RAIO-0719-66521

July 31, 2019

Docket: PROJ0769

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Supplemental Response to NRC Request for Additional Information No. 9466 (eRAI No. 9466) on the NuScale Topical Report, "Non-Loss of Coolant Accident Analysis Methodology," TR-0516-49416, Revision 1

REFERENCES:

1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 9466 (eRAI No. 9466)," dated May 07, 2018
2. NuScale Power, LLC Response to NRC "Request for Additional Information No. 9466 (eRAI No.9466)," dated September 27, 2018
3. NuScale Topical Report, "Non-Loss of Coolant Accident Analysis Methodology," TR-0516-49416, Revision 1, dated August 2017

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. 9466:

- 15.00.02-6

The topical report TR-0516-49416, “Non-Loss-of-Coolant Accident Analysis Methodology” contained export controlled information. The markup pages in the enclosed RAI response for TR-0516-49416 are therefore labeled “Export Controlled,” although these markup pages do not contain any export controlled information.

Enclosure 1 is the proprietary version of the NuScale Supplemental Response to NRC RAI No. 9466 (eRAI No. 9466). 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,

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Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9466, proprietary

Enclosure 2: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9466, nonproprietary

Enclosure 3: Affidavit of Zackary W. Rad, AF-0719-66522

Enclosure 1:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9466, proprietary

Enclosure 2:

NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 9466, nonproprietary

Response to Request for Additional Information
Docket: PROJ0769

eRAI No.: 9466
Date of RAI Issue: 04/02/2018

NRC Question No.: 15.00.02-6

General Design Criterion (GDC) 10, "Reactor design," requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits (SAFDLs) are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences (AOOs). In addition, GDC 15, "Reactor coolant system design," requires that the reactor coolant system (RCS) 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 (RCPB) are not exceeded during any condition of normal operation, including AOOs.

Topical report (TR) TR-0516-49416-P, "Non-Loss-of-Coolant Accident [Non-LOCA] Analysis Methodology," supports the conclusions relative to GDC 10 and 15 in the NuScale Final Safety Analysis Report (FSAR), which under 10 CFR 52.47 must describe the facility, present the design bases and the limits on its operation, and present a safety analysis of the structures, systems, and components and of the facility as a whole.

Chapter 15 of NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants," describes a subset of the transients and accidents that should be considered in the safety analyses. SRP Section 15.0.2, "Review of Transient and Accident Analysis Methods," directs the staff in reviewing methodologies used to conduct the safety analyses required by 10 CFR 52.47 and states:

When the code is used in a licensing calculation, the combined code and application uncertainty must be less than the design margin for the safety parameter of interest. The analysis must include a sample uncertainty evaluation for a typical plant application. In some cases, bounding values are used for input parameters as described in SRP sections or Regulatory Guides and

are used for plant operating conditions such as accident initial conditions, set points, and boundary conditions.

While the representative calculations for the non-LOCA evaluation model (EM) in TR-0516-49416-P, Section 8, include initial condition and parameter biasing, there is no assessment of uncertainty to ensure that the combined uncertainty in the code, plant inputs, and plant model is less than the design margin, such as that required by GDC 10 and 15. The representative analyses appear to meet non-LOCA figure of merit (FOM) acceptance criteria, but it is not clear how the code uncertainty associated with these best estimate NRELAP5 code results factor into the assessment.

In addition, as a result of the concerns in the third question of RAI 9351, the staff is seeking specific information regarding uncertainty related to the SIET assessments.

Information Requested:

1. Based upon the code assessment against the separate effects tests (SETs) and integral effects tests (IETs) (and any revised analyses related to the presented SETs and IETs), state the determined code uncertainties and biases.

2. Justify that the combined effect of conservative input parameters, parameters that are conservatively biased, the plant model, and the code uncertainty is less than the design margin for the FOMs.

3. Address parts (a) and (b) above specifically for the assessments against the SIET tests, i.e.:

- Based upon the code assessment against the SIET tests and the response to the third question in RAI 9351, provide the NRELAP5 code steam generator model uncertainties and biases.
- Justify that the combined effect of conservative input parameters and conservatively biased parameters bounds the steam generator model uncertainty.

NuScale Response:

The original NuScale response was submitted in NuScale correspondence RAIO-0918-61995 and dated September 27, 2018. Use of a steam generator (SG) heat transfer coefficient uncertainty in the Non-LOCA topical report (TR-0516-49416) was discussed with the staff in phone calls on January 9, 2019 and March 5, 2019. In the March 5 phone call, NuScale committed to supplement the most pertinent RAI response with the following information, to

include justification for the use of a nominal value of steam generator (SG) heat transfer and a list of which other RAI responses are affected with this supplement.

Margins to acceptance criteria for the Chapter 15 event results are not sensitive to the use of nominal compared to biased SG heat transfer based on either sensitivity studies or the logic of how the events progress, as described in the following discussion. First, the non-LOCA LTR events and acceptance criteria of interest are listed. Then, SG factors that affect the SG secondary system conditions, and the impact of the secondary system conditions on the reactor module steady-state conditions are discussed. The effect of SG heat transfer on margin to non-LOCA event acceptance criteria is discussed in general terms considering the NuScale power module (NPM) design and key characteristics of non-LOCA event transient progression. Finally, each non-LOCA event is discussed individually and impact on the topical report is identified.

