NuScale Power

RAIO-0218-58787

February 21, 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. 321 (eRAI No. 9092) on the NuScale Design Certification Application

REFERENCE: U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 321 (eRAI No. 9092)," dated January 04, 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. 9092:

- 15.04.01-3

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 Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com.

Sincerely,

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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 9092

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 9092

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

eRAI No.: 9092
Date of RAI Issue: 01/04/2018

NRC Question No.: 15.04.01-3

Standard Review Plan (SRP) Section 15.4.1, “Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power Startup Position;” SRP Section 15.4.2, “Uncontrolled Control Rod Assembly Withdrawal at Power;” and SRP Section 15.4.3, “Control Rod Misoperation (System Malfunction or Operator Error),” provide guidance for complying with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, “General Design Criteria [(GDC)] for Nuclear Power Plants,” 10, “Reactor design;” 13, “Instrumentation and control;” 17,

“Electric power systems;” 20, “Protection system functions;”; and 25, “Protection system requirements for reactivity control malfunctions.” Per the above SRP sections, the reviewer is to evaluate whether the initial conditions and parameter values selected for each analysis are justified. In addition, the reviewer is to evaluate the sequence of events to ensure it is justified based upon expected values of relevant monitored parameters and instrument indications.

Reactor coolant system (RCS) pressure is one acceptance criterion for anticipated operational occurrences. The staff notes that Final Safety Analysis Report (FSAR) Tier 2, Sections 15.4.1 through 15.4.3, evaluate limiting RCS pressure scenarios but do not provide the key inputs or the sequence of events for these scenarios. To enable the staff to evaluate whether the initial conditions/parameter values and sequence of events for the limiting RCS pressure scenarios are justified, please provide the following:

1. Key inputs for the limiting RCS pressure cases in FSAR Tier 2, Sections 15.4.1 through 15.4.3 (similar to those provided for the limiting maximum critical heat flux ratio (MCHFR) cases in FSAR Tier 2, Tables 15.4-2, 15.4-4, 15.4-6, and 15.4-8)
2. Sequence of events for the limiting RCS pressure cases in FSAR Tier 2, Sections 15.4.1 through 15.4.3 (similar to those for the limiting MCHFR cases in FSAR Tables 15.4-1, 15.4-3, 15.4-5, and 15.4-7).

NuScale Response:

The events in FSAR Section 15.4.1 through Section 15.4.3 are evaluated to find the limiting transient cases with respect to the anticipated operational occurrence acceptance criteria. The NRC has requested that NuScale add key inputs tables and sequence of events tables to these sections for the cases resulting in the limiting reactor coolant system (RCS) pressure. The following tables have been added to FSAR Section 15.4:

- Table 15.4-25: Key Inputs for Limiting RCS Pressure Case (15.4.1 Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power or Startup Condition)
- Table 15.4-26: Sequence of Events for Limiting RCS Pressure Case (15.4.1 Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power or Startup Condition)
- Table 15.4-27: Key Inputs for Limiting RCS Pressure Case (15.4.2 Uncontrolled Control Rod Assembly Withdrawal at Power)
- Table 15.4-28: Sequence of Events for Limiting RCS Pressure Case (15.4.2 Uncontrolled Control Rod Assembly Withdrawal at Power)
- Table 15.4-29: Key Inputs for Limiting RCS Pressure Case (15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)
- Table 15.4-30: Sequence of Events for Limiting RCS Pressure Case (15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)

As stated in FSAR Section 15.4.3, RCS pressure is not a concern for the control rod assembly drop event. The RCS pressure plot in Figure 15.4-24 demonstrates that RCS pressure decreases during a control rod assembly drop transient. Therefore, a separate case maximizing RCS pressure is not provided for the control rod assembly drop event. The limiting RCS pressure for a control rod misoperation event is for a single control rod assembly withdrawal (see Table 15.4-29 and Table 15.4-30).

An unrelated editorial change was made to text in FSAR Section 15.4.2.2 as shown in the markup provided in this response.

