides, blue at minimum critical temperature) constrained by the following considerations:

RAI 15-12S1, RAI 16-44S1

- ~~Right-hand limit: core power and inlet temperature for given pressures that result in MCHFR at the CHF analysis limit~~Upper RCS pressure bound: analytical limit protects against exceeding RPV pressure limits for reactivity and heatup events

- Upperbound: analytical limit protects against exceeding RPV pressure limits for reactivity and heatup eventsLower RCS pressure bound: analytical limit ensures riser subcooling is maintained.

RAI 15-12S1, RAI 16-44S1

- Left-hand boundary: analytical limit on minimum temperature for criticalityLeft-hand temperature boundary: analytical limit on minimum temperature for criticality
- Right-hand average temperature limit: analytical riser temperature limit protects against exceeding MCHFR limits for reactivity and heatup events.

RAI 15-12S1, RAI 16-44S1

The low-RCS pressure analytical limit ensures riser subcooling is maintained. If hot leg temperature is below 600 degrees F, the low pressure analytical limit is constant at 1600 psia. If hot leg temperature is above 600 degrees F, then the low pressure analytical limit increases as:If hot leg temperature is below 600 degrees F, the low pressure analytical limit is constant at 1600 psia. If hot leg temperature is above 600 degrees F, then the low pressure analytical limit increases to 1720 psia. The saturation curve and a parallel, 5 degrees F margin are illustrated on the right side of the figure showing the margin to saturation in the riser based on the analytical limits shown.

$$P_{limit} = (T_{hot} - 600)*12 + 1600 \quad \text{Eq. 4.4-2}$$

RAI 15-12S1, RAI 16-44S1

where,

T = temperature in degrees F, and

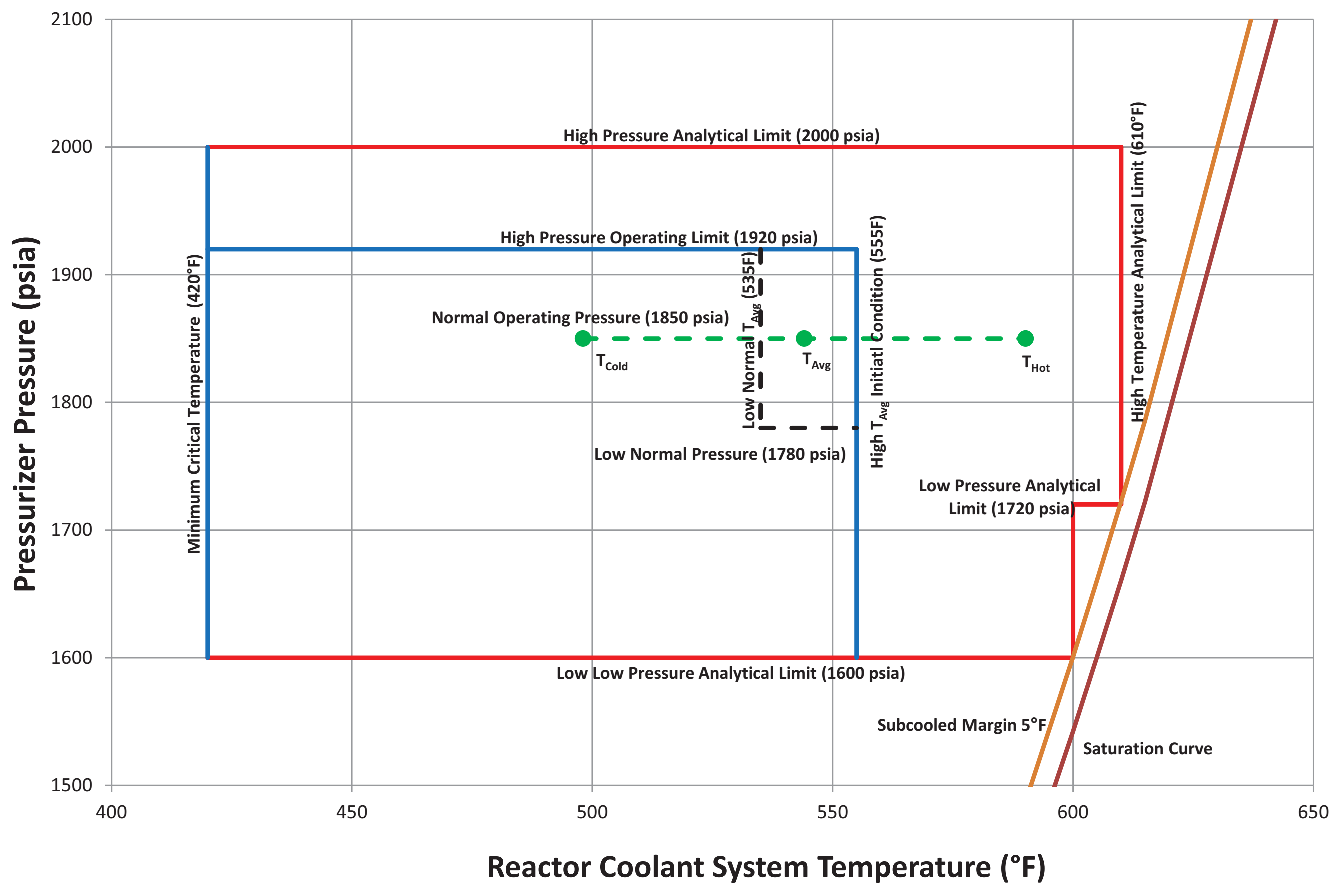
P = pressure in psia.