The Non-LOCA LTR events and acceptance criteria of interest are listed below.

7.2.1 Decrease in Feedwater Temperature (MCHFR)

7.2.2 Increase in Feedwater Flow (MCHFR)

7.2.3 Increase in Steam Flow (MCHFR)

7.2.4 Steam System Piping Failure Inside or Outside Containment (MCHFR; dose)

7.2.5 Containment Flooding / Loss of Containment Vacuum (MCHFR)

7.2.6 Turbine Trip / Loss of External Load (RPV pressure; SG pressure)

7.2.7 Loss of Condenser Vacuum (RPV pressure; SG pressure)

7.2.8 Main Steam Isolation Valve(s) Closure (RPV pressure; SG pressure)

7.2.9 Loss of Normal AC Power (RPV pressure; SG pressure)

7.2.10 Loss of Normal Feedwater Flow (RPV pressure; SG pressure)

7.2.11 Inadvertent DHRS Actuation (RPV pressure; SG pressure)

7.2.12 Feedwater System Pipe Break Inside or Outside Containment (RPV pressure; SG pressure)

7.2.13 Uncontrolled CRA Bank Withdrawal from Subcritical or Low Power Startup Conditions (MCHFR; fuel temperature)

7.2.14 Uncontrolled CRA Bank Withdrawal at Power (MCHFR; fuel temperature)

7.2.15 Control Rod Misoperation: Single CRA Withdrawal (MCHFR; fuel temperature) Dropped CRA(s) (MCHFR; fuel temperature)

7.2.16 Inadvertent Decrease in Boron Concentration (MCHFR)

7.2.17 CVCS Malfunction that Increases RCS Inventory (RPV pressure; SG pressure)

7.2.18 Failure of Small Lines Outside Containment (dose)

7.2.19 Steam Generator Tube Failure (dose)

Assessment of Steam Generator Heat Transfer Biasing

A review of the Non-LOCA LTR was performed. The SG heat transfer bias as applied to the acceptance criteria noted above are discussed below for each event.

First, however, SG factors that affect the SG secondary system conditions, and the impact of the secondary system conditions on the reactor module steady-state conditions are discussed. Response to RAI 9351, Question15.0.02-32 provided results from single-parameter bias impacts on SG level and the effect of these steam generator parameters on the initial SG level are summarized in Table 1 below. Other factors such as primary side temperature and RCS flow rate can also affect the initial SG inventory; as these parameters are not the focus of the RAI supplement they are not discussed further. Steam generator factors that affect the SG secondary system conditions include the steam pressure, feedwater temperature, and SG tube plugging. The effect of biasing calculated SG heat transfer efficiency is considered in comparison.

- Steam pressure: The secondary system steam pressure affects the latent heat of vaporization. At low pressure bias conditions the latent heat of vaporization is higher and therefore the SG boiling length is shorter and total inventory lower compared to high steam pressure bias conditions.
- Feedwater temperature: The inlet feedwater temperature affects how much energy is used to raise the feedwater from subcooled to saturated conditions. However, as the majority of heat transfer in the SGs is through boiling, the feedwater temperature range

of +/- 10°F has minimal impact. Therefore, lower feedwater temperature results in slightly higher SG level.

- SG tube plugging: SG tube plugging affects the area available for primary to secondary system heat transfer and therefore results in a longer boiling length and higher inventory per tube in the remaining unplugged tubes to transfer the same energy from the primary side under steady-state conditions.
- SG heat transfer: Low calculated steam generator heat transfer results in a longer boiling length and therefore higher inventory compared to nominal or high biased calculated steam generator heat transfer.

The results in Table 1 show that the effect of varying the SG heat transfer by plus or minus 30% {{

}}2(a),(c)

Due to the natural circulation design of the NPM, as the SG boiling length increases and the total secondary side inventory increases, the thermal center elevation of the SG increases; therefore, for a given RCS primary loop resistance and power generation rate, the RCS flow rate will increase. For calculations performed in accordance with the non-LOCA EM, RCS flow is typically biased low for conservatism for MCFHR acceptance criteria.

For a given power level in the NPM, the steam generator inventory affects the superheated steam temperature. Higher inventory will result in lower steam superheat while lower inventory will result in higher steam superheat temperature. The initial steam pressure and temperature determines the amount that the steam pressure or temperature would need to change to reach the MPS actuation limits for high or low steam pressure, or high or low steam temperature. Therefore, the initial steam generator secondary side conditions can affect the transient progression depending on which process condition is first reached that actuates reactor trip and/or other engineered safety systems. This is particularly relevant for transients that analyze a spectrum of conditions. Events analyzing a spectrum of conditions, such as a decrease in feedwater temperature or increase in steam flow, typically show a trend in event progression as a function of the change from the initiating events. For example, large decreases in feedwater temperature reach different trip conditions compared to smaller decreases in feedwater temperature, and typically the limiting MCHFR conditions are at a moderate decrease rate rather than the maximum or minimum values. Therefore, changes in the SG secondary initial

conditions that affect the transient progression will tend to shift the limiting change but not otherwise change the types of event progression observed.