Impact on DCA:

FSAR Table 15.4-25 through Table 15.4-30 as well as associated text in FSAR Section 15.4 have been revised as described in the response above and as shown in the markup provided in this response.

15.4 Reactivity and Power Distribution Anomalies

Section 15.4 covers the various events that are caused by reactivity and power distribution anomalies. The sections for these events will cover the following:

- Section 15.4.1 - uncontrolled control rod assembly (CRA) withdrawal from a subcritical or low power startup condition.
- Section 15.4.2 - uncontrolled CRA withdrawal at power.
- Section 15.4.3 - control rod misoperation (CRM) (system malfunction or operator error).
- Section 15.4.4 - startup of an inactive loop or recirculation loop at an incorrect temperature. Although this event is not applicable to NuScale, this event will be addressed in Section 15.4.4 for consistency with the Standard Review Plan (SRP).
- Section 15.4.5 - flow controller malfunction causing an increase in boiling water reactor core flow rate. Although this event is not applicable to NuScale, this event will be addressed in Section 15.4.5 for consistency with the SRP.
- Section 15.4.6 - inadvertent decrease in boron concentration in the reactor coolant system (RCS).
- Section 15.4.7 - inadvertent loading and operation of a fuel assembly in an improper position.
- Section 15.4.8 - spectrum of rod ejection accidents (REAs).
- Section 15.4.9 - spectrum of rod drop accidents. Although this event is not applicable to NuScale, this event will be addressed in Section 15.4.9 for consistency with the SRP.

15.4.1 Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power or Startup Condition

15.4.1.1 Identification of Causes and Accident Description

An uncontrolled CRA withdrawal from a subcritical or low power or startup condition event could result in a rapid insertion of reactivity into the reactor core. There is an increase in reactor power due to the unexpected addition of reactivity as the CRA is withdrawn from the core. The core power increases at a faster rate than heat can be removed, resulting in an increase in RCS temperature and a decrease in minimum critical heat flux ratio (MCHFR).

An uncontrolled CRA withdrawal from a subcritical or low power or startup condition is expected to occur one or more times in the life of the reactor, and it is classified as an anticipated operational occurrence (AOO). The categorization of the NuScale design basis events are provided in Table 15.0-1.

15.4.1.2 Sequence of Events and Systems Operation

RAI 15.04.01-3

The sequence of events for an uncontrolled CRA withdrawal from a subcritical or low power or startup condition is provided in ~~Table 15.1-1~~Table 15.4-1 for the limiting MCHFR case and in Table 15.4-25 for the limiting RCS pressure case.

- Loss of normal DC power system (EDNS), in addition to loss of normal AC power: power to the trip breakers is provided via the EDNS. This results in a reactor trip, which terminates bank withdrawal, and therefore is non-limiting.
- Loss of the highly reliable DC power system (EDSS), in addition to loss of both EDNS and Normal AC power: this scenario results in reactor trip and actuation of all ESFs. This terminates the bank withdrawal, and therefore is non-limiting.

There are no single failures that could occur during an uncontrolled CRA withdrawal from a subcritical or low power or startup condition event that would result in more severe conditions for the limiting case.

15.4.1.3 Thermal Hydraulic and Subchannel Analyses

15.4.1.3.1 Evaluation Models

The thermal hydraulic analysis of the plant response to an uncontrolled CRA withdrawal from a subcritical or low power or startup condition is performed using NRELAP5. The NRELAP5 model is based on the design features of a NuScale module. The non-loss-of-coolant accident (LOCA) NRELAP5 model is discussed in Section 15.0.2. The relevant boundary conditions from the NRELAP5 analyses are provided to the downstream subchannel critical heat flux (CHF) analysis.

The subchannel core CHF analysis is performed using VIPRE-01. VIPRE-01 is a subchannel analysis tool designed for general-purpose thermal-hydraulic analysis under normal operating conditions, operational transients, and events of moderate severity. See Section 15.0.2.3 for a discussion of the VIPRE-01 code and evaluation model.

