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Evaluation of Joint Cyber/Safety Risk in Nuclear Power Systems

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ABSTRACT

This report presents an analysis of the Emergency Core Cooling System (ECCS) for a generic Boiling Water Reactor (BWR)-4 NPP. The Electric Power Research Institute (EPRI) developed Hazards and Consequences Analysis for Digital Systems (HAZCADS) process is applied to the ECCS and its subsystems to identify unsafe control actions (UCAs) which act as possible cyber events of concern. The analysis is performed for two design basis events: Small-break Loss of Coolant Accident (SLOCA) and general transients (TRANS), such as unintended reactor trip.

In previous work, HAZCADS UCAs were combined with other cyber-attack analysis to develop a risk-informed approach [1]; however, this was for a single system. This report explores advanced systems engineering modeling approaches to model the interactions between digital assets across multiple systems which may be targeted by cyber adversaries. The complex and interdependent design of digital systems has the potential to introduce emergent cyber properties that are generally not covered by hazard analyses nor formal nuclear Probabilistic Risk Assessment (PRA). The R&D and supporting analysis presented here explores approaches to predict and manage how interdependent system properties effect risk.

To show the potential impact of a successful cyber-attack to formal PRA event tree probabilities, HAZCADS analysis was also used. HAZCADS was also used to model the automatic depressurization system (ADS) automatic actuation. This analysis extended to an integrated system analysis for common-cause failure (CCF). In this aspect, the HAZCADS analysis continued by analyzing plant design details for system connectivity in support of critical plant functions. A dependency matrix was developed to depict the integrated functionality of the interconnected systems. Areas of potential CCF are indicated. Future work could include adversary attack development to show how CCF could be caused, resulting in PRA events.

Across the multiple systems that comprise the ECCS, the analysis shows that the change in such probabilities was very different between systems. This indicates that some systems have a larger potential risk impact from successful cyber-attack or digital failure, which indicates a need for these systems to have a higher priority for design and defensive measures. Furthermore, we were able to establish that a risk analysis using any arbitrary threat model establishes an ordering of components with regard to cyber-risk. This ordering can be used to influence the overall system design with an eye to lowering risk, or as a way to understand real-time risk to operational systems based on a current threat landscape.

Expert knowledge of both the analysis process and the system being analyzed is required to perform a HAZCADS analysis. The need for a tiered risk analysis is demonstrated by the results of this report.

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ACRONYMS AND DEFINITIONS

Acronym	Definition
ADS	Automatic Depressurization System
AOO	Anticipated Operation Occurrences
BWR	Boiling Water Reactor
CCF	Common-Cause Failure
CDA	Critical Digital Asset
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CS	Containment Spray
CST	Condensate Storage Tank
DCS	Digital Control System
DCSA	Defensive Computer Security Architecture
DEG	Digital Engineering Guide
DiD	Defense-in-Depth
ECCS	Emergency Core Cooling System
EOP	Emergency Operating Procedures
EPRI	Electric Power Research Institute
ESF	Event Sequence Frequency
FTA	Fault Tree Analysis
HAZCADS	Hazards and Consequence Analysis for Digital Systems
HAZOP	Hazards and Operability Studies
HPCI	High-Pressure Coolant Injection
IAEA	International Atomic Energy Agency
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LPCI	Low-Pressure Coolant Injection
NEI	Nuclear Energy Institute
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NSSSS	Nuclear Steam Supply Shutoff System

Acronym	Definition
P&ID	Piping and Instrumentation Diagrams
PRA	Probabilistic Risk Assessment
R&D	Research and Development
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RVIS	Reactor Vessel Instrumentation System
SIFT	System-Theoretic Informed Fault Tree
SLOCA	Small Break Loss of Coolant Accident
SPAR	Standardized Plank Analysis Risk
SRV	Safety Relief Valve
SSCs	Systems, Structures, And Components
SSMP	Safe Shutdown Makeup Pumps
STPA	Systems-Theoretic Process Analysis
TRANS	Transients
UCA	Unsafe Control Action

1. INTRODUCTION

One of the goals of utilizing a risk-informed cyber security approach is that the risk results can be used to identify systems and components which have the greatest effect on risk and can be used to inform cyber security analysis. For decades, plants have taken risk-informed approaches to safety allowing licensees to quantify their risk posture. This is achieved through a systematic and structured risk assessment process that includes technical elements such as accident sequence analysis, success criteria analysis, data analysis, and consequence quantification [2], [3]. Unlike safety analyses that benefit from thousands of reactor-years of operational data and experience, cyber security data is largely unavailable

Nuclear power plants (NPPs) use redundant and diverse systems to ensure that critical safety functions are achieved. In past work, we have proposed that a risk-informed approach to cyber security might leverage risk results and insights from the safety analysis. However, digital modifications introduce layers of complexity not previously encountered in the plant risk assessment model. Systems-Theoretic Process Analysis (STPA) and HAZards and OPERability studies (HAZOP) provide hazard methodologies that can assess the complexity of digital modifications. Additionally, STPA and HAZOP provide results which can be incorporated into existing risk assessment models [4], [5].

This report performs an analysis of the ECCS for a generic BWR-4 NPP [6]. The EPRI developed HAZCADS process is applied to the ECCS and its subsystems to identify UCAs [4]. Unsafe control actions are signals sent by digital controllers to process components that create a system function misbehavior, thus, UCAs can act as possible cyber events of concern. The analysis is performed for two design basis events: SLOCA and general TRANS, such as unintended reactor trip. Risk-informed results and insights are applied to the event sequences for SLOCA and TRANS to identify low safety significant and potential safety significant systems and components.

Additionally, the analysis seeks advanced systems engineering modeling approaches for interactions between digital assets across multiple systems which may be targeted by cyber adversaries. Interdependent system properties are generally not considered in risk assessments, yet they are the key to CCF from digital failure or cyber-attack which must be prevented either in system design or security measures. The analysis presented here examines approaches to evaluate how interdependent system properties effect risk.

1.1. Background on Cyber Security Guidance in the Nuclear Industry

The U.S. Nuclear Regulatory Commission (NRC) has provided licensees with regulatory requirements to establish and maintain cyber security programs in accordance with Title 10 of the Code of Federal Regulations (CFR) 73.54 [7]. Regulatory Guide 5.71 provides NRC guidance for completing a cyber security program for nuclear facilities in accordance with 10 CFR 73.54 [8]. Industry guidance towards satisfying 10 CFR 73.54 has been provided by the Nuclear Energy Institute (NEI) 08-09 Rev 6 [9] whereby licensees identify critical digital assets (CDAs) under the process outlined in NEI 10-04 Revision 2 [10]. Once identified, defensive control measures are derived from National Institute of Standards and Technology Special Publication (NIST SP) 800-53 Revision 4 [11] and NIST SP 800-82 [12] if technically feasible.

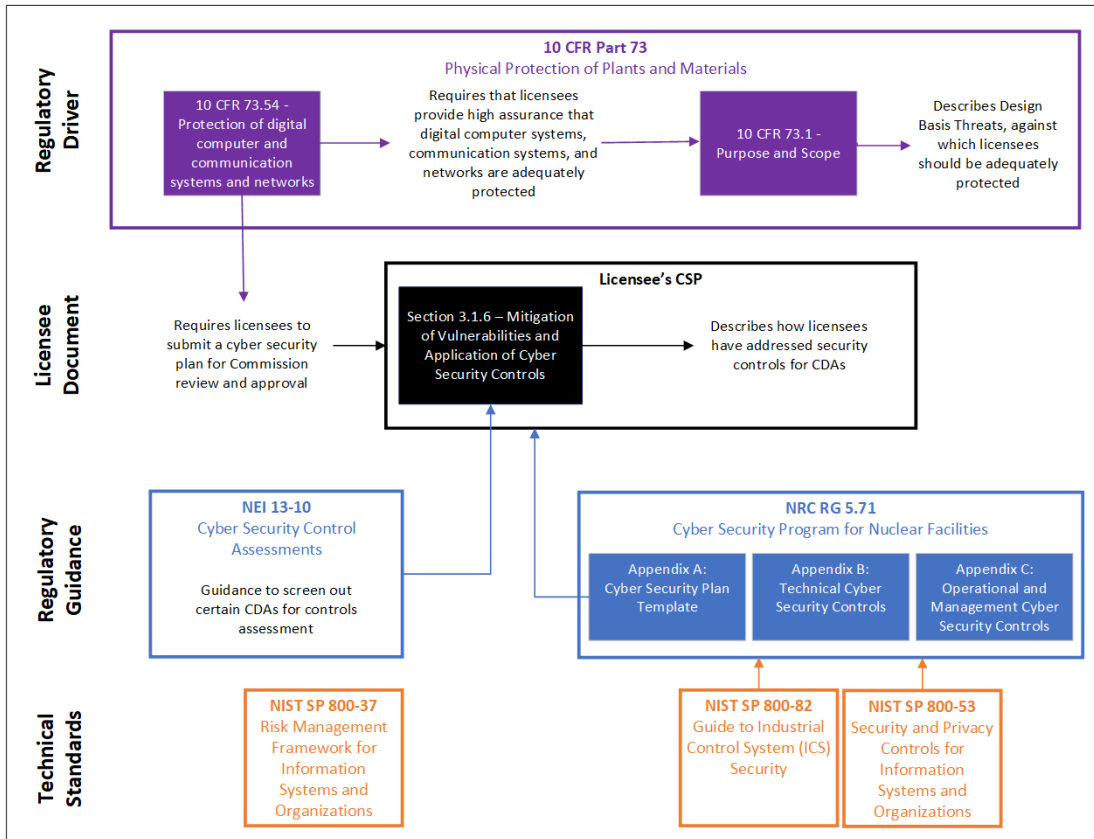


Figure 1: US cyber security risk management approach

Figure 1 presents the current US risk management approach for cyber security. The processes of digital asset identification are deterministic, meaning that digital asset categorization is based solely on the system classification. Furthermore, the application of control methods to digital assets is bottom-up, which often results in control measures that are not proportionate with the risk of that specific digital asset. Cyber security programs, as a result, consist of large lists of CDAs and a process of applying security controls that is based on quantity of controls instead of control efficacy. The prescriptive process currently utilized across the nuclear industry does not support risk-informed approaches, however the licensee is allowed to submit alternate (perhaps risk-informed) approaches [9].

1.2. Assumptions

The analysis presented here includes several assumptions with respect to the safety assessment that affect the risk results and insights. These assumptions are made either to simplify the analysis or because specific system information was not present at the time of this analysis.

1.2.1. Safety

The following safety assumptions were made for this analysis:

- All modeled cyber events occur during defined initiating events. Modeling cyber events which may act as initiating events increases the complexity of the risk assessment because new accident sequences would need to be predicted, system success criteria determined, along with many other analyses that are beyond the scope of this report. However, the HAZCADS analysis in this

report, coupled with the possible CCF concerns identified in this report, support follow on work to identify and mitigate cyber-attacks that might result in initiating events.

- System timing considerations are not considered in this analysis, as timing is not considered in nuclear industry PRAs.
- Human operators would not impact ECCS system responses during the cyber events. It is assumed that all ECCS and subsystem actuations are automatic and result solely from the digital assets.

1.2.2. Security

This analysis identifies unsafe actions that can occur in a system and cut sets of those actions that may lead to consequence if exploited by an attacker. The following security assumptions were made for this analysis:

- The methods by which an adversary can exploit system susceptibilities (i.e. attack paths and scenarios) are not considered in this report but techniques to describe such have been previously demonstrated [1].
- In this analysis, we assume the CS system to be completely analog.

1.3. Structure of this Report

Section 2 of this report provides background of the methodologies and approaches used throughout the analysis. Section 3 presents the STPA and HAZCADS process for the ECCS and discusses the risk results, insights, and Defense-in-Depth (DiD) assessment of the hypothetical ECCS digital system. Section 4 expands the analysis in Section 3 to interdependent system properties and provides a DiD assessment of the interdependent system properties. Finally, Section 6 provides a conclusion of the analysis and offers future areas of R&D related to this work.

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2. BACKGROUND

Relying on analysis of a detailed system design, STPA identifies UCAs, which link to system hazards, which in turn are linked to losses (specific control system impacts from UCAs). To quantify the risk of abnormal states, PRA relies on fault and event trees. System fault trees that support PRA rely on detailed system design, component failure rates, and other statistical data to infer the probabilities of faults and their effects. For this report, the STPA losses and PRA accidents are linked and provide common endpoints for the analysis. This section gives an overview of both STPA and PRA and describe how they are combined.

2.1. Overview of PRA

The nuclear industry uses a powerful tool, PRA, to assess risk of core damage under various plant conditions and operating states. The PRA models typically include fault and event trees to quantify the risk of abnormal states that occur at NPPs to ensure the safety of the plant and minimal (or no) risk to the public.

Development of PRA models employ a systematic and structured process that consists of several technical elements, in the following descriptions [13]. Each technical element will, in the future, require consideration for risk-informed cyber security.

- *Initiating event analysis* – identify and quantify events that could directly or indirectly lead to a consequence (e.g., core damage at a NPP).
- *Accident sequence analysis* – describe the specific scenarios that lead to a consequence following each initiating event; ensure system-specific dependencies are represented in the accident sequence.
- *Success criteria analysis* – define the system-specific measures of success and failure that support the accident sequence development.
- *Systems analysis* – identify the causes of failure for all system(s) components represented in the initiating event analysis and accident sequence analysis.
- *Human reliability analysis* – ensure that the impacts of human actions are represented in the assessment of risk.
- *Data analysis* – provide estimates of the parameters used to determine the probabilities of basic events representing component failures and non-availabilities modeled in the PRA.
- *Quantification* – provide an estimate of the consequence frequency based upon the system-specific accident sequences resulting in a consequence. Quantification also entails uncertainty and sensitivity analysis to evaluate the system-level risk impact from parameter and model uncertainties.
- *Large Early Release Frequency* – identify and quantify the contributors to large early releases, based upon the plant-specific core damage scenarios.

2.1.1. Fault Trees

Fault trees contain the logic models that contain the system level failures and interdependencies of systems and components. Boolean logic is used to determine the failure probability of a component, sub-system, or the entire NPP. Failure rates for each component are included, which form the basis of the results that flow through the analysis. Typically, fault trees model the systems, structures, and components (SSCs), operator actions, and common-cause failure events that contribute to a system

hazard or loss of system function. Fault trees can grow to be complex and include dependencies of various support systems, such as instrument air or power supplies.

2.1.2. Event Trees

Event trees model various initiating events and the accident progression or sequence of events that lead to plant endstates, which contain both success sequences and core damage sequences. Event trees are binary in nature where each decision (branch) point either occurs or does not occur. Branch points are often represented by fault trees (see Section 2.1.1). Each event is put in the order it occurs and results in a unique endstate. There may be hundreds of event trees and accident sequences included in a PRA model which model all the unique permutations of an accident. Event sequences are quantified using the initiating event frequency and probability of the branching (based on the fault trees).

2.2. Overview of STPA

The STPA methodology has four main steps (Figure 2), described in the following sections. Detailed descriptions of the steps are provided in the STPA Handbook [14].

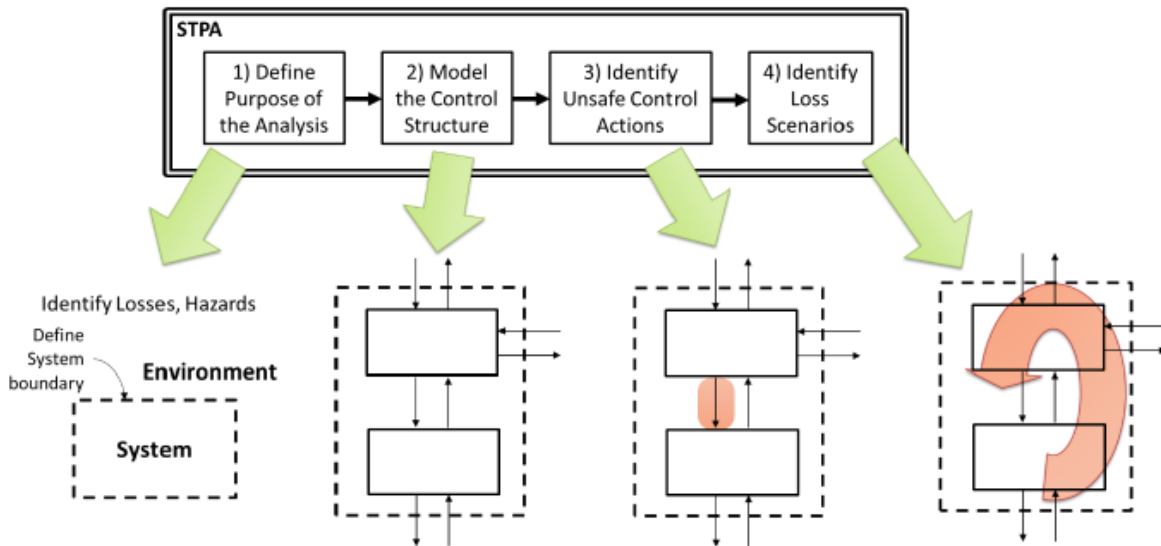


Figure 2. Overview of the Basic STPA Method [14]

2.2.1. STPA Step 1 – Define Purpose of the Analysis

Step 1 of STPA is meant to scope the analysis. Based on several studies of NPPs, losses tend to be the same or very similar from one plant to another. The losses typically of concern for NPPs are provided in Table 2-1. Note that safety and risk assessments (e.g. PRA) performed at NPPs typically only consider one loss or consequence at a time. One of STPA's strengths is that it can consider multiple losses or consequences in parallel. The losses provided in Table 2-1 are adopted for the current study.

Table 2-1. Losses for a Nuclear Power Plant

Losses	
L1	Core Damage
L2	Large Early Release
L3	Lost Generation
L4	Reputation Damage
L5	Personnel Injury or Death
L6	Major Equipment Damage

The STPA Handbook defines losses as:

- “A loss involves something of value to stakeholders. Losses may include a loss of human life or human injury, property damage, environmental pollution, loss of mission, loss of reputation, loss or leak of sensitive information, or any other loss that is unacceptable to the stakeholders” [14].

After defining losses, the next step is to define the hazards. The analyzed system and the system boundary need definition before identifying the hazards. The STPA handbook defines hazards and systems as follows:

- “A hazard is a system state or set of conditions that, together with a particular set of worst-case environmental conditions, will lead to a loss” [14].
- “A system is a set of components that act together as a whole to achieve some common goal, objective, or end. A system may contain subsystems and may also be part of a larger system” [14].

The systems being analyzed are BWR safety systems. The hazards associated with the NPP safety systems are shown in Table 2-2. Each hazard is provided an identifier (for quick reference in subsequent sections), the hazard description, and the losses that are associated with the hazard.

Table 2-2. Nuclear Power Plant Hazards

H#	Description	Link to Losses
H1	Plant Releases Radioactive Material	[L1, L2]
H2	Plant Shutdown	[L3, L4]
H3	Plant Physically Damaged, Degraded, or Needs Repair	[L1-L6]
H3.1	Reactor Internal Damage	[L1, L3, L4, L6]
H3.2	Equipment Damage	[L3, L4, L6]
H3.3	System Structure Damage	[L3, L4, L6]
H3.4	Containment Damage	[L1-L6]
H4	Plant Violates Regulatory Licensing Basis	[L3, L4]
H5	Plant Releases Kinetic Energy (e.g., explosion)	[L1-L6]

An important note should be made with respect to mapping hazards to losses. For example, Table 2-2 shows that Hazard H3.2, Equipment Damage, maps to Loss L3, Lost Generation. The STPA Losses-Hazards mapping is not intended to imply that if H3.2 occurs, then generation loss will result, simply that generation loss has the potential to happen. For each potential loss, the DiD

present at NPPs, and the many SSCs help prevent losses from occurring. Thus, there is not always a linear relationship between hazards and losses for NPPs.

For example, in response to a SLOCA, the reactor will first attempt to use the feedwater system. If the feedwater does not respond, then High-Pressure Coolant Injection (HPCI). If HPCI fails, then ADS, Residual Heat Removal (RHR) in Low Pressurize Coolant Injection (LPCI) mode, Safe Shutdown Makeup Pumps, Containment Sprays (CS), venting, and several operator actions are used to prevent core damage. Furthermore, there are several branching scenarios, timing considerations, and procedures that factor into the specific accident scenario occurring.

Drawing the comparison to STPA definitions, Loss L1, Core Damage, would only occur when the multitude of systems needed to prevent core damage incur a hazard that results in loss of function or degraded system response. This is the advantage of the event tree/fault tree approaches used in PRA where the dependencies and success/failure of systems are used to predict plant damage states, such as core damage. Other losses may not require such a complex approach.

2.2.2. STPA Step 2 – Model the Control Structure

The STPA handbook, Chapter 2 [14], page 22, defines a hierarchical control structure (also known simply as a control structure) as, “a system model that is composed of feedback control loops. An effective control structure will enforce constraints on the behavior of the overall system.” The control structure combines information from several different sources of documentation at NPPs. A list of documentation typically used for developing the control structure is provided below:

- System Notebooks
- Piping and Instrumentation Diagrams (P&ID)
- Digital System Block Diagrams
- Plant procedures (e.g., Anticipated Operation Occurrences (AOO), Emergency Operating Procedures (EOP), etc.)

The preceding list is not intended to be exhaustive but highlight the primary sources of information used for STPA. Another tool used to develop the control structures is expert elicitation, which is not always documented. Figure 3 presents the fundamental information that should be captured by the control structure. Process components should be mapped to their controllers while additionally recognizing the feedback loops that also have an impact on the system. Note that the hierarchy of control is also modeled in Figure 3 as the human operator can take precedent over the controller.

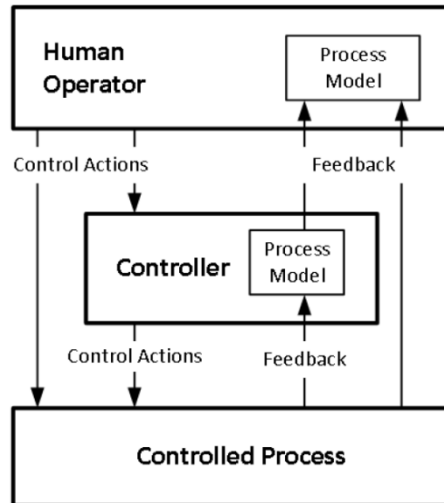


Figure 3: Control structure for a process with a human operator and controller [4]

2.2.3. STPA Step 3 – Identify UCAs

Page 35 of the STPA Handbook [14] defines UCAs as, “a control action that, in a particular context and worst-case environment, will lead to a hazard.” There are four ways a control action can be unsafe:

- Not providing the control action leads to a hazard (Needed, Not Provided)
- Providing the control action leads to a hazard (Provided, Not Needed)
- Providing a potentially safe control action but too early, too late, or in the wrong order
- The control action lasts too long or is stopped too soon (for continuous control actions, not discrete ones)

When identifying the unsafe control actions, the analyst should consider all the scenarios in which the system may be used, such as: stand-by, initiation, steady-state operation, trip/coast down, maintenance, etc. There are several characteristics of UCA tables to highlight. First, each of the column headers refers to one of the four ways a control action can be unsafe. Second, each UCA follows a general formula, as shown below:

$$\langle \text{Controller} \rangle + \langle \text{Type} \rangle + \langle \text{Control Action} \rangle + \langle \text{Context} \rangle . \langle \text{Link to Hazards} \rangle$$

The first three parts of the UCA formula are “fill in the blank”, meaning that STPA prescribes these parts of the formula given the structure of the STPA analysis. The “critical thinking” part of the UCA is the $\langle \text{Context} \rangle$ and $\langle \text{Link to Hazards} \rangle$. The context requires expert knowledge of system operation to know the limits or bounds of system operation which would cause the control action to be unsafe. The link to hazards identifies the hazard that would result if the UCA were to occur and is important when predicting accident sequences.

2.2.4. STPA Step 4 – Identify Loss Scenarios

Page 42 of the STPA Handbook [14] defines loss scenarios as, “... the causal factors that can lead to the unsafe control actions and to hazards.” Two types of loss scenarios should be considered:

1. Why would unsafe control actions occur?
2. Why would control actions be improperly executed or not executed, leading to hazards?

Step 4 of the STPA considers how feedback is collected, how it is processed, how control actions are derived, and how control actions are executed. Thus, STPA Step 4 considers the causes that lead to unsafe control actions.

Controllers must rely on system feedback to know how the system is behaving and then send control actions when deviations are present. Loss scenarios may consider what happens when a controller *believes* that the process is not performing at its desired set points. The controller's process *belief* is dependent on the feedback signals it receives. Loss scenarios may also consider what happens when a controller's process model is changed or implemented incorrectly.

When considering cyber security analysis, several different loss scenarios and attack vectors would need to be considered, including the scenarios described previously. Adversaries can attack: the sensors responsible for the feedback; the process model (e.g., the controller's mathematical framework); the control algorithm (e.g., the controller's actions being sent based on the feedback and process model); or the actuators in the controlled process. Depending on an adversary's tactics, techniques, and procedures, the adversary can utilize just one attack vector, or it may need to utilize several attack vectors to achieve their goal.

Consider an example unsafe control action in which a controller sends Decrease Valve Position signal when pump flow is adequate. The cyber-attack could take several approaches to executing this UCA:

1. Why would unsafe control actions occur?
 - a. Sensor has been compromised during the supply chain resulting in flow being measured incorrectly by +1000 gpm.
 - b. Sensor has been miscalibrated during maintenance by faulted software.
 - c. Controller process model improperly translates the feedback signals.
2. Why would controls actions be improperly executed or not executed, leading to hazards?
 - a. (See previous items 1a through 1c)
 - b. Control algorithm has been reprogrammed to always decrease valve signal when reaching desired flow.
 - c. Controller has been adjusted to always decrease the signal when exiting the controller.
 - d. The actuator is faulted to always reduce the signal to the control valve.

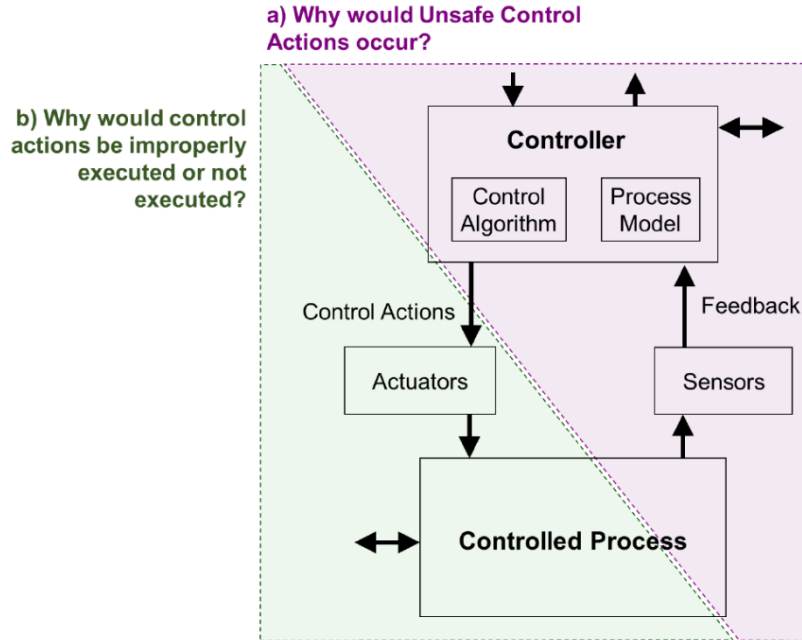


Figure 4. Types of Scenarios Used for Consideration when Identifying Loss [14]

Each of the causal scenarios described in steps 1 and 2 previously cause the example UCA, and this list is not exhaustive. The possibilities by which one UCA may occur from a cyber-attack are not easily bounded. However, the combination of STPA with PRA can help prioritize UCAs and corresponding cyber-attack analysis by linking the UCAs with PRA events and faults. The UCAs would represent attacker goals and cyber security experts identify how the UCA may be executed. This approach is similar to EPRI's DEG [15].

The UCAs help identify several key aspects of the system and process to help focus the cyber-attack scenario development. First, it identifies what control action must be sent when the process has reached a specific condition. Second, it identifies the sensors that are responsible for providing feedback to the controller which factor into its process model. Third, it highlights the actuators and process components that are associated with the control action.

2.3. HAZCADS and SIFTs

Developed by EPRI and SNL, HAZCADS is one suite of tools used in EPRI's Digital Engineering Guide (DEG). The HAZCADS process combines the two hazard methodologies discussed previously, STPA and Fault Tree Analysis (FTA) and produces STPA System-theoretic Informed Fault Trees (SIFTs). The SIFTs merge the baseline fault trees from existing PRAs with the STPA-identified UCAs. Additionally, SIFTs identify non-traditional, emergent failure modes for digital components that effect system functions and FTA incorporates the STPA failure modes into a system logic model. The HAZCADS methodology is a continuously evolving process being led by EPRI [4].

System-theoretic Informed Fault Trees merge the baseline fault trees from existing PRAs with the STPA-identified UCAs. Note that by utilizing existing PRAs, the analysis is focused on system hazards and events that contribute to core damage. When constructing SIFTs, special considerations must be taken to ensure UCAs are represented accurately and that the fault tree logic is not broken in the process. The SIFTs generated in this analysis for the different ECCS subsystems are presented in Appendix F.

3. RISK ANALYSIS ON ECCS SYSTEMS

The risk analysis discussed in this chapter and the appendices is segmented into several parts. First, STPA was performed on the ECCS system and the subsystems that make up the ECCS¹ (i.e., HPCI, ADS, RHR-LPCI). Next, the STPA results feed into HAZCADS where the UCAs are integrated with the system PRA (fault tree models). Finally, the PRA models are executed to observe how digital events (i.e., UCAs) impact facility risk.

Although outside the scope of this report, the HAZCADS output can also support integrated system analysis. In this aspect, the analysis continues by analyzing plant design details for system connectivity in support of critical plant functions. A Dependency Matrix is developed to depict the integrated functionality. If areas of potential common-cause failure are indicated, previously identified techniques (HPCI Reference) can be used to develop adversary attack techniques that result in PRA events. Lastly, such adversary actions must be countered by DiD. The analysis process is depicted in Figure 5 below.

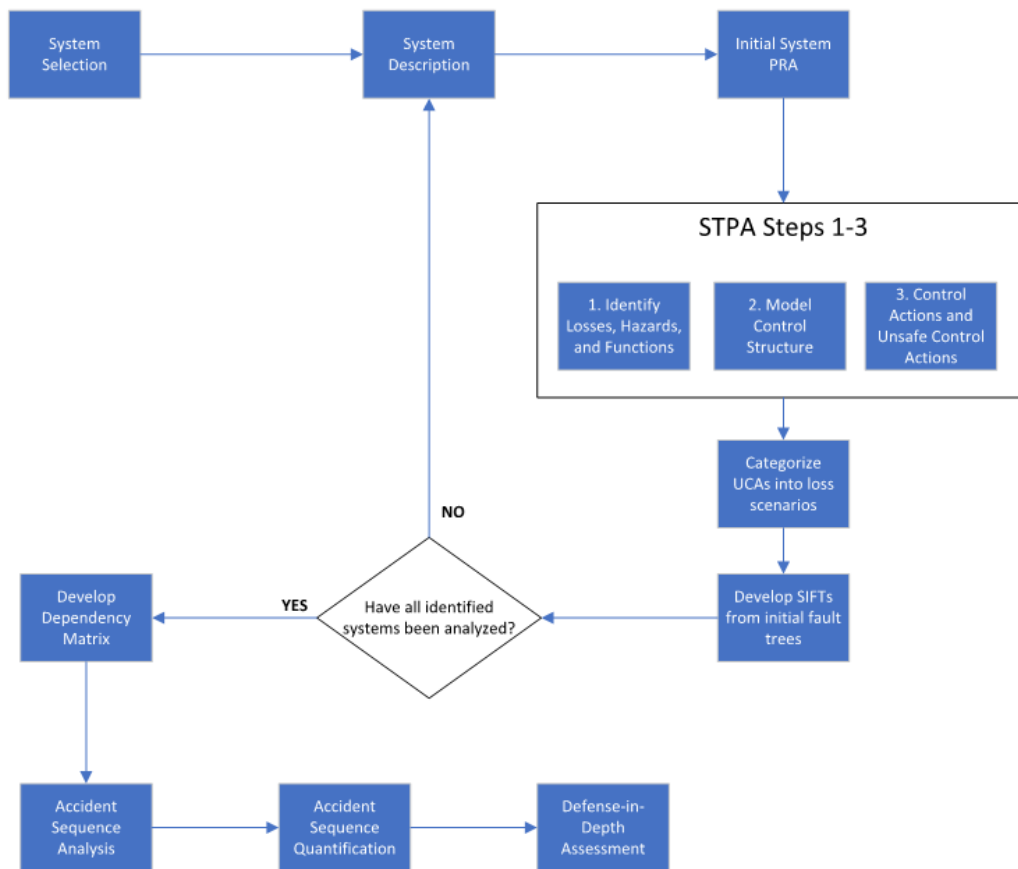


Figure 5 Risk Analysis Process

¹ Note that other subsystems make up the ECCS, such as the Core Spray (CS) system, but these systems were not analyzed in this report.

3.1. System Selection

The ECCS system was selected for several reasons. First, the ECCS is the primary system relied upon during a Loss of Coolant Accident (LOCA). Second, the ECCS is a system that responds by demand, meaning ECCS is largely in standby mode until it is required to operate. Assuming some or all ECCS systems are digital systems, the second reason logically implies that digital systems will need to respond on demand. Third, the ECCS benefits from decades of analysis and risk insights which will be reflected in the results.

3.2. System Description

The primary purpose of ECCS is to provide coolant makeup and core cooling under LOCA conditions². ECCS and its subsystems may be used in other accident scenarios, such as Loss-Of-Offsite-Power (LOOP) and general transients. ECCS is made up of two high pressure (HPCI and ADS) and two low pressure (RHR-LPCI and CS) systems. These four systems have sufficient redundancy and diversity to provide adequate inventory to the reactor vessel under LOCA conditions.

The primary functions of HPCI are to provide coolant makeup and depressurize the reactor coolant system (RCS). HPCI is a single train³ system that diverts steam from the main steam line to turn a turbine. The turbine is responsible for supplying the rotational power to the pumps that take suction from either the condensate storage tank (CST) or the suppression pool. While there are redundant suction paths, there is only a single pump and injection line to the main feedwater supply line. In the following analysis, it is assumed that HPCI is actuated and operated by a digital controller.