Next, the effect of SG heat transfer on margin to acceptance criteria is discussed in general terms considering the NuScale power module (NPM) design and key characteristics of non-LOCA event transient progression.

Maximum RCS Pressure

In the NPM design, for events that could challenge the RCS pressure acceptance criteria, the maximum RCS pressure is primarily driven by the reactor safety valve (RSV) lift pressure due to the sizing of the valve, resulting in very little transient-dependent pressure overshoot. As discussed below, steam generator heat transfer has little impact on the rate of RCS pressurization (event timing) and since the magnitude of the peak pressure is limited by the RSV performance, the SG heat transfer efficiency does not affect the maximum magnitude or the margin to acceptance criteria.

Maximum Secondary Pressure

In the NPM design, maximum secondary side pressure occurs after secondary system isolation (SSI) and actuation of DHRS. After secondary side isolation and DHRS acutation, the primary side temperatures and inventory in the secondary system drive the secondary system pressure response. As discussed below, biasing the steam generator heat transfer efficiency can vary the calculated maximum secondary side pressure {{ }}[2(a),(c)]. However, the secondary side design pressure is equal to the primary side design pressure of 2100 psia to provide over-pressure protection of the steam generators. As discussed in the non-LOCA topical report Section 4.2, with the boiling/condensing operation of the SG and DHRS, the maximum pressure of the secondary side is physically limited to the saturation pressure at the maximum primary side temperature. Therefore, except for the steam generator tube failure event, calculation results indicate that the maximum secondary side pressures are less than 1700 psia even considering plus or minus 30% bias of steam generator heat transfer; for the steam generator tube failure event, the maximum pressure is less than 1900 psia since the faulted steam generator remains connected to the primary side after secondary side isolation. In this context, for a physically limited system with at least 600 psi margin to maximum pressure acceptance criteria (200 to 400 psia margin to design pressure and 200 to 400 psi additional margin to the 110% or 120% design pressure acceptance criteria), variation of {{ }}[2(a),(c)] in maximum pressure does not substantively affect margin to acceptance criteria.

MCHFR

From the system thermal-hydraulic analysis, boundary conditions for total power, system flow rate, core inlet temperature, and pressurizer pressure are provided as input to to the subchannel analysis for evaluation of SAFDLs, particularly MCHFR. Inspection of the sequence of events tables and plotted MCHFR results for the FSAR Ch 15 events shows that in the NuScale design MCHFR occurs around the time of reactor trip. After reactor trip, the core power decrease results in significant increase in CHFR. As the core power decreases to decay heat levels, RCS flow also decreases. However, sensitivity calculations show that the power decrease is much more rapid than the flow rate decrease. Selected transient results are given as an example below for the increase in steam flow event. Variation in the steam generator heat transfer rate does not substantially affect the RCS flow coast-down response to reactor trip, or core inlet temperature before control rods are inserted, and therefore, the minimum CHFR limit occurs around the time of reactor trip.

Mass Release and Iodine Spiking Time for Radiological Dose

The events analyzed for radiological dose analysis acceptance criteria (main steam line break outside containment, failure of small lines outside containment, and SGTF) have different transient progressions and therefore each event is discussed below. Based on the radiological analysis dose results presented in the FSAR Table 15.0-12, the dose results for these events are 1-2 orders of magnitude less than the acceptance criteria. The changes in the mass release due to differently biased steam generator conditions are considered in the context of this margin.

Table 1. Single-Parameter Bias Impact on SG Level, 102% Power Steady-State

Bias Description	Bias	Initial SG Level (%)
{{		
		}}2(a),(c)

Decrease in Feedwater Temperature (Table 7-7): No changes to the Bias as currently described for SG heat transfer to address MCHFR as the sole acceptance criterion. {{

}}2(a),(c)

Increase in Feedwater Flow (Table 7-14): Since MCHFR is the sole acceptance criterion, the Bias and Basis for SG heat transfer are changed to ”Nominal" and {{

}}2(a),(c)

Increase in Steam Flow (Table 7-19): Since MCHFR is the sole acceptance criterion, the Bias and Basis for SG heat transfer are changed to ”Nominal" and {{

}}2(a),(c)

{{

}}2(a),(c)

<u>Steam System Piping Failure Inside or Outside Containment (Table 7-24)</u>: Since MCHFR and dose are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

Containment Flooding / Loss of Containment Vacuum (Table 7-28): Since MCHFR is the sole acceptance criterion, the Bias and Basis for SG heat transfer are correct as stated, i.e., "Nominal" and {{

}}2(a),(c)

Turbine Trip / Loss of External Load (Table 7-32) Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

Loss of Condenser Vacuum (Table 7-36): Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

Main Steam Isolation Valve Closure (Table 7-40): Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

Loss of Normal AC Power (Table 7-44): Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

<u>Loss of Normal Feedwater (Table 7-48)</u>: Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

<u>Inadvertent DHRS Actuation (Table 7-52)</u>: Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

<u>Feedwater System Pipe Break Inside or Outside Containment (Table 7-56)</u>: Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are changed to “Nominal” and {{

}}2(a),(c)

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}}2(a),(c)

<u>Uncontrolled CRA Bank Withdrawal from Subcritical or Low Power Startup Conditions (Table 7-60)</u>: Since MCHFR and fuel centerline temperature are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

