RAIO-0517-54212

May 24, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information (eRAI No. 8765) on the NuScale Design Certification Application

REFERENCE: 1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 09 (eRAI No. 8765)," dated April 25, 2017

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. 8765:

- 15.04.03-1

This letter and the enclosed response makes 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,

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

Distribution: Greg Cranston, NRC, TWFN-6E55
Samuel Lee, NRC, TWFN-6C20
Rani Franovich, NRC, TWFN-6E55

Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8765
RAI 15.04.03-1

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8765 - RAI 15.04.03-1

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

eRAI No.: 8765
Date of RAI Issue: 04/25/2017

NRC Question No.: 15.04.03-1

Standard Review Plan (SRP) Section 15.4.3, “Control Rod Misoperation (System Malfunction or Operator Error),” provides guidance for complying with Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criteria 10, “Reactor design”; 13, “Instrumentation and control”; 20, “Protection system functions”; and 25, “Protection system requirements for reactivity control malfunctions.” SRP Section 15.4.3 directs the reviewer to review results of the analyses, including, in part, plots of critical heat flux for the limiting fuel rod. This is necessary to confirm compliance with the aforementioned GDC.

FSAR Tier 2, Figure 15.4-27 is titled “Critical Heat Flux Ratio (15.4.3 Control Rod Misoperation, Control Rod Assembly drop),” but it appears to show fuel reactivity instead. As a result, no plot of critical heat flux ratio (CHFR) is provided for FSAR Section 15.4.3. To demonstrate compliance with GDC 10, 13, 20, and 25, please add a plot of CHFR to the FSAR and correct the title of FSAR Tier 2, Figure 15.4-27.

NuScale Response:

FSAR Figure 15.4-19 and FSAR Figure 15.4-27 were incorrectly labeled "Critical Heat Flux Ratio," but should have been labeled "Fuel Reactivity." The titles for FSAR Figure 15.4-19 and FSAR Figure 15.4-27 have been corrected. A new figure for CHFR for the single control rod assembly withdrawal (FSAR Figure 15.4-35) and a new figure for CHFR for the control rod assembly drop (FSAR Figure 15.4-36) have been added to FSAR Section 15.4.3.

Impact on DCA:

FSAR Sections 15.4.3.4.3, 15.4.3.5.3, and FSAR Figures 15.4-19, 15.4-27, 15.4-35, and 15.4-36 have been revised as described in the response above and as shown in the markups provided in this response.

   - 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

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The sequence of events for a representative single CRA withdrawal that results in the minimum MCHFR is provided in Table 15.4-5. 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.

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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.

15.4.3.5 Control Rod Assembly Drop Analysis

15.4.3.5.1 Evaluation Models

The thermal hydraulic analysis of the plant response to a CRA drop 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 15.0.2.3 for a discussion of the VIPRE-01 code and evaluation model.

15.4.3.5.2 Input Parameters and Initial Conditions

A spectrum of initial conditions is analyzed to find the limiting reactivity insertion due to a single or multiple CRA drop. The initial conditions of the CRA drop evaluation result in a conservative calculation. Key inputs and the associated biases for the limiting CRA drop analysis are provided in Table 15.4-8. The following initial conditions and assumptions ensure that the results have sufficient conservatism.

- The initial power for the limiting CRA drop case is 102 percent of nominal power. 25 percent, 50 percent, 75 percent, and 102 percent of nominal power are analyzed to find the limiting cases.

- Reactivity insertion rate: A single CRA drop is more limiting than the drop of a bank of CRAs. The smaller negative reactivity insertion delays the detection by the MPS, allowing the regulating CRA bank to insert the most positive reactivity before the reactor trips. For the bounding single CRA drop analysis, the minimum possible rod worth of 474 pcm is assumed for the dropped rod. The drop rate of the CRA is assumed to be the same drop rate of the CRA during a reactor trip.
- Time in cycle: The EOC core conditions are implemented in the limiting CRA drop cases. The most negative reactivity coefficients occur at the EOC and provide the most reactivity feedback to mitigate the power decrease due to a CRA drop.
- 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.

