RAIO-0618-60696

June 29, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 443 (eRAI No. 9450) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 443 (eRAI No. 9450)," dated April 30, 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 Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 9450:

- 15.02.07-1

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,

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9450

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9450

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

eRAI No.: 9450
Date of RAI Issue: 04/30/2018

NRC Question No.: 15.02.07-1

10 CFR 50, Appendix A, General Design Criterion (GDC) 15, "Reactor coolant system design," requires the reactor coolant system and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

To meet the requirements of GDC 15, the applicant should use suitably conservative parameters in the analytical model, as specified by NuScale's Design-Specific Review Standard (DSRS) Section 15.2.7, DSRS Acceptance Criterion 3.

In Final Safety Analysis Report (FSAR) Tier 2, Table 15.2-22, "Input Parameters Loss of Feedwater - Limiting Cases," the applicant reports the initial values used for input into the limiting loss of feedwater (LOFW) events. However, the applicant does not justify the use of the biased parameters and the staff cannot understand why some parameters have been biased the way they have. For example, for the limiting reactor coolant system (RCS) pressure event, the applicant reports that the initial RCS temperature and RCS pressure are biased low; however, the staff understands that biased high RCS temperature and pressure typically maximize peak RCS pressure. Similarly, the pressurizer level is reported to be biased high for the limiting minimum critical heat flux ratio (MCHFR) event; however, the staff understands that a low initial pressurizer level typically leads to a more limiting MCHFR. Another example is the steam generator (SG) tube heat transfer. The applicant currently adds 30% uncetainty to this in the limiting RCS pressure case; however, the staff understands that to conservatively maximize RCS pressure, the applicant should assume the minimal amount of heat being transferred through the SG, i.e. conservative low bias. The staff also found during its audit that tube plugging and fouling were assumed to be minimal, and for the reason mentioned above, the staff does not understand how this conservatively maximizes RCS pressure.

The staff request the applicant to provide justification in the FSAR for the input parameters used in each LOFW event.

NuScale Response:

Additional sensitivity cases for the Loss of Normal Feedwater Flow (LOFW) event were generated to provide further justification for the limiting initial conditions presented in the Final Safety Analysis Report (FSAR) Section 15.2.7. It is noted that the current discussion on initial conditions presented in FSAR Section 15.2.7.3.2 is consistent in detail compared to other Section 15.2 events; therefore no changes are made to the FSAR regarding justification of initial conditions. However, sensitivity results and additional justification for the selected limiting initial conditions are provided in this response for each LOFW event. Additionally, it is noted that FSAR Table 15.2-22 incorrectly reports initial reactor coolant system (RCS) average temperature for the limiting RCS pressure case as a low bias when a high bias was actually applied in the limiting event; this discrepancy is corrected in the attached FSAR markup. Finally, it is noted that presented pressure results are captured through NRELAP5 control variables to eliminate any variance caused by plot frequency.

The limiting RCS pressure case presented in FSAR Section 15.2.7 has been re-evaluated using eleven different sets of varying initial conditions to examine the impact of initial average RCS temperature, RCS pressure, pressurizer (PZR) level, and steam generator (SG) heat transfer biasing on peak RCS pressure. These results are presented in Table 1.

Table 1. RCS Pressure Sensitivity Cases

Description	RCS T_{avg} Bias (°F)	RCS Pressure Bias (psi)	PZR Level Bias (%)	SG Heat Transfer Bias (%)	Peak RCS Pressure (s)	Time of Peak RCS Pressure (s)	Time of RTS Actuation (s)
FSAR 15.2.7 RCS Pressure Case	10	-70	8	30	2162	21	18
Case 1	-10	-70	8	30	2161	23	19
Case 2	10	70	8	30	2159	16	12
Case 3	10	-70	-8	30	2155	27	21
Case 4	10	-70	8	-30	2163	24	21
Case 5	-10	70	8	30	2158	17	12
Case 6	-10	-70	-8	30	2154	33	23
Case 7	10	70	-8	30	2154	22	13
Case 8	10	70	8	-30	2158	19	14
Case 9	10	-70	-8	-30	2155	30	24
Case 10	10	70	-8	-30	2154	25	16
Case 11	-10	70	-8	30	2149	27	14

These results are discussed below:

RCS Average Temperature - Results presented in Table 1 confirm that a high bias maximizes peak RCS pressure for all cases which compare high and low RCS temperature bias. However, it is noted that the influence is small, with differences ranging in magnitude from 1 to 5 psi. A high bias for initial RCS average temperature is applied to the limiting case presented in FSAR Section 15.2.7.