The primary function of ADS is to depressurize the RCS so that low pressure systems (i.e., RHR and CS) can provide long term injection and cooling. ADS is a backup to HPCI such that if HPCI fails or is unable to fulfill its function, ADS should actuate. The ADS modeled in this analysis has 11 safety relief valves (SRVs) that will open to divert steam from the main steam line to the suppression pool. Each SRV has two redundant solenoid pilot valves where any pilot valve actuation will actuate the SRV and divert steam from the main steam line. The two solenoid pilot valves are on individual logic channels. In the following analysis, it is assumed that each solenoid pilot valve is actuated by its own digital controller and that the actuation logic is programmed on the controller.

The primary function of RHR-LPCI system is to provide coolant makeup at low pressure and core cooling. RHR-LPCI is a two-train system where each train has redundant pumps that take suction from the suppression pool. Downstream of the pumps is a heat exchanger that provides the core cooling function. RHR-LPCI injects water to the reactor vessel via the recirculation loops to provide core cooling by flooding. In the following analysis, it is assumed that each RHR-LPCI train is controlled by a digital controller.

The ECCS also contains the Core Spray (CS) system which provides low pressure makeup water to the reactor vessel. The CS system is a two-train system that takes suction from the suppression pool and delivers water via sprays onto the fuel assemblies. In this analysis, the CS system is assumed to be an analog system with no digital devices. Thus, the CS systems is absent from the STPA and HAZCADS analysis.

² Unless stated otherwise, the descriptions in this report are referring to small and medium break LOCAs.

³ “Train” refers to the number of injection loops in the system. For example, “single train” system means that there is only one loop that injects water into a given system

The ECCS is assumed to consist of three digital control system (DCS) networks. HPCI is isolated from the other systems and is on its own dedicated DCS network, DCS Network Division 3. In this potential digital ECCS design, there are two redundant DCS networks for ADS and RHR-LPCI. Each controller in the ECCS system has its own dedicated network division. The DCS network diagram, along with ECCS functions overlaid for each ECCS subsystem is provided in Figure 6.

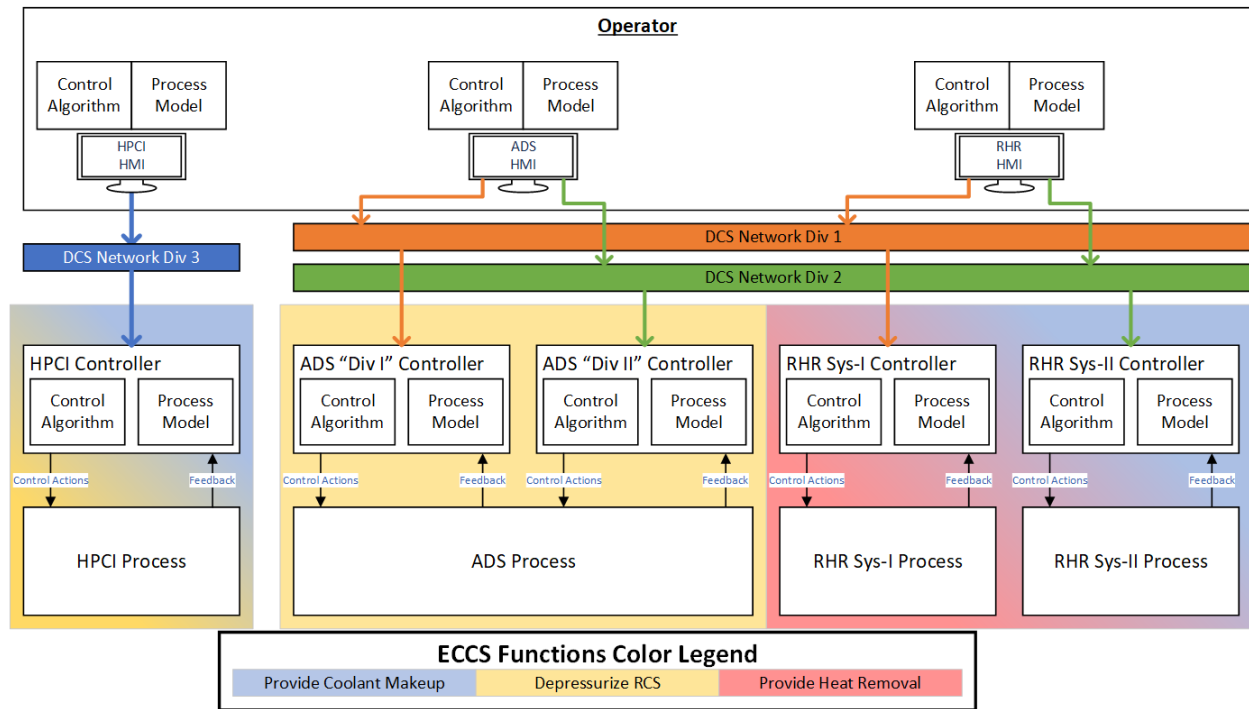


Figure 6. Potential ECCS DCS network diagram with ECCS functions⁴

3.3. Initial Plant PRA

The initial PRA model is a Standardized Plant Analysis Risk (SPAR) of a generic BWR-4 reactor provided by the U.S. NRC [16]. The SPAR model contained event trees and faults trees for quantifying Core Damage Frequency (CDF). There were several issues identified with the initial SPAR model that was received, such as: (1) all the common cause basic events were set to 1.0; (2) the original event trees could not be opened and analyzed; and (3) some of the fault trees were empty but utilized in the event trees.

Each of the previous three issues were resolved before conducting the HAZCADS analysis. The previous issue (1) was resolved by applying the base components to each common cause basic event. Next, the (2) issue, was resolved by re-building the event trees with the sequence information that the model provided and were quantified and compared against the original results to ensure that the rebuilt event tree results matched the original event trees. Finally, the (3) issue, was resolved by not adding surrogate basic events (Appendix G) to the broken fault trees and due to a lack of SSC reliability information, four sensitivity failure rates were tested to identify the potential impact of the fault trees on the event sequences of interest. These issues had no impact on the risk results as all

⁴ The potential design is known to have cyber weaknesses (and other deficiencies) but was selected to simplify the analysis with respect to PRA and HAZCADS.

insights are a *delta risk calculation* from the base case model. Note that broken fault tree issues were not present for ECCS system fault trees (i.e., ADS, HPCI, and RHR) and did not affect the HAZCADS results and insights.

For this analysis the ADS, HPCI, and RHR-LPCI fault trees were used to demonstrate the impact of UCAs. For simplicity, only accident sequences for TRANS and SLOCA events were analyzed in this report. The fault trees and event trees used in this analysis are in Appendix A and Appendix B, respectively.

3.4. ECCS STPA Analysis

STPA can be done in stages where, for example, the first stage would model the interactions between subsystems, the second stage would model interactions between controllers, and the third stage would model interactions with controller submodules. Following this staged approach, an STPA analysis was performed for the entire ECCS.

3.4.1. Step 1: Losses, Hazards, and Functions

Section 2.2.1 provided the losses of concerns for a NPP and no new losses were identified during the ECCS analysis. The hazards provided in Section 2.2.1, Table 2-2 are abstracted for the entire NPP. ECCS specific hazards were identified during this analysis. The three ECCS functions identified are provide coolant makeup at high and low RCS pressure, depressurize the RCS, and provide heat removal from the core. Each of these functions can be translated into a hazard, for example, if the ECCS fails to depressurize the RCS, the hazard would be, “RCS Pressure is Not Depressurized.” The complete set of ECCS hazards is provided in Table 3-1. Note that the ECCS hazards map to H1, H2, and H3 in Table 2-2, which have a grey font to visually separate them. A complete STPA analysis of ECCS across all operating modes would likely result in ECCS hazards mapping to one or all hazards in Table 2-2.

Table 3-1. ECCS specific hazards.

H#	Description	Link to Losses
<i>H1</i>	<i>Plant releases radioactive material</i>	<i>[L1, L2]</i>
H1.1	ECCS is unable to provide coolant makeup at high pressure	
H1.2	ECCS is unable to provide coolant makeup at low pressure	
H1.3	ECCS is unable to depressurize RCS	
H1.4	ECCS is unable to remove core heat/cool core	
<i>H2</i>	<i>Plant is shutdown</i>	<i>[L3, L4]</i>
H2.1	ECCS actuates during normal operation	
<i>H3</i>	<i>Plant is physically damaged, degraded, or needs repair</i>	<i>[L1-L6]</i>
H3.1	ECCS actuates during normal operation	
H3.2	ECCS actuates incorrectly	
<i>The grey-font hazards H1, H2, and H3 originate from the larger NPP hazards identified in Table 2-2.</i>		

Note that the “Link to Losses” is omitted from the ECCS hazards in Table 3-1. The reason for omitting the link to losses is to not misconstrue the consequences that result from a single hazard. Each accident sequence in the PRA event trees will have a unique combination of these hazards such that release of radioactive material would result. In other words, there is no single hazard—or conversely, loss of function—that results in core damage. This is true because there are other systems besides ECCS that help mitigate and prevent the release of radioactive material that are outside the scope of the ECCS analysis presented here.

3.4.2. Step 2: Control Structure

The hierarchical control structure for the ECCS is provided in Figure 7. Note that two new systems are displayed which have not been discussed previously: Nuclear Steam Supply Shutoff System (NSSSS) and Reactor Vessel Instrumentation System (RVIS). Thorough analysis of these systems is beyond the scope of this report, but the relevant interactions between RVIS/NSSSS and ECCS are discussed.

The RVIS continuously monitors the reactor vessel water level and certain setpoints are used to initiate systems across the plant. The ECCS subsystems will receive a reactor water level 1, 2, or 3⁵ from the RVIS which signals to the system to actuate—ADS receives a level 1 and level 3 signal, where the level 3 signal is a confirmatory signal in case level 1 channel fails. HPCI and RHR also receive a high drywell pressure as part of the actuation logic. Finally, the RHR receives an RCS pressure signal that ensures the RHR does not actuate when pressure is too high.

The NSSSS is used to isolate systems to prevent the release of radioactive materials. Each of the ECCS subsystems have a containment bypass pathway that if not isolated, could lead to inadvertent release of radioactive material. For the purposes of this analysis, it is assumed that all signals received by the RVIS and NSSSS are correctly sent.

There are two takeaways from the hierarchical control structure in Figure 7. First, note the feedback that is sent from CS and RHR systems to ADS. For automatic initiation of ADS, at least one of these signals must be received in conjunction with the reactor water level sensors from RVIS. This interdependent interaction is crucial to the ADS automatic actuation. As will be described in future sections, these interdependent interactions are difficult to model in existing PRA models. The second takeaway is the RCS pressure that provides input to the CS and RHR systems. The RCS pressure setpoint for actuation is determined by the operation of HPCI and ADS. These layers of complexity highlight the importance of STPA. Traditionally, each system would be modeled in isolation, but STPA facilitates analysis of interdependent system interactions. To put it another way, these interactions need to be modeled to ensure ECCS maintains its intended function. ECCS interdependencies and their effect on ECCS function and risk are described in more detail in Section 4.

The ECCS control structure in Figure 7 can also be overlaid onto the DCS network in Figure 6, which will assist the DiD assessment in Section 4. Modeling the control structure with the DCS network overlaid has two advantages for cyber security analysis.

1. A DCS dependency matrix is more readily developed from Figure 6 and Figure 7. The control structure shows how control actions and feedback are dependent on the DCS design to facilitate signals being sent and received. Dependency matrices for the ECCS DCS network will be discussed further in Section 3.5.

⁵ Level 3 elevation is greater than the level 2 elevation which is greater than the level 1 elevation.

2. Cyber security analyst and the safety analyst have a cohesive model to facilitate a unified process for discussing security and safety together, as is done in Section 4.

The control structures for HPCI, ADS, and RHR are provided in Appendix C.

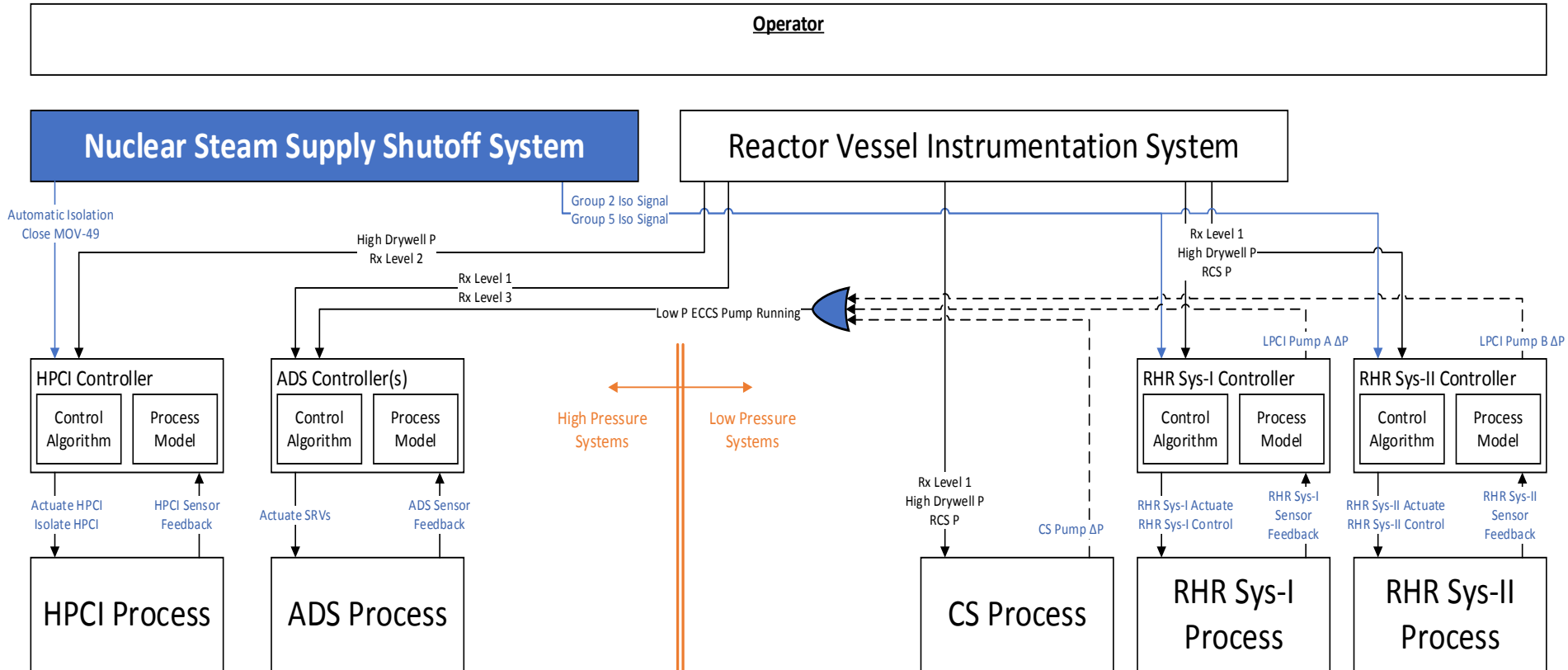


Figure 7. Hierarchical control structure for ECCS.

3.4.3. Step 3: Control Actions and UCAs

An STPA was ultimately performed for each ECCS subsystem, and the results are presented in Appendix C and Appendix D. In addition to individual analysis on the ECCS subsystems, STPA was also performed on the ECCS system and presented here. This analysis includes control actions and feedback between ECCS subsystems as well as control actions and feedback from external systems, such as RVIS and NSSSS.

All the control actions and feedback discussed in this section are interdependent system properties which are typically overlooked but crucial to the operation of the ECCS. As will be shown in later in Section 4, the flow of information across individual systems occurs through the digital network design. The complete set of control actions and UCAs can be found in Appendix D and Appendix E. The assessment was simplified to only a few control actions modeled in Figure 7

Error! Reference source not found., which are listed in Table 3-2.

Table 3-2. ECCS control actions assessed using STPA

#	Description
CA101	RHR-LPCI Sys-I Controller sends Pump A, C ΔP to ADS Div I Controller
CA102	RHR-LPCI Sys-I Controller sends Pump A, C ΔP to ADS Div II Controller
CA103	RHR-LPCI Sys-II Controller sends Pump B, D ΔP to ADS Div I Controller
CA104	RHR-LPCI Sys-II Controller sends Pump B, D ΔP to ADS Div II Controller
CA105	CS pump sensors send Pump A, B ΔP to ADS Div I Controller
CA106	CS pump sensors send Pump A, B ΔP to ADS Div II Controller

Following the process and formula described in Section 2.2.3 for identifying UCAs, Table 3-3 provides the table of ECCS UCAs for the control actions listed in Table 3-2. Table 3-4 UCAs are important for two reasons:

1. ADS needs to initiate to depressurize the RCS so low-pressure systems (i.e., CS and RHR-LPCI) can function. Without this the ECCS fails because both CS and RHR-LPCI are in danger of not being able to operate.
2. ADS initiation before the low-pressure system pumps (RHR-LPCI System I/II or CS) have started up and reached their required pressure differential (ΔP) could lead to catastrophic damage rendering those components and systems inoperable.

Table 3-3. ECCS UCAs between systems

	Needed, Not Provided	Provided, Not Needed	Provided Too Early / Too Late / Wrong Order	Stopped Too Soon / Engaged Too Long
CA101	UCA101-A1: RHR-LPCI Sys-I controller does not send Pump A or C ΔP to ADS Div I controller when RCS needs to depressurize. [H1.2,H1.3]	UCA101-B1: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div I controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA101-C1: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div I controller before pumps reach required ΔP . [H1.2,H1.4,H3.2] UCA101-C2: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div I controller after RCS depressurization was required. [H1.2,H1.3]	UCA101-D1: RHR-LPCI Sys-I controller stops sending Pump A or C ΔP to ADS Div I controller before ADS timer expires. [H1.2,H1.3]
CA102	UCA102-A1: RHR-LPCI Sys-I controller does not send Pump A or C ΔP to ADS Div II controller when RCS needs to depressurize. [H1.2,H1.3]	UCA102-B1: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div II controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA102-C1: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div II controller before pumps reach required ΔP . [H1.2,H1.4,H3.2] UCA102-C2: RHR-LPCI Sys-I controller sends Pump A or C ΔP to ADS Div II controller after RCS depressurization was required. [H1.2,H1.3]	UCA102-D1: RHR-LPCI Sys-I controller stops sending Pump A or C ΔP to ADS Div II controller before ADS timer expires. [H1.2,H1.3]
CA103	UCA103-A1: RHR-LPCI Sys-II controller does not send Pump B or D ΔP to ADS Div I controller when RCS needs to depressurize. [H1.2,H1.3]	UCA103-B1: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div I controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA103-C1: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div I controller before pumps reach required ΔP . [H1.2,H1.4,H3.2] UCA103-C2: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div I controller after RCS depressurization was required. [H1.2,H1.3]	UCA103-D1: RHR-LPCI Sys-II controller stops sending Pump B or D ΔP to ADS Div I controller before ADS timer expires. [H1.2,H1.3]
CA104	UCA104-A1: RHR-LPCI Sys-II controller does not send Pump B or D ΔP to ADS Div II controller when RCS needs to depressurize. [H1.2,H1.3]	UCA104-B1: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div II controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA104-C1: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div II controller before pumps reach required ΔP . [H1.2,H1.4,H3.2] UCA104-C2: RHR-LPCI Sys-II controller sends Pump B or D ΔP to ADS Div II controller after RCS depressurization was required. [H1.2,H1.3]	UCA104-D1: RHR-LPCI Sys-II controller stops sending Pump B or D ΔP to ADS Div II controller before ADS timer expires. [H1.2,H1.3]
CA105	UCA105-A1: CS pump sensors do not send Pump A or B ΔP to ADS Div I controller when RCS needs to depressurize. [H1.2,H1.3]	UCA105-B1: CS pump sensors send pump A or B ΔP to ADS Div I controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA105-C1: CS pump sensors send Pump A or B ΔP to ADS Div I controller before pumps reach required ΔP . [H1.2,H1.4,H3.2] UCA105-C2: CS pump sensors send Pump A or B ΔP to ADS Div I controller after RCS depressurization was required. [H1.2,H1.3]	UCA105-D1: CS pump sensors stop sending Pump A or B ΔP to ADS Div I controller before ADS timer expires. [H1.2,H1.3]

	Needed, Not Provided	Provided, Not Needed	Provided Too Early / Too Late / Wrong Order	Stopped Too Soon / Engaged Too Long
CA106	UCA106-A1: CS pump sensors do not send Pump A or B ΔP to ADS Div II controller when RCS needs to depressurize. [H1.2,H1.3]	UCA106-B1: CS pump sensors send pump A or B ΔP to ADS Div II controller when pumps are not running. [H1.2,H1.4,H2.1, H3.2]	UCA106-C1: CS pump sensors send Pump A or B ΔP to ADS Div II controller before pumps reach required ΔP. [H1.2,H1.4,H3.2] UCA106-C2: CS pump sensors send Pump A or B ΔP to ADS Div II controller after RCS depressurization was required. [H1.2,H1.3]	UCA106-D1: CS pump sensors stop sending Pump A or B ΔP to ADS Div II controller before ADS timer expires. [H1.2,H1.3]

3.5. Extending STPA Steps 1-3

Section 3.4.2 described how overlaying the ECCS control structure onto DCS network diagram enables developing dependency matrices which is an important input into evaluating the DiD of a system. Dependency matrices are commonly developed in safety assessments to map the dependency between systems, subsystems, and support systems. For example, safety system and electrical supply dependencies are developed to ensure no single source of power is responsible for an entire set of safety systems. Thus, the dependency matrix ensures that there is sufficient redundancy, diversity, and independence to prevent common-cause failures from dominating risk. Adopting this concept for the DCS network, Table 3-4 presents a dependency matrix for Figure 6 and Figure 7.

From Table 3-4, HPCI, RHR Sys-I, and RHR Sys-II are the only three systems that have complete dependency on a DCS network, however, the RHR system has redundancy because System I and II are separated digitally (similarly for ADS).

Table 3-4. Dependency matrix for ECCS subsystems.

	HPCI	ADS Div I	ADS Div II	RHR Sys-I	RHR Sys-II
DCS Network Div 1	N	P ⁶	P ⁶	C	N ⁷
DCS Network Div 2	N	P ⁶	P ⁶	N ⁷	C
DCS Network Div 3	C	N	N	N	N
C = Complete Dependency P = Partial Dependency N = No Dependency					

From the previous three steps of STPA, it was identified that ADS relies on control actions and feedback from the RHR Systems to initiate automatically. Reframing the actions, feedback, and dependencies, provides a visual representation of the “flow of information.” The significance of visualizing the STPA analysis in terms of the “flow of information” is to further discretize how digital communication occurs between systems, which in turn allows the cyber security analyst to determine how the flow of information may be spoofed, tampered, or denied.

⁶ ADS Division I and II receive redundant signals from DCS Networks Division 1 and 2

⁷ Although RHR System I and II send redundant signal to both DCS Network Division 1 and 2, the “N” designation means that the respective RHR Systems are not dependent on that DCS Network division for operating.

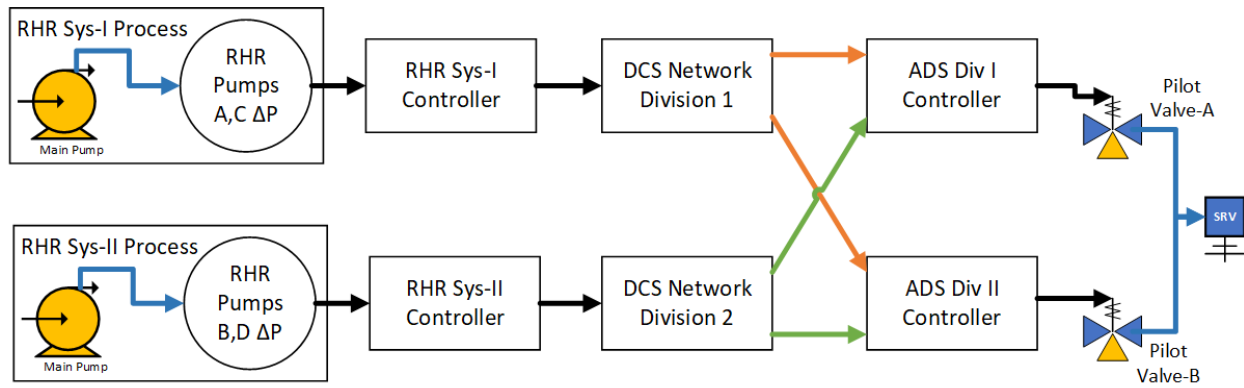


Figure 8. Information flow from RHR system pumps to ADS actuation of safety relief valves.

3.6. Event Sequence Results

The ECCS system and subsystem responses are demanded for several different accident sequences in the SPAR models. A SLOCA and TRANS sequences are considered here. Each subsystem had UCAs added as initiating events. If we set the assumed probability of UCA occurring to 1.0, thus assuming a successful cyber-attack resulting in the UCA, we can determine the impact to overall Event Sequence Frequency (ESF).

In the results following, the ‘Base Case ESF’ is the system result of the model with no added UCAs, ‘UCA Case ESF’ is the result system result with UCAs, ‘UCA Contribution’ is the delta risk calculation related to adding the UCAs to each individual subsystem, and ‘% UCA Contribution’ is the percentage of risk that the UCAs add to the system. This number is not indicative of a true risk metric. However, the difference is a “delta risk calculation” showing how ESF changes with UCAs. The change was different for each subsystem.

3.6.1. SLOCA Comparisons

The base case ESF for SLOCA is 4.67E-09. The loss of RHR-A and RHR-B have similar impacts on risk and comparatively more than ADS and HPCI. The ESF results for each system are displayed in Figure 9.

Table 3-5. SLOCA Results Comparisons

System	Base Case ESF	UCA Case ESF	UCA Contribution	% UCA Contribution
ADS	4.67E-09	2.01E-07	1.96E-07	97.7%
HPCI	4.67E-09	1.80E-08	1.33E-08	74.1%
RHR	Not Completed			
RHR-A	4.67E-09	3.54E-06	3.54E-06	99.9%
RHR-B	4.67E-09	7.72E-06	7.72E-06	99.9%

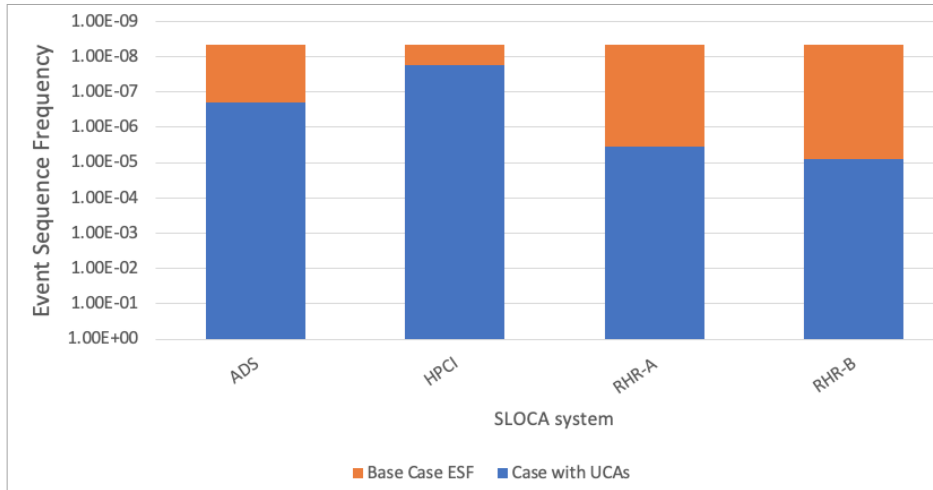


Figure 9. SLOCA system results.

3.6.2. TRANS Comparisons

The base case ESF for TRANS is 2.07E-07. Unlike SLOCA, ADS has the greatest impact on risk. These insights indicate that cyber security efforts should be focused on ADS to achieve the largest impact on risk. The ESF results for each system are displayed in Figure 10.

Table 3-6. TRANS Results Comparisons

System	Base Case ESF	UCA Case ESF	UCA contribution	% UCA contribution
ADS	2.07E-07	4.38E-04	4.38E-04	99.95%
HPCI	2.07E-07	3.01E-05	2.99E-05	99.31%
RHR	Not Completed			
RHR-A	2.07E-07	8.89E-05	8.87E-05	99.77%
RHR-B	2.07E-07	1.60E-04	1.60E-04	99.87%

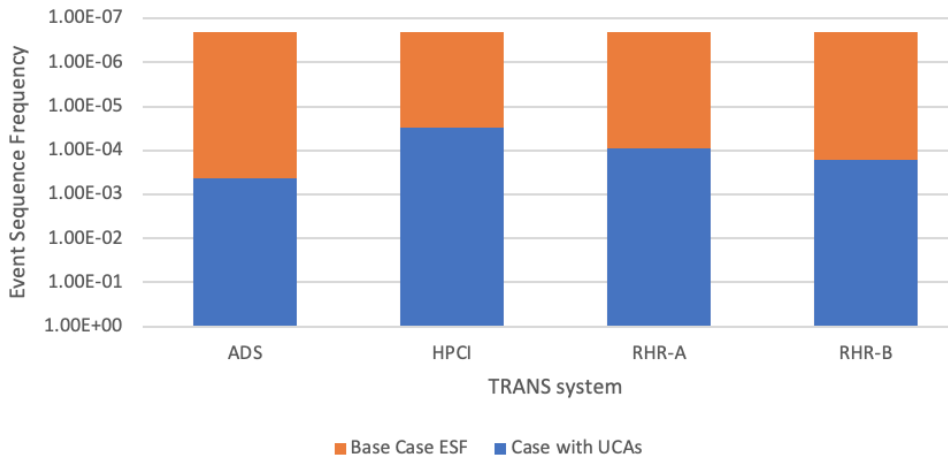


Figure 10. TRANS system results.

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4. ASSESSMENT OF INTERDEPENDENT SYSTEMS

The STPA and PRA models, along with the risk results and insights from Section 3 support the further assessment of interdependent system interactions. Section 3.4 presented STPA results for the entire ECCS system. Considering the risk results and insights, the analysis is extended to consider emerging interdependent system properties which result from the whole system rather than the individual parts. An example is ECCS information that is shared among subsystems and sent and received across system boundaries. The DCS network design introduces additional layers of system interdependency that are not readily assessed by the HAZCADS or risk analysis.

The ADS is a critical safety system. When considering just the ADS system boundary, the ADS controllers and network devices are included in the critical system designation. The DCS Network Divisions make ADS Division I and Division II independent and the two controllers provide redundancy.

Section 3.4 illustrated how ADS automatic actuation relies on the DCS Network and includes signals which traverse system boundaries. In other words, the digital assessment of ADS is more complex and has ramifications beyond just the ADS system boundary. The ADS automatic actuation relies on signals from the RHR system, CS system, and RVIS system to actuate automatically (Figure 8). To determine the set of events necessary to prevent ADS automatic actuation, the DCS network design and ADS actuation logic are examined for signals required to prevent ADS actuation. The results are presented in a new fault tree that includes CCF placeholders which may represent points where a single UCA would result in a PRA significant event. These CCFs, along with the random and systematic failures (i.e., UCAs) are presented in Figure 11.

The fault tree analysis provides insights into the DCS network design and its effect on ADS automatic actuation. First is that RHR Network Division CCFs, RHR Controller CCFs, and RHR Sensor CCFs must be combined with at least one other, non-CCF event to prevent automatic ADS actuation. So, the DCS network design with respect to ADS automatic actuation displays redundancy.

The second insight is that CCF of ADS Controllers, CCF of ADS Network Divisions, and CCF of DCS Network Divisions are single events which can prevent ADS automatic actuation. While considered “single events” from a risk model perspective, the cyber-attack mechanisms are surely complex. Further analysis of these events is outside the scope of this report and is proposed for future work.

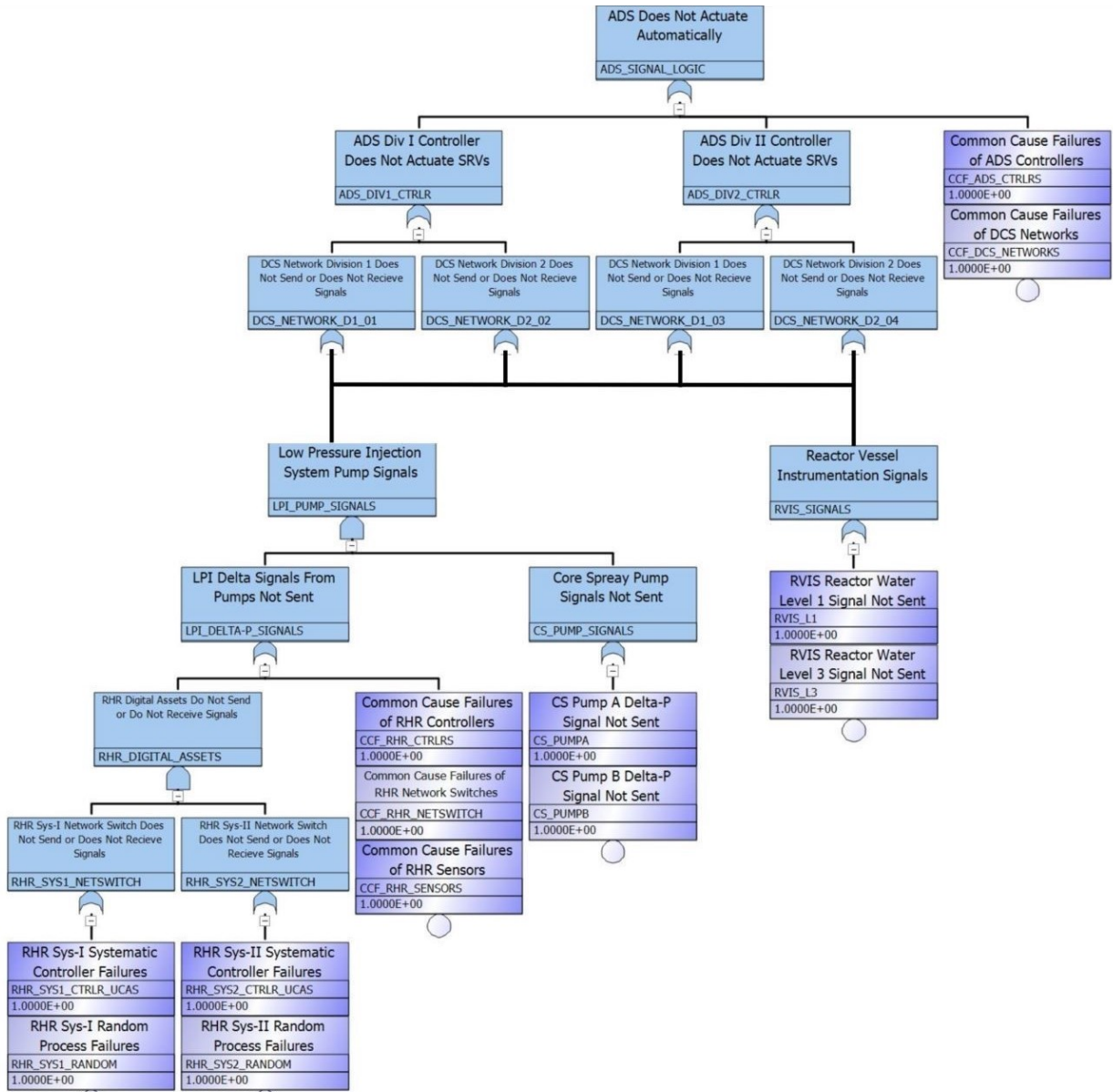


Figure 11. ADS actuation failure due to DCS signals.