15.4.3.5.3 Results

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The sequence of events for the bounding single CRA drop is provided in Table 15.4-7. Figure 15.4-21 through Figure 15.4-27 and Figure 15.4-36 show the transient behavior of key parameters for a single CRA drop. Following a CRA drop in the NuScale reactor, there is a rapid drop in the core reactivity and power. The high power rate limit is reached just after 1 second into the transient. The MPS sends a reactor trip signal, terminating the event. At lower powers, the power decrease is less pronounced, and the reactor does not trip. In the lower power cases, the regulating CRA bank brings the reactor back to the initial power after an initial power overshoot. However, these cases are non-limiting with respect to MCHFR.

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Exceeding the RPV design pressure is not a concern for the limiting rod drop case, which is demonstrated in the RCS pressure plot. The MCHFR for the limiting case, Figure 15.4-36, remains above the design limit. The LHGR calculated for the limiting rod drop case is below the limits for fuel melting and cladding strain.

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Figure 15.4-19: ~~CHFR~~Fuel Reactivity
(15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)

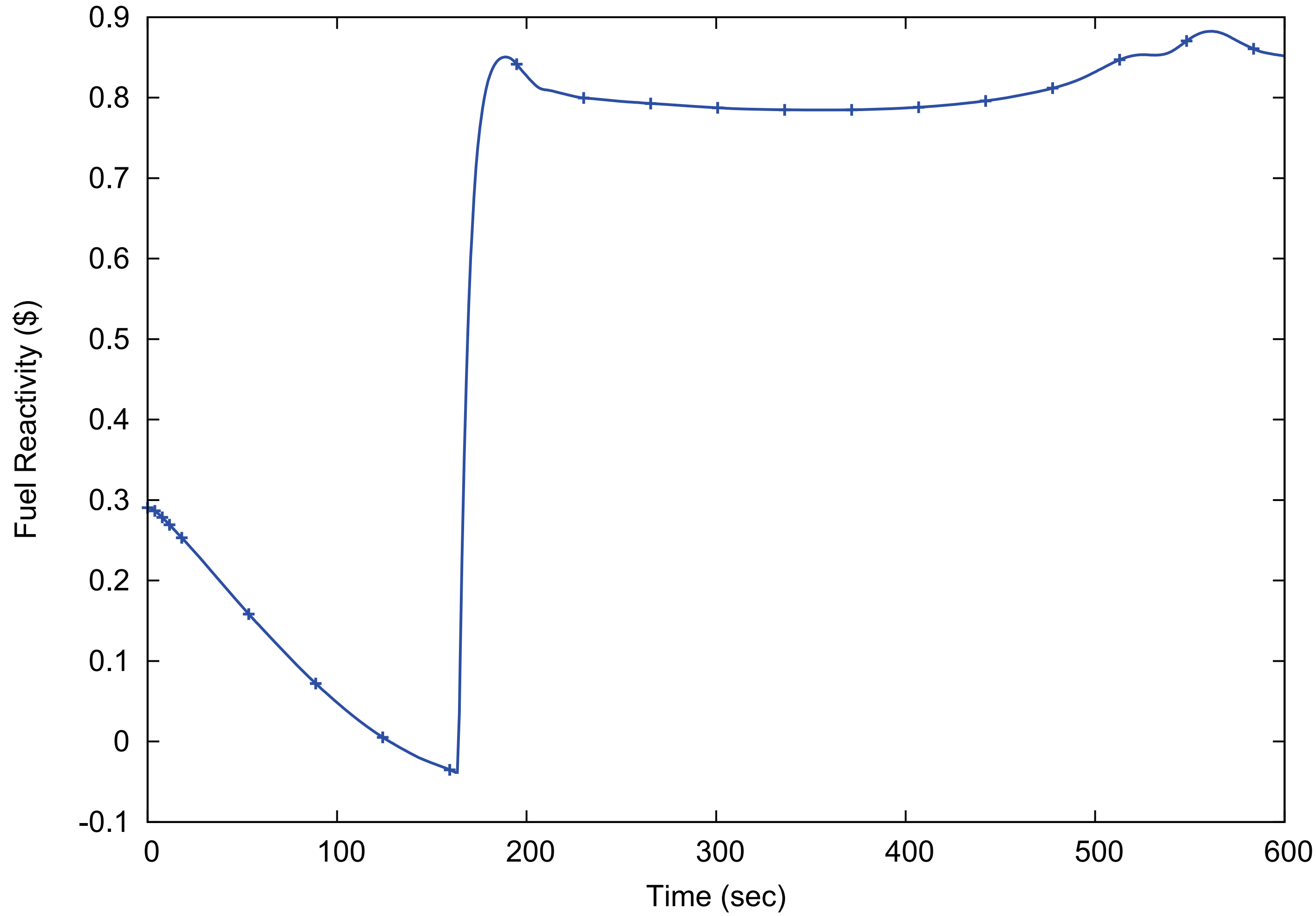

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Figure 15.4-27: ~~Critical Heat Flux Ratio~~Fuel Reactivity
(15.4.3 Control Rod Misoperation, Control Rod Assembly drop)