4.4.3.3 Thermal Margin Limit Map

A series of CHF calculations are performed for a range of power levels between hot zero power (HZP) and HFP to establish trends and operating conditions of the limiting MCHFR, and to determine the limiting axial flux shapes for subchannel calculations. The limiting axial flux shape is determined based on a nuclear analysis (Section 4.3) of all of the possible axial flux shapes that could occur during the equilibrium cycle from operation within the operating limits. The operating limits in this context are the axial offset window, the power dependent insertion limits, and the cycle burnup. The analysis of axial flux shapes is described in Section 4.3. From these axial shapes, limiting top-peaked, middle-peaked, and bottom-peaked shapes are identified at 5 percent, 25 percent, 50 percent, 75 percent, and 102 percent. At each power level, a subchannel analysis is performed using VIPRE-01 to determine the MCHFR for a top-peaked, a middle-peaked, and a bottom-peaked shape. Figure 4.4-10 shows the MCHFR versus power from this analysis. The MCHFR calculations are performed including the deterministically combined uncertainties discussed in Section 4.4.2.9 and summarized in Table 4.4-4. The results of this analysis identify a unique limiting shape for each

RAI 15-12, RAI 15-12S1, RAI 16-44S1

Figure 4.4-9: Analytical Design Operating Limits



BASES

APPLICABLE SAFETY ANALYSES (continued)

The NSP2 and NSP4 correlation limits are used for comparison to conditions representative of normal operation, operational transients, anticipated operational occurrences, and accidents other than events that are initiated by rapid reductions in primary system inventory. The Hench-Levy correlation is used to evaluate events for which analyses postulate a rapid reduction in primary system inventory. An assumption for the analysis of these events is that the core power distribution is within the limits of LCO 3.1.6, “Regulating Group Insertion Limits”; LCO 3.2.1, "Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$)," and LCO 3.2.2, “AXIAL OFFSET (AO).”

The flow resistance in the RCS directly affects the reactor coolant natural circulation flow rate established by THERMAL POWER, RCS pressure, and RCS temperature. The safety analyses assume flow rates that are based on a conservative value of flow resistance through the RCS. Therefore the resistance must be verified to ensure that the assumptions in the safety analyses remain valid.

The pressurizer pressure operating limit and the RCS average~~cold~~ temperature limit specified in the COLR, as shown on the Analytical Design Operating Limits~~Thermal Margins Limit Map~~, correspond to operating~~analytical~~ limits, with an allowance for steady state fluctuations and measurement errors. These are the analytical initial conditions assumed in transient and LOCA analyses.

The RCS CHF parameters satisfy Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

This LCO specifies limits on the monitored process variables, pressurizer pressure and RCS cold temperature to ensure the core operates within the limits assumed in the safety analyses. It also specifies the limit on RCS flow resistance to ensure that the RCS flow is consistent with the flow assumed in the safety analyses. These variables are contained in the COLR to provide operating and analysis flexibility from cycle to cycle. Operating within these limits will result in meeting CHFR criterion in the event of a CHF-limited transient.