5. CONCLUSIONS AND FUTURE WORK

Nuclear power plants use redundant and diverse systems to ensure the critical safety functions are achieved and critical consequences are avoided. As such, cyber events on a single system are unlikely to result in appreciable consequences, but complex, interdependent system interactions are concerning and must be analyzed for cyber-attacks that could result in a digital CCF.

The analysis presented in this report leverages the HAZCADs approach to identify UCAs from system controllers, where the UCAs represent actions a cyber adversary desire to cause to incur a consequence to the victim. The analysis on the ECCS subsystems modeled the set of UCAs from digital controllers that could cause the system to not perform its intended function (i.e., result in ECCS not providing coolant injection, RCS depressurization, and/or heat removal from the core). The analysis then considers event trees which model the event sequences which lead to plant end states, which may be successful or result in core damage. Event tree results include the combinations of system failures and successes that would lead to the various end states. When combined with the HAZCADs system results, the risk results include the combinations of cyber events across various systems that result in consequences.

This report aimed to combine reliability data of non-digital systems with HAZCADs, incorporating the results within PRA event trees to determine which set of cyber events have the most significant impact on risk. The analysis considered SLOCA and TRANS event sequences which bounds the spectrum of design basis events. Overall, the concept of interpreting cyber risk by adding UCAs as initiating events in traditional PRA is straightforward in concept and very easy to analyze numerically. The initial results for a single system analysis were logical, in that an increase in event sequence frequency was realized when adding the impacts.

Across the multiple systems that comprise the ECCS, analysis shows that changes in failure probabilities were very different across systems implying that some systems have a larger potential risk impact from successful cyber-attack or digital failure. These systems to have a higher priority for design and defensive measures. We were also able to establish that a risk analysis using an arbitrary threat model creates an ordering of assets regarding cyber-risk. This ordering can be used to influence the overall system design with an eye to lowering risk, or to understand real-time risk to operational systems based on a current threat landscape.

5.1. Future Work

The complexity of cyber-attacks and their impacts on system functions will only increase the complexity and likelihood for errors in analysis involving a greater number of systems and interactions. There is a clear need for a tiered analysis that can inform System Fault Trees for use in PRA at a level of abstraction that addresses the strategic risks of cyber-attacks to safety significant systems. STPA is a bottom-up approach that identifies faults in the systems (i.e., UCAs) that then require SME expertise to include into system fault trees (i.e., SIFT). However, once the worst consequences of cyber-attacks are considered (i.e., indeterminate design, unexpected behaviors, or actions), STPA can merely identify constraints on what the adversary is permitted to initiate rather than inform how those faults propagate through a system (or systems).

Throughout this work, several areas of future R&D were identified. First, the researchers could not identify cyber security guidance related to redundancy, diversity, and independence that was applicable to the safety DiD insights. As such, future research will seek to develop guidance that utilizes both safety and security insights for DiD assessments through tiers of analysis that leverage abstraction to simplify analysis. Second, the risk results space is very large and introduced

computational issues along the way. This contributed to a significant number of UCAs for each system. Future research will involve engagement with cyber security experts to determine screening criteria that can be applied to UCAs. A potential taxonomy of UCAs to support the tiered analysis would simplify research into risk assessment leveraging STPA-based approaches. Screening criteria may include technical and administrative control methods that give credibility to UCAs being screened out of the analysis or physical system features that increase system resiliency. This would greatly help reduce the number of UCA considerations and help focus the risk results into more tangible decision-making.

HAZCADS, when performed on a complex system-of-systems, results in a large set of UCAs that is challenging to conducting an effective analysis. Future work in this area should consider HAZCADS as a component of a larger Tiered Risk Management assessment (Figure 12). A tiered approach would provide the advantage of filtering systems and components, reducing the scope of the STPA analysis. HAZCADS would be performed as part of the Tier 3 (System-Level) analysis, after security analyses of the facility and functions have been completed. This results in a much smaller subset of components to be analyzed, and therefore a more manageable controls assessment. Once systems and components are identified for Tier 3 analysis, UCAs from this report can be leveraged for an assessment that would evaluate component vulnerabilities and controls toward the goal of developing system-specific Cyber Security Plans.

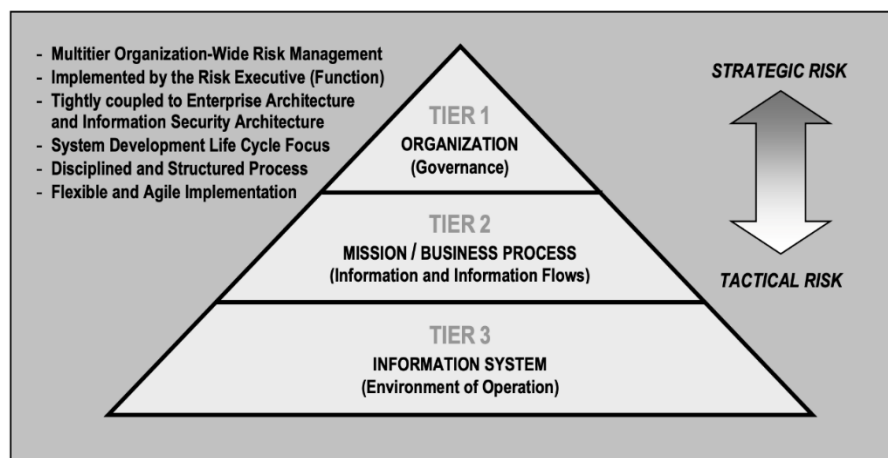


Figure 12: Tiered Risk Management Approach [NIST SP800-37]

A Tier 2 analysis could provide further insights into the role of RVIS in ECCS susceptibilities at a level of abstraction that would simplify analysis. Figure 7 shows that RVIS is a source of common information to HPCI, ADS, and RHR systems, and therefore is a source of CCF. This is an example of a design attribute that would be examined prior to performing STPA. Tier 2 analysis would look at the design and information flows of the system and determine that mitigations should be put in place prior to performing lower-level analyses. In the example of RVIS, this may result in restricting these information flows via implementation of a Defensive Cyber Security Architecture (DCSA) and supporting elements such as use of unidirectional communication gateways (e.g., data diodes) to ensure that a breach of the RVIS system cannot allow an adversary to cause harm to the ECCS systems. The Tier 2 analysis would investigate major attack vectors for each system (wired, wireless, physical access, interfaces, supply chain). A Tier 3 analysis can leverage the results from an STPA on a system’s components to develop a specific cyber security plan for the system.

There are many ways in which cyber security analysts can leverage the outputs from HAZCADS. Smaller system analyses with fewer cut sets may choose to use the resulting cut sets to develop a list

of high-priority digital devices and network nodes for purposes of identifying the potential for common-point susceptibilities failure and applying defensive measures. In this case, the effectiveness of the controls can be verified by performing red team activities on the network and devices (e.g. hiring an external security firm to complete a penetration test in an emulated environment and report any potential vulnerabilities). However, system-of-systems analysis leveraging HAZCADS will result in too many cut sets for this method to efficiently apply. Instead, the results presented in this report are meant to serve as inputs to a cyber security analysis.

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APPENDIX A. INITIAL FAULT TREES

A.1. Automatic Depressurization Fault Tree

Figure A.1 includes the original ADS fault tree in the model.

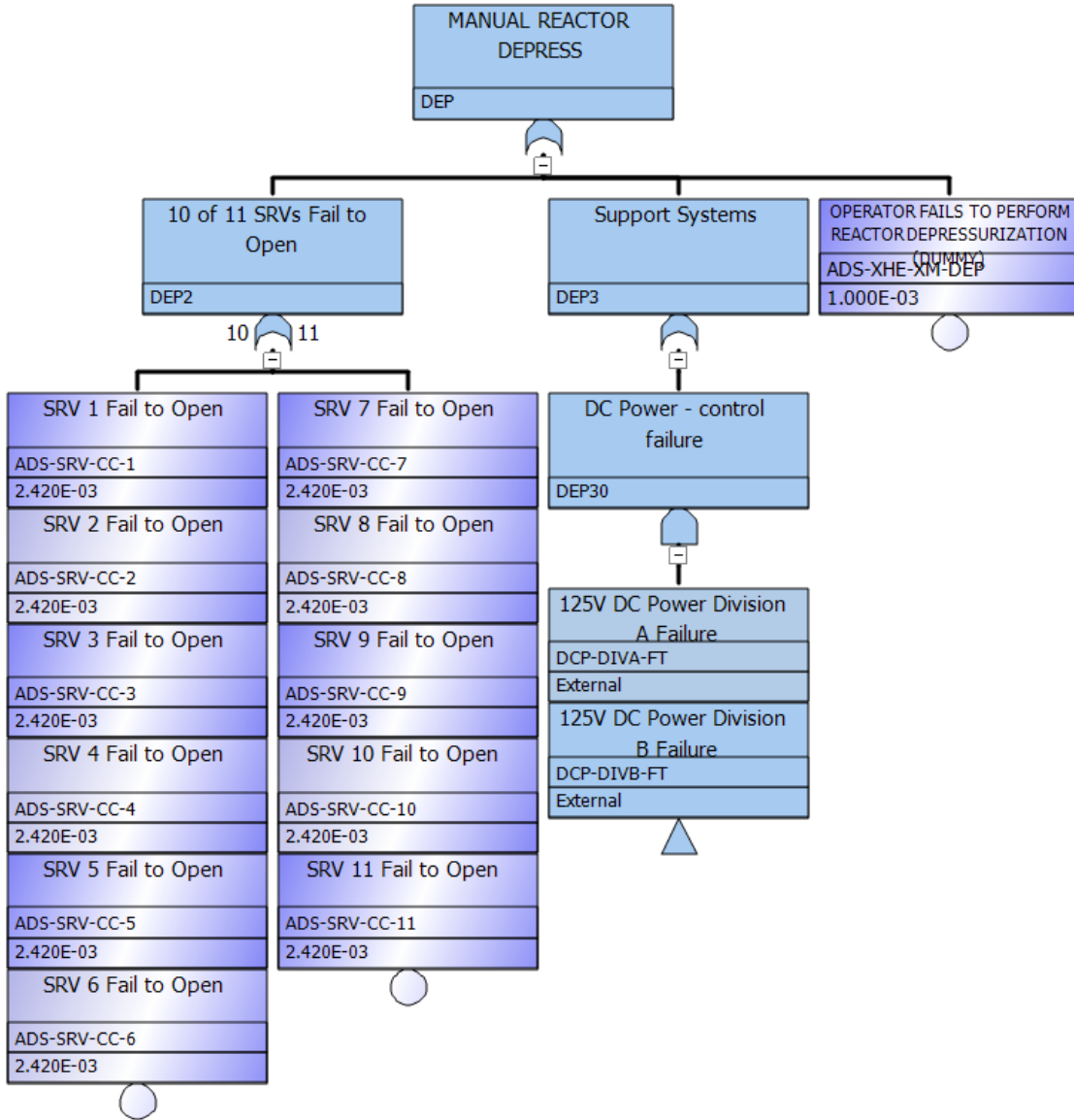


Figure A.1. ADS Fault Tree

A.2. High Pressure Injection Fault Tree

Figure A.2 includes the original HPCI fault tree in the model.

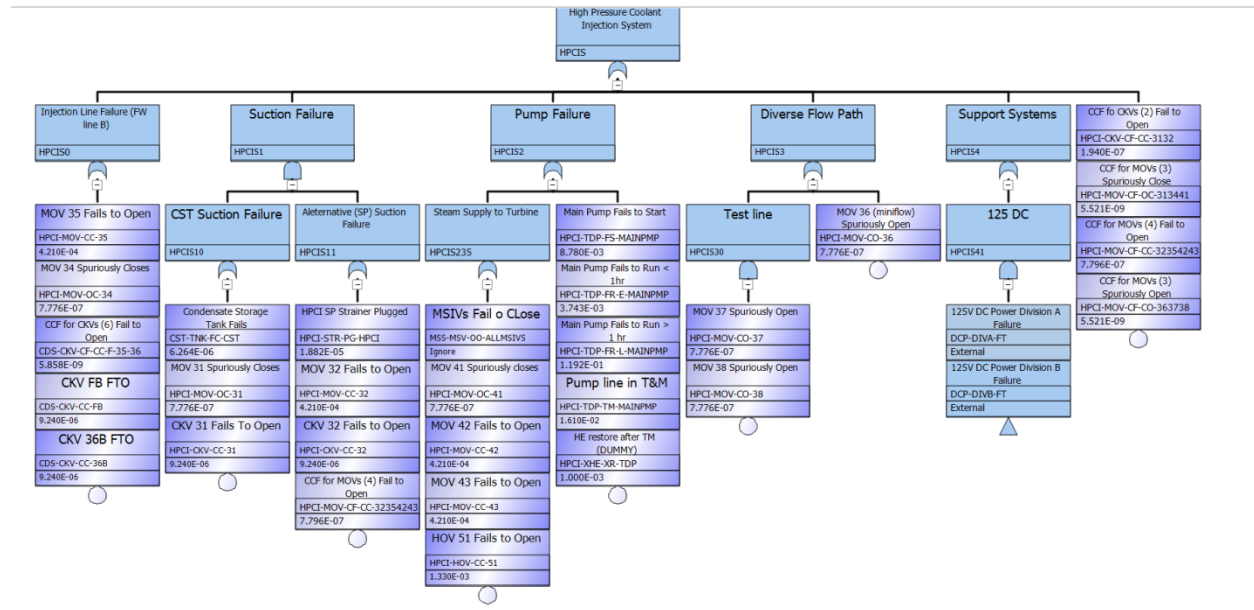


Figure A.2. HPCI Fault Tree.

A.3. Residual Heat Removal Fault Tree

Figure A.3 through Figure A.6 includes the original RHR fault tree in the model.

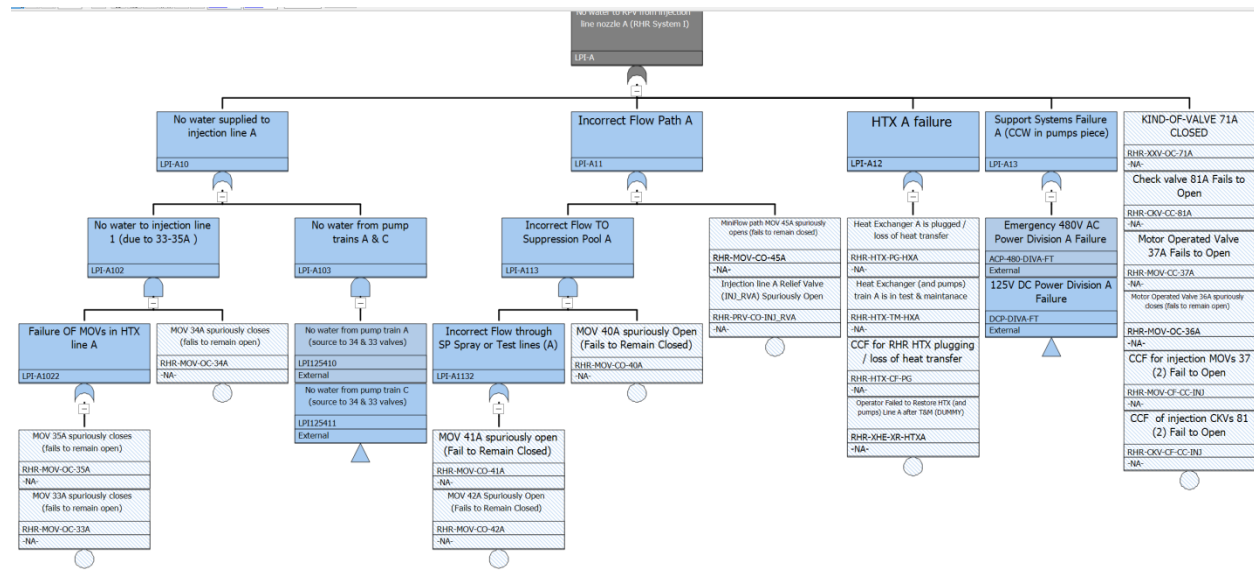


Figure A.3. RHR LPI-A Fault Tree

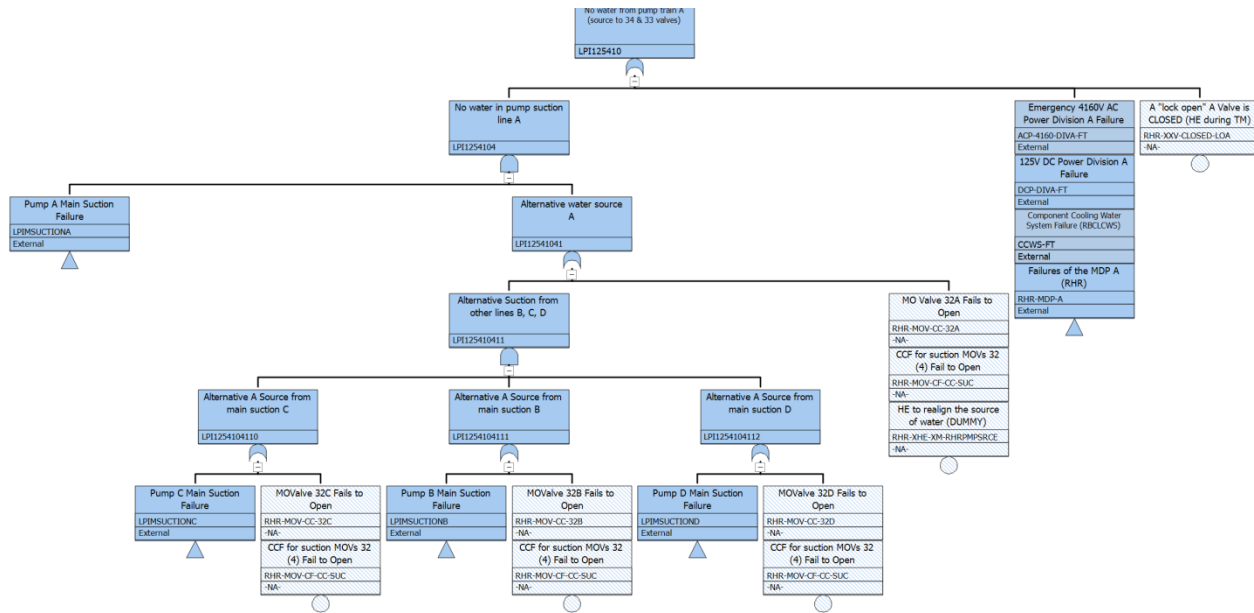


Figure A.4. RHR Alternate Injection Fault Tree

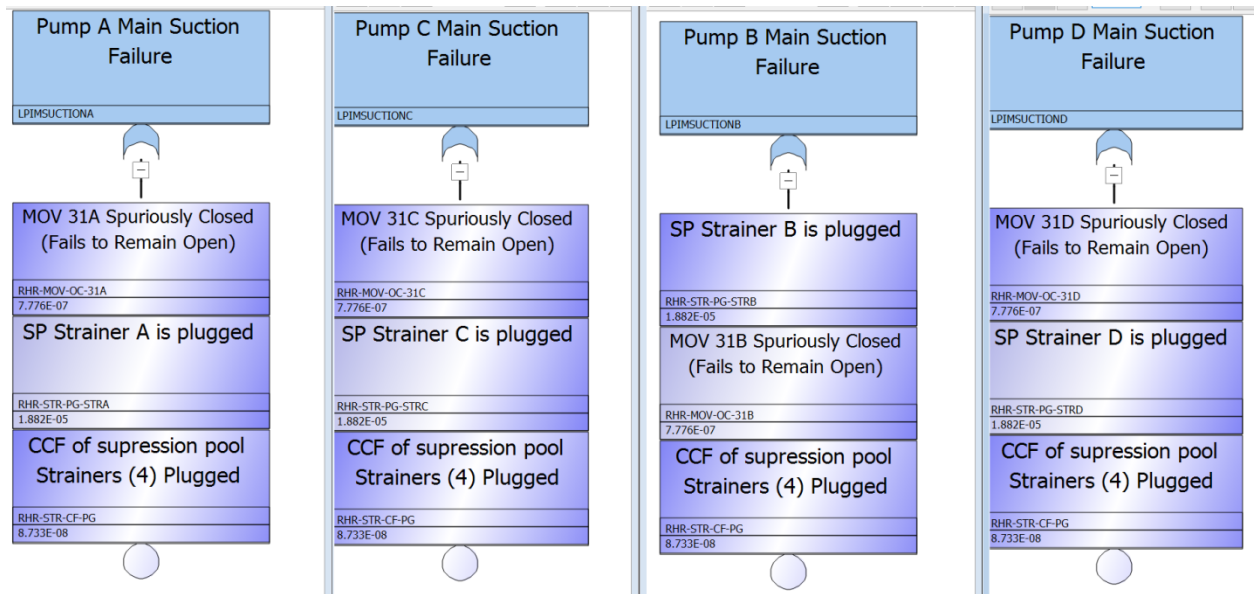


Figure A.5. RHR Suction Fault Trees

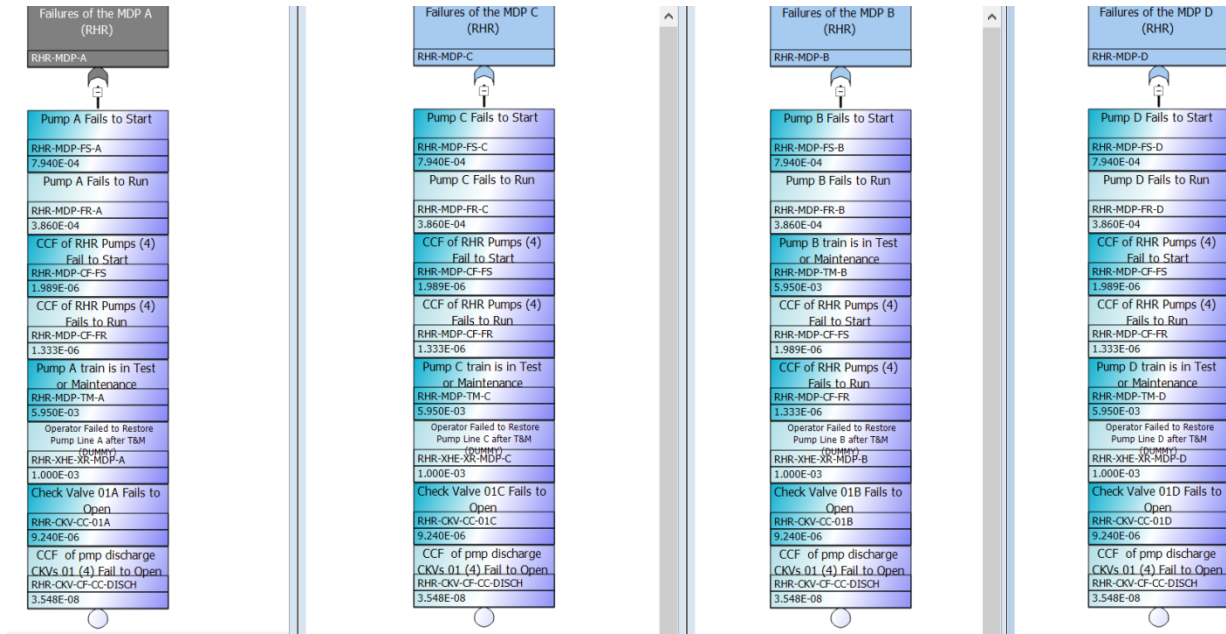


Figure A.6. RHR Pump Fault Trees

APPENDIX B. INITIAL EVENT TREES

For this analysis the SLOCA and TRANS event trees were used to demonstrate the impact of UCAs.

B.1. Quantification Settings

SAPHIRE version 8.2.3 was used to quantify the model results. All base cases were solved at a truncation of 1E-12, which is in line with what most NPP PRAs are solved at. Some UCA cases were solved at lower truncation levels due to computational issues with the software. Those specific cases are called out and clearly denote the truncation setting. Figure B.7 shows the remaining truncation settings used for the analysis.

The screenshot displays the 'Settings' tab of the SAPHIRE software interface. It is divided into several sections:

- Cut Set Truncation Options:** Contains two rows. The first row is 'By Probability' with a dropdown menu set to 'Normal' and a text input field containing '1.000E-12'. The second row is 'By Size' with a dropdown menu set to 'None' and an empty text input field.
- Solve using Flag Set:** A checkbox is unchecked. Below it is a greyed-out dropdown menu.
- Threads to use on solve:** A numeric input field contains the value '1' with up and down arrow buttons.
- Quantification Method:** A dropdown menu is set to '* Min Cut Upper Bound'.
- Solution Steps:** A list of ten options with checkboxes:
 - Solve for Cut Sets
 - Apply Post-processing Rules
 - Update / Quantify Cut Sets
 - Quantify Cut Sets
 - Clear Cut Set Partitions
 - Apply Partition Rules
 - Copy Cut Sets to Nominal Case
 - Clear Current Case
 - Clear Current Case (All Models)
 - Copy Cut Sets to Nominal Case (All Models)

Figure B.7. SAPHIRE event tree quantification settings.

B.2. SLOCA Event Tree

The SLOCA event tree consists of 71 total sequences, 38 of which that result in core damage. Only the sequences that result in core damage are quantified. Table B.1 provides the list of fault trees associated with each sequence. Where a backslash (/) before a fault tree name represents the complement of the fault tree quantification.

Table B.1. SLOCA Sequences

Sequence	Fault Trees
SLOCA, 04=	/RPS /VSS /PCS SPC SDC /CVS LI11 .
SLOCA, 06=	/RPS /VSS /PCS SPC SDC CVS LI12 .
SLOCA, 08=	/RPS /VSS PCS /HPI /SPC LI10 .
SLOCA, 10=	/RPS /VSS PCS /HPI SPC /SDC LI10 .
SLOCA, 12=	/RPS /VSS PCS /HPI SPC SDC /PCSR LI10 .
SLOCA, 14=	/RPS /VSS PCS /HPI SPC SDC PCSR /CVS LI11 .
SLOCA, 16=	/RPS /VSS PCS /HPI SPC SDC PCSR CVS LI12 .
SLOCA, 21=	/RPS /VSS PCS HPI /DEPO /LPI SPC SDC PCSR /CVS LI08 .
SLOCA, 23=	/RPS /VSS PCS HPI /DEPO /LPI SPC SDC PCSR CVS LI09 .
SLOCA, 28=	/RPS /VSS PCS HPI /DEPO LPI /VA1 SPC1 SDC1 PCSR /CVS LI01 .
SLOCA, 30=	/RPS /VSS PCS HPI /DEPO LPI /VA1 SPC1 SDC1 PCSR CVS LI02 .
SLOCA, 31=	/RPS /VSS PCS HPI /DEPO LPI VA1 .
SLOCA, 32=	/RPS /VSS PCS HPI DEPO .
SLOCA, 34=	/RPS VSS LI09 .
SLOCA, 35-02-03=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP /LPI /LVL SPC /CVS LI06 .
SLOCA, 35-02-05=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP /LPI /LVL SPC CVS LI07 .
SLOCA, 35-02-06=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP /LPI LVL .
SLOCA, 35-02-09=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP LPI /VA /LVL SPC1 /CVS LI01 .
SLOCA, 35-02-11=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP LPI /VA /LVL SPC1 CVS LI02 .
SLOCA, 35-02-12=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP LPI /VA LVL .
SLOCA, 35-02-13=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF /DEP LPI VA .
SLOCA, 35-02-14=	RPS /PPR /RRS /PCS1 /SLC /NX MSV /TAF DEP .
SLOCA, 35-03=	RPS /PPR /RRS /PCS1 /SLC /NX MSV TAF .
SLOCA, 35-04=	RPS /PPR /RRS /PCS1 /SLC NX .

Sequence	Fault Trees
SLOCA, 35-05=	RPS /PPR /RRS /PCS1 SLC .
SLOCA, 35-06-03=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP /LPI /LVL SPC /CVS LI06 .
SLOCA, 35-06-05=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP /LPI /LVL SPC CVS LI07 .
SLOCA, 35-06-06=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP /LPI LVL .
SLOCA, 35-06-09=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP LPI /VA /LVL SPC1 /CVS LI01 .
SLOCA, 35-06-11=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP LPI /VA /LVL SPC1 CVS LI02 .
SLOCA, 35-06-12=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP LPI /VA LVL .
SLOCA, 35-06-13=	RPS /PPR /RRS PCS1 /SLC /NX /TAF /DEP LPI VA .
SLOCA, 35-06-14=	RPS /PPR /RRS PCS1 /SLC /NX /TAF DEP .
SLOCA, 35-07=	RPS /PPR /RRS PCS1 /SLC /NX TAF .
SLOCA, 35-08=	RPS /PPR /RRS PCS1 /SLC NX .
SLOCA, 35-09=	RPS /PPR /RRS PCS1 SLC .
SLOCA, 35-10=	RPS /PPR RRS .
SLOCA, 35-11=	RPS PPR .

Figure A.8 through Figure A.12 demonstrate event sequences in the SLOCA event tree.