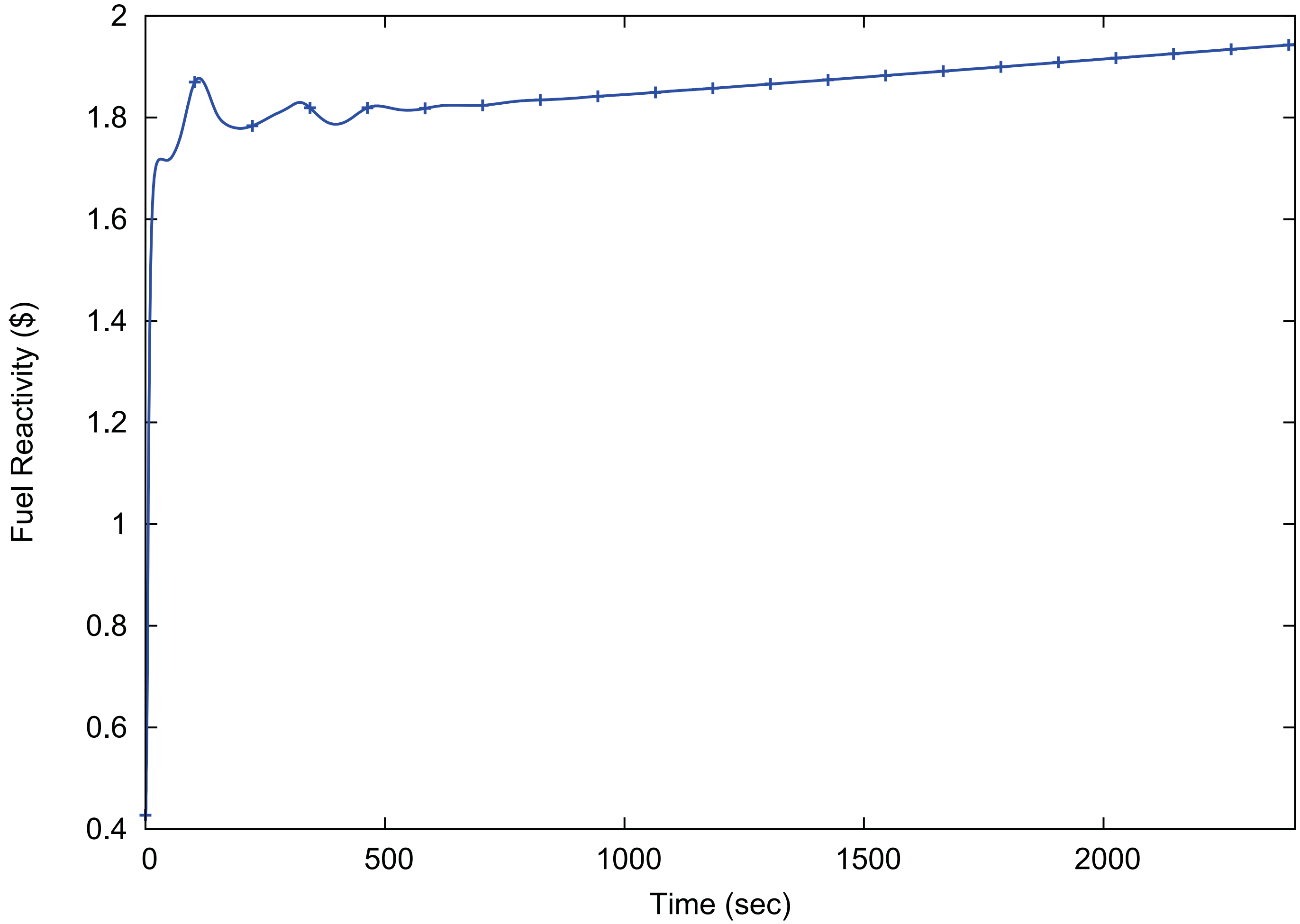

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Figure 15.4-35: Critical Heat Flux Ratio (15.4.3 Control Rod Misoperation, Single Control Rod Assembly Withdrawal)