RCS Pressure - Results presented in Table 1 confirm that a low bias for initial RCS pressure maximizes peak RCS pressure for all cases which compare high and low RCS pressure bias. This is due to the event sequence for a loss of normal feedwater flow where all sensitivity cases trip on the high RCS pressure signal. With an initially low RCS pressure, the transient time until reactor scram is extended, which increases the thermal momentum of the transient toward a higher peak RCS pressure as the core remains at power for a longer duration after feedwater is isolated.

Pressurizer Level - Results presented in Table 1 confirm that a high bias maximizes peak RCS pressure for all cases which compare high and low PZR level bias. A high bias for PZR level minimizes the vapor space within the PZR, increasing the pressure response as RCS temperature and volume increase following the loss of feedwater. It is noted that the limiting minimum critical heat flux ratio (MCHFR) typically occurs at high pressure. A high PZR level bias is selected for the MCHFR case in order to maximize RCS pressure for subchannel evaluation.

Steam Generator Heat Transfer - Unlike the previous sensitivities, results for SG heat transfer do not consistently indicate a limiting bias direction (see FSAR case compared to Case 4, Case 2 compared to Case 8, Case 3 compared to Case 9, and Case 7 compared to Case 10). However, the influence is minor with differences ranging in magnitude from 0 to 1 psi. It is generally expected that the influence of SG heat transfer bias is small compared to the rapid decrease in secondary system cooling caused by a complete loss of feedwater. It is concluded that SG heat transfer biasing has minor influence on peak RCS pressure for the loss of normal feedwater flow event, and the current FSAR 15.2.7 results are maintained. In order to bound uncertainty due to SG heat transfer biasing, the limiting RCS pressure reported in FSAR 15.2.7 is rounded up to 2165 psia in the attached FSAR markup.

To address peak RCS pressure sensitivity to SG tube plugging, Case 4 is repeated assuming 10 percent of the SG tubes are plugged. Results are presented in Table 2.

Table 2. SG Tube Plugging Sensitivity Cases

Description	Peak RCS Pressure (s)	Time of Peak RCS Pressure (s)	Time of RTS Actuation (s)
Case 4	2163	24	21
Case 4 with 10% Plugging	2163	25	21

With 10 percent of the SG tubes plugged, no change in peak RCS pressure is observed. It is concluded that SG tube plugging has insignificant influence on peak RCS pressure relative to the rapid decrease in secondary system heat removal caused by a loss of feedwater flow, and the current FSAR 15.2.7 results are maintained.

The limiting SG pressure case presented in FSAR Section 15.2.7 is also re-evaluated using the same sets of initial conditions to examine the impact on peak SG pressure. As stated in FSAR Section 15.2.7.2, the limiting SG pressure event occurs for a partial loss of feedwater flow. Sensitivity results presented in Table 3 identify peak SG pressure for each set of conditions at an interval of 1 percent decrease in feedwater flow. Given the partial loss of feedwater flow, certain cases are observed to extend beyond 30 minutes before the module protection system (MPS) is activated. These cases are excluded from the presented results which is consistent with Section 7.1.7 of the "Non-Loss-of-Coolant Accident Analysis Methodology", TR-0516-49416 Revision 1.

Table 3. SG Pressure Sensitivity Cases

Description	RCS T_{avg} Bias (°F)	RCS Pressure Bias (psi)	PZR Level Bias (%)	SG Heat Transfer Bias (%)	Limiting Decrease in Feedwater Flow (%)	Peak SG Pressure (psia)
FSAR 15.2.7 SG Pressure Case	10	-70	8	30	2	1426
Case 1	-10	-70	8	30	6	1317
Case 2	10	70	8	30	2	1433
Case 3	10	-70	-8	30	2	1424
Case 4	10	-70	8	-30	4	1391
Case 5	-10	70	8	30	3	1279
Case 6	-10	-70	-8	30	8	1345
Case 7	10	70	-8	30	2	1432
Case 8	10	70	8	-30	3	1361
Case 9	10	-70	-8	-30	3	1390
Case 10	10	70	-8	-30	3	1389
Case 11	-10	70	-8	30	4	1293

These results are discussed below:

RCS Average Temperature and Steam Generator Heat Transfer - Results presented in Table 3 show that peak SG pressure is strongly influenced by a high bias in RCS average temperature and in SG heat transfer. Limiting SG pressure occurs post-decay heat removal system (DHRS) actuation as loop temperature and pressure increase towards thermal equilibrium with the RCS. Temperature and pressure inside the DHRS loop are maximized by high heat transfer from the RCS, which is increased by a high bias for RCS average temperature and SG heat transfer.