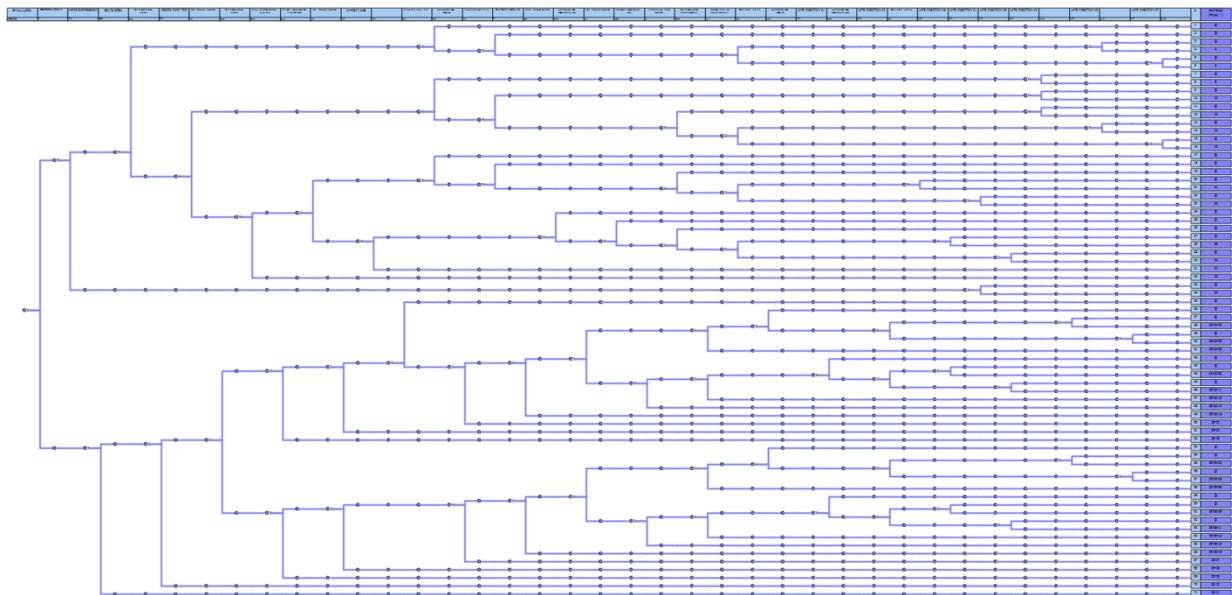


Figure A.8. Entire SLOCA Event Tree

SMALL LOCA	REACTOR SHUTDOWN	VAPOR SUPPRESSION	SRV'S OPEN	POWER CONVERSION SYSTEM	RECIRC PUMP TRIP	HIGH PRESSURE INJECTION	POWER CONVERSION SYSTEM	MANUAL REACTOR DEPRESS (higher HEP)	STANDBY LIQUID CONTROL FAILS TO INJECT	LOW PRESSURE INJECTION	INHIBIT ADS	
IE-SLOCA	RPS	VSS	PPR	PCS	RRS	HPI	PCS1	DEPD	SLC	LPI	NK	VAL

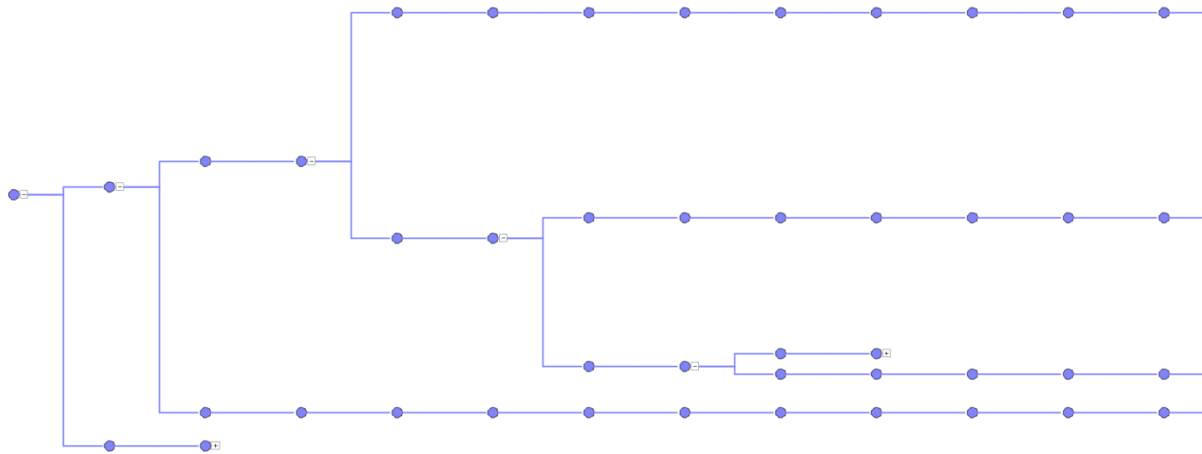


Figure A.9. Section-A of SLOCA Event Tree

INHIBIT ADS	BYPASS MSIV LEVEL 1 TRIP	SUPPRESSION POOL COOLING	TRANSFER BRANCH ATWS-1	SHUTDOWN COOLING	MANUAL REACTOR DEPRESS	SUPPRESSION POOL COOLING (Sine Wave)	LOW PRESSURE INJECTION	SHUTDOWN COOLING (Sine Wave)	ALTERNATE LOW PRESS INJECTION	POWER CONVERSION SYSTEM RECOVERY	RESTORE LEVEL AND PREVENT OVERFILL	
NK	VAL	MSV	SPC	TAF	SDC	DEP	SPCL	LPI	SDCL	VA	PCSR	LVL

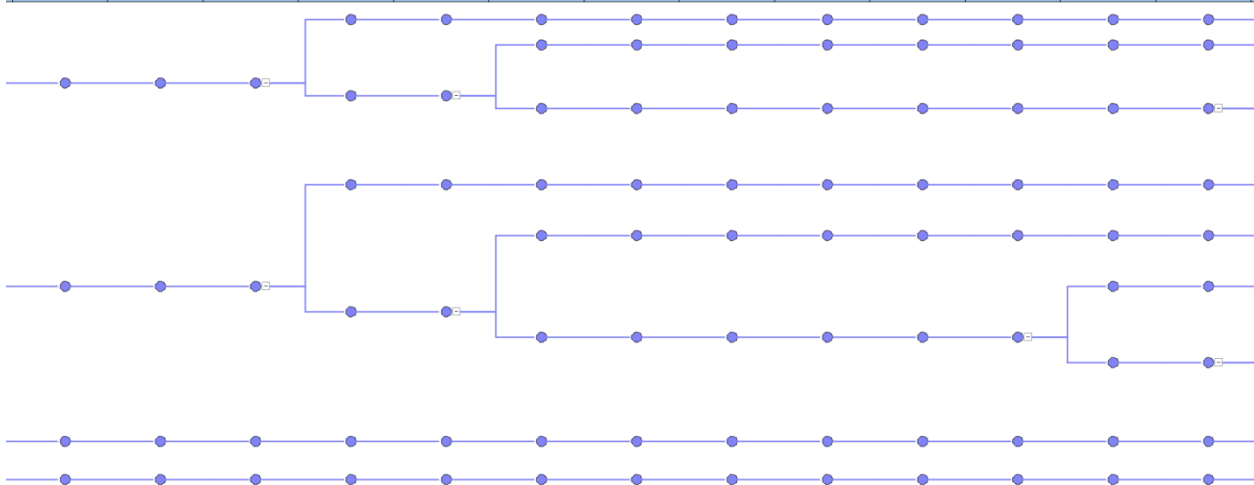


Figure A.10. Section-B of SLOCA Event Tree

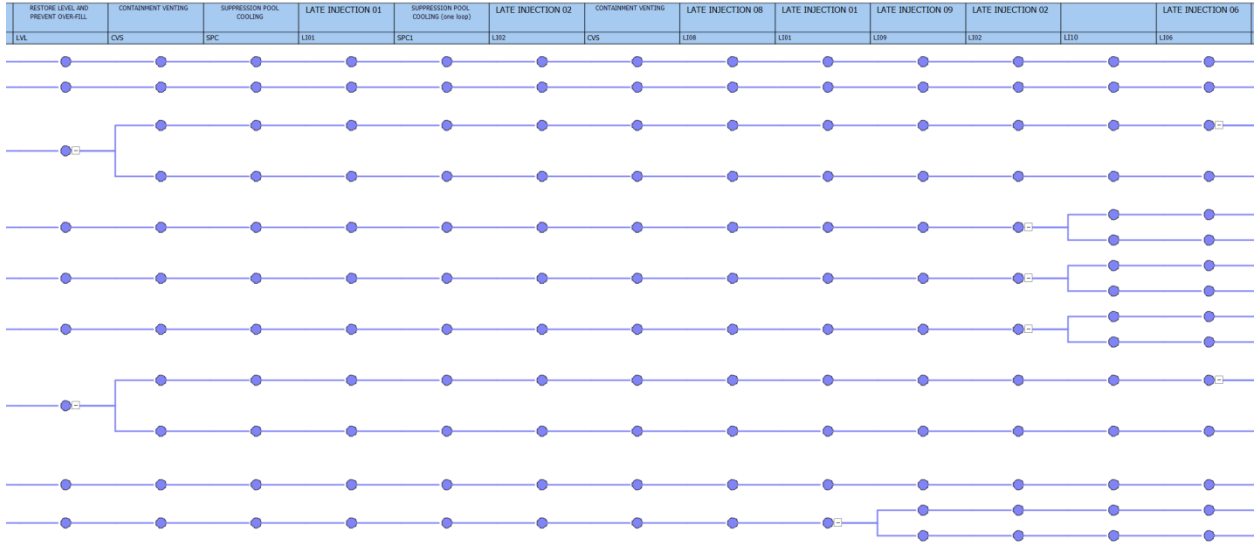


Figure A.11. Section-C of SLOCA Event Tree

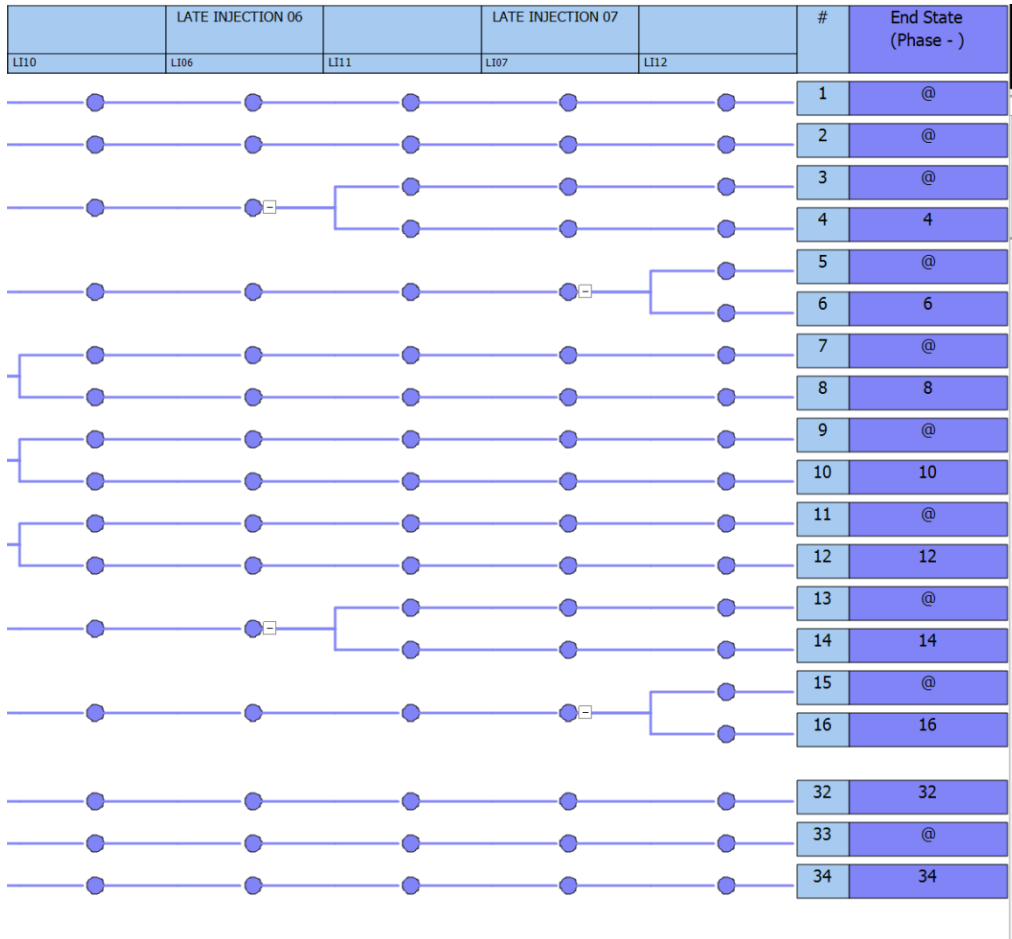


Figure A.12. Section-D of SLOCA Event Tree

B.3. Transient Event Tree

The TRANS event tree consists of 119 total sequences, 38 of which that result in core damage. Only the sequences that result in core damage are quantified. Table A.2 provides the list of fault trees associated with each sequence. Where a backslash (/) before a fault tree name represents the complement of the fault tree quantification. The transient event tree was re-built as three separate event trees to account for; all SRV's closing, one stuck open SRV, and two or more stuck open SRVs. Whereas the original TRANS event tree, which could not be open (but could be solved), was only developed as one single event tree. The original and re-built event trees were quantified on an event sequence basis and confirmed to produce the same results. Thus, all the transient results presented in the report are quantified using the original event tree, to make quantification and documentation easier.

Table A.2. TRANS Sequences

Sequence	Fault Trees
TRANS, 07=	/RPS /SRV PCS /HPI SPC /DEP /CRD CND RHR PCSR /CVS LI01 .
TRANS, 09=	/RPS /SRV PCS /HPI SPC /DEP /CRD CND RHR PCSR CVS LI02 .
TRANS, 14=	/RPS /SRV PCS /HPI SPC /DEP CRD /CDS CND RHR PCSR /CVS LI01 .
TRANS, 16=	/RPS /SRV PCS /HPI SPC /DEP CRD /CDS CND RHR PCSR CVS LI02 .
TRANS, 21=	/RPS /SRV PCS /HPI SPC /DEP CRD CDS /LPI CND RHR PCSR /CVS LI06 .
TRANS, 23=	/RPS /SRV PCS /HPI SPC /DEP CRD CDS /LPI CND RHR PCSR CVS LI07 .
TRANS, 28=	/RPS /SRV PCS /HPI SPC /DEP CRD CDS LPI /VA CND RHR PCSR /CVS LI01 .
TRANS, 30=	/RPS /SRV PCS /HPI SPC /DEP CRD CDS LPI /VA CND RHR PCSR CVS LI02 .
TRANS, 31=	/RPS /SRV PCS /HPI SPC /DEP CRD CDS LPI VA .
TRANS, 36=	/RPS /SRV PCS /HPI SPC DEP /CRD CND RHR PCSR /CVS LI01 .
TRANS, 38=	/RPS /SRV PCS /HPI SPC DEP /CRD CND RHR PCSR CVS LI02 .
TRANS, 39=	/RPS /SRV PCS /HPI SPC DEP CRD .
TRANS, 44=	/RPS /SRV PCS HPI /DEPO /CDS CND RHR PCSR /CVS LI01 .
TRANS, 46=	/RPS /SRV PCS HPI /DEPO /CDS CND RHR PCSR CVS LI02 .
TRANS, 51=	/RPS /SRV PCS HPI /DEPO CDS /LPI CND RHR PCSR /CVS LI06 .
TRANS, 53=	/RPS /SRV PCS HPI /DEPO CDS /LPI CND RHR PCSR CVS LI07 .
TRANS, 58=	/RPS /SRV PCS HPI /DEPO CDS LPI /VA0 CND RHR PCSR /CVS LI01 .
TRANS, 60=	/RPS /SRV PCS HPI /DEPO CDS LPI /VA0 CND RHR PCSR CVS LI02 .
TRANS, 61=	/RPS /SRV PCS HPI /DEPO CDS LPI VA0 .
TRANS, 62=	/RPS /SRV PCS HPI DEPO .
TRANS, 63-04=	/RPS P1 /PCS SPC SDC /CVS LI01 .

Sequence	Fault Trees
TRANS, 63-06=	/RPS P1 /PCS SPC SDC CVS LI02 .
TRANS, 63-11=	/RPS P1 PCS /HPI /CRD SPC SDC PCSR /CVS LI01 .
TRANS, 63-13=	/RPS P1 PCS /HPI /CRD SPC SDC PCSR CVS LI02 .
TRANS, 63-18=	/RPS P1 PCS /HPI CRD /LPI SPC SDC PCSR /CVS LI08 .
TRANS, 63-20=	/RPS P1 PCS /HPI CRD /LPI SPC SDC PCSR CVS LI09 .
TRANS, 63-25=	/RPS P1 PCS /HPI CRD LPI /VA SPC1 SDC1 PCSR /CVS LI01 .
TRANS, 63-27=	/RPS P1 PCS /HPI CRD LPI /VA SPC1 SDC1 PCSR CVS LI02 .
TRANS, 63-28=	/RPS P1 PCS /HPI CRD LPI VA .
TRANS, 63-33=	/RPS P1 PCS HPI /DEPO /LPI SPC SDC PCSR /CVS LI06 .
TRANS, 63-35=	/RPS P1 PCS HPI /DEPO /LPI SPC SDC PCSR CVS LI07 .
TRANS, 63-40=	/RPS P1 PCS HPI /DEPO LPI /VA0 SPC1 SDC1 PCSR /CVS LI01 .
TRANS, 63-42=	/RPS P1 PCS HPI /DEPO LPI /VA0 SPC1 SDC1 PCSR CVS LI02 .
TRANS, 63-43=	/RPS P1 PCS HPI /DEPO LPI VA0 .
TRANS, 63-44=	/RPS P1 PCS HPI DEPO .
TRANS, 64-4=	/RPS P2 /LPI SPC SDC /CVS LI08 .
TRANS, 64-6=	/RPS P2 /LPI SPC SDC CVS LI09 .
TRANS, 64-7=	/RPS P2 LPI .

Figure A.13 and Figure A.14 demonstrate the event sequences in the TRANS event tree with no stuck open SRVs.

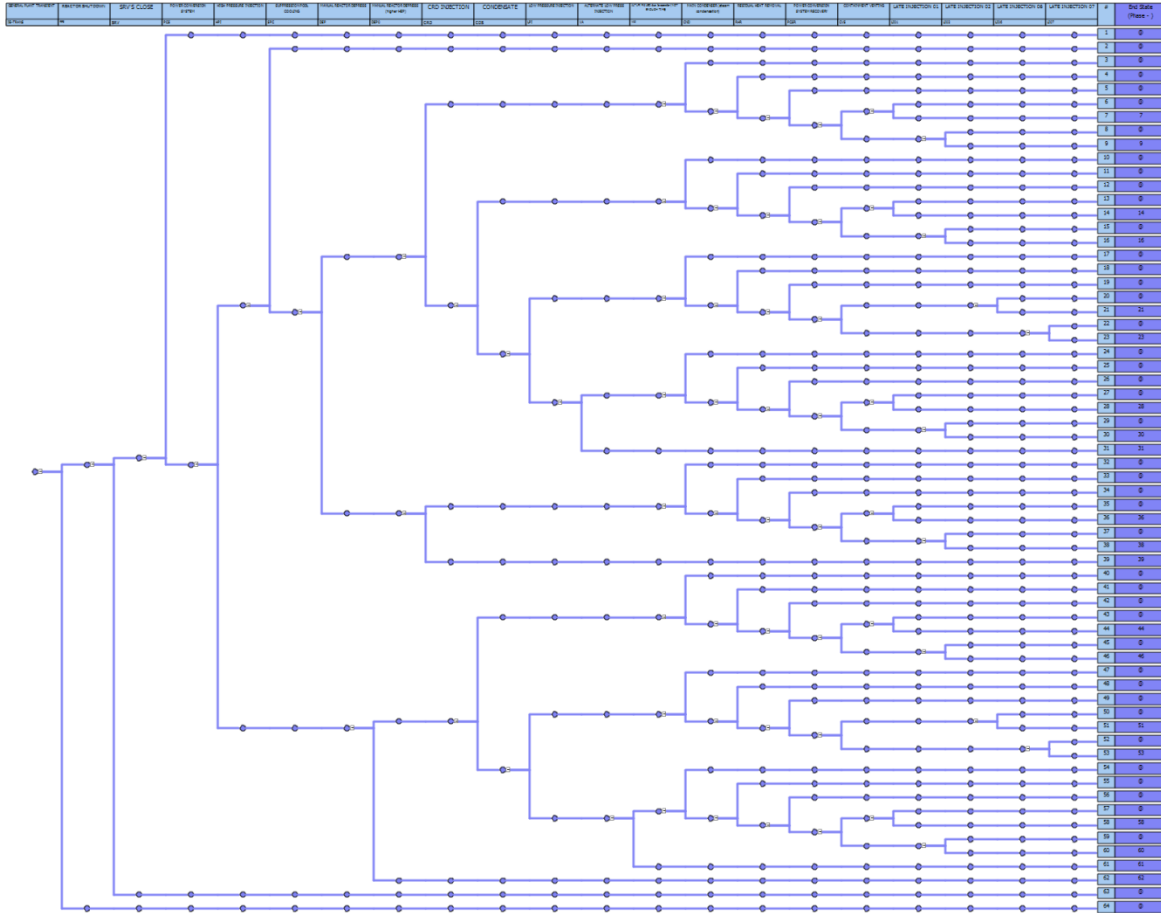


Figure A.13. No Stuck Open SRVs TRANS Event Tree



Figure A.14. Condensed No Stuck Open SRVs TRANS Event Tree

Figure A.15 and Figure A.16 demonstrate the event sequences in the TRANS event tree with one stuck open SRV.

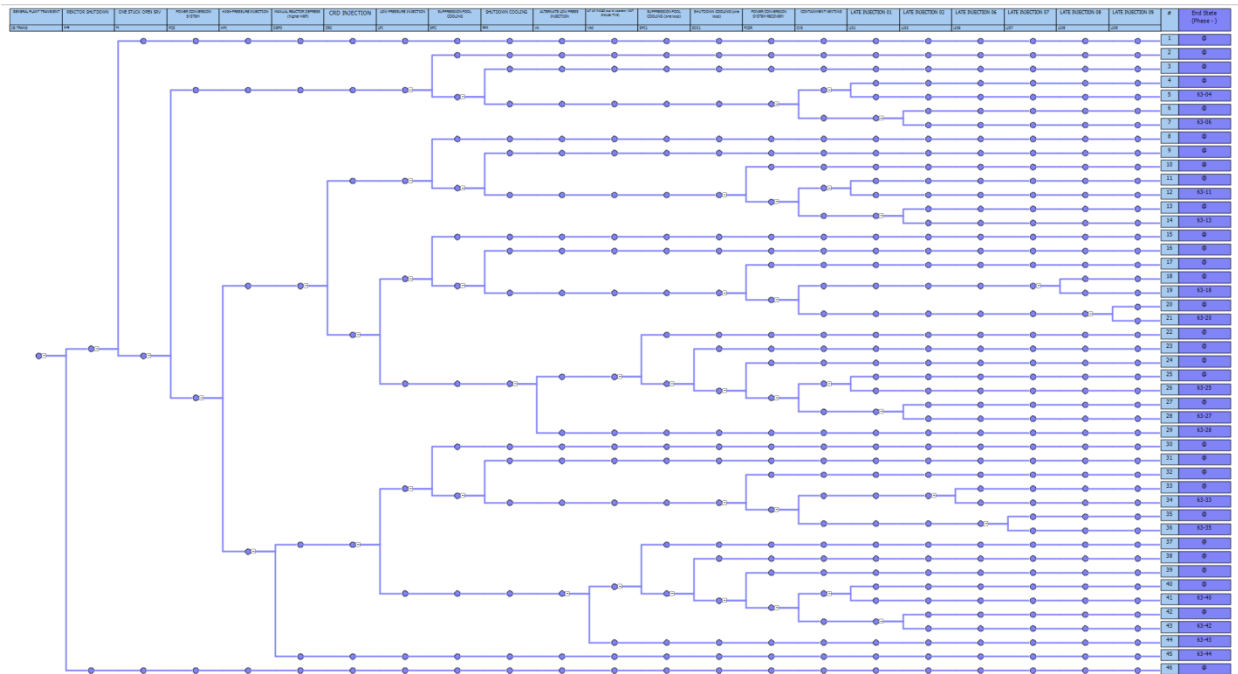


Figure A.15. One Stuck Open SRVs TRANS Event Tree



Figure A.16. Condensed One Stuck Open SRVs TRANS Event Tree

Figure A.17 demonstrates the event sequences in the TRANS event tree with two or more stuck open SRVs.

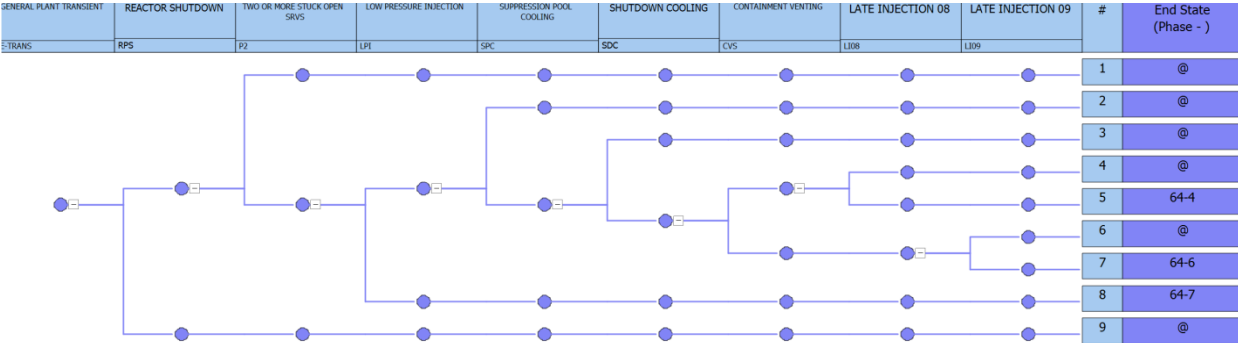


Figure A.17. Two+ Stuck Open SRVs TRANS Event Tree

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APPENDIX C. CONTROL STRUCTURE DIAGRAMS

The control structure for the ADS is provided in Figure A.18. Note that the auxiliary systems are colored in a light orange color to clearly separate them from the ADS boundary.

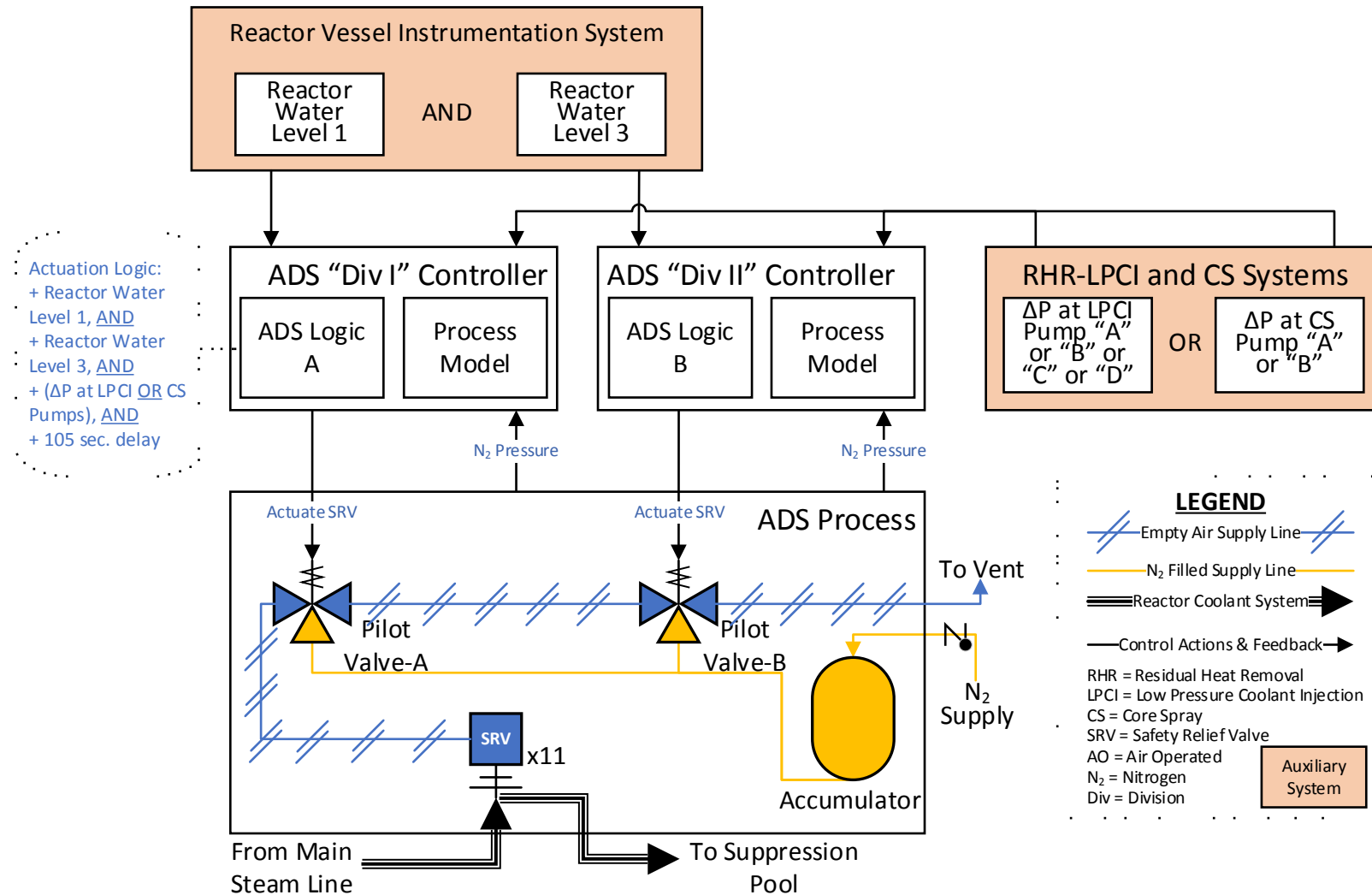


Figure A.18. Control structure for ADS.

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APPENDIX D. MODELED CONTROL ACTIONS AND UCAS

Control Action	UCA	Basic Event
CA31-101: ADS Div-I Controller sends open signal to SRV-A1	UCA31-101A1: ADS Div-I controller does not send open signal to SRV-A1 when RCS depressurization needed. [H1]	SRV-A1_UCA31-101A1
CA31-102: ADS Div-I Controller sends open signal to SRV-A2	UCA31-102A1: ADS Div-I controller does not send open signal to SRV-A2 when RCS depressurization needed. [H1]	SRV-A2_UCA31-102A1
CA31-103: ADS Div-I Controller sends open signal to SRV-A3	UCA31-103A1: ADS Div-I controller does not send open signal to SRV-A3 when RCS depressurization needed. [H1]	SRV-A3_UCA31-103A1
CA31-104: ADS Div-I Controller sends open signal to SRV-A4	UCA31-104A1: ADS Div-I controller does not send open signal to SRV-A4 when RCS depressurization needed. [H1]	SRV-A4_UCA31-104A1
CA31-105: ADS Div-I Controller sends open signal to SRV-A5	UCA31-105A1: ADS Div-I controller does not send open signal to SRV-A5 when RCS depressurization needed. [H1]	SRV-A5_UCA31-105A1
CA31-106: ADS Div-I Controller sends open signal to SRV-A6	UCA31-106A1: ADS Div-I controller does not send open signal to SRV-A6 when RCS depressurization needed. [H1]	SRV-A6_UCA31-106A1
CA31-107: ADS Div-I Controller sends open signal to SRV-A7	UCA31-107A1: ADS Div-I controller does not send open signal to SRV-A7 when RCS depressurization needed. [H1]	SRV-A7_UCA31-107A1
CA31-108: ADS Div-I Controller sends open signal to SRV-A8	UCA31-108A1: ADS Div-I controller does not send open signal to SRV-A8 when RCS depressurization needed. [H1]	SRV-A8_UCA31-108A1
CA31-109: ADS Div-I Controller sends open signal to SRV-A9	UCA31-109A1: ADS Div-I controller does not send open signal to SRV-A9 when RCS depressurization needed. [H1]	SRV-A9_UCA31-109A1
CA31-110: ADS Div-I Controller sends open signal to SRV-A10	UCA31-110A1: ADS Div-I controller does not send open signal to SRV-A10 when RCS depressurization needed. [H1]	SRV-A10_UCA31-110A1
CA31-111: ADS Div-I Controller sends open signal to SRV-A11	UCA31-111A1: ADS Div-I controller does not send open signal to SRV-A11 when RCS depressurization needed. [H1]	SRV-A11_UCA31-111A1

Control Action	UCA	Basic Event
CA32-101: ADS Div-II Controller sends open signal to SRV-B1	UCA32-101A1: ADS Div-II controller does not send open signal to SRV-B1 when RCS depressurization needed. [H1]	SRV-B1_UCA32-101A1
CA32-102: ADS Div-II Controller sends open signal to SRV-B2	UCA32-102A1: ADS Div-II controller does not send open signal to SRV-B2 when RCS depressurization needed. [H1]	SRV-B2_UCA32-102A1
CA32-103: ADS Div-II Controller sends open signal to SRV-B3	UCA32-103A1: ADS Div-II controller does not send open signal to SRV-B3 when RCS depressurization needed. [H1]	SRV-B3_UCA32-103A1
CA32-104: ADS Div-II Controller sends open signal to SRV-B4	UCA32-104A1: ADS Div-II controller does not send open signal to SRV-B4 when RCS depressurization needed. [H1]	SRV-B4_UCA32-104A1
CA32-105: ADS Div-II Controller sends open signal to SRV-B5	UCA32-105A1: ADS Div-II controller does not send open signal to SRV-B5 when RCS depressurization needed. [H1]	SRV-B5_UCA32-105A1
CA32-106: ADS Div-II Controller sends open signal to SRV-B6	UCA32-106A1: ADS Div-II controller does not send open signal to SRV-B6 when RCS depressurization needed. [H1]	SRV-B6_UCA32-106A1
CA32-107: ADS Div-II Controller sends open signal to SRV-B7	UCA32-107A1: ADS Div-II controller does not send open signal to SRV-B7 when RCS depressurization needed. [H1]	SRV-B7_UCA32-107A1
CA32-108: ADS Div-II Controller sends open signal to SRV-B8	UCA32-108A1: ADS Div-II controller does not send open signal to SRV-B8 when RCS depressurization needed. [H1]	SRV-B8_UCA32-108A1
CA32-109: ADS Div-II Controller sends open signal to SRV-B9	UCA32-109A1: ADS Div-II controller does not send open signal to SRV-B9 when RCS depressurization needed. [H1]	SRV-B9_UCA32-109A1
CA32-110: ADS Div-II Controller sends open signal to SRV-B10	UCA32-110A1: ADS Div-II controller does not send open signal to SRV-B10 when RCS depressurization needed. [H1]	SRV-B10_UCA32-110A1
CA32-111: ADS Div-II Controller sends open signal to SRV-B11	UCA32-111A1: ADS Div-II controller does not send open signal to SRV-B11 when RCS depressurization needed. [H1]	SRV-B11_UCA32-111A1
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	UCA11-102B: HPCI Controller sends CLOSE command to MOV-41 when HPCI System is actively providing coolant to the reactor vessel. [H1]	HPCI-MOV-OC-41_UCA11-102B

Control Action	UCA	Basic Event
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	UCA11-102C2 (PTL): HPCI Controller sends CLOSE command to MOV-41 too long after receiving HPCI Isolation Signal. [H1]	HPCI-MOV-OC-41_UCA11-102C2
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	UCA11-102D (ETL): HPCI Controller continues to send CLOSE command to MOV-41 when HPCI is returning to normal lineup state following HPCI Isolation Conditions. [H1]	HPCI-MOV-OC-41_UCA11-102D
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103A1: HPCI Controller does not send OPEN command to MOV-42 when it receives the HPCI Initiation Signal. [H1]	HPCI-MOV-CC-42_UCA11-103A1
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103A2: HPCI Controller does not send OPEN command to MOV-42 when it receives the RCIC Initiation Signal. [H1]	HPCI-MOV-CC-42_UCA11-103A2
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103C2 (PTL):HPCI Controller sends OPEN command to MOV-42 too long after Reactor Vessel Water Level drops to Level 2 (-38.5in).[H2]	HPCI-MOV-CC-42_UCA11-103C2
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103C3 (WO): HPCI Controller sends OPEN command to MOV-42 while MOV-48 is OPEN. [H2]	HPCI-MOV-CC-42_UCA11-103C3
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104B: HPCI Controller sends CLOSE command to MOV-42 when HPCI System is actively providing coolant to the reactor vessel. [H1]	HPCI-MOV-CC-42_UCA11-104B

Control Action	UCA	Basic Event
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104C2 (PTL): HPCI Controller sends CLOSE command to MOV-42 too long after receiving HPCI Isolation Signal. [H1]	HPCI-MOV-CC-42_UCA11-104C2
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104D (ETL): HPCI Controller continues to send CLOSE command to MOV-42 when HPCI is returning to normal lineup state following HPCI Isolation Conditions. [H1]	HPCI-MOV-CC-42_UCA11-104D
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301A: HPCI Flow Controller does not send INCREASE POSITION command to HOV-52 when flow at outlet of HPCI Pump is below the setpoint specified by the Operator. [H8]	HPCI-HOV-CC-52_UCA11-301A
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301B: HPCI Flow Controller sends INCREASE POSITION command to HOV-52 when HPCI Pump outlet flow is at or above 4250 GPM. [H3, H9, H10]	HPCI-HOV-CC-52_UCA11-301B
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301C1 (PTE): HPCI Flow Controller sends INCREASE POSITION command to HOV-52 before HPCI Pump outlet flow has dropped below the specified setpoint. [H3, H9, H10]	HPCI-HOV-CC-52_UCA11-301C1
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301C2 (PTL):HPCI Flow Controller sends INCREASE POSITION command to HOV-52 too long after HPCI Pump outlet flow has dropped below the specified setpoint.[H8]	HPCI-HOV-CC-52_UCA11-301C2

Control Action	UCA	Basic Event
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301D1 (ETL): HPCI Flow Controller continues to send INCREASE POSITION command to HOV-52 when specified HPCI Pump outlet flow has been reached. [H3, H9, H10]	HPCI-HOV-CC-52_UCA11-301D1
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	UCA11-301D2 (STS): HPCI Flow Controller stops sending INCREASE POSITION command to HOV-52 before specified HPCI Pump outlet flow has been reached. [H8]	HPCI-HOV-CC-52_UCA11-301D2
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302A: HPCI Flow Controller does not send DECREASE POSITION command to HOV-52 when flow at outlet of HPCI Pump is above 4250 GPM. [H3, H9, H10]	HPCI-HOV-CC-52_UCA11-302A
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302C1 (PTE): HPCI Flow Controller sends DECREASE POSITION command to HOV-52 before HPCI Pump outlet flow has reached the specified setpoint. [H2, H8]	HPCI-HOV-CC-52_UCA11-302C1
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302C2 (PTL): HPCI Flow Controller sends DECREASE POSITION command to HOV-52 too late after HPCI Pump outlet flow turbine trip setpoint of 5312.5 GPM. [H3, H9, H10]	HPCI-HOV-CC-52_UCA11-302C2
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302D1 (ETL): HPCI Flow Controller continues to send DECREASE POSITION command to HOV-52 when specified HPCI Pump outlet flow has been reached. [H8]	HPCI-HOV-CC-52_UCA11-302D1