<u>Uncontrolled CRA Bank Withdrawal at Power (Table 7-64)</u>: Since MCHFR and fuel centerline temperature are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

Control Rod Misoperation (Table 7-68 and Table 7-70): Since MCHFR and fuel centerline temperature are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

Inadvertent Decrease in Boron Concentration (Table 7-74): Since MCHFR is the acceptance criterion of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Excluded” and {{

}}2(a),(c)

CVCS Malfunction that Increases RCS Inventory (Table 7-82): Since RCS pressure and SG pressure are the acceptance criteria of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

{{

}}2(a),(c)

<u>Failure of Small Lines Outside Containment (Table 7-86)</u>: Since dose is the acceptance criterion of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

<u>Steam Generator Tube Failure (Table 7-91):</u> Since dose is the acceptance criterion of interest, the Bias and the Basis currently described for SG heat transfer are correct, i.e., “Nominal” and {{

}}2(a),(c)

Supporting Transient Plots

Plots of reactor power, RCS flow rate, control bank reactivity, average RCS temperature, core inlet temperature and core outlet temperature are provided for a set of sensitivity calculations for the increase in steam flow event. Both transients are initiated from full power and a 12% increase in steam flow is modeled. {{ }}[2(a),(c)] The relevant biasing is provided in Table 1. This sensitivity calculation provides an example response demonstrating that the secondary system biases including heat transfer do not have a significant direct influence on system transient conditions affecting MCHFR.

Table 1: Example Increase in Steam Flow Transient Biasing

Case ID	SG Pressure (psia)	Feedwater Temperature (F)	SG heat transfer (%)	Disable High Steam Superheat Signal (y/n)
Case 1	+35	0	+0	No
Case 6 [(1)]	-35	-10	+30	Yes

[(1)] {{ }}[2(a),(c)]

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}}2(a),(c)

Figure 1: Reactor Power

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}}2(a),(c)

Figure 2: RCS Flow Rate

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}}2(a),(c)

Figure 3: Control Bank Reactivity

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}}2(a),(c)

Figure 4: Average RCS Temperature

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

Figure 5: Core Inlet Temperature

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}}2(a),(c)

Figure 6: Core Outlet Temperature

Affected RAI Responses

Below is a matrix of RAI responses which are revised by changing to the use of a nominal SG heat transfer:

RAI	Question	Response Letter/ Date	Change Needed	Doc Affected	Where Change Addressed
9351	15.0.2-32	RAIO-0718-60877 July 13, 2018	Conclusion to response b), c) and SG HT to nominal in Table 7-14 change to nominal HT acceptable due to minor effect.	Non-LOCA LTR	Changed pages with this response
9351	15.0.2-32S1	RAIO-0219-64477 February 11, 2019	Item 1 in list of changes to response, CP: text prior to Table 7-15.	Non-LOCA LTR	Changed pages with this response
9513	15.0.2-16	RAIO-0918-61932 September 25, 2018	CP:Sec 7.1.6.1 SG tubes HT Coeff biasing,	Non-LOCA LTR	Changed pages with this response

Impact on Topical Report:

Topical Report TR-0516-49416, Non-Loss of Coolant Accident Analysis Methodology, has has been revised as described in the response above and as shown in the markup provided in this response.

The calculated fluid temperature inside the DHRS heat exchanger tubes predicted the trends of the measured data. {{

}}2(a),(c)

The calculated differential pressure across the DHRS steam line {{

}}2(a),(c)

Four different transients were performed for code-to-code benchmarking between NRELAP5 and RETRAN-3D: Reactivity insertion representative of a fast UCRW from full power conditions, reactivity insertion representative of a slow UCRW from full power conditions, negative reactivity insertion to reduce power from 100 percent to 50 percent power, and negative reactivity insertion simulating a dropped rod from 50 percent power. The results from all four of the transients showed that the comparison between the power and the total reactivity were consistently excellent, in that the calculation results of the two codes were nearly identically with one another.

NuScale's LOCA Topical Report (Reference 2) Section 7.4~~3~~ discusses the validation of NRELAP5 for helical coil SG modeling. The validation was mainly against SIET TF-1 and TF-2 test data. The operating range of the helical coil SG primary and secondary side is demonstrated to be sufficiently covered by the validated range of NRELAP5. It was concluded that NRELAP5 showed reasonable to excellent agreement with test data for all phenomena at conditions important for the non-LOCA analysis.

A nodalization sensitivity of the steam generator for a main steam line break scenario was performed comparing the effect of modeling the SG {{

}}2(a)(c)

Considering the high-ranked phenomena identified from the PIRT process, the NRELAP5 code along with the NPM system model is applicable for calculation of the NPM system response for the non-LOCA short-term transient event progression as part of this EM based on separate effects and integral effects testing, code-to-code benchmarking, and appropriate conservative input for initial and boundary conditions.

7.2 Event Specific Methodology

The non-LOCA event simulations are performed using conservative methodologies. Pertinent event-specific methodologies, as well as representative inputs and results for non-LOCA event simulations are presented herein, and compared with the regulatory acceptance criteria listed in Table 7-4. See Section 4.1 for additional discussion of Chapter 15 design basis events and acceptance criteria.