RCS Pressure and PZR Level - Results presented in Table 3 indicate that RCS pressure and PZR level do not consistently influence peak SG pressure. Generally, SG pressure is maximized by an extended transient duration to allow RCS temperature to increase. For cases which result in non-limiting SG pressure, the influence of low RCS pressure and PZR level biasing is primarily due to avoiding the high RCS pressure trip and thus extending the transient duration. However, for cases which result in more limiting SG pressure (FSAR 15.2.7 case, Case 2, Case 3, and Case 7 due to high RCS average temperature and SG heat transfer bias), it is observed that a high bias for RCS pressure and PZR level maximize peak SG pressure, with all four cases tripping on high RCS hot temperature. It is also noted that a high bias for RCS pressure tended to decreased initial RCS flow, which is also limiting for peak SG pressure. It is concluded that a high bias for RCS pressure and PZR level are limiting for SG pressure when other conditions are biased such that early transient termination on the high RCS pressure signal does not occur.

To confirm that the limiting SG pressure event is identified, Case 2 and Case 7 are evaluated with a feedwater flow decrease interval of 0.1 percent. Limiting results are presented in Table 4.

Table 4. Additional SG Pressure Sensitivity Cases

Description	RCS T_{avg} Bias (°F)	RCS Pressure Bias (psi)	PZR Level Bias (%)	SG Heat Transfer Bias (%)	Limiting Decrease in Feedwater Flow (%)	Peak SG Pressure (psia)
Case 2	10	70	8	30	1.7	1434
Case 7	10	70	-8	30	1.6	1432

Results from Table 4 indicate that Case 2 yields a more limiting SG pressure than presented in FSAR Section 15.2.7, where the limiting biasing direction changes from low RCS pressure to high RCS pressure. These results are incorporated into FSAR Section 15.2.7 according to the attached markup with a new reported peak SG pressure of 1434 psia.

Impact on DCA:

FSAR Tables 15.2-21, 15.2-22, 15.2-23 and Figure 15.2-33 have been revised as described in the response above and as shown in the markup provided in this response.

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Table 15.2-21: Loss of Feedwater Event - Maximum SG Pressure - Sequence of Events

Event	Time [s]
Loss of feedwater initiation Feedwater flow begins 0.1 second ramp down to ~~97.7~~98.3% of initial value	0
RCS hot leg high temperature MPS signal	~~690~~1431
Turbine Trip	~~697~~1439
Loss of Normal AC	~~697~~1439
MSIVs close signal	~~697~~1439
RTS actuation	~~698~~1439
DHRS actuation	~~698~~1439
Control rods fully inserted	~~700~~1441
Peak RCS pressure	~~708~~1450
DHRS valve fully open	~~728~~1469
Peak secondary pressure	~~769~~1509

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Table 15.2-22: Input Parameters Loss of Feedwater - Limiting Cases

Parameter	RCS Overpressure and MCHFR	SG Overpressure
Initial RCS pressure	1780 psia	~~1780~~1920 psia
Initial RCS temperature	~~535~~555°F	555°F
Initial PZR level	68%	68%
Initial Feedwater temperature	313°F	313°F
Initial SG Pressure	535 psia	535 psia
Drift on RSV setpoint	2137 psia (+3%)	2137 psia (+3%)
Moderator and Doppler coefficients of reactivity	0.0/-1.40pcm/°F	0.0/-1.40pcm/°F
RCS Flowrate	1179 lbm/s	~~1179~~1171 lbm/s
Core Average Fuel Temperature	960°F	~~960~~964°F
Pool Temperature	200°F	200°F
SG Tube Heat Transfer	+30%	+30%
Loss of FW Flow at initialization	100%	~~2.3~~1.7%

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Table 15.2-23: Loss of Feedwater - Limiting Analysis Results

Acceptance Criteria	Limit	Analysis Value
Maximum RCS Pressure	2310 psia	~~2159~~2165 psia
Maximum SG Pressure	2310 psia	~~1422~~1434 psia
MCHFR	1.284	2.569

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Figure 15.2-33: Steam Generator Inlet Pressure (Typical) - Peak SG Pressure Case (15.2.7 Loss of Feedwater)