Control Action	UCA	Basic Event
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	UCA13-101A: HPCI Controller does not send OPEN command to MOV-35 when HPCI system initiation signal is received. [H7]	HPCI-MOV-CC-35_UCA13-101A
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	UCA13-101C2(PTL):HPCI Controller sends OPEN command to MOV-35 after HPCI system initiation signal is received.[H7]	HPCI-MOV-CC-35_UCA13-101C2
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	UCA13-103A: HPCI Controller does not send OPEN command to MOV-32 when low CST level signal has been received. [H6, H7]	HPCI-MOV-CC-32_UCA13-103A
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	UCA13-103C2(PTL): HPCI Controller sends OPEN command to MOV-31 after low CST level signal has been received. [H6, H7]	HPCI-MOV-CC-32_UCA13-103C2
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401A: RHR system I Controller does not send Start Pump signal to RHR Pump A when LPCI mode is required [H1, H6]	RHR-MDP-FS-A_UCA21-401A
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401B2: RHR System I Controller sends start pump signal to RHR Pump A when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-A_UCA21-401B2

Control Action	UCA	Basic Event
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401C1 (Too Early): RHR System I Controller sends start pump signal to RHR Pump A before downstream valves are aligned for RHR LPCI mode [H6]	RHR-MDP-FS-A_UCA21-401C1
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401C4 (Wrong Order): RHR System I Controller sends start pump signal to RHR Pump A when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-A_UCA21-401C4
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402B: RHR System I Controller sends Stop pump signal to RHR Pump A when reactor cooling has not been achieved AND all valves in suction path are fully-open[H6]	RHR-MDP-FR-A_UCA21-402B
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402C1 (Too Early): RHR System I Controller sends Stop pump signal to RHR Pump A before reactor cooling has been achieved [H6]	RHR-MDP-FR-A_UCA21-402C1
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402C3 (Wrong Order): RHR System I Controller sends Stop pump signal to RHR Pump A after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	RHR-MDP-FR-A_UCA21-402C3

Control Action	UCA	Basic Event
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403A: RHR Pump A does not send Pump Status Signal to RHR System I Controller when Pump Stopped signal is needed [H2, H6]	RHR-MDP-A_NSIG_UCA21-403A
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403C2 (Too Late): RHR Pump A sends Pump Status Signal to RHR System I Controller after Stopped signal is needed [H2, H6]	RHR-MDP-A_LSIG_UCA21-403C2
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404A: RHR system I Controller does not send Start Pump signal to RHR Pump C when LPCI mode is required [H1, H6]	RHR-MDP-FS-C_UCA21-404A
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404B2: RHR System I Controller sends start pump signal to RHR Pump C when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-C_UCA21-404B2
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404C1 (Too Early): RHR System I Controller sends start pump signal to RHR Pump C before downstream valves are aligned for RHR LPCI mode[H6]	RHR-MDP-FS-C_UCA21-404C1
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404C4 (Wrong Order): RHR System I Controller sends start pump signal to RHR Pump C when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-C_UCA21-404C4

Control Action	UCA	Basic Event
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405B: RHR System I Controller sends Stop pump signal to RHR Pump C when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	RHR-MDP-FR-C_UCA21-405B
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405C1 (Too Early): RHR System I Controller sends Stop pump signal to RHR Pump C before reactor cooling has been achieved [H6]	RHR-MDP-FR-C_UCA21-405C1
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405C3 (Wrong Order): RHR System I Controller sends Stop pump signal to RHR Pump C after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	RHR-MDP-FR-C_UCA21-405C3
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406A: RHR Pump C does not send Pump Status Signal to RHR System I Controller when Pump Stopped signal is needed [H2, H6]	RHR-MDP-C_NSIG_UCA21-406A
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406C2 (Too Late): RHR Pump C sends Pump Status Signal to RHR System I Controller after Stopped signal is needed[H2, H6]	RHR-MDP-C_LSIG_UCA21-406C2
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410B: RHR System I Controller sends Close signal to MOV-31A while RHR is providing reactor cooling [H1, H2, H6]	RHR-MOV-OC-31A_UCA21-410B

Control Action	UCA	Basic Event
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410C1 (Too Early): RHR System I Controller sends Close signal to MOV-31A while RHR Pump A is taking suction from the suppression pool [H1, H2, H6]	RHR-MOV-OC-31A_UCA21-410C1
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410C3 (Wrong Order): RHR System I Controller sends Close signal to MOV-31A before RHR Pump A stops [H2]	RHR-MOV-OC-31A_UCA21-410C3
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411A: MOV-31A does not send MOV-31A Valve Position Feedback to RHR System I Controller when valve state is changed (fully-open / fully-closed) [H1, H2, H4, H6]	RHR-MOV-OC-31A_UCA21-411A
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411C1 (Too Early): MOV-31A sends valve open OR closed signal before the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31A_UCA21-411C1
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411C2 (Too Late): MOV-31A sends valve open OR closed signal some time after the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31A_UCA21-411C2
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413B: RHR System I Controller sends Close signal to MOV-31C while RHR is providing reactor cooling [H1, H2, H6]	RHR-MOV-OC-31C_UCA21-413B

Control Action	UCA	Basic Event
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413C1 (Too Early): RHR System I Controller sends Close signal to MOV-31C while RHR Pump C is taking suction from the suppression pool[H1, H2, H6]	RHR-MOV-OC-31C_UCA21-413C1
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413C3 (Wrong Order): RHR System I Controller sends Close signal to MOV-31C before RHR Pump C stops [H2]	RHR-MOV-OC-31C_UCA21-413C3
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414A: MOV-31C does not send MOV-31C Valve Position Feedback to RHR System I Controller when valve state is changed (fully-open / fully-closed) [H1, H2, H4, H6]	RHR-MOV-OC-31C_UCA21-414A
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414C1 (Too Early): MOV-31C sends valve open OR closed signal before the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31C_UCA21-414C1
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414C2 (Too Late): MOV-31C sends valve open OR closed signal some time after the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31C_UCA21-414C2
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418B: RHR System I Controller sends Open signal to MOV-40A when LPCI Mode is in operation [H1, H6]	RHR-MOV-CO-40A_UCA21-418B

Control Action	UCA	Basic Event
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418C1 (Too Early): RHR System I Controller sends Open signal to MOV-40A before LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-40A_UCA21-418C1
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418C2 (Too Late): RHR System I Controller sends Open signal to MOV-40A after LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-40A_UCA21-418C2
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA21-420A: MOV-40A does not send MOV-40A Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CO-40A_UCA21-420A
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA21-420C1 (Too Early): MOV-40A sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CO-40A_UCA21-420C1
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA21-420C2 (Too Late): MOV-40A sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CO-40A_UCA21-420C2
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA21-421B: RHR System I Controller sends Open signal to MOV-41A when LPCI Mode is in operation [H1, H6]	RHR-MOV-CO-41A_UCA21-421B

Control Action	UCA	Basic Event
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA21-421C1 (Too Early): RHR System I Controller sends Open signal to MOV-41A before LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-41A_UCA21-421C1
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA21-421C2 (Too Late): RHR System I Controller sends Open signal to MOV-41A after LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-41A_UCA21-421C2
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA21-423A:MOV-41A does not send MOV-41A Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller[H8]	RHR-MOV-CO-41A_UCA21-423A
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA21-423C1 (Too Early): MOV-41A sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CO-41A_UCA21-423C1
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA21-423C2 (Too Late): MOV-41A sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CO-41A_UCA21-423C2
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424A: RHR System I Controller does not send Open signal to MOV-37A when LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37A_UCA21-424A

Control Action	UCA	Basic Event
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424B: RHR System I Controller sends Open signal to MOV-37A when plant is at-power. [H4, H7]	RHR-MOV-CC-37A_UCA21-424B
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424C1 (Too Early): RHR System I Controller sends Open signal to MOV-37A before LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37A_UCA21-424C1
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424C2 (Too Late): RHR System I Controller sends Open signal to MOV-37A after LOCA conditions are indicated AND Rx Pressure < 338 psig [H4, H7]	RHR-MOV-CC-37A_UCA21-424C2
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425B: RHR System I Controller sends Close signal to MOV-37A while LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37A_UCA21-425B
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425C1 (Too Early): RHR System I Controller sends Close signal to MOV-37A before adequate LPCI has been achieved [H1, H4, H5]	RHR-MOV-CC-37A_UCA21-425C1
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425C2 (Too Late): RHR System I Controller sends Close signal to MOV-37A after adequate LPCI has been achieved [H1, H4, H5]	RHR-MOV-CC-37A_UCA21-425C2

Control Action	UCA	Basic Event
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426A: MOV-37A does not send MOV-39A Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CC-37A_UCA21-426A
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426C1 (Too Early): MOV-37A sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-37A_UCA21-426C1
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426C2 (Too Late): MOV-37A sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-37A_UCA21-426C2
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442A: RHR System I Controller does not send MOV-37A position to RHR System II Controller. [H1, H2, H8]	RHR-MOV-CC-37A_UCA21-442A
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442C1 (Too Early): RHR System I Controller sends MOV-37A position to RHR System II Controller before valve position changes.[H1, H2, H8]	RHR-MOV-CC-37A_UCA21-442C1
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442C2 (Too Late): RHR System I Controller sends MOV-37A position to RHR System II Controller after valve position changes. [H1, H2, H8]	RHR-MOV-CC-37A_UCA21-442C2

Control Action	UCA	Basic Event
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401A: RHR system II Controller does not send Start Pump signal to RHR Pump B when LPCI mode is required [H1, H6]	RHR-MDP-FS-B_UCA22-401A
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401B2: RHR System II Controller sends start pump signal to RHR Pump B when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-B_UCA22-401B2
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401C1 (Too Early): RHR System II Controller sends start pump signal to RHR Pump B before downstream valves are aligned for RHR LPCI mode [H6]	RHR-MDP-FS-B_UCA22-401BC1
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401C4 (Wrong Order): RHR System II Controller sends start pump signal to RHR Pump B when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-B_UCA22-401BC4
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402B: RHR System II Controller sends Stop pump signal to RHR Pump B when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	RHR-MDP-FS-B_UCA22-402B
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402C1 (Too Early): RHR System II Controller sends Stop pump signal to RHR Pump B before reactor cooling has been achieved[H6]	RHR-MDP-FS-B_UCA22-402C1

Control Action	UCA	Basic Event
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402C3 (Wrong Order): RHR System II Controller sends Stop pump signal to RHR Pump B after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	RHR-MDP-FS-B_UCA22-402C3
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403A: RHR Pump B does not send Pump Status Signal to RHR System II Controller when Pump Stopped signal is needed [H2, H6]	RHR-MDP-B_NSIG_UCA22-403A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403C2 (Too Late): RHR Pump B sends Pump Status Signal to RHR System II Controller after Pump Running/Stopped signal is needed [H2, H6]	RHR-MDP-B_LSIG_UCA22-403C2
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404A: RHR system II Controller does not send Start Pump signal to RHR Pump D when LPCI mode is required [H1, H6]	RHR-MDP-FS-D_UCA22-404A
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404B2: RHR System II Controller sends start pump signal to RHR Pump D when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	RHR-MDP-FS-D_UCA22-404B2
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404C1 (Too Early): RHR System II Controller sends start pump signal to RHR Pump D before downstream valves are aligned for RHR LPCI mode [H6]	RHR-MDP-FS-D_UCA22-404C1

Control Action	UCA	Basic Event
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404C4 (Wrong Order):RHR System II Controller sends start pump signal to RHR Pump D when suppression pool suction valves OR shutdown cooling valves are not fully-open[H2, H6]	RHR-MDP-FS-D_UCA22-404C4
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405B: RHR System II Controller sends Stop pump signal to RHR Pump D when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	RHR-MDP-FS-D_UCA22-405B
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405C1 (Too Early): RHR System II Controller sends Stop pump signal to RHR Pump D before reactor cooling has been achieved [H6]	RHR-MDP-FS-D_UCA22-405C1
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405C3 (Wrong Order): RHR System II Controller sends Stop pump signal to RHR Pump D after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	RHR-MDP-FS-D_UCA22-405C3
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406A: RHR Pump D does not send Pump Status Signal to RHR System II Controller when Pump Stopped signal is needed [H2, H6]	RHR-MDP-D_NSIG_UCA22-406A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406C2 (Too Late): RHR Pump D sends Pump Status Signal to RHR System II Controller after Pump Running/Stopped signal is needed [H2, H6]	RHR-MDP-D_LSIG_UCA22-406C2

Control Action	UCA	Basic Event
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410B: RHR System II Controller sends Close signal to MOV-31B while RHR is providing reactor cooling [H1, H2, H6]	RHR-MOV-OC-31B_UCA22-410B
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410C1 (Too Early): RHR System II Controller sends Close signal to MOV-31B while RHR Pump B is taking suction from the suppression pool[H1, H2, H6]	RHR-MOV-OC-31B_UCA22-410C1
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410C3 (Wrong Order): RHR System II Controller sends Close signal to MOV-31B before RHR Pump B stops [H2]	RHR-MOV-OC-31B_UCA22-410C3
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411A: MOV-31B does not send MOV-31B Valve Position Feedback to RHR System II Controller when valve state is changed (fully-open / fully-closed) [H1, H2, H4, H6]	RHR-MOV-OC-31B_UCA22-411A
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411C1 (Too Early): MOV-31B sends valve open OR closed signal before the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31B_UCA22-411C1
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411C2 (Too Late): MOV-31B sends valve open OR closed signal some time after the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31B_UCA22-411C2

Control Action	UCA	Basic Event
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413B: RHR System II Controller sends Close signal to MOV-31D while RHR is providing reactor cooling [H1, H2, H6]	RHR-MOV-OC-31D_UCA22-413B
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413C1 (Too Early): RHR System II Controller sends Close signal to MOV-31D while RHR Pump D is taking suction from the suppression pool [H1, H2, H6]	RHR-MOV-OC-31D_UCA22-413C1
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413C3 (Wrong Order):RHR System II Controller sends Close signal to MOV-31D before RHR Pump D stops[H2]	RHR-MOV-OC-31D_UCA22-413C3
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414A: MOV-31D does not send MOV-31D Valve Position Feedback to RHR System II Controller when valve state is changed (fully-open / fully-closed) [H1, H2, H4, H6]	RHR-MOV-OC-31D_UCA22-414A
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414C1 (Too Early): MOV-31D sends valve open OR closed signal before the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31D_UCA22-414C1
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414C2 (Too Late): MOV-31D sends valve open OR closed signal some time after the valve is fully engaged in the respective position [H1, H2, H4, H6]	RHR-MOV-OC-31D_UCA22-414C2

Control Action	UCA	Basic Event
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA22-418B: RHR System II Controller sends Open signal to MOV-40B when LPCI Mode is in operation [H1, H6]	RHR-MOV-CO-40B_UCA22-418B
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA22-418C1 (Too Early): RHR System II Controller sends Open signal to MOV-40B before LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-40B_UCA22-418C1
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA22-418C2 (Too Late): RHR System II Controller sends Open signal to MOV-40B after LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-40B_UCA22-418C2
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA22-420A: MOV-40B does not send MOV-40B Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CO-40B_UCA22-420A
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA22-420C1 (Too Early): MOV-40B sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CO-40B_UCA22-420C1
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA22-420C2 (Too Late): MOV-40B sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CO-40B_UCA22-420C2

Control Action	UCA	Basic Event
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA22-421B: RHR System II Controller sends Open signal to MOV-41B when LPCI Mode is in operation [H1, H6]	RHR-MOV-CO-41B_UCA22-421B
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA22-421C1 (Too Early): RHR System II Controller sends Open signal to MOV-41B before LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-41B_UCA22-421C1
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA22-421C2 (Too Late): RHR System II Controller sends Open signal to MOV-41B after LPCI has adequately provided cooling to recirculation [H1, H6]	RHR-MOV-CO-41B_UCA22-421C2
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA22-423A: MOV-41B does not send MOV-41B Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CO-41B_UCA22-423A
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA22-423C1 (Too Early): MOV-41B sends valve open OR closed signal before the valve is fully engaged in the respective position[H8]	RHR-MOV-CO-41B_UCA22-423C1
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA22-423C2 (Too Late): MOV-41B sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CO-41B_UCA22-423C2

Control Action	UCA	Basic Event
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424A: RHR System II Controller does not send Open signal to MOV-37B when LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37B_UCA22-424A
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424B: RHR System II Controller sends Open signal to MOV-37B when plant is at-power. [H4, H7]	RHR-MOV-CC-37B_UCA22-424B
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424C1 (Too Early): RHR System II Controller sends Open signal to MOV-37B before LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37B_UCA22-424C1
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424C2 (Too Late): RHR System II Controller sends Open signal to MOV-37B after LOCA conditions are indicated AND Rx Pressure < 338 psig [H4, H7]	RHR-MOV-CC-37B_UCA22-424C2
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425B: RHR System II Controller sends Close signal to MOV-37B while LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	RHR-MOV-CC-37B_UCA22-425B
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425C1 (Too Early): RHR System II Controller sends Close signal to MOV-37B before adequate LPCI has been achieved[H1, H4, H5]	RHR-MOV-CC-37B_UCA22-425C1

Control Action	UCA	Basic Event
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425C2 (Too Late): RHR System II Controller sends Close signal to MOV-37B after adequate LPCI has been achieved [H1, H4, H5]	RHR-MOV-CC-37B_UCA22-425C2
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426A: MOV-37B does not send MOV-39B Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CC-37B_UCA22-426A
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426C1 (Too Early): MOV-37B sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-37B_UCA22-426C1
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426C2 (Too Late): MOV-37B sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-37B_UCA22-426C2
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445A: RHR System II Controller does not send MOV-37B position to RHR System I Controller. [H1, H2, H8]	RHR-MOV-CC-37B_UCA22-445A
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445C1 (Too Early): RHR System II Controller sends MOV-37B position to RHR System I Controller before valve position changes. [H1, H2, H8]	RHR-MOV-CC-37B_UCA22-445C1

Control Action	UCA	Basic Event
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445C2 (Too Late): RHR System II Controller sends MOV-37B position to RHR System I Controller after valve position changes.[H1, H2, H8]	RHR-MOV-CC-37B_UCA22-445C2
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448A: RHR System I Controller does not send Open signal to MOV-32A when LPCI initiation signal is received and RHR Pump A is needed. [H1, H2, H6]	RHR-MOV-CC-32A_UCA21-448A
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448B: RHR System I Controller sends Open signal to MOV-32A when plant is at-power. [H4, H7]	RHR-MOV-CC-32A_UCA21-448B
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448C1 (Too Early): RHR System I Controller sends Open signal to MOV-32A before LOCA conditions are indicated [H4, H7]	RHR-MOV-CC-32A_UCA21-448C1
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448C2 (Too Late): RHR System I Controller sends Open signal to MOV-32A after LOCA conditions are indicated AND System I controller determines that Train A is needed. [H1, H2, H6]	RHR-MOV-CC-32A_UCA21-448C2
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449B: RHR System I Controller sends Close signal to MOV-32A while core cooling operations on RHR Train A are required. [H1, H2, H6]	RHR-MOV-CC-32A_UCA21-449B
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449C1 (Too Early): RHR System I Controller sends Close signal to MOV-32A before adequate core cooling has been achieved. [H4, H7]	RHR-MOV-CC-32A_UCA21-449C1

Control Action	UCA	Basic Event
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449C2 (Too Late): RHR System I Controller sends Close signal to MOV-32A after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-CC-32A_UCA21-449C2
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450A:MOV-32A does not send Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller[H8]	RHR-MOV-CC-32A_UCA21-450A
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450C1 (Too Early): MOV-32A sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-32A_UCA21-450C1
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450C2 (Too Late): MOV-32A sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-32A_UCA21-450C2
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451A: RHR System I Controller does not send Open signal to MOV-32C when LPCI initiation signal is received and RHR Pump C is needed. [H1, H2, H6]	RHR-MOV-CC-32C_UCA21-451A
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451B: RHR System I Controller sends Open signal to MOV-32C when plant is at-power. [H4, H7]	RHR-MOV-CC-32C_UCA21-451B
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451C1 (Too Early): RHR System I Controller sends Open signal to MOV-32C before LOCA conditions are indicated [H4, H7]	RHR-MOV-CC-32C_UCA21-451C1

Control Action	UCA	Basic Event
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451C2 (Too Late): RHR System I Controller sends Open signal to MOV-32C after LOCA conditions are indicated AND System I controller determines that Train C is needed. [H1, H2, H6]	RHR-MOV-CC-32C_UCA21-451C2
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452B: RHR System I Controller sends Close signal to MOV-32C while core cooling operations on RHR Train C are required. [H1, H2, H6]	RHR-MOV-CC-32C_UCA21-452B
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452C1 (Too Early): RHR System I Controller sends Close signal to MOV-32C before adequate core cooling has been achieved.[H4, H7]	RHR-MOV-CC-32C_UCA21-452C1
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452C2 (Too Late): RHR System I Controller sends Close signal to MOV-32C after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-CC-32C_UCA21-452C2
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453A: MOV-32C does not send Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CC-32C_UCA21-453A
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453C1 (Too Early): MOV-32C sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-32C_UCA21-453C1
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453C2 (Too Late): MOV-32C sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-32C_UCA21-453C2

Control Action	UCA	Basic Event
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448A: RHR System II Controller does not send Open signal to MOV-32B when LPCI initiation signal is received and RHR Pump B is needed. [H1, H2, H6]	RHR-MOV-CC-32B_UCA22-448A
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448B: RHR System II Controller sends Open signal to MOV-32B when plant is at-power. [H4, H7]	RHR-MOV-CC-32B_UCA22-448B
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448C1 (Too Early): RHR System II Controller sends Open signal to MOV-32B before LOCA conditions are indicated [H4, H7]	RHR-MOV-CC-32B_UCA22-448C1
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448C2 (Too Late): RHR System II Controller sends Open signal to MOV-32B after LOCA conditions are indicated AND System I controller determines that Train B is needed.[H1, H2, H6]	RHR-MOV-CC-32B_UCA22-448C2
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449B: RHR System II Controller sends Close signal to MOV-32B while core cooling operations on RHR Train B are required. [H1, H2, H6]	RHR-MOV-CC-32B_UCA22-449B
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449C1 (Too Early): RHR System II Controller sends Close signal to MOV-32B before adequate core cooling has been achieved. [H4, H7]	RHR-MOV-CC-32B_UCA22-449C1
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449C2 (Too Late): RHR System II Controller sends Close signal to MOV-32B after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-CC-32B_UCA22-449C2

Control Action	UCA	Basic Event
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450A: MOV-32B does not send Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CC-32B_UCA22-450A
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450C1 (Too Early): MOV-32B sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-32B_UCA22-450C1
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450C2 (Too Late): MOV-32B sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-32B_UCA22-450C2
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451A: RHR System II Controller does not send Open signal to MOV-32D when LPCI initiation signal is received and RHR Pump D is needed. [H1, H2, H6]	RHR-MOV-CC-32D_UCA22-451A
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451B: RHR System II Controller sends Open signal to MOV-32D when plant is at-power.[H4, H7]	RHR-MOV-CC-32D_UCA22-451B
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451C1 (Too Early): RHR System II Controller sends Open signal to MOV-32D before LOCA conditions are indicated [H4, H7]	RHR-MOV-CC-32D_UCA22-451C1
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451C2 (Too Late): RHR System II Controller sends Open signal to MOV-32D after LOCA conditions are indicated AND System I controller determines that Train D is needed. [H1, H2, H6]	RHR-MOV-CC-32D_UCA22-451C2

Control Action	UCA	Basic Event
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452B: RHR System II Controller sends Close signal to MOV-32D while core cooling operations on RHR Train D are required. [H1, H2, H6]	RHR-MOV-CC-32D_UCA22-452B
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452C1 (Too Early): RHR System II Controller sends Close signal to MOV-32D before adequate core cooling has been achieved. [H4, H7]	RHR-MOV-CC-32D_UCA22-452C1
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452C2 (Too Late): RHR System II Controller sends Close signal to MOV-32D after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-CC-32D_UCA22-452C2
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453A: MOV-32D does not send Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	RHR-MOV-CC-32D_UCA22-453A
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453C1 (Too Early): MOV-32D sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	RHR-MOV-CC-32D_UCA22-453C1
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453C2 (Too Late): MOV-32D sends valve open OR closed signal after the valve has been moved from its position [H8]	RHR-MOV-CC-32D_UCA22-453C2
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455B:RHR System I Controller sends Close signal to MOV-33A while core cooling operations on RHR Train A are required.[H1]	RHR-MOV-OC-33A_UCA21-455B

Control Action	UCA	Basic Event
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455C1 (Too Early): RHR System I Controller sends Close signal to MOV-33A before adequate core cooling has been achieved. [H4, H7]	RHR-MOV-OC-33A_UCA21-455C1
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455C2 (Too Late): RHR System I Controller sends Close signal to MOV-33A after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-OC-33A_UCA21-455C2
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455B: RHR System II Controller sends Close signal to MOV-33B while core cooling operations on RHR Train B are required. [H1]	RHR-MOV-OC-33B_UCA22-455B
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455C1 (Too Early): RHR System II Controller sends Close signal to MOV-33B before adequate core cooling has been achieved. [H4, H7]	RHR-MOV-OC-33B_UCA22-455C1
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455C2 (Too Late): RHR System II Controller sends Close signal to MOV-33B after adequate core cooling has been achieved. [H1, H4, H5]	RHR-MOV-OC-33B_UCA22-455C2

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APPENDIX E. CONTROL ACTIONS AND UCAS NOT MODELED

Control Action	UCA	Modeled
CA31-101: ADS Div-I Controller sends open signal to SRV-A1	UCA31-101B1: ADS Div-I controller sends open signal to SRV-A1 when plant is operating normally. [H2]	No - Loss scenario
CA31-102: ADS Div-I Controller sends open signal to SRV-A2	UCA31-102B1: ADS Div-I controller sends open signal to SRV-A2 when plant is operating normally. [H2]	No - Loss scenario
CA31-103: ADS Div-I Controller sends open signal to SRV-A3	UCA31-103B1: ADS Div-I controller sends open signal to SRV-A3 when plant is operating normally. [H2]	No - Loss scenario
CA31-104: ADS Div-I Controller sends open signal to SRV-A4	UCA31-104B1: ADS Div-I controller sends open signal to SRV-A4 when plant is operating normally. [H2]	No - Loss scenario
CA31-105: ADS Div-I Controller sends open signal to SRV-A5	UCA31-105B1: ADS Div-I controller sends open signal to SRV-A5 when plant is operating normally. [H2]	No - Loss scenario
CA31-106: ADS Div-I Controller sends open signal to SRV-A6	UCA31-106B1: ADS Div-I controller sends open signal to SRV-A6 when plant is operating normally. [H2]	No - Loss scenario
CA31-107: ADS Div-I Controller sends open signal to SRV-A7	UCA31-107B1: ADS Div-I controller sends open signal to SRV-A7 when plant is operating normally. [H2]	No - Loss scenario
CA31-108: ADS Div-I Controller sends open signal to SRV-A8	UCA31-108B1: ADS Div-I controller sends open signal to SRV-A8 when plant is operating normally. [H2]	No - Loss scenario
CA31-109: ADS Div-I Controller sends open signal to SRV-A9	UCA31-109B1: ADS Div-I controller sends open signal to SRV-A9 when plant is operating normally. [H2]	No - Loss scenario
CA31-110: ADS Div-I Controller sends open signal to SRV-A10	UCA31-110B1: ADS Div-I controller sends open signal to SRV-A10 when plant is operating normally. [H2]	No - Loss scenario
CA31-111: ADS Div-I Controller sends open signal to SRV-A11	UCA31-111B1: ADS Div-I controller sends open signal to SRV-A11 when plant is operating normally. [H2]	No - Loss scenario

Control Action	UCA	Modeled
CA32-101: ADS Div-II Controller sends open signal to SRV-B1	UCA32-101B1: ADS Div-II controller sends open signal to SRV-B1 when plant is operating normally. [H2]	No - Loss scenario
CA32-102: ADS Div-II Controller sends open signal to SRV-B2	UCA32-102B2: ADS Div-II controller sends open signal to SRV-B2 when plant is operating normally. [H2]	No - Loss scenario
CA32-103: ADS Div-II Controller sends open signal to SRV-B3	UCA32-103B1: ADS Div-II controller sends open signal to SRV-B3 when plant is operating normally. [H2]	No - Loss scenario
CA32-104: ADS Div-II Controller sends open signal to SRV-B4	UCA32-104B1: ADS Div-II controller sends open signal to SRV-B4 when plant is operating normally. [H2]	No - Loss scenario
CA32-105: ADS Div-II Controller sends open signal to SRV-B5	UCA32-105B1: ADS Div-II controller sends open signal to SRV-B5 when plant is operating normally. [H2]	No - Loss scenario
CA32-106: ADS Div-II Controller sends open signal to SRV-B6	UCA32-106B1: ADS Div-II controller sends open signal to SRV-B6 when plant is operating normally. [H2]	No - Loss scenario
CA32-107: ADS Div-II Controller sends open signal to SRV-B7	UCA32-107B1: ADS Div-II controller sends open signal to SRV-B7 when plant is operating normally. [H2]	No - Loss scenario
CA32-108: ADS Div-II Controller sends open signal to SRV-B8	UCA32-108B1: ADS Div-II controller sends open signal to SRV-B8 when plant is operating normally. [H2]	No - Loss scenario
CA32-109: ADS Div-II Controller sends open signal to SRV-B9	UCA32-109B1: ADS Div-II controller sends open signal to SRV-B9 when plant is operating normally. [H2]	No - Loss scenario
CA32-110: ADS Div-II Controller sends open signal to SRV-B10	UCA32-110B1: ADS Div-II controller sends open signal to SRV-B10 when plant is operating normally. [H2]	No - Loss scenario
CA32-111: ADS Div-II Controller sends open signal to SRV-B11	UCA32-111B1: ADS Div-II controller sends open signal to SRV-B11 when plant is operating normally. [H2]	No - Loss scenario
CA31-101: ADS Div-I Controller sends open signal to SRV-A1	UCA31-101C1: ADS Div-I controller sends open signal to SRV-A1 before HPCI has failed. [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA31-101: ADS Div-I Controller sends open signal to SRV-A1	UCA31-101C2: ADS Div-I controller sends open signal to SRV-A1 before 105-second time delay. [H3]	No - Loss scenario
CA31-102: ADS Div-I Controller sends open signal to SRV-A2	UCA31-102C1: ADS Div-I controller sends open signal to SRV-A2 before HPCI has failed. [H3]	No - Loss scenario
CA31-102: ADS Div-I Controller sends open signal to SRV-A2	UCA31-102C2: ADS Div-I controller sends open signal to SRV-A2 before 105-second time delay. [H3]	No - Loss scenario
CA31-103: ADS Div-I Controller sends open signal to SRV-A3	UCA31-103C1: ADS Div-I controller sends open signal to SRV-A3 before HPCI has failed. [H3]	No - Loss scenario
CA31-103: ADS Div-I Controller sends open signal to SRV-A3	UCA31-103C2: ADS Div-I controller sends open signal to SRV-A3 before 105-second time delay. [H3]	No - Loss scenario
CA31-104: ADS Div-I Controller sends open signal to SRV-A4	UCA31-104C1: ADS Div-I controller sends open signal to SRV-A4 before HPCI has failed. [H3]	No - Loss scenario
CA31-104: ADS Div-I Controller sends open signal to SRV-A4	UCA31-104C2: ADS Div-I controller sends open signal to SRV-A4 before 105-second time delay. [H3]	No - Loss scenario
CA31-105: ADS Div-I Controller sends open signal to SRV-A5	UCA31-105C1: ADS Div-I controller sends open signal to SRV-A5 before HPCI has failed. [H3]	No - Loss scenario
CA31-105: ADS Div-I Controller sends open signal to SRV-A5	UCA31-105C2: ADS Div-I controller sends open signal to SRV-A5 before 105-second time delay. [H3]	No - Loss scenario
CA31-106: ADS Div-I Controller sends open signal to SRV-A6	UCA31-106C1: ADS Div-I controller sends open signal to SRV-A6 before HPCI has failed. [H3]	No - Loss scenario
CA31-106: ADS Div-I Controller sends open signal to SRV-A6	UCA31-106C2: ADS Div-I controller sends open signal to SRV-A6 before 105-second time delay. [H3]	No - Loss scenario
CA31-107: ADS Div-I Controller sends open signal to SRV-A7	UCA31-107C1: ADS Div-I controller sends open signal to SRV-A7 before HPCI has failed. [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA31-107: ADS Div-I Controller sends open signal to SRV-A7	UCA31-107C2: ADS Div-I controller sends open signal to SRV-A7 before 105-second time delay. [H3]	No - Loss scenario
CA31-108: ADS Div-I Controller sends open signal to SRV-A8	UCA31-108C1: ADS Div-I controller sends open signal to SRV-A8 before HPCI has failed. [H3]	No - Loss scenario
CA31-108: ADS Div-I Controller sends open signal to SRV-A8	UCA31-108C2: ADS Div-I controller sends open signal to SRV-A8 before 105-second time delay. [H3]	No - Loss scenario
CA31-109: ADS Div-I Controller sends open signal to SRV-A9	UCA31-109C1: ADS Div-I controller sends open signal to SRV-A9 before HPCI has failed. [H3]	No - Loss scenario
CA31-109: ADS Div-I Controller sends open signal to SRV-A9	UCA31-109C2: ADS Div-I controller sends open signal to SRV-A9 before 105-second time delay. [H3]	No - Loss scenario
CA31-110: ADS Div-I Controller sends open signal to SRV-A10	UCA31-110C1: ADS Div-I controller sends open signal to SRV-A10 before HPCI has failed. [H3]	No - Loss scenario
CA31-110: ADS Div-I Controller sends open signal to SRV-A10	UCA31-110C2: ADS Div-I controller sends open signal to SRV-A10 before 105-second time delay. [H3]	No - Loss scenario
CA31-111: ADS Div-I Controller sends open signal to SRV-A11	UCA31-111C1: ADS Div-I controller sends open signal to SRV-A11 before HPCI has failed. [H3]	No - Loss scenario
CA31-111: ADS Div-I Controller sends open signal to SRV-A11	UCA31-111C2: ADS Div-I controller sends open signal to SRV-A11 before 105-second time delay. [H3]	No - Loss scenario
CA32-101: ADS Div-II Controller sends open signal to SRV-B1	UCA32-101C1: ADS Div-II controller sends open signal to SRV-B1 before HPCI has failed. [H3]	No - Loss scenario
CA32-101: ADS Div-II Controller sends open signal to SRV-B1	UCA32-101C2: ADS Div-II controller sends open signal to SRV-B1 before 105-second time delay. [H3]	No - Loss scenario
CA32-102: ADS Div-II Controller sends open signal to SRV-B2	UCA32-102C1: ADS Div-II controller sends open signal to SRV-B2 before HPCI has failed. [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA32-102: ADS Div-II Controller sends open signal to SRV-B2	UCA32-102C2: ADS Div-II controller sends open signal to SRV-B2 before 105-second time delay. [H3]	No - Loss scenario
CA32-103: ADS Div-II Controller sends open signal to SRV-B3	UCA32-103C1: ADS Div-II controller sends open signal to SRV-B3 before HPCI has failed. [H3]	No - Loss scenario
CA32-103: ADS Div-II Controller sends open signal to SRV-B3	UCA32-103C2: ADS Div-II controller sends open signal to SRV-B3 before 105-second time delay. [H3]	No - Loss scenario
CA32-104: ADS Div-II Controller sends open signal to SRV-B4	UCA32-104C1: ADS Div-II controller sends open signal to SRV-B4 before HPCI has failed. [H3]	No - Loss scenario
CA32-104: ADS Div-II Controller sends open signal to SRV-B4	UCA32-104C2: ADS Div-II controller sends open signal to SRV-B4 before 105-second time delay. [H3]	No - Loss scenario
CA32-105: ADS Div-II Controller sends open signal to SRV-B5	UCA32-105C1: ADS Div-II controller sends open signal to SRV-B5 before HPCI has failed. [H3]	No - Loss scenario
CA32-105: ADS Div-II Controller sends open signal to SRV-B5	UCA32-105C2: ADS Div-II controller sends open signal to SRV-B5 before 105-second time delay. [H3]	No - Loss scenario
CA32-106: ADS Div-II Controller sends open signal to SRV-B6	UCA32-106C1: ADS Div-II controller sends open signal to SRV-B6 before HPCI has failed. [H3]	No - Loss scenario
CA32-106: ADS Div-II Controller sends open signal to SRV-B6	UCA32-106C2: ADS Div-II controller sends open signal to SRV-B6 before 105-second time delay. [H3]	No - Loss scenario
CA32-107: ADS Div-II Controller sends open signal to SRV-B7	UCA32-107C1: ADS Div-II controller sends open signal to SRV-B7 before HPCI has failed. [H3]	No - Loss scenario
CA32-107: ADS Div-II Controller sends open signal to SRV-B7	UCA32-107C2: ADS Div-II controller sends open signal to SRV-B7 before 105-second time delay. [H3]	No - Loss scenario
CA32-108: ADS Div-II Controller sends open signal to SRV-B8	UCA32-108C1: ADS Div-II controller sends open signal to SRV-B8 before HPCI has failed. [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA32-108: ADS Div-II Controller sends open signal to SRV-B8	UCA32-108C2: ADS Div-II controller sends open signal to SRV-B8 before 105-second time delay. [H3]	No - Loss scenario
CA32-109: ADS Div-II Controller sends open signal to SRV-B9	UCA32-109C1: ADS Div-II controller sends open signal to SRV-B9 before HPCI has failed. [H3]	No - Loss scenario
CA32-109: ADS Div-II Controller sends open signal to SRV-B9	UCA32-109C2: ADS Div-II controller sends open signal to SRV-B9 before 105-second time delay. [H3]	No - Loss scenario
CA32-110: ADS Div-II Controller sends open signal to SRV-B10	UCA32-110C1: ADS Div-II controller sends open signal to SRV-B10 before HPCI has failed. [H3]	No - Loss scenario
CA32-110: ADS Div-II Controller sends open signal to SRV-B10	UCA32-110C2: ADS Div-II controller sends open signal to SRV-B10 before 105-second time delay. [H3]	No - Loss scenario
CA32-111: ADS Div-II Controller sends open signal to SRV-B11	UCA32-111C1: ADS Div-II controller sends open signal to SRV-B11 before HPCI has failed. [H3]	No - Loss scenario
CA32-111: ADS Div-II Controller sends open signal to SRV-B11	UCA32-111C2: ADS Div-II controller sends open signal to SRV-B11 before 105-second time delay. [H3]	No - Loss scenario
CA11-101: HPCI Controller sends OPEN Command to MOV-41	(STS) - NA	N/A
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	(WO) - NA	N/A
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	(STS) - NA	N/A
CA11-103: HPCI Controller sends OPEN Command to MOV-42	(STS) - NA	N/A
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	(WO) - NA	N/A