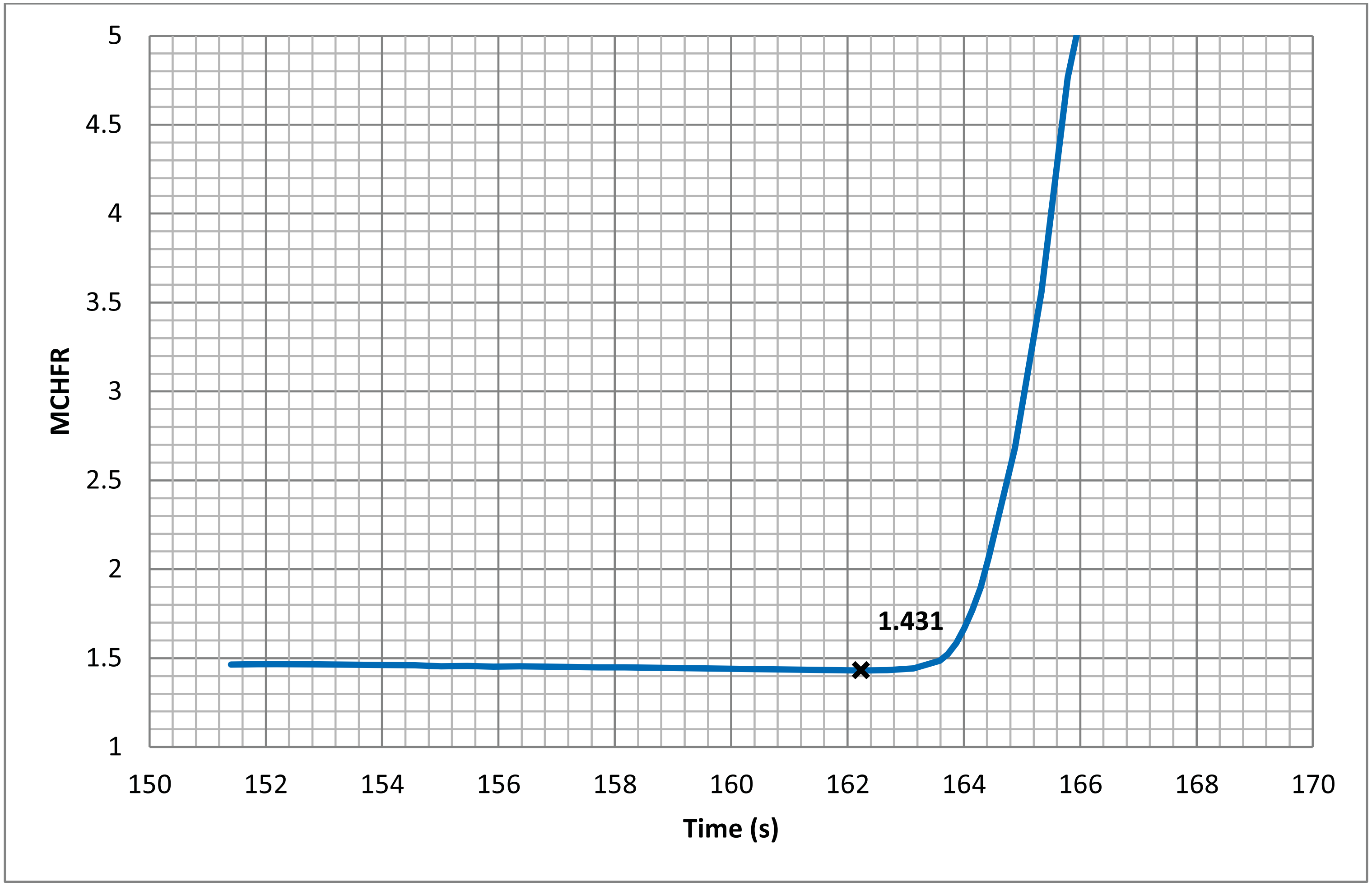

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Figure 15.4-36: Critical Heat Flux Ratio (15.4.3 Control Rod Misoperation, Control Rod Assembly drop)