15.4.1.3.2 Input Parameters and Initial Conditions

RAI 15.04.01-3

A spectrum of initial conditions is analyzed to find the limiting reactivity insertion due to an uncontrolled CRA withdrawal from a subcritical or low power or startup condition. The initial conditions of the transient evaluation result in a conservative calculation. Table 15.4-2 and Table 15.4-26 provide~~s~~ key inputs and the associated biases for ~~this event~~the limiting MCHFR and RCS pressure cases, respectively. The following initial conditions and assumptions ensure that the results have sufficient conservatism.

- The minimum initial power assumed for this analysis is 1 Watt. The transient analyses for this event evaluate cases with initial powers ranging from this minimum power of 1 Watt to 25% of full power. The SRP guidance states that minimizing initial power provides the most conservative conditions for a CRA withdrawal from a subcritical or low power because it provides the maximum power peak. However, this is not the case for the NuScale design. The SR power rate trip signal prevents a significant power increase at lower powers.
- The least negative/most positive reactivity feedback coefficients are used to minimize the reactivity feedback. A positive MTC for low power (<25%)

conditions is assumed. The lower reactivity feedback coefficients provide less reactivity feedback to mitigate the surge in power.

- A direct moderator heating value of 2.5 percent is investigated to determine if there is a significant impact on the peak power. The input had a negligible effect on the transient, and is not presented in this section.
- The maximum worth is assumed in the bank withdrawal to provide the highest possible peak power.

RAI 15.04.01-1, RAI 15.04.01-2

- Reactivity insertion rate: The positive reactivity inserted by the CRA withdrawal is modeled as a constant reactivity addition beginning at the transient initiation. The maximum rod speed of 15 inches/min corresponds to a maximum reactivity insertion of 18.15 pcm/s. However to bound the reactivity insertion from possible boron dilution scenarios, a maximum reactivity insertion of 35 pcm/s is analyzed.
  - The reactivity insertion rate for the limiting MCHFR case is 13.37 pcm/s.
  - The reactivity insertion rate for the limiting RCS pressure case is 0.01337 pcm/s.
- Conservative scram characteristics are used, including a maximum time delay, holding the most reactive rod out of the core, and utilizing a bounding control rod drop rate.

The results from the thermal hydraulic evaluation are used as input to the subchannel analysis to determine the MCHFR for this event. The subchannel model is discussed in Section 15.0.2.

15.4.1.3.3 Results

RAI 15.04.01-1, RAI 15.04.01-2, RAI 15.04.01-3

The sequence of events for a representative uncontrolled CRA withdrawal from a low power or startup condition is provided in Table 15.4-1 for the limiting MCHFR case and in Table 15.4-25 for the limiting RCS pressure case. Figure 15.4-1 through Figure 15.4-5 show the transient behavior of key parameters for the case that is limiting with respect to MCHFR. Figure 15.4-34 shows the RCS pressure from the limiting pressure case.

The CRA bank begins to withdraw at the transient initiation, which begins to raise power, RCS temperature, and RCS pressure. The cases that are limiting for RCS pressure and MCHFR have an initial power of 1MW. This initial power, coupled with a slow withdrawal rate, demonstrates that initially avoiding the high power and power rate trips allows a heatup and pressurization prior to scram. The reactor power rises until the high power (25%) limit is reached. This initiates a scram 2 seconds later, when the peak power is achieved. The maximum pressure occurs after the scram has completed.

The limiting cases for an uncontrolled CRA withdrawal from a low power or startup condition demonstrate margin to the acceptance criteria. The peak RCS pressure

An uncontrolled CRA withdrawal is expected to occur one or more times in the life of the reactor, and it is classified as an AOO. The categorization of the NuScale design basis events are provided in Table 15.0-1.