Control Action	UCA	Modeled
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	(STS) - NA	N/A
CA11-105: HPCI Controller sends CLOSE Command to MOV-47	N/A	N/A
CA11-106: HPCI Controller sends CLOSE Command to MOV-48	N/A	N/A
CA11-107: HPCI Controller sends OPEN Command to MOV-43	N/A	N/A
CA11-108: HPCI Controller sends CLOSE Command to MOV-43	N/A	N/A
CA11-109: HPCI Controller sends OPEN Command to HOV-51	N/A	N/A
CA11-110: HPCI Controller sends CLOSE Command to HOV-51	N/A	N/A
CA11-111: HPCI Controller sends CLOSE Command to AOV-81	N/A	N/A
CA11-112: HPCI Controller sends CLOSE Command to AOV-82	N/A	N/A
CA11-301: HPCI Flow Controller sends INCREASE POSITION Command to HOV-52	(WO) - NA	N/A
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	(WO) - NA	N/A
CA11-201: Operator sends OPEN Command to MOV-41	N/A	N/A

Control Action	UCA	Modeled
CA11-202: Operator sends OPEN Command to MOV-47	N/A	N/A
CA11-203: Operator sends OPEN Command to MOV-48	N/A	N/A
CA11-204: Operator sends CLOSE Command to MOV-43	(WO) - NA	N/A
CA11-204: Operator sends CLOSE Command to MOV-43	(STS) - NA	N/A
CA11-205: Operator sends AUTO signal to HPCI Flow Controller	N/A	N/A
CA11-206: Operator Sends MANUAL signal to HPCI Flow Controller	N/A	N/A
CA11-207: Operator set flow setpoint on HPCI Flow Controller	N/A	N/A
CA11-208: Operator manually INCREASES HOV-52 position by adjusting potentiometer	N/A	N/A
CA11-209: Operator manually DECREASES HOV-52 position by adjusting potentiometer	N/A	N/A
FB11-101: Reactor Vessel Water Level	N/A	N/A
FB11-102: Drywell Pressure	N/A	N/A
FB11-103: Turbine Trip Signal	N/A	N/A
CA12-101: HPCI Controller sends CLOSE command to MOV-44	N/A	N/A
CA12-401: NSSSS Controller sends CLOSE command to MOV-49	N/A	N/A

Control Action	UCA	Modeled
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	(WO) - NA	N/A
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	(ETL) - NA	N/A
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	(STS) - NA	N/A
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	(WO) - NA	N/A
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	(ETL) - NA	N/A
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	(STS) - NA	N/A
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	(WO) - NA	N/A
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	(ETL) - NA	N/A
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	(STS) - NA	N/A

Control Action	UCA	Modeled
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101B: HPCI Controller sends OPEN command to MOV-41 when HPCI system is in standby lineup. [H3]	No - Loss scenario
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101C1 (PTE): HPCI Controller sends OPEN command to MOV-41 before Reactor Vessel Water Level drops to Level 2 (-38.5in). [H3]	No - Loss scenario
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101D (ETL): HPCI Controller continues to send OPEN command to MOV-41 after Reactor Vessel Water Level has recovered from Level 2 (-38.5in) to Level 8 (+56.5in). [H3]	No - Loss scenario
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	UCA11-102A: HPCI Controller does not send CLOSE command to MOV-41 when it receives HPCI Isolation Signal. [H3]	No - Loss scenario
CA11-102: HPCI Controller sends CLOSE Command to MOV-41	UCA11-102C1 (PTE): HPCI Controller sends CLOSE command to MOV-41 before receiving HPCI Isolation Signal. [H3]	No - Loss scenario
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103B: HPCI Controller sends OPEN command to MOV-42 when HPCI system is in standby lineup. [H3]	No - Loss scenario
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103C1 (PTE): HPCI Controller sends OPEN command to MOV-42 before Reactor Vessel Water Level drops to Level 2 (-38.5in). [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA11-103: HPCI Controller sends OPEN Command to MOV-42	UCA11-103D (ETL): HPCI Controller continues to send OPEN command to MOV-42 after Reactor Vessel Water Level has recovered from Level 2 (-38.5in) to Level 8 (+56.5in). [H3]	No - Loss scenario
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104A1:HPCI Controller does not send CLOSE command to MOV-42 when it receives HPCI Isolation Signal.[H3]	No - Loss scenario
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104A2: HPCI Controller does not send CLOSE command to MOV-42 when Reactor Vessel Water Level has recovered from Level 2 (-38.5in) to Level 8 (+56.5in). [H3]	No - Loss scenario
CA11-104: HPCI Controller sends CLOSE Command to MOV-42	UCA11-104C1 (PTE): HPCI Controller sends CLOSE command to MOV-42 before receiving HPCI Isolation Signal. [H3]	No - Loss scenario
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302D2 (STS): HPCI Flow Controller stops sending DECREASE POSITION command to HOV-52 before specified HPCI Pump outlet flow has been reached. [H9]	No - Loss scenario
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	UCA13-101B: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal has not been received. [H9]	No - Loss scenario
CA13-101: HPCI Controller sends OPEN command to MOV-35 when HPCI system initiation signal is received.	UCA13-101C1 (PTE): HPCI Controller sends OPEN command to MOV-35 before HPCI system initiation signal has been received. [H9]	No - Loss scenario

Control Action	UCA	Modeled
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	UCA13-102B: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal has not been received. [H9]	No - Loss scenario
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	UCA13-102C1 (PTE): HPCI Controller sends OPEN command to MOV-31 before HPCI system initiation signal has been received. [H9]	No - Loss scenario
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	UCA13-103B: HPCI Controller sends OPEN command to MOV-32 when HPCI CST level is adequate. [H9]	No - Loss scenario
CA13-103: HPCI Controller sends OPEN command to MOV-32 when low CST level is detected.	UCA13-103C1 (PTE):HPCI Controller sends OPEN command to MOV-32 before low CST level signal has been received.[H9]	No - Loss scenario
CA11-302: HPCI Flow Controller sends DECREASE POSITION Command to HOV-52	UCA11-302B: HPCI Flow Controller sends DECREASE POSITION command to HOV-52 when HPCI Pump outlet flow is below the setpoint specified by the Operator. [H2, H8]	No - Operator Action
CA11-204: Operator sends CLOSE Command to MOV-43	UCA11-204A: Operator does not send CLOSE command to MOV-43 when it aligning the HPCI system to normal stand-by. [H3]	No - Operator Action
CA11-204: Operator sends CLOSE Command to MOV-43	UCA11-204B: Operator sends CLOSE command to MOV-43 when HPCI System is actively providing coolant to the reactor vessel. [H1]	No - Operator Action

Control Action	UCA	Modeled
CA11-204: Operator sends CLOSE Command to MOV-43	UCA11-204C1 (PTE): Operator sends CLOSE command to MOV-43 before receiving HPCI Isolation Signal. [H3]	No - Operator Action
CA11-204: Operator sends CLOSE Command to MOV-43	UCA11-204C2 (PTL): Operator sends CLOSE command to MOV-43 too long after receiving HPCI Isolation Signal. [H1]	No - Operator Action
CA11-204: Operator sends CLOSE Command to MOV-43	UCA11-204D (ETL): Operator continues to send CLOSE command to MOV-41 when HPCI is returning to normal lineup state following HPCI Isolation Conditions. [H1]	No - Operator Action
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101A1: HPCI Controller does not send OPEN command to MOV-41 when it receives the HPCI Initiation Signal. [H1]	Removed - UCA aligns with normal operating state
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101A2: HPCI Controller does not send OPEN command to MOV-41 when it receives the RCIC Initiation Signal. [H1]	Removed - UCA aligns with normal operating state
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101C2 (PTL):HPCI Controller sends OPEN command to MOV-41 too long after Reactor Vessel Water Level drops to Level 2 (-38.5in).[H2]	Removed - UCA aligns with normal operating state
CA11-101: HPCI Controller sends OPEN Command to MOV-41	UCA11-101C3 (WO): HPCI Controller sends OPEN command to MOV-41 while MOV-47 is OPEN. [H2]	Removed - UCA aligns with normal operating state
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	UCA13-102A: HPCI Controller does not send OPEN command to MOV-31 when HPCI system initiation signal is received. [H6, H7]	Removed - UCA aligns with normal operating state

Control Action	UCA	Modeled
CA13-102: HPCI Controller sends OPEN command to MOV-31 when HPCI system initiation signal is received.	UCA13-102C2(PTL): HPCI Controller sends OPEN command to MOV-31 after HPCI system initiation signal is received. [H6, H7]	Removed - UCA aligns with normal operating state
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101C3 (Wrong Order): NA	N/A
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102C3 (Wrong Order): NA	N/A
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103C3 (Wrong Order): NA	N/A
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104C3 (Wrong Order): NA	N/A
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105C3 (Wrong Order): NA	N/A
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C5 (Wrong Order): NA	N/A
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107C3 (Wrong Order): NA	N/A
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101C3 (Wrong Order): NA	N/A
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102C3 (Wrong Order):NA	N/A

Control Action	UCA	Modeled
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202C3 (Wrong Order): NA	N/A
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202D1 (STS): NA	N/A
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202D2 (ETL): NA	N/A
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301D1 (STS): NA	N/A
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301D2 (ETL): NA	N/A
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401D1 (STS): NA	N/A
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401D2 (ETL): NA	N/A
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402D1 (STS): NA	N/A
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402D2 (ETL): NA	N/A
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403B: NA	N/A

Control Action	UCA	Modeled
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403C1 (Too Early): NA	N/A
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403C3 (Wrong Order):NA	N/A
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403D1 (STS): NA	N/A
CA21-403: RHR Pump A sends Pump Status Signal to RHR System I Controller	UCA21-403D2 (ETL): NA	N/A
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404D1 (STS): NA	N/A
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404D2 (ETL): NA	N/A
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405D1 (STS): NA	N/A
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405D2 (ETL): NA	N/A
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406B: NA	N/A
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406C1 (Too Early): NA	N/A

Control Action	UCA	Modeled
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA17C3 (Wrong Order): NA	N/A
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406D1 (STS): NA	N/A
CA21-406: RHR Pump C sends Pump Status Signal to RHR System I Controller	UCA21-406D2 (ETL): NA	N/A
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407C3 (Wrong Order): NA	N/A
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407D1 (STS): NA	N/A
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407D2 (ETL): NA	N/A
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408C3 (Wrong Order): NA	N/A
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408D1 (STS): NA	N/A
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408D2 (ETL): NA	N/A
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409B: NA	N/A

Control Action	UCA	Modeled
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409C1 (Too Early): NA	N/A
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409C3 (Wrong Order): NA	N/A
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409D1 (STS): NA	N/A
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409D2 (ETL): NA	N/A
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410A: NA	N/A
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410C2 (Too Late): NA	N/A
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410D1 (STS): NA	N/A
CA21-410: RHR System I Controller sends Close Signal to MOV-31A	UCA21-410D2 (ETL): NA	N/A
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411B: NA	N/A
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411D1 (STS): NA	N/A
CA21-411: MOV-31A sends MOV-31A Valve Position feedback to RHR System I Controller	UCA21-411D2 (ETL): NA	N/A
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412B: NA	N/A
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412C1 (Too Early): NA	N/A
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412C3 (Wrong Order): NA	N/A
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412D1 (STS): NA	N/A
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412D2 (ETL): NA	N/A
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413A: NA	N/A
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413C2 (Too Late): NA	N/A
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA21-413: RHR System I Controller sends Close Signal to MOV-31C	UCA21-413D2 (ETL): NA	N/A
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414B: NA	N/A
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414C3 (Wrong Order): NA	N/A
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414D1 (STS): NA	N/A
CA21-414: MOV-31C sends MOV-31C Valve Position feedback to RHR System I Controller	UCA21-414D2 (ETL): NA	N/A
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415A: NA	N/A
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415C1 (Too Early): NA	N/A
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415C2 (Too Late): NA	N/A
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415C3 (Wrong Order): NA	N/A
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415D2 (ETL): NA	N/A
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416C3 (Wrong Order): NA	N/A
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416D1 (STS): NA	N/A
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416D2 (ETL): NA	N/A
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417B: NA	N/A
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417C3 (Wrong Order): NA	N/A
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417D1 (STS): NA	N/A
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417D2 (ETL): NA	N/A
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418A: NA for LPCI Alignment	N/A
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418D1 (STS): NA	N/A
CA21-418: RHR System I Controller sends Open Signal to MOV-40A	UCA21-418D2 (ETL): NA	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30B: NA for LPCI Alignment	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30C1 (Too Early): NA	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30C2 (Too Late): NA	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30C3 (Wrong Order): NA	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30D1 (STS): NA	N/A
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA30D2 (ETL): NA	N/A
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA31B: NA	N/A
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA31C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA31D1 (STS): NA	N/A
CA21-420: MOV-40A sends MOV-40A Valve Position feedback to RHR System I Controller	UCA31D2 (ETL): NA	N/A
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA32A: NA for LPCI Alignment	N/A
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA32C3 (Wrong Order): NA	N/A
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA32D1 (STS): NA	N/A
CA21-421: RHR System I Controller sends Open Signal to MOV-41A	UCA32D2 (ETL): NA	N/A
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33B: NA for LPCI Alignment	N/A
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33C1 (Too Early): NA	N/A
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33C2 (Too Late): NA	N/A
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33C3 (Wrong Order):NA	N/A

Control Action	UCA	Modeled
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33D1 (STS): NA	N/A
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA33D2 (ETL): NA	N/A
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA34B: NA	N/A
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA34C3 (Wrong Order): NA	N/A
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA34D1 (STS): NA	N/A
CA21-423: MOV-41A sends MOV-41A Valve Position feedback to RHR System I Controller	UCA34D2 (ETL): NA	N/A
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424C3 (Wrong Order): NA	N/A
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424D1 (STS): NA	N/A
CA21-424: RHR System I Controller sends Open Signal to MOV-37A	UCA21-424D2 (ETL): NA	N/A
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425A: NA	N/A

Control Action	UCA	Modeled
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425C3 (Wrong Order): NA	N/A
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425D1 (STS): NA	N/A
CA21-425: RHR System I Controller sends Close Signal to MOV-37A	UCA21-425D2 (ETL): NA	N/A
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426B: NA	N/A
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426C3 (Wrong Order): NA	N/A
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426D1 (STS): NA	N/A
CA21-426: MOV-37A sends MOV-37A Valve Position feedback to RHR System I Controller	UCA21-426D2 (ETL): NA	N/A
CA21-427: RHR System I Controller sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-427: RHR System I Controller sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-427: RHR System I Controller sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-427: RHR System I Controller sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A

Control Action	UCA	Modeled
CA21-428: RHR System I Controller sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-428: RHR System I Controller sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-428: RHR System I Controller sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-428: RHR System I Controller sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	N/A
CA21-429: MOV-50 sends MOV-50 Valve Position feedback to RHR System I Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-429: MOV-50 sends MOV-50 Valve Position feedback to RHR System I Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-429: MOV-50 sends MOV-50 Valve Position feedback to RHR System I Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-429: MOV-50 sends MOV-50 Valve Position feedback to RHR System I Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430B: NA	N/A
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430D1 (STS): NA	N/A
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430D2 (ETL): NA	N/A
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431B: NA	N/A
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431C3 (Wrong Order): NA	N/A
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431D1 (STS): NA	N/A
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431D2 (ETL): NA	N/A
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432B:NA	N/A
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432C3 (Wrong Order): NA	N/A
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432D2 (ETL): NA	N/A
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433B: NA	N/A
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433C3 (Wrong Order): NA	N/A
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433D1 (STS): NA	N/A
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433D2 (ETL): NA	N/A
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63B: NA	N/A
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63C3 (Wrong Order): NA	N/A
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63D1 (STS): NA	N/A
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435B: NA	N/A
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435C3 (Wrong Order): NA	N/A
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435D1 (STS): NA	N/A
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435D2 (ETL): NA	N/A
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA65B: NA	N/A
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA65C3 (Wrong Order): NA	N/A
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA65D1 (STS): NA	N/A
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA65D2 (ETL): NA	N/A
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA66B: NA	N/A

Control Action	UCA	Modeled
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA66C3 (Wrong Order): NA	N/A
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA66D1 (STS): NA	N/A
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA66D2 (ETL): NA	N/A
CA21-438: RHR System I Controller sends MOV-50 Valve Position feedback to Control Room Indicator	NA - Normally Locked-Closed, De-energized	N/A
CA21-438: RHR System I Controller sends MOV-50 Valve Position feedback to Control Room Indicator	NA - Normally Locked-Closed, De-energized	N/A
CA21-438: RHR System I Controller sends MOV-50 Valve Position feedback to Control Room Indicator	NA - Normally Locked-Closed, De-energized	N/A
CA21-438: RHR System I Controller sends MOV-50 Valve Position feedback to Control Room Indicator	NA - Normally Locked-Closed, De-energized	N/A
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439B: NA	N/A
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439D1 (STS): NA	N/A
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439D2 (ETL): NA	N/A
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440B: NA	N/A
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440C3 (Wrong Order):NA	N/A
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440D1 (STS): NA	N/A
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440D2 (ETL): NA	N/A
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441B: NA	N/A
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441C3 (Wrong Order): NA	N/A
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441D2 (ETL): NA	N/A
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442B: NA	N/A
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442C3 (Wrong Order): NA	N/A
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442D1 (STS): NA	N/A
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442D2 (ETL): NA	N/A
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72B:NA	N/A
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72C3 (Wrong Order): NA	N/A
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72D1 (STS): NA	N/A
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442B: NA	N/A
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442C3 (Wrong Order): NA	N/A
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442D1 (STS): NA	N/A
CA21-444: RHR System I Controller sends MOV-37A Valve Position feedback to RHR System II Controller	UCA21-442D2 (ETL): NA	N/A
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UC74B: NA	N/A
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA74C3 (Wrong Order): NA	N/A
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA74D1 (STS): NA	N/A
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA74D2 (ETL): NA	N/A
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA75B: NA	N/A

Control Action	UCA	Modeled
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA75C3 (Wrong Order): NA	N/A
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA75D1 (STS): NA	N/A
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA75D2 (ETL): NA	N/A
CA21-447: RHR System I Controller sends MOV-50 Valve Position feedback to RHR System II Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-447: RHR System I Controller sends MOV-50 Valve Position feedback to RHR System II Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-447: RHR System I Controller sends MOV-50 Valve Position feedback to RHR System II Controller	NA - Normally Locked-Closed, De-energized	N/A
CA21-447: RHR System I Controller sends MOV-50 Valve Position feedback to RHR System II Controller	NA - Normally Locked-Closed, De-energized	N/A
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101C3 (Wrong Order): NA	N/A
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C3 (Wrong Order):NA	N/A
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C3 (Wrong Order): NA	N/A
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201D1 (STS): NA	N/A
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201D2 (ETL): NA	N/A
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80D1 (STS): NA	N/A
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80D2 (ETL): NA	N/A
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81D1 (STS): NA	N/A
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81D2 (ETL): NA	N/A
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401D1 (STS): NA	N/A
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402D1 (STS): NA	N/A
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402D2 (ETL): NA	N/A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403B: NA	N/A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403C1 (Too Early): NA	N/A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403C3 (Wrong Order): NA	N/A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403D1 (STS): NA	N/A
CA22-403: RHR Pump B sends Pump Status Signal to RHR System II Controller	UCA22-403D2 (ETL): NA	N/A
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404D1 (STS): NA	N/A
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404D2 (ETL): NA	N/A
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405D2 (ETL): NA	N/A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406B: NA	N/A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406C1 (Too Early): NA	N/A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406C3 (Wrong Order): NA	N/A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406D1 (STS): NA	N/A
CA22-406: RHR Pump D sends Pump Status Signal to RHR System II Controller	UCA22-406D2 (ETL): NA	N/A
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407C3 (Wrong Order): NA	N/A
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407D1 (STS): NA	N/A
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407D2 (ETL): NA	N/A
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408D1 (STS): NA	N/A
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408D2 (ETL): NA	N/A
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409B: NA	N/A
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409C1 (Too Early): NA	N/A
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409C3 (Wrong Order): NA	N/A
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409D1 (STS): NA	N/A
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409D2 (ETL): NA	N/A
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410A: NA	N/A
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410C2 (Too Late): NA	N/A
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-410: RHR System II Controller sends Close Signal to MOV-31B	UCA22-410D2 (ETL): NA	N/A
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411B: NA	N/A
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411C3 (Wrong Order): NA	N/A
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411D1 (STS): NA	N/A
CA22-411: MOV-31B sends MOV-31B Valve Position feedback to RHR System II Controller	UCA22-411D2 (ETL): NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412B: NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412C1 (Too Early): NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412C3 (Wrong Order): NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412C1 (Too Early): NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412D1 (STS): NA	N/A
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412D2 (ETL): NA	N/A
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413A: NA	N/A
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413C2 (Too Late): NA	N/A
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413D1 (STS): NA	N/A
CA22-413: RHR System II Controller sends Close Signal to MOV-31D	UCA22-413D2 (ETL): NA	N/A
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414B: NA	N/A
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414C3 (Wrong Order): NA	N/A
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414D1 (STS): NA	N/A
CA22-414: MOV-31D sends MOV-31D Valve Position feedback to RHR System II Controller	UCA22-414D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96A: NA	N/A
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96C1 (Too Early): NA	N/A
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96C2 (Too Late): NA	N/A
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96C3 (Wrong Order): NA	N/A
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96D1 (STS): NA	N/A
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96D2 (ETL): NA	N/A
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97C3 (Wrong Order): NA	N/A
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97D1 (STS): NA	N/A
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97D2 (ETL): NA	N/A
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98B: NA	N/A

Control Action	UCA	Modeled
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98C3 (Wrong Order): NA	N/A
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98D1 (STS): NA	N/A
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98D2 (ETL): NA	N/A
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA99A: NA for LPCI Alignment	N/A
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA99C3 (Wrong Order):NA	N/A
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA99D1 (STS): NA	N/A
CA22-418: RHR System II Controller sends Open Signal to MOV-40B	UCA99D2 (ETL): NA	N/A
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100B: NA for LPCI Alignment	N/A
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100C1 (Too Early): NA	N/A
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100C2 (Too Late): NA	N/A

Control Action	UCA	Modeled
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100C3 (Wrong Order): NA	N/A
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100D1 (STS): NA	N/A
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA100D2 (ETL): NA	N/A
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA101B: NA	N/A
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA101C3 (Wrong Order): NA	N/A
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA101D1 (STS): NA	N/A
CA22-420: MOV-40B sends MOV-40B Valve Position feedback to RHR System II Controller	UCA101D2 (ETL): NA	N/A
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA102A:NA for LPCI Alignment	N/A
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA102C3 (Wrong Order): NA	N/A
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA102D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-421: RHR System II Controller sends Open Signal to MOV-41B	UCA102D2 (ETL): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103B: NA for LPCI Alignment	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103C1 (Too Early): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103C2 (Too Late): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103C3 (Wrong Order): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103D1 (STS): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103D2 (ETL): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103D1 (STS): NA	N/A
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA103D2 (ETL): NA	N/A
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA104B: NA	N/A

Control Action	UCA	Modeled
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA104C3 (Wrong Order):NA	N/A
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA104D1 (STS): NA	N/A
CA22-423: MOV-41B sends MOV-41B Valve Position feedback to RHR System II Controller	UCA104D2 (ETL): NA	N/A
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424C3 (Wrong Order): NA	N/A
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424D1 (STS): NA	N/A
CA22-424: RHR System II Controller sends Open Signal to MOV-37B	UCA22-424D2 (ETL): NA	N/A
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425A: NA	N/A
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425C3 (Wrong Order): NA	N/A
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425D1 (STS): NA	N/A
CA22-425: RHR System II Controller sends Close Signal to MOV-37B	UCA22-425D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426B: NA	N/A
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426C3 (Wrong Order): NA	N/A
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426D1 (STS): NA	N/A
CA22-426: MOV-37B sends MOV-37B Valve Position feedback to RHR System II Controller	UCA22-426D2 (ETL): NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108A: NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108C1 (Too Early): NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108C2 (Too Late): NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108C3 (Wrong Order): NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108D1 (STS): NA	N/A
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109C3 (Wrong Order): NA	N/A
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109D1 (STS): NA	N/A
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109D2 (ETL): NA	N/A
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110B: NA	N/A
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110C3 (Wrong Order): NA	N/A
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110D1 (STS): NA	N/A
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110D2 (ETL): NA	N/A
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430B: NA	N/A
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430C3 (Wrong Order): NA	N/A
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430D2 (ETL): NA	N/A
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431B: NA	N/A
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431C3 (Wrong Order): NA	N/A
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431D1 (STS): NA	N/A
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431D2 (ETL): NA	N/A
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432B: NA	N/A
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432C3 (Wrong Order): NA	N/A
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432D1 (STS): NA	N/A
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433B: NA	N/A
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433C3 (Wrong Order): NA	N/A
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433D1 (STS): NA	N/A
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433D2 (ETL): NA	N/A
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133B: NA	N/A
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133C3 (Wrong Order): NA	N/A
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133D1 (STS): NA	N/A
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133D2 (ETL): NA	N/A
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134B: NA	N/A

Control Action	UCA	Modeled
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134C3 (Wrong Order):NA	N/A
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134D1 (STS): NA	N/A
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134D2 (ETL): NA	N/A
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436B: NA	N/A
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436C3 (Wrong Order): NA	N/A
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436D1 (STS): NA	N/A
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436D2 (ETL): NA	N/A
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA136B: NA	N/A
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA136C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA136D1 (STS): NA	N/A
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA136D2 (ETL): NA	N/A
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA137B:NA	N/A
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA137C3 (Wrong Order): NA	N/A
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA137D1 (STS): NA	N/A
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA137D2 (ETL): NA	N/A
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439B: NA	N/A
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439C3 (Wrong Order): NA	N/A
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439D2 (ETL): NA	N/A
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440B: NA	N/A
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440C3 (Wrong Order): NA	N/A
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440D1 (STS): NA	N/A
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440D2 (ETL): NA	N/A
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441B: NA	N/A
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441C3 (Wrong Order): NA	N/A
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441D1 (STS): NA	N/A
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442B: NA	N/A
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442C3 (Wrong Order): NA	N/A
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442D1 (STS): NA	N/A
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442D2 (ETL): NA	N/A
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142B: NA	N/A
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142C3 (Wrong Order): NA	N/A
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142D1 (STS): NA	N/A
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142D2 (ETL): NA	N/A
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143B: NA	N/A

Control Action	UCA	Modeled
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143C3 (Wrong Order): NA	N/A
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143D1 (STS): NA	N/A
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143D2 (ETL): NA	N/A
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445B: NA	N/A
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445C3 (Wrong Order): NA	N/A
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445D1 (STS): NA	N/A
CA22-445: RHR System II Controller sends MOV-37B Valve Position feedback to RHR System I Controller	UCA22-445D2 (ETL): NA	N/A
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UC145B: NA	N/A
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UCA145C3 (Wrong Order):NA	N/A

Control Action	UCA	Modeled
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UCA145D1 (STS): NA	N/A
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UCA145D2 (ETL): NA	N/A
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA136B: NA	N/A
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA136C3 (Wrong Order): NA	N/A
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA136D1 (STS): NA	N/A
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA136D2 (ETL): NA	N/A
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448C3 (Wrong Order): NA	N/A
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448D1 (STS): NA	N/A
CA21-448: RHR System I Controller sends Open Signal to MOV-32A	UCA21-448D2 (ETL): NA	N/A
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449A: NA	N/A

Control Action	UCA	Modeled
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449C3 (Wrong Order): NA	N/A
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449D1 (STS): NA	N/A
CA21-449: RHR System I Controller sends Close Signal to MOV-32A	UCA21-449D2 (ETL): NA	N/A
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450B: NA	N/A
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450C3 (Wrong Order): NA	N/A
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450D1 (STS): NA	N/A
CA21-450: MOV-32A sends Valve Position feedback to RHR System I Controller	UCA21-450D2 (ETL): NA	N/A
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451C3 (Wrong Order): NA	N/A
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451D1 (STS): NA	N/A
CA21-451: RHR System I Controller sends Open Signal to MOV-32C	UCA21-451D2 (ETL): NA	N/A
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452A: NA	N/A
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452C3 (Wrong Order): NA	N/A

Control Action	UCA	Modeled
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452D1 (STS): NA	N/A
CA21-452: RHR System I Controller sends Close Signal to MOV-32C	UCA21-452D2 (ETL): NA	N/A
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453B: NA	N/A
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453C3 (Wrong Order): NA	N/A
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453D1 (STS): NA	N/A
CA21-453: MOV-32C sends Valve Position feedback to RHR System I Controller	UCA21-453D2 (ETL): NA	N/A
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448C3 (Wrong Order): NA	N/A
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448D1 (STS): NA	N/A
CA22-448: RHR System II Controller sends Open Signal to MOV-32B	UCA22-448D2 (ETL): NA	N/A
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449A: NA	N/A
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449C3 (Wrong Order): NA	N/A
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449D1 (STS): NA	N/A

Control Action	UCA	Modeled
CA22-449: RHR System II Controller sends Close Signal to MOV-32B	UCA22-449D2 (ETL): NA	N/A
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450B: NA	N/A
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450C3 (Wrong Order): NA	N/A
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450D1 (STS): NA	N/A
CA22-450: MOV-32B sends Valve Position feedback to RHR System II Controller	UCA22-450D2 (ETL): NA	N/A
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451C3 (Wrong Order): NA	N/A
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451D1 (STS): NA	N/A
CA22-451: RHR System II Controller sends Open Signal to MOV-32D	UCA22-451D2 (ETL): NA	N/A
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452A:NA	N/A
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-449C3 (Wrong Order): NA	N/A
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452D1 (STS): NA	N/A
CA22-452: RHR System II Controller sends Close Signal to MOV-32D	UCA22-452D2 (ETL): NA	N/A