All criteria are considered for each event, and the criteria with the potential for being challenged are identified and evaluated in further detail (i.e., overcooling events will not challenge the acceptance criterion for primary side pressure, but may challenge the CHFR acceptance criteria). An event-specific parameter that is relevant to the acceptance criterion may be described as "challenging" in the event-specific summary, however, it is recognized that the parameter may not present the highest challenge for any event.

Table 7-4 Regulatory acceptance criteria

Description	AOO Criteria	IE Criteria	Accident Criteria
RCS pressure (P_{design}= 2100 psia)	< 110% of design (2310 psia)	<120% of design (2520 psia)	< 120% of design (2520 psia)
SG pressure (P_{design}= 2100 psia)	< 110% of design (2310 psia)	< 120% of design (2520 psia)	< 120% of design (2520 psia)
CHFR(1)	> Limit	Note (3)	Note (3)
Maximum fuel centerline temperature(1)	< Limit	Note (3)	Note (3)
Containment integrity(2)	< Limits	< Limits	< Limits
Escalation of an AOO to an accident (AOO) or consequential loss of system functionality (IE or accident)?	No	No	No
Dose(1)	Normal operations	< Limit	< Limit

1. This criterion is confirmed as part of a separate follow-on analysis.
2. Containment integrity is evaluated by a separate analysis methodology.
3. If the minimum CHFR is less than or equal to the 95/95 CHFR limit, or if the maximum fuel centerline temperature exceeds the melting temperature, the fuel rod is assumed to be failed. If fuel failure is calculated, this is accounted for in the downstream radiological dose analysis.

For each event analyzed following the non-LOCA evaluation model, a description of the event progression, significant inputs and results, and representative results of sensitivity studies are presented in the following sections. Sensitivity studies are performed to identify plant conditions that result in bounding transient analyses. Studies that identify acceptance criteria challenges or bounding transient forcing functions are discussed as well. Other sensitivity studies that determine bounding inputs for RCS flow, fuel parameters, ~~SG and DHRS heat transfer characteristics,~~ etc. may not necessarily be

Table 7-14 Initial conditions, biases, and conservatisms – increase in feedwater flow

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Biased to the high condition.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Biased to the high condition.	{{ }}2(a)(c)
Initial PZR level	Biased to the high condition.	{{ }}2(a)(c)
Initial feedwater temperature	Low.	{{ }}2(a)(c)
Initial fuel temperature	Nominal.	{{ }}2(a)(c)
MTC	Biased to EOC conditions.	{{ }}2(a)(c)
Kinetics	Biased to the EOC condition.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
~~Automatic rod control~~	~~Enabled.~~	~~{{~~ ~~}}2(a)(c)~~
Decay heat	Biased to the low condition.	{{ }}2(a)(c)
Initial SG pressure(1)	High	{{ }}2(a)(c)
SG heat transfer	~~Low~~Nominal	{{ }}2(a)(c)
~~PZR spray~~	~~Disabled~~	~~{{~~ ~~}}2(a)(c)~~

Parameter	Bias / Conservatism	Basis
PZR Level Control Charging	Not credited.	{{ }}2(a)(c)
Letdown	Disabled.	{{ }}2(a)(c)
Steam Pressure Control Turbine throttle valves	Enabled.	{{ }}2(a)(c)
Turbine bypass valves	Disabled.	
Feedwater and Turbine Load Control feedwater pump speed	N/A.	Not applicable to this event.
CNV Pressure Control CNV evacuation system	Enabled.	{{ }}2(a)(c)

1. {{ }}2(a)(c)

Sensitivity studies are performed as needed to identify the limiting response(s) for the acceptance criteria parameter(s) challenged by the event (i.e., system pressures for overheating events, MCHFR for overcooling events). Consequently, sensitivity studies are performed to identify cases with the lowest CHFR response for this overcooling event. For example, two sensitivity studies are performed to identify the most challenging ~~SG liquid inventory and~~secondary biases for the feedwater flow transient for MCHFR. {{

}}2(a),(c)

{{

}}2(a),(c) Representative results for these studies are presented in Table 7-15 and Table 7-16.

Table 7-15 Representative increase in feedwater flow study – ~~low~~high ~~liquid inventory~~SG performance with maximum power and minimum RCS flow

{{

}}2(a),(c)

Table 7-16 Representative increase in feedwater flow study – ~~high~~low ~~liquid inventory~~SG performance with maximum power and minimum RCS flow

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}}2(a),(c)

Table 7-19 Initial conditions, biases, and conservatisms – increase in steam flow

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Biased to the high condition.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Biased to the high condition.	{{ }}2(a)(c)
Initial PZR level	Biased to the high condition.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)
Initial fuel temperature	Nominal.	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Biased to EOC conditions.	{{ }}2(a)(c)
Kinetics	Biased to the EOC condition.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Enabled~~	~~{{~~ ~~}}2(a)(c)~~
Decay heat	Biased to the low condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Biased to the high condition.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
SG heat transfer	~~Varied~~Nominal	{{ }}2(a)(c)
~~PZR spray~~	~~Disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~Letdown~~	~~Disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~PZR heaters~~	~~Nominal~~	~~{{~~ ~~}}2(a)(c)~~
RSV lift setpoint	Nominal	{{ }}2(a)(c)
SG tube plugging	Biased to the low condition.	{{ }}2(a)(c)
Steam flow increase	Varied	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control	Enabled.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
		{{ }}2(a)(c)

1. {{ }}2(a)(c)
2. {{ }}2(a)(c)

Sensitivity studies are performed as needed to identify the limiting response(s) for the acceptance criteria parameter(s) challenged by the event (i.e., system pressures for overheating events, MCHFR for overcooling events). Consequently, sensitivity studies are performed to identify cases with the lowest CHFR response for this overcooling event. For example, two sensitivity studies are performed to identify the most challenging increase in steam flow for MCHFR. {{ }}2(a),(c) Representative results for these studies are presented in Table 7-20 and Table 7-21.