15.4.2.2 Sequence of Events and Systems Operation

RAI 15.04.01-3, RAI 15.04.02-1, RAI 15.04.02-2

The sequence of events for a representative uncontrolled CRA withdrawal at power is provided in ~~Table 15.4-2~~Table 15.4-4 for the limiting MCHFR case and in Table 15.4-27 for the limiting RCS pressure case.

Unless specified below, the analysis of an uncontrolled CRA withdrawal event assumes the plant control systems and engineered safety features perform as designed, with allowances for instrument inaccuracy. No operator action is credited to mitigate the effects of an uncontrolled CRA withdrawal event.

RAI 15.04.01-3, RAI 15.04.06-1

The regulating CRA banks contain the only CRAs that are not fully withdrawn during power operation. The power dependent insertion limit (PDIL) restricts the amount of insertion steps that the regulating banks can achieve during power operation. The uncontrolled CRA withdrawal analysis assumes that both regulating banks are inserted to the PDILs with an uncertainty of six insertion steps added to the position. The expected normal travel rate of the CRAs is 6 in./min. However, the maximum allowed withdrawal rate of a CRA is 15 in./min, with a step size no greater than three-eighths inch. This corresponds to a maximum possible reactivity insertion of 21 pcm/s. A spectrum of constant ~~rod withdrawal~~reactivity insertion rates ~~up to~~that includes the maximum rate and bounds possible boron dilution scenarios is included in the uncontrolled CRA withdrawal analysis.

The effect of a reactivity insertion event on the RCS is an increase in temperature, which decreases density and causes flow into the pressurizer, increasing RCS pressure. As a result, the normal module control system response would be to decrease pressurizer heater power. In uncontrolled CRA withdrawal cases analyzing peak RCS pressure, the heater output is held constant at the steady-state value. The pressurizer spray and letdown flow are disabled in these cases to maximize RCS pressure.

For some uncontrolled CRA withdrawal cases analyzing MCHFR, the heater is disabled to synchronize the pressurizer pressure trip with other trips. Pressurizer spray is allowed to function in these cases to prevent a trip on high pressurizer pressure from occurring until the high reactor power limit is reached.

The MPS is credited to protect the plant in the event of an uncontrolled CRA withdrawal. The following MPS signals provide the plant with protection during an uncontrolled CRA withdrawal:

- high core power
- high core power rate
- high hot leg temperature

15.4.2.3.2 Input Parameters and Initial Conditions

RAI 15.04.01-3

A spectrum of initial conditions is analyzed to find the limiting reactivity insertion due to an uncontrolled CRA withdrawal. Key inputs of the uncontrolled CRA withdrawal evaluation are provided in Table 15.4-5 for the limiting MCHFR case and in Table 15.4-28 for the limiting RCS pressure case. The following initial conditions and assumptions ensure that the results have sufficient conservatism.

RAI 15.04.02-1, RAI 15.04.02-2

- Initial power level: 25 percent, 50 percent, 75 percent, and 102 percent of nominal power are analyzed in the uncontrolled CRA withdrawal evaluation. The power level for the limiting MCHFR and RCS pressure cases is 75 percent and 102 percent of nominal power, respectively.

RAI 15.04.02-1, RAI 15.04.02-2, RAI 15.04.06-1

- Reactivity insertion rate: The positive reactivity inserted by the CRA withdrawal is modeled as a constant reactivity addition beginning at the transient initiation. ~~The uncontrolled CRA withdrawal evaluation considers reactivity addition rates up to 21 pcm/s. This value corresponds to the maximum CRA withdrawal rate of 15 in./min.~~ The maximum rod speed of 15 inches/min corresponds to a maximum reactivity insertion of 21 pcm/s. However, to bound the reactivity insertion from possible boron dilution scenarios, a maximum reactivity insertion of 35 pcm/s is analyzed.
  - The reactivity insertion rate for the limiting MCHFR case is ~~1.0~~0.9 pcm/s.
  - The reactivity insertion rate for the limiting RCS pressure case is 15.2 pcm/s.
- Time in cycle: The BOC core conditions are implemented in the limiting uncontrolled CRA withdrawal cases. The least negative reactivity coefficients occur at the BOC, and provide the least amount of feedback to mitigate the power increase due to an uncontrolled CRA withdrawal.
- The turbine bypass system is not credited in this analysis to minimize heat removal by the secondary side.
- Conservative scram characteristics are used, including a maximum time delay, holding the most reactive rod out of the core, and using a bounding control rod drop rate.
- Allowances for instrument inaccuracy are accounted for in the analytical limits of mitigating systems in accordance with the guidance provided in Regulatory Guide (RG) 1.105.