Control Action	UCA	Modeled
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453B: NA	N/A
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453C3 (Wrong Order): NA	N/A
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453D1 (STS): NA	N/A
CA22-453: MOV-32D sends Valve Position feedback to RHR System II Controller	UCA22-453D2 (ETL): NA	N/A
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454C3 (Wrong Order): NA	N/A
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454D1 (STS): NA	N/A
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454D2 (ETL): NA	N/A
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455A: NA	N/A
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455C3 (Wrong Order): NA	N/A
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455D1 (STS): NA	N/A
CA21-455: RHR System I Controller sends Close Signal to MOV-33A	UCA21-455D2 (ETL): NA	N/A
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454C3 (Wrong Order):NA	N/A

Control Action	UCA	Modeled
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454D1 (STS): NA	N/A
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454D2 (ETL): NA	N/A
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455A: NA	N/A
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455C3 (Wrong Order): NA	N/A
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455D1 (STS): NA	N/A
CA22-455: RHR System II Controller sends Close Signal to MOV-33B	UCA22-455D2 (ETL): NA	N/A
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401C2 (Too Early): RHR System I Controller sends start pump signal to RHR Pump A prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401C3 (Too Late): RHR System I Controller sends start pump signal to RHR Pump A after '2' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404C2 (Too Early): RHR System I Controller sends start pump signal to RHR Pump C prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems

Control Action	UCA	Modeled
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404C3 (Too Late): RHR System I Controller sends start pump signal to RHR Pump C after '2' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401C2 (Too Early): RHR System II Controller sends start pump signal to RHR Pump B prior to 'x' second time delay upon receiving LPCI initiation signal.[H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401C3 (Too Late): RHR System II Controller sends start pump signal to RHR Pump B after '2' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404C2 (Too Early): RHR System II Controller sends start pump signal to RHR Pump D prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404C3 (Too Late): RHR System II Controller sends start pump signal to RHR Pump D after '7' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407A: RHR Pump A Controller does not send Low Pressure signal to ADS Controller when Discharge Pressure <125 psig [H4, H5]	No - Controller Communication
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407B: RHR Pump A Controller sends Low Pressure signal to ADS Controller when Discharge Pressure >=125 psig [H3, H4]	No - Controller Communication

Control Action	UCA	Modeled
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407C1 (Too Early): RHR Pump A Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H3, H4]	No - Controller Communication
CA21-407: RHR Pump A Controller sends open permissive signal to ADS Controller	UCA21-407C2 (Too Late): RHR Pump A Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H4, H5]	No - Controller Communication
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408A:RHR Pump C Controller does not send Low Pressure signal to ADS Controller when Discharge Pressure <125 psig[H4, H5]	No - Controller Communication
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408B: RHR Pump C Controller sends Low Pressure signal to ADS Controller when Discharge Pressure >=125 psig [H3, H4]	No - Controller Communication
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408C1 (Too Early): RHR Pump C Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H3, H4]	No - Controller Communication
CA21-408: RHR Pump C Controller sends open permissive signal to ADS Controller	UCA21-408C2 (Too Late): RHR Pump C Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H4, H5]	No - Controller Communication

Control Action	UCA	Modeled
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407A: RHR Pump B Controller does not send Low Pressure signal to ADS Controller when Discharge Pressure <125 psig [H4, H5]	No - Controller Communication
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407B: RHR Pump B Controller sends Low Pressure signal to ADS Controller when Discharge Pressure >=125 psig [H3, H4]	No - Controller Communication
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407C1 (Too Early): RHR Pump B Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H3, H4]	No - Controller Communication
CA22-407: RHR Pump B Controller sends open permissive signal to ADS Controller	UCA22-407C2 (Too Late): RHR Pump B Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H4, H5]	No - Controller Communication
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408A:RHR Pump D Controller does not send Low Pressure signal to ADS Controller when Discharge Pressure <125 psig[H4, H5]	No - Controller Communication
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408B: RHR Pump D Controller sends Low Pressure signal to ADS Controller when Discharge Pressure >=125 psig [H3, H4]	No - Controller Communication

Control Action	UCA	Modeled
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408C1 (Too Early): RHR Pump D Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H3, H4]	No - Controller Communication
CA22-408: RHR Pump D Controller sends open permissive signal to ADS Controller	UCA22-408C2 (Too Late): RHR Pump D Controller sends Low Pressure signal to ADS Controller before Discharge Pressure <125 psig [H4, H5]	No - Controller Communication
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101A: RV Level Transmitter does not send Level 1 signal to LPCI Initiation detectors when RV level <= -132.5in [H5]	No - Component Not Modeled
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101D1 (STS): RV Level Transmitter stops sending Level 1 signal to LPCI Initiation detectors before RV level > -132.5in [H5]	No - Component Not Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102A: Drywell Pressure Sensors do not send Pressure signal to LPCI Initiation Detectors when drywell pressure >= 1.69 psig [H5]	No - Component Not Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102B: Drywell Pressure Sensors send High Pressure signal to LPCI Initiation Detectors when drywell pressure < 1.69 psig [H3, H4]	No - Component Not Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102C1 (Too Early): Drywell Pressure Sensors send High Pressure signal to LPCI Initiation Detectors before drywell pressure >= 1.69 psig [H3, H4]	No - Component Not Modeled

Control Action	UCA	Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102C2 (Too Late): Drywell Pressure Sensors send High Pressure signal to LPCI Initiation Detectors after drywell pressure \geq 1.69 psig [H5]	No - Component Not Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-102D1 (STS): Drywell Pressure Sensors stop sending High Pressure signal to LPCI Initiation detectors before Drywell Pressure $<$ 1.69 psig [H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106A1: RV Level Transmitter does not send Level 1 signal to NSSSS Controller when RV level \leq -132.5in [H1, H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106A2: RV Level Transmitter does not send Level 3 signal to NSSSS Controller when RV level \leq +12.5in [H1, H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106B1: RV Level Transmitter sends RV Level 1 signal to NSSSS Controller when RV Level $>$ -132.5in [H3, H4, H6] UCA20-106B2: RV Level Transmitter sends RV Level 3 signal to NSSSS Controller when RV Level $>$ +12.5in [H3, H4, H6]	No - Component Not Modeled

Control Action	UCA	Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C1 (Too Early): RV Level Transmitter sends RV Level 1 signal to NSSSS Controller before RV Level \leq -132.5in [H3, H4, H6]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C4 (Too Late): RV Level Transmitter sends Level 3 signal to NSSSS Controller after RV Level \leq -132.5in[H1, H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C3 (Too Late): RV Level Transmitter sends Level 1 signal to NSSSS Controller after RV Level \leq -132.5in [H1, H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C3 (Too Late): RV Level Transmitter sends Level 1 signal to NSSSS Controller after RV Level \leq -132.5in [H1, H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106D1 (STS): RV Level Transmitter stops sending Level 1 signal to NSSSS Controller before RV level $>$ -132.5in [H5]	No - Component Not Modeled
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106D2 (STS): RV Level Transmitter stops sending Level 3 signal to NSSSS Controller before RV level $>$ +12.5in [H5]	No - Component Not Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107A: RV Pressure Sensor does not send High Pressure signal to NSSSS Controller when RV Pressure \geq 125 psig [H5]	No - Component Not Modeled

Control Action	UCA	Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107B: RV Pressure Sensor sends High Pressure signal to NSSSS Controller when RV Pressure < 125 psig [H1, H2, H3]	No - Component Not Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107C1 (Too Early): RV Pressure Sensor sends High Pressure signal to NSSSS Controller before RV Pressure >= 125 psig [H1, H2, H3]	No - Component Not Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107C2 (Too Late): RV Pressure Sensor sends High Pressure signal to NSSSS Controller after RV Pressure >= 125 psig [H5]	No - Component Not Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107D1 (STS): RV Pressure Sensor stops sending High Pressure signal to NSSSS Controller before RV Pressure < 125 psig[H5]	No - Component Not Modeled
CA20-107: RV Pressure Sensors send Reactor Pressure signal to NSSSS Controller	UCA20-107D2 (ETL): RV Pressure Sensor continues to send High Pressure signal to NSSSS Controller after RV Pressure < 125 psig [H1, H2, H3]	No - Component Not Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101A: RV Pressure Sensors do not send Pressure signal to RHR System I Controller when RV Pressure < 338 psig [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101B: RV Pressure Sensors send Pressure signal to RHR System I Controller when RV Pressure \geq 338 psig [H6]	No - Component Not Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101C1 (Too Early): RV Pressure Sensors send Pressure signal to RHR System I Controller before RV Pressure $<$ 338 psig [H6]	No - Component Not Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101C2 (Too Late): RV Pressure Sensors send Pressure signal to RHR System I Controller after RV Pressure \geq 338 psig [H1]	No - Component Not Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101D1 (STS): RV Pressure Sensors stop sending Pressure signal to RHR System I Controller before RV Pressure \geq 338 psig [H1]	No - Component Not Modeled
CA21-101: RV Pressure Sensors send Reactor Pressure signal to RHR System I Controller	UCA21-101D2 (ETL): RV Pressure Sensors continue to send Pressure signal to RHR System I Controller after RV Pressure \geq 338 psig [H1]	No - Component Not Modeled
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102A:RV Pressure Sensors do not send Pressure signal to Recirculation Loop A Controller when RV Pressure $<$ 310 psig[H1]	No - Component Not Modeled
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102C2 (Too Late): RV Pressure Sensors send Pressure signal to Recirculation Loop A Controller after RV Pressure \geq 310 psig [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102D1 (STS): RV Pressure Sensors stop sending Pressure signal to Recirculation Loop A Controller before RV Pressure \geq 310 psig [H1]	No - Component Not Modeled
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202A: LPCI Initiation detectors do not send LPCI Initiation signal to RHR System I Controller when Initiation one-out-of-two-twice Logic is satisfied [H5]	No - Component Not Modeled
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202B: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller when Initiation one-out-of-two-twice Logic has not been satisfied [H3, H7]	No - Component Not Modeled
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202C1 (Too Early): LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller before Initiation one-out-of-two-twice Logic has been satisfied [H3, H7]	No - Component Not Modeled
CA21-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller	UCA21-202C2 (Too Late): LPCI Initiation detectors send LPCI Initiation signal to RHR System I Controller after Initiation one-out-of-two-twice Logic has been satisfied [H5]	No - Component Not Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301A: NSSSS Controller does not send Isolation signal to MOV-39A when high drywell pressure signal OR RV Level \leq -132.5in signal is received [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301B: NSSSS Controller sends Isolation signal to MOV-39A when neither high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301C1 (Too Early): NSSSS Controller sends Isolation signal to MOV-39A before high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301C2 (Too Late): NSSSS Controller sends Isolation signal to MOV-39A after high drywell pressure signal OR RV Level <=-132.5in signal is received [H1]	No - Component Not Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301C3 (Wrong Order): NSSSS Controller sends isolation signal to MOV-39A before flow path to recirculation system is established with RHR pumps running [H1]	No - Component Not Modeled
CA21-301: NSSSS Controller sends Isolation (Close) signal to MOV-39A	UCA21-301C4 (Wrong Order): NSSSS Controller sends isolation signal to MOV-39A after flow path to recirculation system is established with RHR pumps running [H6]	No - Component Not Modeled
CA21-415: RHR System I Controller sends Open Signal to MOV-39A	UCA21-415B: RHR System I Controller sends Open signal to MOV-39A when LPCI initiation signal is received [H1, H6]	No - Component Not Modeled

Control Action	UCA	Modeled
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416A: RHR System I Controller does not send Close signal to MOV-39A when LPCI initiation signal is received [H1, H6]	No - Component Not Modeled
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416B:RHR System I Controller sends Close signal to MOV-39A while RHR is providing cooling via drywell sparger[H1, H4, H6]	No - Component Not Modeled
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416C1 (Too Early): RHR System I Controller sends Close signal to MOV-39A before LPCI initiation signal is received [H1, H4, H6]	No - Component Not Modeled
CA21-416: RHR System I Controller sends Close Signal to MOV-39A	UCA21-416C2 (Too Late): RHR System I Controller sends Close signal to MOV-39A after LPCI initiation signal is received [H1, H6]	No - Component Not Modeled
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417A: MOV-39A does not send MOV-39A Valve Position feedback to RHR System I Controller when valve position is changed by RHR Controller [H8]	No - Component Not Modeled
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417C1 (Too Early): MOV-39A sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	No - Component Not Modeled

Control Action	UCA	Modeled
CA21-417: MOV-39A sends MOV-39A Valve Position feedback to RHR System I Controller	UCA21-417C2 (Too Late): MOV-39A sends valve open OR closed signal after the valve has been moved from its position [H8]	No - Component Not Modeled
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72A: RHR System I Controller does not send MOV-39A position to RHR System II Controller. [H1, H2, H8]	No - Component Not Modeled
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72C1 (Too Early): RHR System I Controller sends MOV-39A position to RHR System II Controller before valve position changes.[H1, H2, H8]	No - Component Not Modeled
CA21-443: RHR System I Controller sends MOV-39A Valve Position feedback to RHR System II Controller	UCA72C2 (Too Late): RHR System I Controller sends MOV-39A position to RHR System II Controller after valve position changes. [H1, H2, H8]	No - Component Not Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101A: RV Pressure Sensors do not send Pressure signal to RHR System II Controller when RV Pressure < 338 psig [H1]	No - Component Not Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101B: RV Pressure Sensors send Pressure signal to RHR System II Controller when RV Pressure >= 338 psig [H6]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101C1 (Too Early): RV Pressure Sensors send Pressure signal to RHR System II Controller before RV Pressure < 338 psig [H6]	No - Component Not Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101C2 (Too Late): RV Pressure Sensors send Pressure signal to RHR System II Controller after RV Pressure >= 338 psig [H1]	No - Component Not Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101D1 (STS): RV Pressure Sensors stop sending Pressure signal to RHR System II Controller before RV Pressure >= 338 psig [H1]	No - Component Not Modeled
CA22-101: RV Pressure Sensors send Reactor Pressure signal to RHR System II Controller	UCA22-101D2 (ETL): RV Pressure Sensors continue to send Pressure signal to RHR System II Controller after RV Pressure >= 338 psig [H1]	No - Component Not Modeled
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102A:RV Pressure Sensors do not send Pressure signal to Recirculation Loop B Controller when RV Pressure < 310 psig[H1]	No - Component Not Modeled
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102C2 (Too Late): RV Pressure Sensors send Pressure signal to Recirculation Loop B Controller after RV Pressure >= 310 psig [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102D1 (STS): RV Pressure Sensors stop sending Pressure signal to Recirculation Loop B Controller before RV Pressure \geq 310 psig [H1]	No - Component Not Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201A: LPCI Initiation detectors do not send LPCI Initiation signal to RHR System II Controller when Initiation one-out-of-two-twice Logic is satisfied [H5]	No - Component Not Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201B: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller when Initiation one-out-of-two-twice Logic has not been satisfied [H3, H7]	No - Component Not Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C1 (Too Early): LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller before Initiation one-out-of-two-twice Logic has been satisfied [H3, H7]	No - Component Not Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C2 (Too Late): LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller after Initiation one-out-of-two-twice Logic has been satisfied [H5]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C1 (Too Early): LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller before Initiation one-out-of-two-twice Logic has been satisfied[H3, H7]	No - Component Not Modeled
CA22-201: LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller	UCA22-201C2 (Too Late): LPCI Initiation detectors send LPCI Initiation signal to RHR System II Controller after Initiation one-out-of-two-twice Logic has been satisfied [H5]	No - Component Not Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80A: NSSSS Controller does not send Isolation signal to MOV-39B when high drywell pressure signal OR RV Level <=-132.5in signal is received [H1]	No - Component Not Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80B: NSSSS Controller sends Isolation signal to MOV-39B when neither high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80C1 (Too Early): NSSSS Controller sends Isolation signal to MOV-39B before high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80C2 (Too Late): NSSSS Controller sends Isolation signal to MOV-39B after high drywell pressure signal OR RV Level <=-132.5in signal is received [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80C3 (Wrong Order): NSSSS Controller sends isolation signal to MOV-39B before flow path to recirculation system is established with RHR pumps running [H1]	No - Component Not Modeled
CA22-301: NSSSS Controller sends Isolation (Close) signal to MOV-39B	UCA80C4 (Wrong Order):NSSSS Controller sends isolation signal to MOV-39B after flow path to recirculation system is established with RHR pumps running[H6]	No - Component Not Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81A: NSSSS Controller does not send Isolation signal to MOV-53 when high drywell pressure signal OR RV Level <=-132.5in signal is received [H1]	No - Component Not Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81B: NSSSS Controller sends Isolation signal to MOV-53 when neither high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81C1 (Too Early): NSSSS Controller sends Isolation signal to MOV-53 before high drywell pressure signal OR RV Level <=-132.5in signal is received [H1, H6]	No - Component Not Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81C2 (Too Late): NSSSS Controller sends Isolation signal to MOV-53 after high drywell pressure signal OR RV Level <=-132.5in signal is received [H1]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81C3 (Wrong Order): NSSSS Controller sends isolation signal to MOV-53 before flow path to recirculation system is established with RHR pumps running [H1]	No - Component Not Modeled
CA22-302: NSSSS Controller sends Isolation (Close) signal to MOV-53	UCA81C4 (Wrong Order): NSSSS Controller sends isolation signal to MOV-53 after flow path to recirculation system is established with RHR pumps running [H6]	No - Component Not Modeled
CA22-415: RHR System II Controller sends Open Signal to MOV-39B	UCA96B: RHR System II Controller sends Open signal to MOV-39B when LPCI initiation signal is received [H1, H6]	No - Component Not Modeled
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97A:RHR System II Controller does not send Close signal to MOV-39B when LPCI initiation signal is received[H1, H6]	No - Component Not Modeled
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97B: RHR System II Controller sends Close signal to MOV-39B while RHR is providing cooling via drywell sparger [H1, H4, H6]	No - Component Not Modeled
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97C1 (Too Early): RHR System II Controller sends Close signal to MOV-39B before LPCI initiation signal is received [H1, H4, H6]	No - Component Not Modeled
CA22-416: RHR System II Controller sends Close Signal to MOV-39B	UCA97C2 (Too Late): RHR System II Controller sends Close signal to MOV-39B after LPCI initiation signal is received [H1, H6]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98A: MOV-39B does not send MOV-39B Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	No - Component Not Modeled
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98C1 (Too Early): MOV-39B sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	No - Component Not Modeled
CA22-417: MOV-39B sends MOV-39B Valve Position feedback to RHR System II Controller	UCA98C2 (Too Late): MOV-39B sends valve open OR closed signal after the valve has been moved from its position [H8]	No - Component Not Modeled
CA22-427: RHR System II Controller sends Open Signal to MOV-53	UCA108B: RHR System II Controller sends Open signal to MOV-53 when LPCI initiation signal is received [H1, H6]	No - Component Not Modeled
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109A:RHR System II Controller does not send Close signal to MOV-53 when LPCI initiation signal is received[H1, H6]	No - Component Not Modeled
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109B: RHR System II Controller sends Close signal to MOV-53 while RHR is providing cooling via head spray [H1, H4, H6]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109C1 (Too Early): RHR System II Controller sends Close signal to MOV-53 before LPCI initiation signal is received [H1, H4, H6]	No - Component Not Modeled
CA22-428: RHR System II Controller sends Close Signal to MOV-53	UCA109C2 (Too Late): RHR System II Controller sends Close signal to MOV-53 after LPCI initiation signal is received [H1, H6]	No - Component Not Modeled
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110A: MOV-53 does not send MOV-53 Valve Position feedback to RHR System II Controller when valve position is changed by RHR Controller [H8]	No - Component Not Modeled
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110C1 (Too Early): MOV-53 sends valve open OR closed signal before the valve is fully engaged in the respective position [H8]	No - Component Not Modeled
CA22-429: MOV-53 sends MOV-53 Valve Position feedback to RHR System II Controller	UCA110C2 (Too Late): MOV-53 sends valve open OR closed signal after the valve has been moved from its position [H8]	No - Component Not Modeled
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142A: RHR System II Controller does not send MOV-53 position to RHR System I Controller. [H1, H2, H8]	No - Component Not Modeled

Control Action	UCA	Modeled
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142C1 (Too Early): RHR System II Controller sends MOV-53 position to RHR System I Controller before valve position changes.[H1, H2, H8]	No - Component Not Modeled
CA22-443: RHR System II Controller sends MOV-53 Valve Position feedback to RHR System I Controller	UCA142C2 (Too Late): RHR System II Controller sends MOV-53 position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Component Not Modeled
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143A: RHR System II Controller does not send MOV-39B position to RHR System I Controller. [H1, H2, H8]	No - Component Not Modeled
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143C1 (Too Early): RHR System II Controller sends MOV-39B position to RHR System I Controller before valve position changes. [H1, H2, H8]	No - Component Not Modeled
CA22-444: RHR System II Controller sends MOV-39B Valve Position feedback to RHR System I Controller	UCA143C2 (Too Late): RHR System II Controller sends MOV-39B position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Component Not Modeled
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101B: RV Level Transmitter sends Level 1 signal to LPCI Initiation detectors when RV Level is greater than -132.5in [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101C1 (Too Early): RV Level Transmitter sends Level 1 signal to LPCI Initiation detectors when RV Level is greater than -132.5in [H3]	No - Loss scenario
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101C2 (Too Late): RV Level Transmitter sends Level 1 signal to LPCI Initiation detectors after RV level \leq -132.5in [H3]	No - Loss scenario
CA20-101: RV Level Transmitter sends Level signal to LPCI Initiation detectors	UCA20-101D2 (ETL): RV Level Transmitter continues to send Level 1 signal to LPCI Initiation detectors after RV Level $>$ -132.5in [H3]	No - Loss scenario
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106D3 (ETL): RV Level Transmitter continues to send Level 1 signal to NSSSS Controller after RV Level $>$ -132.5in [H3]	No - Loss scenario
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106D4 (ETL): RV Level Transmitter continues to send Level 3 signal to NSSSS Controller after RV Level $>$ -132.5in [H3]	No - Loss scenario
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402A: RHR system I Controller does not send Stop Pump signal to RHR Pump A when reactor cooling has been achieved [H3]	No - Loss scenario
CA21-402: RHR System I Controller sends Stop Pump signal to RHR Pump A	UCA21-402C2 (Too Late): RHR System I Controller sends Stop pump signal to RHR Pump A after reactor cooling via RHR is achieved [H3]	No - Loss scenario

Control Action	UCA	Modeled
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405A: RHR system I Controller does not send Stop Pump signal to RHR Pump C when reactor cooling has been achieved [H3]	No - Loss scenario
CA21-405: RHR System I Controller sends Stop Pump signal to RHR Pump C	UCA21-405C2 (Too Late): RHR System I Controller sends Stop pump signal to RHR Pump C after reactor cooling via RHR is achieved [H3]	No - Loss scenario
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402A: RHR system II Controller does not send Stop Pump signal to RHR Pump B when reactor cooling has been achieved [H3]	No - Loss scenario
CA22-402: RHR System II Controller sends Stop Pump signal to RHR Pump B	UCA22-402C2 (Too Late): RHR System II Controller sends Stop pump signal to RHR Pump B after reactor cooling via RHR is achieved [H3]	No - Loss scenario
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405A:RHR system II Controller does not send Stop Pump signal to RHR Pump D when reactor cooling has been achieved[H3]	No - Loss scenario
CA22-405: RHR System II Controller sends Stop Pump signal to RHR Pump D	UCA22-405C2 (Too Late): RHR System II Controller sends Stop pump signal to RHR Pump D after reactor cooling via RHR is achieved [H3]	No - Loss scenario
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102B: RV Pressure Sensors send Pressure signal to Recirculation Loop A Controller when RV Pressure >= 310 psig [H10]	No - No Impact

Control Action	UCA	Modeled
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102C1 (Too Early): RV Pressure Sensors send Pressure signal to Recirculation Loop A Controller before RV Pressure < 310 psig [H10]	No - No Impact
CA21-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop A Controller	UCA21-102D2 (ETL): RV Pressure Sensors continue to send Pressure signal to Recirculation Loop A Controller after RV Pressure >= 310 psig [H10]	No - No Impact
CA21-401: RHR System I Controller sends Start Pump signal to RHR Pump A after 2 second delay	UCA21-401B1: RHR System I Controller sends start pump signal to RHR Pump A when At-Power [H10]	No - No Impact
CA21-404: RHR System I Controller sends Start Pump signal to RHR Pump C after 2 second delay	UCA21-404B1: RHR System I Controller sends start pump signal to RHR Pump C when At-Power [H10]	No - No Impact
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102B: RV Pressure Sensors send Pressure signal to Recirculation Loop B Controller when RV Pressure >= 310 psig [H10]	No - No Impact
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102C1 (Too Early): RV Pressure Sensors send Pressure signal to Recirculation Loop B Controller before RV Pressure < 310 psig [H10]	No - No Impact
CA22-102: RV Pressure Sensors send Reactor Pressure signal to Recirculation Loop B Controller	UCA22-102D2 (ETL): RV Pressure Sensors continue to send Pressure signal to Recirculation Loop B Controller after RV Pressure >= 310 psig [H10]	No - No Impact

Control Action	UCA	Modeled
CA22-401: RHR System II Controller sends Start Pump signal to RHR Pump B after 2 second delay	UCA22-401B1: RHR System II Controller sends start pump signal to RHR Pump B when At-Power [H3, H4, H7]	No - No Impact
CA22-404: RHR System II Controller sends Start Pump signal to RHR Pump D after 7 second delay	UCA22-404B1: RHR System II Controller sends start pump signal to RHR Pump D when At-Power [H10]	No - No Impact
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41A: Operator does not send Start Pump signal to RHR Pump A when LPCI mode is required [H1, H6]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41B1: Operator sends start pump signal to RHR Pump A when At-Power [H3, H4, H7]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41B2: Operator sends start pump signal to RHR Pump A when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41C1 (Too Early): Operator sends start pump signal to RHR Pump A before downstream valves are aligned for RHR LPCI mode [H6]	No - Operator Action

Control Action	UCA	Modeled
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41C2 (Too Early): Operator sends start pump signal to RHR Pump A prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41C3 (Too Late): Operator sends start pump signal to RHR Pump A after 'x' second time delay upon receiving LPCI initiation signal[H2, H6]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41C4 (Wrong Order): Operator sends start pump signal to RHR Pump A when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41D1 (STS): NA	No - Operator Action
CA21-501: Operator sends Start Pump signal to RHR Pump A	UCA41D2 (ETL): NA	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42A: Operator does not send Stop Pump signal to RHR Pump A when reactor cooling has been achieved [H3]	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42B: Operator sends Stop pump signal to RHR Pump A when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	No - Operator Action

Control Action	UCA	Modeled
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42C1 (Too Early): Operator sends Stop pump signal to RHR Pump A before reactor cooling has been achieved [H6]	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42C2 (Too Late): Operator sends Stop pump signal to RHR Pump A after reactor cooling via RHR is achieved [H3]	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42C3 (Wrong Order): Operator sends Stop pump signal to RHR Pump A after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42D1 (STS): NA	No - Operator Action
CA21-502: Operator sends Stop Pump signal to RHR Pump A	UCA42D2 (ETL): NA	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43A: Operator does not send Start Pump signal to RHR Pump C when LPCI mode is required [H1, H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43B1: Operator sends start pump signal to RHR Pump C when At-Power [H3, H4, H7]	No - Operator Action

Control Action	UCA	Modeled
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43B2: Operator sends start pump signal to RHR Pump C when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43C1 (Too Early): Operator sends start pump signal to RHR Pump C before downstream valves are aligned for RHR LPCI mode [H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43C2 (Too Early): Operator sends start pump signal to RHR Pump C prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43C3 (Too Late): Operator sends start pump signal to RHR Pump C after 'x' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43C4 (Wrong Order): Operator sends start pump signal to RHR Pump C when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43D1 (STS): NA	No - Operator Action
CA21-503: Operator sends Start Pump signal to RHR Pump C	UCA43D2 (ETL): NA	No - Operator Action

Control Action	UCA	Modeled
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44A: Operator does not send Stop Pump signal to RHR Pump C when reactor cooling has been achieved [H3]	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44B: Operator sends Stop pump signal to RHR Pump C when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44C1 (Too Early): Operator sends Stop pump signal to RHR Pump C before reactor cooling has been achieved [H6]	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44C2 (Too Late): Operator sends Stop pump signal to RHR Pump C after reactor cooling via RHR is achieved [H3]	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44C3 (Wrong Order): Operator sends Stop pump signal to RHR Pump C after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44D1 (STS): NA	No - Operator Action
CA21-504: Operator sends Stop Pump signal to RHR Pump C	UCA44D2 (ETL): NA	No - Operator Action

Control Action	UCA	Modeled
CA21-505: Operator sends Open Signal to MOV-31A	UCA45A: Operator does not send Open signal to MOV-31A when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45B: NA	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45C1 (Too Early): NA	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45C2 (Too Late): Operator sends Open signal to MOV-31A after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45C3 (Wrong Order): NA	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45D1 (STS): NA	No - Operator Action
CA21-505: Operator sends Open Signal to MOV-31A	UCA45D2 (ETL): NA	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46A: NA	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46B: Operator sends Close signal to MOV-31A while RHR is providing reactor cooling [H1, H2, H6]	No - Operator Action

Control Action	UCA	Modeled
CA21-506: Operator sends Close Signal to MOV-31A	UCA46C1 (Too Early): Operator sends Close signal to MOV-31A while RHR Pump A is taking suction from the suppression pool [H1, H2, H6]	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46C2 (Too Late): NA	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46C3 (Wrong Order): Operator sends Close signal to MOV-31A before RHR Pump A stops [H2]	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46D1 (STS): NA	No - Operator Action
CA21-506: Operator sends Close Signal to MOV-31A	UCA46D2 (ETL): NA	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47A:Operator does not send Open signal to MOV-31C when LPCI initiation signal is received from LPCI Initiation Detectors[H1, H2]	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47B: NA	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47C1 (Too Early): NA	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47C2 (Too Late): Operator sends Open signal to MOV-31C after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action

Control Action	UCA	Modeled
CA21-507: Operator sends Open Signal to MOV-31C	UCA47C3 (Wrong Order): NA	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47D1 (STS): NA	No - Operator Action
CA21-507: Operator sends Open Signal to MOV-31C	UCA47D2 (ETL): NA	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48A: NA	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48B: Operator sends Close signal to MOV-31C while RHR is providing reactor cooling [H1, H2, H6]	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48C1 (Too Early): Operator sends Close signal to MOV-31C while RHR Pump C is taking suction from the suppression pool [H1, H2, H6]	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48C2 (Too Late): NA	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48C3 (Wrong Order): Operator sends Close signal to MOV-31C before RHR Pump C stops [H2]	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48D1 (STS): NA	No - Operator Action
CA21-508: Operator sends Close Signal to MOV-31C	UCA48D2 (ETL): NA	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49A: NA	No - Operator Action

Control Action	UCA	Modeled
CA21-509: Operator sends Open Signal to MOV-39A	UCA49B: Operator sends Open signal to MOV-39A when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49C1 (Too Early): NA	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49C2 (Too Late): NA	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49C3 (Wrong Order): NA	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49D1 (STS): NA	No - Operator Action
CA21-509: Operator sends Open Signal to MOV-39A	UCA49D2 (ETL): NA	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50A: Operator does not send Close signal to MOV-39A when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50B: Operator sends Close signal to MOV-39A while RHR is providing cooling via drywell sparger [H1, H4, H6]	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50C1 (Too Early): Operator sends Close signal to MOV-39A before LPCI initiation signal is received [H1, H4, H6]	No - Operator Action

Control Action	UCA	Modeled
CA21-510: Operator sends Close Signal to MOV-39A	UCA50C2 (Too Late): Operator sends Close signal to MOV-39A after LPCI initiation signal is received [H1, H6]	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50C3 (Wrong Order):NA	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50D1 (STS): NA	No - Operator Action
CA21-510: Operator sends Close Signal to MOV-39A	UCA50D2 (ETL): NA	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51A: NA for LPCI Alignment	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51B: Operator sends Open signal to MOV-40A when LPCI Mode is in operation [H1, H6]	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51C1 (Too Early): Operator sends Open signal to MOV-40A before LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51C2 (Too Late): Operator sends Open signal to MOV-40A after LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51C3 (Wrong Order): NA	No - Operator Action
CA21-511: Operator sends Open Signal to MOV-40A	UCA51D1 (STS): NA	No - Operator Action

Control Action	UCA	Modeled
CA21-511: Operator sends Open Signal to MOV-40A	UCA51D2 (ETL): NA	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52A: Operator does not send Close signal to MOV-40A when LPCI initiation signal is received [H1]	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52B: NA for LPCI Alignment	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52C1 (Too Early): NA	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52C2 (Too Late): NA	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52C3 (Wrong Order): NA	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52D1 (STS): NA	No - Operator Action
CA21-512: Operator sends Close Signal to MOV-40A	UCA52D2 (ETL): NA	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53A: NA for LPCI Alignment	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53B: Operator sends Open signal to MOV-41A when LPCI Mode is in operation [H1, H6]	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53C1 (Too Early): Operator sends Open signal to MOV-41A before LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action

Control Action	UCA	Modeled
CA21-513: Operator sends Open Signal to MOV-41A	UCA53C2 (Too Late): Operator sends Open signal to MOV-41A after LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53C3 (Wrong Order): NA	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53D1 (STS): NA	No - Operator Action
CA21-513: Operator sends Open Signal to MOV-41A	UCA53D2 (ETL): NA	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54A: Operator does not send Close signal to MOV-41A when LPCI initiation signal is received [H1]	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA354B: NA for LPCI Alignment	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54C1 (Too Early): NA	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54C2 (Too Late): NA	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54C3 (Wrong Order): NA	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54D1 (STS): NA	No - Operator Action
CA21-514: Operator sends Close Signal to MOV-41A	UCA54D2 (ETL): NA	No - Operator Action

Control Action	UCA	Modeled
CA21-515: Operator sends Open Signal to MOV-37A	UCA55A: Operator does not send Open signal to MOV-37A when LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55B: Operator sends Open signal to MOV-37A when plant is at-power. [H4, H7]	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55C1 (Too Early): Operator sends Open signal to MOV-37A before LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55C2 (Too Late): Operator sends Open signal to MOV-37A after LOCA conditions are indicated AND Rx Pressure < 338 psig [H4, H7]	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55C3 (Wrong Order): NA	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55D1 (STS): NA	No - Operator Action
CA21-515: Operator sends Open Signal to MOV-37A	UCA55D2 (ETL): NA	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56A: NA	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56B: Operator sends Close signal to MOV-37A while LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	No - Operator Action