Table 7-20 Representative steam flow study – nominal steam generator heat transfer

{{ }}2(a),(c)

Table 7-24 Initial conditions, biases, and conservatisms – steam line break

Parameter	Bias / Conservatism	Basis
Initial reactor power	Biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	~~Biased to the high condition~~Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Varied	{{ }}2(a)(c)
Initial PZR level	Varied	{{ }}2(a)(c)
Initial feedwater temperature	Varied.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the low condition.	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Both EOC and BOC conditions.	{{ }}2(a)(c)
Kinetics	Both EOC and BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Enabled or disabled~~	~~{{ }}2(a)(c)~~
Decay heat	Both high and low conditions	{{ }}2(a)(c)
Initial SG pressure(1)	~~Biased to the high condition~~Varied.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
SG heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Nominal~~	~~{{~~ ~~}}2(a)(c)~~
~~Letdown~~	~~Disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~PZR heaters~~	~~Normal heater operation is allowed.~~	~~{{~~ ~~}}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Varied to consider both the low and high ends of the allowable range.	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control	Enabled. (MCHFR) Varied. (dose)	{{ }}2(a)(c)

Table 7-31 Acceptance criteria – turbine trip / loss of external load

Acceptance Criteria	Discussion
Primary pressure	Primary pressure quickly rises to the peak value, then drops as the lowest setpoint RSV lifts to reduce pressure.
Secondary pressure	Peak secondary pressurization is largely a function of DHRS actuation, in addition to the actual turbine trip or loss of external load. The DHRS heat removal is limited by the DHR condenser so some pressurization is expected for every actuation of this system.
Critical heat flux ratio	This criterion is evaluated by downstream subchannel analysis.
Maximum fuel centerline temperature	This criterion is evaluated by downstream subchannel analysis.
Containment integrity	Containment integrity is evaluated by a separate analysis methodology.
Escalation of an AOO to an accident	This criterion is satisfied by demonstrating stable RCS flow rates and constant or downward trending RCS and DHRS pressures and temperatures exist at the end of the transient, all acceptance criteria evaluated in the transient analysis are met, and shutdown margin is maintained at the end of the transient. RCS conditions during extended DHRS cooling are addressed in a separate analysis.

7.2.6.3 Biases, Conservatisms, and Sensitivity Studies

The biases and conservatisms presented in Table 7-32 are considered in identifying the bounding transient simulation for primary and steam generator pressure.

Table 7-32 Initial conditions, biases, and conservatisms – turbine trip / loss of external load

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased to the high condition to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Biased to the high condition.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC conditions.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)
Steam generator heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)

Table 7-36 Initial conditions, biases, and conservatisms – loss of condenser vacuum

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Biased to the high condition.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
Steam generator heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Automatic PZR spray is disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~PZR heaters~~	~~Heat input held constant.~~	~~{{~~ ~~}}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Biased to the low condition.	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control Boron concentration	 Disabled. Not credited.	{{ }}2(a)(c)
PZR Pressure Control PZR spray (normal) (bypass) PZR heaters (non-prop.)	 Disabled. Nominal. Disabled.	{{ }}2(a)(c)

Table 7-40 Initial conditions, biases, and conservatisms – main steam isolation valve closure

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Varied.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Varied.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)
Steam generator heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Automatic PZR spray is disabled~~	~~{{ }}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{ }}2(a)(c)~~
~~PZR heaters~~	~~Heat input held constant.~~	~~{{ }}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)

7.2.9.3 Biases, Conservatisms, and Sensitivity Studies

The biases and conservatisms presented in Table 7-44 are considered in identifying the bounding transient simulation for primary and secondary pressure.

Table 7-44 Initial conditions, biases, and conservatisms – loss of normal AC power

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Biased to the high condition.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
Initial fuel temperature	Biased to the high condition	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)
SG heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Automatic PZR spray is disabled~~	~~{{ }}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{ }}2(a)(c)~~
~~PZR heaters~~	~~Lost on loss of power.~~	~~{{ }}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Biased to the low condition.	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control Boron concentration	Enabled. Not credited.	{{ }}2(a)(c)

Table 7-48 Initial conditions, biases, and conservatisms – loss of normal feedwater flow

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Varied.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Varied.	{{ }}2(a)(c)
Initial feedwater temperature	Varied.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition.	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)
SG heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Automatic PZR spray is disabled~~	~~{{ }}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{ }}2(a)(c)~~
~~PZR heaters~~	~~Held constant until loss of AC power.~~	~~{{ }}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Biased to the low condition.	{{ }}2(a)(c)