The results from the thermal hydraulic evaluation are used as input to the subchannel analysis to determine the MCHFR for this event. The subchannel evaluation model is discussed in Section 15.0.2.

15.4.2.3.3 Results

RAI 15.04.01-3

The sequence of events for a limiting uncontrolled CRA withdrawal with respect to MCHFR is provided in Table 15.4-4. The sequence of events for a limiting uncontrolled CRA withdrawal with respect to RCS pressure is provided in Table 15.4-27. Figure 15.4-6 through Figure 15.4-11 show the transient behavior of key parameters for an uncontrolled CRA withdrawal.

RAI 15.04.02-1, RAI 15.04.02-1S1, RAI 15.04.02-2

The withdrawal of the regulating bank results in a reactivity insertion that increases reactor power. The power increase leads to a rise in RCS temperature, pressurizer level, and RCS pressure. Feedback from the rising fuel and moderator temperatures partially counteracts the reactivity insertion, slowing the power increase. For uncontrolled CRA withdrawal cases with higher reactivity insertion rates, the MPS trips the reactor on high pressurizer pressure or high power rate. These cases are non-limiting because the reactor is tripped before the maximum amount of reactivity can be inserted. The limiting combination of reactivity insertion and reactivity feedback produces the maximum possible power increase prior to trip. The power increase in the limiting MCHFR case is terminated by a reactor trip after a signal delay. The high hot leg temperature limit, the high pressurizer pressure limit, and high power limit are all reached during the reactor trip delay time. The MPS trips the reactor and actuates the DHRS during this event. The most limiting MCHFR occurs at the time of the power peak. The MCHFR remains above the design limit, and no fuel centerline melting is predicted for the uncontrolled CRA withdrawal.

The maximum RCS pressure case is an uncontrolled CRA withdrawal at power with a loss of normal AC power at transient initiation. The pressure for the maximum pressure case is demonstrated in Figure 15.4-12. The loss of AC power at the beginning of the transient trips the turbine and stops feedwater, reducing the heat removal by the secondary side. Simultaneously, the reactivity insertion causes a rapid rise in power. The reactor trips on high power rate, reaching the high pressurizer pressure setpoint almost simultaneously. The pressure continues to rise after the reactor trip, and peaks at the time a reactor safety valve (RSV) opens. Following the RSV opening and reactor trip, the RCS temperature and pressure steadily decrease. The maximum RCS pressure stays below the RPV design limit.

The uncontrolled CRA withdrawal at power cases that result in a reactor trip, actuate DHRS, and maintain stable core cooling.

15.4.2.4 Radiological Consequences

The normal leakage related radiological consequences of this event are bounded by the design basis accident analyses presented in Section 15.0.3.

15.4.2.5 Conclusions

The two applicable acceptance criteria for this AOO are met for the limiting uncontrolled CRA withdrawal cases. These acceptance criteria, followed by how the NuScale Power Plant design meets them are listed below.

15.4.3.4 Single Control Rod Assembly Withdrawal Analysis

15.4.3.4.1 Evaluation Models

The thermal hydraulic analysis of the plant response to a single CRA withdrawal is performed using NRELAP5. The NRELAP5 model is based on the design features of a NuScale module. The non-LOCA NRELAP5 model is discussed in Section 15.0.2. The relevant boundary conditions from the NRELAP5 analyses are provided to the downstream subchannel CHF analysis.

The subchannel core CHF analysis is performed using VIPRE-01. VIPRE-01 is a subchannel analysis tool designed for general-purpose thermal-hydraulic analysis under normal operating conditions, operational transients, and events of moderate severity. See Section 15.0.2 for a discussion of the VIPRE-01 code and evaluation model.

15.4.3.4.2 Input Parameters and Initial Conditions

RAI 15.04.01-3

A spectrum of initial conditions is analyzed to find the limiting reactivity insertion due to a single CRA withdrawal. Key inputs and the associated biases for the limiting single CRA withdrawal analys~~i~~es are provided in Table 15.4-8 with respect to MCHFR and Table 15.4-30 with respect to RCS pressure. The following initial conditions and assumptions ensure that the results have sufficient conservatism.

- Initial power level: 25 percent, 50 percent, 75 percent, and 102 percent of nominal power are analyzed to find the limiting cases.
  - The initial power level for the limiting MCHFR case is 75 percent of nominal power.
  - The initial power level for the limiting RCS pressure case is 102 percent of nominal power.
- Reactivity insertion rate: The positive reactivity inserted by the CRA withdrawal is modeled as a constant reactivity addition beginning at the transient initiation. The uncontrolled CRA withdrawal evaluation considers reactivity addition rates up to 12 pcm/s. This value bounds the 10.48 pcm/s that corresponds to the maximum CRA withdrawal rate of 15 in./min. The reactivity insertion rate for the limiting MCHFR case is 2.5 pcm/s, and the limiting RCS pressure case is the maximum 12 pcm/s.
- Time in cycle: The BOC core conditions are implemented in the limiting CRA withdrawal cases. The least negative reactivity coefficients occur at the BOC, and provide the least amount of feedback to mitigate the power increase due to a CRA withdrawal.
- Conservative scram characteristics are used, including a maximum time delay and holding the most reactive rod out of the core.
- The turbine bypass system is not credited in this analysis to minimize heat removal by the secondary side.

- Allowances for instrument inaccuracy are provided for setpoints of mitigating systems in accordance with RG 1.105.
- The limiting axial and radial power shapes are used in the subchannel analysis to ensure a conservative evaluation of the SAFDLs.

The results from the thermal hydraulic evaluation are used as input to the subchannel analysis to determine the limiting MCHFR and LHGR for this event. The subchannel evaluation model is discussed in Section 15.0.2.

15.4.3.4.3 Results

RAI 15.04.01-3, RAI 15.04.03-1

The sequence of events for a ~~representative~~ single CRA withdrawal that results in the minimum MCHFR is provided in Table 15.4-7. The sequence of events for a single CRA withdrawal that results in the maximum RCS pressure is provided in Table 15.4-29. Figure 15.4-13 through Figure 15.4-19 and Figure 15.4-35 show the transient behavior of key parameters for this event.

The withdrawal of a single CRA that results in a limiting MCHFR has an initial power of 75 percent. The withdrawal of the CRA results in a reactivity insertion that increases reactor power. The power increase leads to a rise in RCS temperature, pressurizer level, and RCS pressure. The CRA misalignment with the rest of the bank causes an asymmetry in the core, where power peaking increases in the location of the withdrawn CRA. Reactivity feedback from the rising fuel and moderator temperatures partially counteracts the reactivity insertion, slowing the power increase. For CRM cases with higher reactivity insertion rates, the MPS trips the reactor on high reactor power or high power rate. These cases are non-limiting because the reactor is tripped before the maximum amount of reactivity can be inserted. The limiting combination of reactivity insertion and reactivity feedback produces the maximum possible power increase without reaching the high reactor power or high power rate limits. The power increase is terminated by the high hot leg temperature trip. The RCS pressure reaches the high pressurizer pressure limit simultaneously.