Table 7-52 Initial conditions, biases, and conservatisms – inadvertent decay heat removal system actuation

Parameter	Bias / Conservatism	Basis
Initial reactor power	Varied—most challenging cases are RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Varied.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Varied.	{{ }}2(a)(c)
Initial feedwater temperature	Nominal.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Varied—most challenging cases biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
Steam generator heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Automatic PZR spray is disabled~~	~~{{ }}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{ }}2(a)(c)~~
~~PZR heaters~~	~~Constant heat input.~~	~~{{ }}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Biased to the low condition.	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control Boron concentration	Disabled. Not credited.	{{ }}2(a)(c)

7.2.12.3 Biases, Conservatisms, and Sensitivity Studies

The biases and conservatisms presented in Table 7-56 are considered in identifying the bounding transient simulation for primary and steam generator pressure.

Table 7-56 Initial conditions, biases, and conservatisms – feedwater line break

Parameter	Bias / Conservatism	Basis
Initial reactor power	RTP biased upwards to account for measurement uncertainty.	{{ }}2(a)(c)
Initial RCS average temperature	Varied.	{{ }}2(a)(c)
Initial RCS flow rate	Biased to the low condition.	{{ }}2(a)(c)
Initial PZR pressure	Varied.	{{ }}2(a)(c)
Initial PZR level	Varied.	{{ }}2(a)(c)
Initial feedwater temperature	Varied.	{{ }}2(a)(c)
Initial fuel temperature	Biased to the high condition.	{{ }}2(a)(c)
~~Moderator temperature coefficient~~MTC	Consistent with BOC kinetics.	{{ }}2(a)(c)
Kinetics	Biased to BOC conditions.	{{ }}2(a)(c)
~~Automatic rod control~~	~~Disabled.~~	~~{{ }}2(a)(c)~~
Decay heat	Biased to the high condition.	{{ }}2(a)(c)
Initial SG pressure(1)	Varied.	{{ }}2(a)(c)

Parameter	Bias / Conservatism	Basis
SG heat transfer	~~Varied~~Nominal.	{{ }}2(a)(c)
~~PZR spray~~	~~Varied, lost on loss of power~~	~~{{~~ ~~}}2(a)(c)~~
~~Letdown~~	~~Automatic RCS inventory control is disabled~~	~~{{~~ ~~}}2(a)(c)~~
~~PZR heaters~~	~~Varied, lost on loss of power.~~	~~{{~~ ~~}}2(a)(c)~~
RSV lift setpoint	Biased to the high condition.	{{ }}2(a)(c)
SG tube plugging	Varied	{{ }}2(a)(c)
Break size / location	Varied.	{{ }}2(a)(c)
RCS Temperature Control Automatic rod control Boron concentration	Disabled. Not credited.	{{ }}2(a)(c)
PZR Pressure Control PZR spray (normal) (bypass) PZR heaters (non-prop.) (prop.)	Varied. Nominal. Varied. Nominal.	{{ }}2(a)(c)

8.1.2 Increase in Steam Flow

The purpose of this section is to present the thermal-hydraulic response of the NPM for an increase in steam flow event. This event is evaluated for MCHFR.

8.1.2.1 Event Description

The general increase in steam flow event description can be found from Section 7.2.3.1. Based on Section 7.2.3.1, MCHFR is the only acceptance criterion that may be potentially challenged during the increase in steam flow event. No single failure is applied since the challenging cases occur when all equipment operates as designed. No loss of power is applied since all loss of power scenarios terminate feedwater or trip the reactor, thus reducing the overcooling event. Chosen from a series of MCHFR sensitivity cases, the representative increase in steam flow case presented here represents a case that could challenge MCHFR, based on the NRELAP5 MCHFR pre-screening. This case features the following conditions:

- Conservative initial condition biasing (as shown in Table 7-19) is applied in order to maximize the consequences of the overcooling event in terms of MCHFR. This representative case is initialized at 102 percent reactor power. RCS average temperature is biased at high condition (555 degrees F). RCS flow rated is biased to the low condition (535 kg/s). Pressurizer pressure is biased to the high condition (1920 psia). Pressurizer level is biased to the high condition (53 percent).
- SG heat transfer is decreased 30 percent by applying a heat transfer coefficient multiplier of 0.7 in the steady state initialization model. As identified in Section 7.2.3.3, this biasing has insignificant impact on the overall limiting MCHFR conditions for the transient.~~This bias slightly reduces RCS flow at the beginning and during the transient, which minimizes the MCHFR.~~
- Steam flow is increased 14.45 percent instantly at the beginning of the event. A time-dependent junction that controls steam mass flow rate is used to model the turbine.
- During the increase in steam flow event, the feedwater pump speed remains constant and the pump curve allows a 1.0 lbm/s increase in feedwater flow for every 1 psi decrease in SG pressure. This maximizes the overcooling event by increasing the available source of secondary coolant.
- EOC reactivity coefficients are applied which maximizes the reactor power response.
- A low fuel temperature bias (applied by increasing gap conductance) is applied in this case although a nominal temperature is acceptable.
- No operator action was credited in the representative case. Normal control system such as PZR spray, heater, letdown controls and automatic rod control are modeled based on the control status shown in Table 7-19.

8.1.3 Main Steam Line Break

The purpose of this section is to present the thermal-hydraulic response of the NPM for a main steam line break event. This event is evaluated for MCHFR, and mass releases are determined for input to downstream accident radiological dose analysis. A representative case evaluated for MCHFR is presented.

8.1.3.1 Event Description

The general description for main steam line break event can be found from Section 7.2.4.1. Based on Section 7.2.4.1, MCHFR is the only acceptance criterion that may be potentially challenged during the main steam line break event. The MCHFR case assumes a failed MSIV on the affected SG train; however, the timing of MCHFR is well before the MSIV would have closed so it is concluded there is no limiting failure for the MCHFR case. No loss of power is applied since all loss of power scenarios terminate feedwater or trip the reactor, thus reducing the overcooling event. Chosen from a series of MCHFR sensitivity cases, the representative main steam line break case presented here represents a case that could challenge MCHFR, based on the NRELAP5 MCHFR pre-screening. This case features the following conditions:

- Conservative initial condition biasing (as shown in Table 7-24) is applied in order to maximize the consequences of the overcooling event in terms of MCHFR. The case is initialized at 102 percent reactor power with conservatively high RCS temperature and pressure. RCS average temperature is biased at high condition (555 degrees F). RCS flow rated is biased to the low condition (535 kg/s). Pressurizer pressure is biased to the high condition (1920 psia). Pressurizer level is biased to the high condition (58 percent). Feedwater temperature is biased to the high condition (310 degrees F). Minimum RCS design flow is assumed.
- SG heat transfer is increased 30 percent by applying a heat transfer coefficient multiplier of 1.3 in the steady state initialization model. As identified in Section 7.2.4.3, this biasing has insignificant impact on the overall limiting MCHFR conditions, spiking time or mass released. There is no tube plugging in the SGs for this representative calculation.
- The feedwater controller is based on FW pressure error rather than turbine load demand. This allows for the implementation of the feedwater pump flow response to the pressure loss events. In the steam line piping failure transient, the details of how the pumps speed controller will respond are ignored and bounded by a conservative pump curve to maximize the flow response due to the drop in FW pressure.
- Steam pressure control is a flow based controller rather than a back pressure control. This is a better physical representation of the turbine response to a drop in steam pressure. During the transients the turbine is treated as a constant steam flow sink without automated runback.
- A low fuel temperature bias (applied via increase gap conductance) is applied which minimizes negative Doppler feedback following an increase in power.
- EOC reactivity coefficients are applied which maximizes the reactor power response.

8.2 Heatup and/or Pressurization of the Reactor Coolant System

8.2.1 Loss of Normal Feedwater Flow

The purpose of this section is to present the thermal-hydraulic response of the NPM for loss of normal feedwater flow. This event is evaluated for primary pressure and secondary pressure. Different initial condition biases and conservatisms are used for the RCS pressure case and the secondary pressure case.

8.2.1.1 Event Description –Reactor Coolant System Pressure Case

The general loss of normal feedwater flow event description can be found in Section 7.2.10. Chosen from a series of RCS pressure sensitivity cases, the sample loss of normal feedwater flow case here represents a case that could challenge the RCS pressure acceptance criterion. No single failure is applied since the challenging cases occur when all equipment operates as designed. Normal AC power is lost at turbine trip since this maximizes the system pressure responses. This case features the following conditions:

- The initial power is 102 percent. RCS average temperature is biased at high condition (555 degrees F). RCS flow rated is biased to the low condition (535 kg/s). Pressurizer pressure is biased to the low condition (1780 psia). Pressurizer level is biased to the high condition (58 percent). Initial feedwater temperature is biased to the high condition (312.5 degrees F). Initial SG pressure is biased to the high condition (535 psia).
- SG heat transfer is increased 30 percent by applying a heat transfer coefficient multiplier of 1.3 on both the primary and secondary sides of the steam generator tubes in the steady state initialization model. As identified in Section 7.2.10.3, this biasing does not significantly affect margin to the RCS pressure acceptance criteria. There is no SG tube plugging for this representative calculation.
- BOC reactivity coefficients are used since they are bounding for overheating events.
- No operator action was credited in the representative case. Normal control system such as PZR spray, heater, letdown controls and automatic rod control are modeled based on the control status shown in Table 7-48.

8.2.1.2 Analysis Results –RCS Pressure Case

The following describes the event sequence of a representative case for the loss of normal feedwater flow event that could challenge the primary pressure. Table 8-4 summarizes the sequence of events. Figure 8-29 through Figure 8-37 show some key parameters during the representative loss of normal feedwater flow event.

The feedwater flow is completely lost at time zero of the transient. Due to the overheating after loss of feedwater, pressurizer pressure and level start to increase (Figure 8-29 and Figure 8-30). At 17.6 seconds after transient initiation, the pressurizer pressure reaches the reactor trip analytical limit (Figure 8-29). At 18.6 seconds, the turbine trips (on the reactor trip signal), normal power is lost—causing MSIV closure—and steam generator

Enclosure 3:

Affidavit of Zackary W. Rad, AF-0719-66522

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 non-loss of coolant accident analysis methodology .

   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. 9466, eRAI No. 9466. 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