RAI 15.04.03-1

The MPS high hot leg temperature signal trips the reactor and actuates the DHRS. The most limiting MCHFR (Figure 15.4-35) occurs at the moment before the power begins to decrease. The MCHFR remains above the design limit, and no fuel centerline melting is predicted for the withdrawal of a single CRA. The LHGR calculated for the single CRA withdrawal is below the calculated limits for cladding strain. The maximum RCS pressure occurs approximately 7 seconds later, and is followed by a steady decrease in RCS temperature and pressure. The limiting RCS pressure for a withdrawal of a single CRA occurs in a case that has an initial power of 102 percent, and assumes a loss of normal AC power occurring at the reactor trip. The loss of normal AC power contributes to a higher pressure peak due to the isolation of the secondary side, which minimizes the heat removal capability of the secondary side. This limiting pressure is plotted in Figure 15.4-20, and shows margin to the RPV design limit.

RAI 15.04.01-3

Table 15.4-25: Sequence of Events for Limiting RCS Pressure Case (15.4.1 Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power or Startup Condition)

Event	Time [s]
Rod withdrawal initiates	0
High power (25%) limit reached	948
Reactor trip actuation	950
Maximum power reached	950
Reactor trip complete	953
Maximum RCS pressure reached	963

RAI 15.04.01-3

Table 15.4-26: Key Inputs for Limiting RCS Pressure Case (15.4.1 Uncontrolled Control Rod Assembly Withdrawal from a Subcritical or Low Power or Startup Condition)

Parameter	Nominal	Bias
Initial power	1 MW	N/A[1]
Pressurizer pressure	1850	N/A
Pressurizer level	60%	+8%
RCS average temperature	N/A	420°F[2]
MTC	6.0 pcm/°F	Most Positive
FTC	-1.40 pcm/°F	Least Negative
[1] A spectrum of initial powers is analyzed, and this value provided the limiting RCS pressure results.		
[2] Minimum temperature for criticality.		

RAI 15.04.01-3

Table 15.4-27: Sequence of Events for Limiting RCS Pressure Case (15.4.2 Uncontrolled Control Rod Assembly Withdrawal at Power)

Event	Time [s]
Rod withdrawal initiates	0
Loss of AC power	0
High power rate limit reached	5
High pressurizer pressure limit reached	5
High power limit reached	6
Reactor trip actuation	7
Reactor safety valve opens	9
Maximum RCS pressure reached	9
Reactor safety valve reseats	16

RAI 15.04.01-3

Table 15.4-28: Key Inputs for Limiting RCS Pressure Case (15.4.2 Uncontrolled Control Rod Assembly Withdrawal at Power)

Parameter	Nominal	Bias
Initial power	160 MW	+2%
RCS flowrate	See Table 15.0-6 for range	1205.4 lbm/s (low[1])
RCS pressure	1850 psia	+70 psia
Pressurizer level	60%	+8%
MTC	0.0 pcm/°F	Most Positive
FTC	-1.4 pcm/°F	Least Negative
[1] RCS flow rate is near the minimum for 102% power.		

RAI 15.04.01-3

Table 15.4-29: Sequence of Events for Limiting RCS Pressure Case (15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)

Event	Time [s]
Rod withdrawal initiates	0
Loss of AC power	0
High pressurizer pressure limit reached	5
Reactor trip actuation	7
Reactor safety valve opens	9
Maximum RCS pressure reached	10
Reactor safety valve reseats	17

RAI 15.04.01-3

Table 15.4-30: Key Inputs for Limiting RCS Pressure Case (15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)

Parameter	**Nominal**	**Bias**
Initial power	160 MW	+2%
RCS flowrate	See Table 15.0-6 for range	1205.2 lbm/s (low[1])
RCS pressure	1850 psia	+70 psia
Pressurizer level	60%	+8%
MTC	-7.0 pcm/°F[2]	Least Negative
FTC	-1.4 pcm/°F	Least Negative
[1] RCS flow rate is near the minimum for 102% power.		
[2] Power dependent MTCs are used in the single CRA withdrawal analyses. The -7 pcm/°F value corresponds to the initial power of 75%.		