Control Action	UCA	Modeled
CA21-516: Operator sends Close Signal to MOV-37A	UCA56C1 (Too Early): Operator sends Close signal to MOV-37A before adequate LPCI has been achieved [H1, H4, H5]	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56C2 (Too Late): Operator sends Close signal to MOV-37A after adequate LPCI has been achieved [H1, H4, H5]	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56C3 (Wrong Order): NA	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56D1 (STS): NA	No - Operator Action
CA21-516: Operator sends Close Signal to MOV-37A	UCA56D2 (ETL): NA	No - Operator Action
CA21-517: Operator sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-517: Operator sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-517: Operator sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-517: Operator sends Open Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-518: Operator sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-518: Operator sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-518: Operator sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action
CA21-518: Operator sends Close Signal to MOV-50	NA - Normally Locked-Closed, De-energized	No - Operator Action

Control Action	UCA	Modeled
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111A: Operator does not send Start Pump signal to RHR Pump B when LPCI mode is required [H1, H6]	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111B1: Operator sends start pump signal to RHR Pump B when At-Power[H3, H4, H7]UCA111B2:Operator sends start pump signal to RHR Pump B when suppression pool suction valves OR shutdown cooling valves are not fully-open[H2, H6]	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111C1 (Too Early): Operator sends start pump signal to RHR Pump B before downstream valves are aligned for RHR LPCI mode [H6]	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111C2 (Too Early): Operator sends start pump signal to RHR Pump B prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111C3 (Too Late): Operator sends start pump signal to RHR Pump B after 'x' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111C4 (Wrong Order): Operator sends start pump signal to RHR Pump B when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action

Control Action	UCA	Modeled
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111D1 (STS): NA	No - Operator Action
CA22-501: Operator sends Start Pump signal to RHR Pump B	UCA111D2 (ETL): NA	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112A: Operator does not send Stop Pump signal to RHR Pump B when reactor cooling has been achieved [H3]	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112B: Operator sends Stop pump signal to RHR Pump B when reactor cooling has not been achieved AND all valves in suction path are fully-open[H6]	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112C1 (Too Early): Operator sends Stop pump signal to RHR Pump B before reactor cooling has been achieved [H6]	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112C2 (Too Late): Operator sends Stop pump signal to RHR Pump B after reactor cooling via RHR is achieved [H3]	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112C3 (Wrong Order): Operator sends Stop pump signal to RHR Pump B after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	No - Operator Action
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112D1 (STS): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-502: Operator sends Stop Pump signal to RHR Pump B	UCA112D2 (ETL): NA	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113A: Operator does not send Start Pump signal to RHR Pump D when LPCI mode is required [H1, H6]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113B1: Operator sends start pump signal to RHR Pump D when At-Power [H3, H4, H7]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113B2: Operator sends start pump signal to RHR Pump D when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113C1 (Too Early): Operator sends start pump signal to RHR Pump D before downstream valves are aligned for RHR LPCI mode[H6]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113C2 (Too Early): Operator sends start pump signal to RHR Pump D prior to 'x' second time delay upon receiving LPCI initiation signal. [H2, H6]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113C3 (Too Late): Operator sends start pump signal to RHR Pump D after 'x' second time delay upon receiving LPCI initiation signal [H2, H6]	No - Operator Action

Control Action	UCA	Modeled
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113C4 (Wrong Order): Operator sends start pump signal to RHR Pump D when suppression pool suction valves OR shutdown cooling valves are not fully-open [H2, H6]	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113D1 (STS): NA	No - Operator Action
CA22-503: Operator sends Start Pump signal to RHR Pump D	UCA113D2 (ETL): NA	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114A: Operator does not send Stop Pump signal to RHR Pump D when reactor cooling has been achieved [H3]	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114B: Operator sends Stop pump signal to RHR Pump D when reactor cooling has not been achieved AND all valves in suction path are fully-open [H6]	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114C1 (Too Early): Operator sends Stop pump signal to RHR Pump D before reactor cooling has been achieved[H6]	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114C2 (Too Late): Operator sends Stop pump signal to RHR Pump D after reactor cooling via RHR is achieved [H3]	No - Operator Action

Control Action	UCA	Modeled
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114C3 (Wrong Order): Operator sends Stop pump signal to RHR Pump D after suppression pool suction valves AND shutdown cooling valves are moved out of fully-open position [H2]	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114D1 (STS): NA	No - Operator Action
CA22-504: Operator sends Stop Pump signal to RHR Pump D	UCA114D2 (ETL): NA	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115A: Operator does not send Open signal to MOV-31B when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115B: NA	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115C1 (Too Early): NA	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115C2 (Too Late): Operator sends Open signal to MOV-31B after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115C3 (Wrong Order): NA	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115D1 (STS): NA	No - Operator Action
CA22-505: Operator sends Open Signal to MOV-31B	UCA115D2 (ETL): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-506: Operator sends Close Signal to MOV-31B	UCA116A: NA	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116B: Operator sends Close signal to MOV-31B while RHR is providing reactor cooling [H1, H2, H6]	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116C1 (Too Early): Operator sends Close signal to MOV-31B while RHR Pump B is taking suction from the suppression pool [H1, H2, H6]	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116C2 (Too Late): NA	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116C3 (Wrong Order): Operator sends Close signal to MOV-31B before RHR Pump B stops [H2]	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116D1 (STS): NA	No - Operator Action
CA22-506: Operator sends Close Signal to MOV-31B	UCA116D2 (ETL): NA	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117A: Operator does not send Open signal to MOV-31B when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117B: NA	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117C1 (Too Early): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-507: Operator sends Open Signal to MOV-31D	UCA117C2 (Too Late): Operator sends Open signal to MOV-31B after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117C3 (Wrong Order): NA	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117D1 (STS): NA	No - Operator Action
CA22-507: Operator sends Open Signal to MOV-31D	UCA117D2 (ETL): NA	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118A: NA	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118B: Operator sends Close signal to MOV-31D while RHR is providing reactor cooling [H1, H2, H6]	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118C1 (Too Early): Operator sends Close signal to MOV-31D while RHR Pump D is taking suction from the suppression pool [H1, H2, H6]	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118C2 (Too Late): NA	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118C3 (Wrong Order): Operator sends Close signal to MOV-31D before RHR Pump D stops [H2]	No - Operator Action
CA22-508: Operator sends Close Signal to MOV-31D	UCA118D1 (STS): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-508: Operator sends Close Signal to MOV-31D	UCA118D2 (ETL): NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119A: NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119B: Operator sends Open signal to MOV-39B when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119C1 (Too Early): NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119C2 (Too Late): NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119C3 (Wrong Order): NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119D1 (STS): NA	No - Operator Action
CA22-509: Operator sends Open Signal to MOV-39B	UCA119D2 (ETL): NA	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120A: Operator does not send Close signal to MOV-39B when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120B: Operator sends Close signal to MOV-39B while RHR is providing cooling via drywell sparger [H1, H4, H6]	No - Operator Action

Control Action	UCA	Modeled
CA22-510: Operator sends Close Signal to MOV-39B	UCA120C1 (Too Early): Operator sends Close signal to MOV-39B before LPCI initiation signal is received [H1, H4, H6]	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120C2 (Too Late): Operator sends Close signal to MOV-39B after LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120C3 (Wrong Order): NA	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120D1 (STS): NA	No - Operator Action
CA22-510: Operator sends Close Signal to MOV-39B	UCA120D2 (ETL): NA	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121A: NA for LPCI Alignment	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121B: Operator sends Open signal to MOV-40B when LPCI Mode is in operation [H1, H6]	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121C1 (Too Early): Operator sends Open signal to MOV-40B before LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121C2 (Too Late): Operator sends Open signal to MOV-40B after LPCI has adequately provided cooling to recirculation[H1, H6]	No - Operator Action

Control Action	UCA	Modeled
CA22-511: Operator sends Open Signal to MOV-40B	UCA121C3 (Wrong Order): NA	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121D1 (STS): NA	No - Operator Action
CA22-511: Operator sends Open Signal to MOV-40B	UCA121D2 (ETL): NA	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122A: Operator does not send Close signal to MOV-40B when LPCI initiation signal is received [H1]	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122B: NA for LPCI Alignment	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122C1 (Too Early): NA	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122C2 (Too Late): NA	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122C3 (Wrong Order): NA	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122D1 (STS): NA	No - Operator Action
CA22-512: Operator sends Close Signal to MOV-40B	UCA122D2 (ETL): NA	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121A: NA for LPCI Alignment	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121B: Operator sends Open signal to MOV-41B when LPCI Mode is in operation [H1, H6]	No - Operator Action

Control Action	UCA	Modeled
CA22-513: Operator sends Open Signal to MOV-41B	UCA121C1 (Too Early): Operator sends Open signal to MOV-41B before LPCI has adequately provided cooling to recirculation [H1, H6]	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121C2 (Too Late): Operator sends Open signal to MOV-41B after LPCI has adequately provided cooling to recirculation[H1, H6]	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121C3 (Wrong Order): NA	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121D1 (STS): NA	No - Operator Action
CA22-513: Operator sends Open Signal to MOV-41B	UCA121D2 (ETL): NA	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124A: Operator does not send Close signal to MOV-41B when LPCI initiation signal is received [H1]	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124B: NA for LPCI Alignment	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124C1 (Too Early): NA	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124C2 (Too Late): NA	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124C3 (Wrong Order): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-514: Operator sends Close Signal to MOV-41B	UCA124D1 (STS): NA	No - Operator Action
CA22-514: Operator sends Close Signal to MOV-41B	UCA124D2 (ETL): NA	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125A: Operator does not send Open signal to MOV-37B when LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125B: Operator sends Open signal to MOV-37B when plant is at-power. [H4, H7]	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125C1 (Too Early): Operator sends Open signal to MOV-37B before LOCA conditions are indicated AND Rx Pressure < 338 psig[H1, H4, H5]	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125C2 (Too Late): Operator sends Open signal to MOV-37B after LOCA conditions are indicated AND Rx Pressure < 338 psig [H4, H7]	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125C3 (Wrong Order): NA	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125D1 (STS): NA	No - Operator Action
CA22-515: Operator sends Open Signal to MOV-37B	UCA125D2 (ETL): NA	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126A: NA	No - Operator Action

Control Action	UCA	Modeled
CA22-516: Operator sends Close Signal to MOV-37B	UCA126B: Operator sends Close signal to MOV-37B while LOCA conditions are indicated AND Rx Pressure < 338 psig [H1, H4, H5]	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126C1 (Too Early): Operator sends Close signal to MOV-37B before adequate LPCI has been achieved [H1, H4, H5]	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126C2 (Too Late): Operator sends Close signal to MOV-37B after adequate LPCI has been achieved [H1, H4, H5]	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126C3 (Wrong Order): NA	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126D1 (STS): NA	No - Operator Action
CA22-516: Operator sends Close Signal to MOV-37B	UCA126D2 (ETL): NA	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127A:NA	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127B: Operator sends Open signal to MOV-53 when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127C1 (Too Early): NA	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127C2 (Too Late): NA	No - Operator Action

Control Action	UCA	Modeled
CA22-517: Operator sends Open Signal to MOV-53	UCA127C3 (Wrong Order): NA	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127D1 (STS): NA	No - Operator Action
CA22-517: Operator sends Open Signal to MOV-53	UCA127D2 (ETL): NA	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128A: Operator does not send Close signal to MOV-53 when LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128B: Operator sends Close signal to MOV-53 while RHR is providing cooling via head spray [H1, H4, H6]	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128C1 (Too Early): Operator sends Close signal to MOV-53 before LPCI initiation signal is received [H1, H4, H6]	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128C2 (Too Late): Operator sends Close signal to MOV-53 after LPCI initiation signal is received [H1, H6]	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128C3 (Wrong Order): NA	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128D1 (STS): NA	No - Operator Action
CA22-518: Operator sends Close Signal to MOV-53	UCA128D2 (ETL): NA	No - Operator Action

Control Action	UCA	Modeled
CA20-102: Drywell Pressure Sensors send Pressure signal to Initiation Detectors	UCA20-103D2 (ETL): RV Level Transmitter continues to send Level 1 signal to Control Room Indicator after RV Level > -132.5in [H3]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103A: RV Level Transmitter does not send Level signal to Control Room Indicator when RV level <= -132.5in [H5]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103B: RV Level Transmitter sends RV Level 1 signal to Control Room Indicator when RV Level > -132.5in [H3, H4]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103C1 (Too Early): RV Level Transmitter sends RV Level 1 signal to Control Room Indicator before RV Level <= -132.5in [H3, H4]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103C2 (Too Late): RV Level Transmitter sends Level 1 signal to Control Room Indicator after RV Level <= -132.5in [H5]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103D1 (STS): RV Level Transmitter stops sending Level 1 signal to Control Room Indicator before RV level > -132.5in [H5]	No - Operator Feedback
CA20-103: RV Level Transmitter sends Level signal to Control Room Indicator	UCA20-103D2 (ETL): RV Level Transmitter continues to send Level 1 signal to Control Room Indicator after RV Level > -132.5in [H3]	No - Operator Feedback

Control Action	UCA	Modeled
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104A: Drywell Pressure Sensors do not send Pressure signal to Control Room Indicator when drywell pressure \geq 1.69 psig [H5]	No - Operator Feedback
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104B: Drywell Pressure Sensors send High Pressure signal to Control Room Indicator when drywell pressure $<$ 1.69 psig [H3, H4]	No - Operator Feedback
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104C1 (Too Early): Drywell Pressure Sensors send High Pressure signal to Control Room Indicator before drywell pressure \geq 1.69 psig [H3, H4]	No - Operator Feedback
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104C2 (Too Late): Drywell Pressure Sensors send High Pressure signal to Control Room Indicator after drywell pressure \geq 1.69 psig [H5]	No - Operator Feedback
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104D1 (STS): Drywell Pressure Sensors stop sending High Pressure signal to Control Room Indicator before Drywell Pressure $<$ 1.69 psig [H5]	No - Operator Feedback
CA20-104: Drywell Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-104D2 (ETL): Drywell Pressure Sensors continue to send High Pressure signal to Control Room Indicator after Drywell Pressure $<$ 1.69 psig [H3, H4]	No - Operator Feedback
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105A: RV Pressure Sensor does not send High Pressure signal to Control Room Indicator when RV Pressure \geq 125 psig [H5]	No - Operator Feedback

Control Action	UCA	Modeled
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105B: RV Pressure Sensor sends High Pressure signal to Control Room Indicator when RV Pressure < 125 psig [H1, H2, H3]	No - Operator Feedback
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105C1 (Too Early): RV Pressure Sensor sends High Pressure signal to Control Room Indicator before RV Pressure >= 125 psig [H1, H2, H3]	No - Operator Feedback
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105C2 (Too Late): RV Pressure Sensor sends High Pressure signal to Control Room Indicator after RV Pressure >= 125 psig [H5]	No - Operator Feedback
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105D1 (STS): RV Pressure Sensor stops sending High Pressure signal to Control Room Indicator before RV Pressure < 125 psig [H5]	No - Operator Feedback
CA20-105: RV Pressure Sensors send Pressure signal to Control Room Indicator	UCA20-105D2 (ETL): RV Pressure Sensor continues to send High Pressure signal to Control Room Indicator after RV Pressure < 125 psig [H1, H2, H3]	No - Operator Feedback
CA20-106: RV Level Transmitter sends Level signal to NSSS Controller	UCA20-106C2 (Too Early): RV Level Transmitter sends RV Level 3 signal to Control Room Indicator before RV Level <= +12.5in [H3, H4, H6]	No - Operator Feedback
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430A: RHR System I Controller does not send RHR Pump A Status to control room indicator. [H1, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430C1 (Too Early): RHR System I Controller sends Pump A status to Control room indicator before pump status is changed. [H1, H8]	No - Operator Feedback
CA21-430: RHR System I Controller sends RHR Pump A Status to Control Room Indicator	UCA21-430C2 (Too Late): RHR System I Controller sends Pump A status to Control room indicator after pump status is changed. [H1, H8]	No - Operator Feedback
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431A: RHR System I Controller does not send RHR Pump C Status to control room indicator. [H1, H8]	No - Operator Feedback
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431C1 (Too Early): RHR System I Controller sends Pump C status to Control room indicator before pump status is changed. [H1, H8]	No - Operator Feedback
CA21-431: RHR System I Controller sends RHR Pump C Status to Control Room Indicator	UCA21-431C2 (Too Late): RHR System I Controller sends Pump C status to Control room indicator after pump status is changed. [H1, H8]	No - Operator Feedback
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432A: RHR System I Controller does not send MOV-31A position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432C1 (Too Early): RHR System I Controller sends MOV-31A position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-432: RHR System I Controller sends MOV-31A Valve Position feedback to Control Room Indicator	UCA21-432C2 (Too Late): RHR System I Controller sends MOV-31A position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433A: RHR System II Controller does not send MOV-31D position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433C1 (Too Early): RHR System I Controller sends MOV-31C position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433C2 (Too Late): RHR System I Controller sends MOV-31C position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63A: RHR System I Controller does not send MOV-39A position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63C1 (Too Early): RHR System I Controller sends MOV-39A position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-434: RHR System I Controller sends MOV-39A Valve Position feedback to Control Room Indicator	UCA63C2 (Too Late): RHR System I Controller sends MOV-39A position to control room indicator after valve position changes.[H1, H2, H8]	No - Operator Feedback
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435A: RHR System I Controller does not send MOV-37A position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435C1 (Too Early): RHR System I Controller sends MOV-37A position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-435: RHR System I Controller sends MOV-37A Valve Position feedback to Control Room Indicator	UCA21-435C2 (Too Late): RHR System I Controller sends MOV-37A position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA21-436A: RHR System I Controller does not send MOV-40A position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA21-436C1 (Too Early): RHR System I Controller sends MOV-40A position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-436: RHR System I Controller sends MOV-40A Valve Position feedback to Control Room Indicator	UCA21-436C2 (Too Late): RHR System I Controller sends MOV-40A position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA21-437A: RHR System I Controller does not send MOV-41A position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA21-437C1 (Too Early): RHR System I Controller sends MOV-41A position to control room indicator before valve position changes.[H1, H2, H8]	No - Operator Feedback
CA21-437: RHR System I Controller sends MOV-41A Valve Position feedback to Control Room Indicator	UCA21-437C2 (Too Late): RHR System I Controller sends MOV-41A position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430A: RHR System II Controller does not send RHR Pump B Status to control room indicator. [H1, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430C1 (Too Early): RHR System II Controller sends Pump B status to Control room indicator before pump status is changed. [H1, H8]	No - Operator Feedback
CA22-430: RHR System II Controller sends RHR Pump B Status to Control Room Indicator	UCA22-430C2 (Too Late): RHR System II Controller sends Pump B status to Control room indicator after pump status is changed. [H1, H8]	No - Operator Feedback
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431A: RHR System II Controller does not send RHR Pump D Status to control room indicator. [H1, H8]	No - Operator Feedback
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431C1 (Too Early): RHR System II Controller sends Pump D status to Control room indicator before pump status is changed. [H1, H8]	No - Operator Feedback
CA22-431: RHR System II Controller sends RHR Pump D Status to Control Room Indicator	UCA22-431C2 (Too Late): RHR System II Controller sends Pump D status to Control room indicator after pump status is changed. [H1, H8]	No - Operator Feedback
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432A: RHR System II Controller does not send MOV-31B position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432C1 (Too Early): RHR System II Controller sends MOV-31B position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-432: RHR System II Controller sends MOV-31B Valve Position feedback to Control Room Indicator	UCA22-432C2 (Too Late): RHR System II Controller sends MOV-31B position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-433: RHR System I Controller sends MOV-31C Valve Position feedback to Control Room Indicator	UCA21-433A: RHR System I Controller does not send MOV-31C position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433C1 (Too Early): RHR System II Controller sends MOV-31D position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-433: RHR System II Controller sends MOV-31D Valve Position feedback to Control Room Indicator	UCA22-433C2 (Too Late): RHR System II Controller sends MOV-31D position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133A: RHR System II Controller does not send MOV-53 position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133C1 (Too Early): RHR System II Controller sends MOV-53 position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-434: RHR System II Controller sends MOV-53 Valve Position feedback to Control Room Indicator	UCA133C2 (Too Late): RHR System II Controller sends MOV-53 position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134A: RHR System II Controller does not send MOV-39B position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134C1 (Too Early): RHR System II Controller sends MOV-39B position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-435: RHR System II Controller sends MOV-39B Valve Position feedback to Control Room Indicator	UCA134C2 (Too Late): RHR System II Controller sends MOV-39B position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436A: RHR System II Controller does not send MOV-37B position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436C1 (Too Early): RHR System II Controller sends MOV-37B position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-436: RHR System II Controller sends MOV-37B Valve Position feedback to Control Room Indicator	UCA22-436C2 (Too Late): RHR System II Controller sends MOV-37B position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA22-437tem II Controller does not send MOV-40B position to control room indicator. [H1, H2, H8]	No - Operator Feedback
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA22-437C1 (Too Early): RHR System II Controller sends MOV-40B position to control room indicator before valve position changes.[H1, H2, H8]	No - Operator Feedback
CA22-437: RHR System II Controller sends MOV-40B Valve Position feedback to Control Room Indicator	UCA22-437C2 (Too Late): RHR System II Controller sends MOV-40B position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA22-438A: RHR System II Controller does not send MOV-41B position to control room indicator. [H1, H2, H8]	No - Operator Feedback

Control Action	UCA	Modeled
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA22-438C1 (Too Early): RHR System II Controller sends MOV-41B position to control room indicator before valve position changes. [H1, H2, H8]	No - Operator Feedback
CA22-438: RHR System II Controller sends MOV-41B Valve Position feedback to Control Room Indicator	UCA22-438C2 (Too Late): RHR System II Controller sends MOV-41B position to control room indicator after valve position changes. [H1, H2, H8]	No - Operator Feedback
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439A: RHR System I Controller does not send RHR Pump A Status to RHR System II Controller. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439C1 (Too Early): RHR System I Controller sends Pump A status to RHR System II Controller before pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-439: RHR System I Controller sends RHR Pump A Status to RHR System II Controller	UCA21-439C2 (Too Late): RHR System I Controller sends Pump A status to RHR System II Controller after pump status is changed.[H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440A: RHR System I Controller does not send RHR Pump C Status to RHR System II Controller. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440C1 (Too Early): RHR System I Controller sends Pump C status to RHR System II Controller before pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-440: RHR System I Controller sends RHR Pump C Status to RHR System II Controller	UCA21-440C2 (Too Late): RHR System I Controller sends Pump C status to RHR System II Controller after pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441A: RHR System I Controller does not send MOV-31A position to RHR System II Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441C1 (Too Early): RHR System I Controller sends MOV-31A position to RHR System II Controller before valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-441: RHR System I Controller sends MOV-31A Valve Position feedback to RHR System II Controller	UCA21-441C2 (Too Late): RHR System I Controller sends MOV-31A position to RHR System II Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442A: RHR System I Controller does not send MOV-31C position to RHR System II Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442C1 (Too Early): RHR System I Controller sends MOV-31C position to RHR System II Controller before valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-442: RHR System I Controller sends MOV-31C Valve Position feedback to RHR System II Controller	UCA21-442C2 (Too Late): RHR System I Controller sends MOV-31C position to RHR System II Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA21-445A: RHR System I Controller does not send MOV-40A position to RHR System II Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA21-445C1 (Too Early): RHR System I Controller sends MOV-40A position to RHR System II Controller before valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-445: RHR System I Controller sends MOV-40A Valve Position feedback to RHR System II Controller	UCA21-445C2 (Too Late): RHR System I Controller sends MOV-40A position to RHR System II Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA21-446A: RHR System I Controller does not send MOV-41A position to RHR System II Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA21-446C1 (Too Early): RHR System I Controller sends MOV-41A position to RHR System II Controller before valve position changes.[H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-446: RHR System I Controller sends MOV-41A Valve Position feedback to RHR System II Controller	UCA21-446C2 (Too Late): RHR System I Controller sends MOV-41A position to RHR System II Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439A: RHR System II Controller does not send RHR Pump B Status to RHR System I Controller. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439C1 (Too Early): RHR System II Controller sends Pump B status to RHR System I Controller before pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-439: RHR System II Controller sends RHR Pump B Status to RHR System I Controller	UCA22-439C2 (Too Late): RHR System II Controller sends Pump B status to RHR System I Controller after pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440A: RHR System II Controller does not send RHR Pump D Status to RHR System I Controller. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440C1 (Too Early): RHR System II Controller sends Pump D status to RHR System I Controller before pump status is changed.[H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-440: RHR System II Controller sends RHR Pump D Status to RHR System I Controller	UCA22-440C2 (Too Late): RHR System II Controller sends Pump D status to RHR System I Controller after pump status is changed. [H1, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441A: RHR System II Controller does not send MOV-31B position to RHR System I Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441C1 (Too Early): RHR System II Controller sends MOV-31B position to RHR System I Controller before valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-441: RHR System II Controller sends MOV-31B Valve Position feedback to RHR System I Controller	UCA22-441C2 (Too Late): RHR System II Controller sends MOV-31B position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442A: RHR System II Controller does not send MOV-31D position to RHR System I Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442C1 (Too Early): RHR System II Controller sends MOV-31D position to RHR System I Controller before valve position changes.[H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-442: RHR System II Controller sends MOV-31D Valve Position feedback to RHR System I Controller	UCA22-442C2 (Too Late): RHR System II Controller sends MOV-31D position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UC22-446A: RHR System II Controller does not send MOV-40B position to RHR System I Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UCA22-446C1 (Too Early): RHR System II Controller sends MOV-40B position to RHR System I Controller before valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-446: RHR System II Controller sends MOV-40B Valve Position feedback to RHR System I Controller	UCA22-446C2 (Too Late): RHR System II Controller sends MOV-40B position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA22-447A: RHR System II Controller does not send MOV-41B position to RHR System I Controller. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication

Control Action	UCA	Modeled
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA22-447C1 (Too Early): RHR System II Controller sends MOV-41B position to RHR System I Controller before valve position changes.[H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA22-447: RHR System II Controller sends MOV-41B Valve Position feedback to RHR System I Controller	UCA22-447C2 (Too Late): RHR System II Controller sends MOV-41B position to RHR System I Controller after valve position changes. [H1, H2, H8]	No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409A: RHR System I Controller does not send Open signal to MOV-31A when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA21-409: RHR System I Controller sends Open Signal to MOV-31A	UCA21-409C2 (Too Late): RHR System I Controller sends Open signal to MOV-31A after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412A: RHR System I Controller does not send Open signal to MOV-31C when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA21-412: RHR System I Controller sends Open Signal to MOV-31C	UCA21-412C2 (Too Late): RHR System I Controller sends Open signal to MOV-31C after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state

Control Action	UCA	Modeled
CA21-419: RHR System I Controller sends Close Signal to MOV-40A	UCA21-419A: RHR System I Controller does not send Close signal to MOV-40A when LPCI initiation signal is received [H1]	Removed - UCA aligns with normal operating state
CA21-422: RHR System I Controller sends Close Signal to MOV-41A	UCA21-422A: RHR System I Controller does not send Close signal to MOV-41A when LPCI initiation signal is received [H1]	Removed - UCA aligns with normal operating state
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409A:RHR System II Controller does not send Open signal to MOV-31B when LPCI initiation signal is received from LPCI Initiation Detectors[H1, H2]	Removed - UCA aligns with normal operating state
CA22-409: RHR System II Controller sends Open Signal to MOV-31B	UCA22-409C2 (Too Late): RHR System II Controller sends Open signal to MOV-31B after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412A: RHR System II Controller does not send Open signal to MOV-31D when LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA22-412: RHR System II Controller sends Open Signal to MOV-31D	UCA22-412C2 (Too Late): RHR System II Controller sends Open signal to MOV-31D after LPCI initiation signal is received from LPCI Initiation Detectors [H1, H2]	Removed - UCA aligns with normal operating state
CA22-419: RHR System II Controller sends Close Signal to MOV-40B	UCA22-419A: RHR System II Controller does not send Close signal to MOV-40B when LPCI initiation signal is received [H1]	Removed - UCA aligns with normal operating state

Control Action	UCA	Modeled
CA22-422: RHR System II Controller sends Close Signal to MOV-41B	UCA22-422A: RHR System II Controller does not send Close signal to MOV-41B when LPCI initiation signal is received [H1]	Removed - UCA aligns with normal operating state
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454A: RHR System I Controller does not send Open signal to MOV-33A when the LPCI initiation signal is received. [H1]	Removed - UCA aligns with normal operating state
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454B: RHR System I Controller sends Open signal to MOV-33A when plant is at-power. [H4, H7]	Removed - UCA aligns with normal operating state
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454C1 (Too Early): RHR System I Controller sends Open signal to MOV-33A before LPCI initiation signal is received. [H4, H7]	Removed - UCA aligns with normal operating state
CA21-454: RHR System I Controller sends Open Signal to MOV-33A	UCA21-454C2 (Too Late): RHR System I Controller sends Open signal to MOV-33A after LPCI initiation signal is received.[H1]	Removed - UCA aligns with normal operating state
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454A: RHR System II Controller does not send Open signal to MOV-33B when the LPCI initiation signal is received. [H1]	Removed - UCA aligns with normal operating state
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454B: RHR System II Controller sends Open signal to MOV-33B when plant is at-power. [H4, H7]	Removed - UCA aligns with normal operating state
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454C1 (Too Early): RHR System II Controller sends Open signal to MOV-33B before LPCI initiation signal is received. [H4, H7]	Removed - UCA aligns with normal operating state

Control Action	UCA	Modeled
CA22-454: RHR System II Controller sends Open Signal to MOV-33B	UCA22-454C2 (Too Late): RHR System II Controller sends Open signal to MOV-33B after LPCI initiation signal is received. [H1]	Removed - UCA aligns with normal operating state

APPENDIX F. SYSTEM-THEORETIC INFORMED FAULT TREES

F.1. Automatic Depressurization SIFTs

Table A.3 contains the list of UCAs that were added to the ADS, all UCAs were set to 1.0. A comprehensive list of UCA dispositions and control actions is in Appendix D.

Table A.3. Modeled ADS UCAs

UCA	New Gate	Basic Event
UCA31-101A1	ADS_UCAS100	SRV-A1_UCA31-101A1
UCA31-102A1	ADS_UCAS110S	SRV-A2_UCA31-102A1
UCA31-103A1	ADS_UCAS120	SRV-A3_UCA31-103A1
UCA31-104A1	ADS_UCAS130	SRV-A4_UCA31-104A1
UCA31-105A1	ADS_UCAS140	SRV-A5_UCA31-105A1
UCA31-106A1	ADS_UCAS150	SRV-A6_UCA31-106A1
UCA31-107A1	ADS_UCAS160	SRV-A7_UCA31-107A1
UCA31-108A1	ADS_UCAS170	SRV-A8_UCA31-108A1
UCA31-109A1	ADS_UCAS180	SRV-A9_UCA31-109A1
UCA31-110A1	ADS_UCAS190	SRV-A10_UCA31-110A1
UCA31-111A1	ADS_UCAS1100	SRV-A11_UCA31-111A1
UCA32-101A1	ADS_UCAS100	SRV-B1_UCA32-101A1
UCA32-102A1	ADS_UCAS110S	SRV-B2_UCA32-102A1
UCA32-103A1	ADS_UCAS120	SRV-B3_UCA32-103A1
UCA32-104A1	ADS_UCAS130	SRV-B4_UCA32-104A1
UCA32-105A1	ADS_UCAS140	SRV-B5_UCA32-105A1
UCA32-106A1	ADS_UCAS150	SRV-B6_UCA32-106A1
UCA32-107A1	ADS_UCAS160	SRV-B7_UCA32-107A1
UCA32-108A1	ADS_UCAS170	SRV-B8_UCA32-108A1
UCA32-109A1	ADS_UCAS180	SRV-B9_UCA32-109A1
UCA32-110A1	ADS_UCAS190	SRV-B10_UCA32-110A1
UCA32-111A1	ADS_UCAS1100	SRV-B11_UCA32-111A1

Figure A.19 shows the additions of the ADS UCAs into the fault tree. The SRV basic events were moved under the UCA gate. Figure A.20 shows the structure of the ADSS_UCAS gate and Figure A.21 shows the individual UCA basic events.

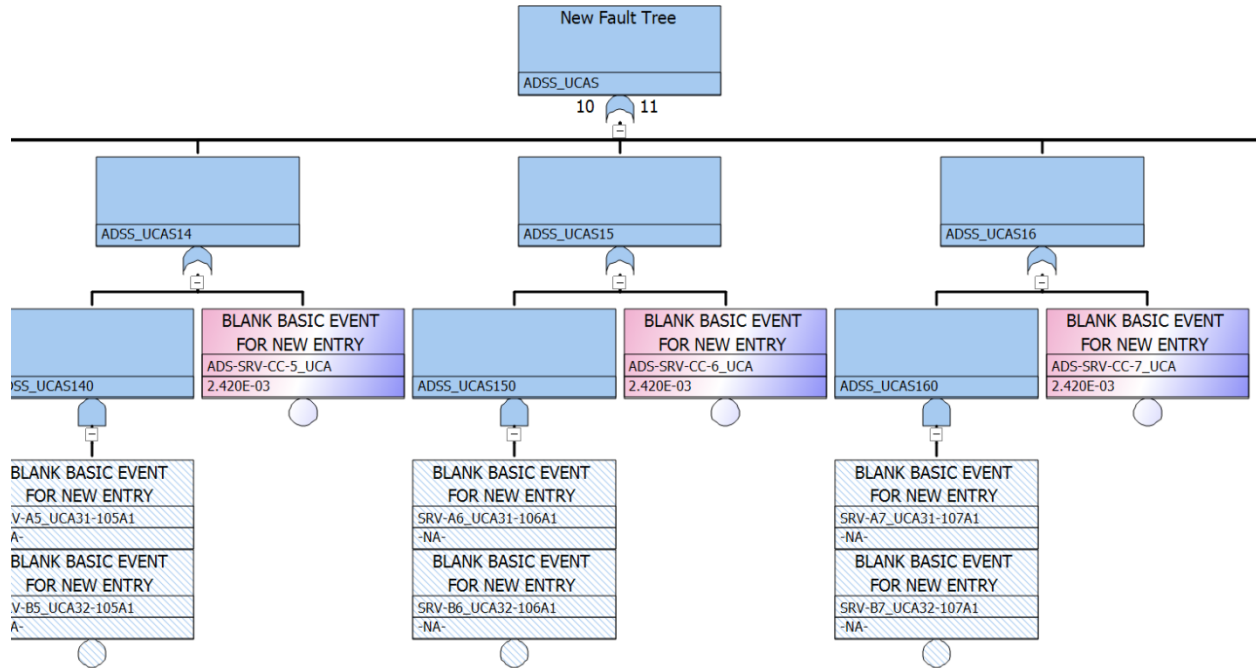


Figure A.19. ADS UCAs

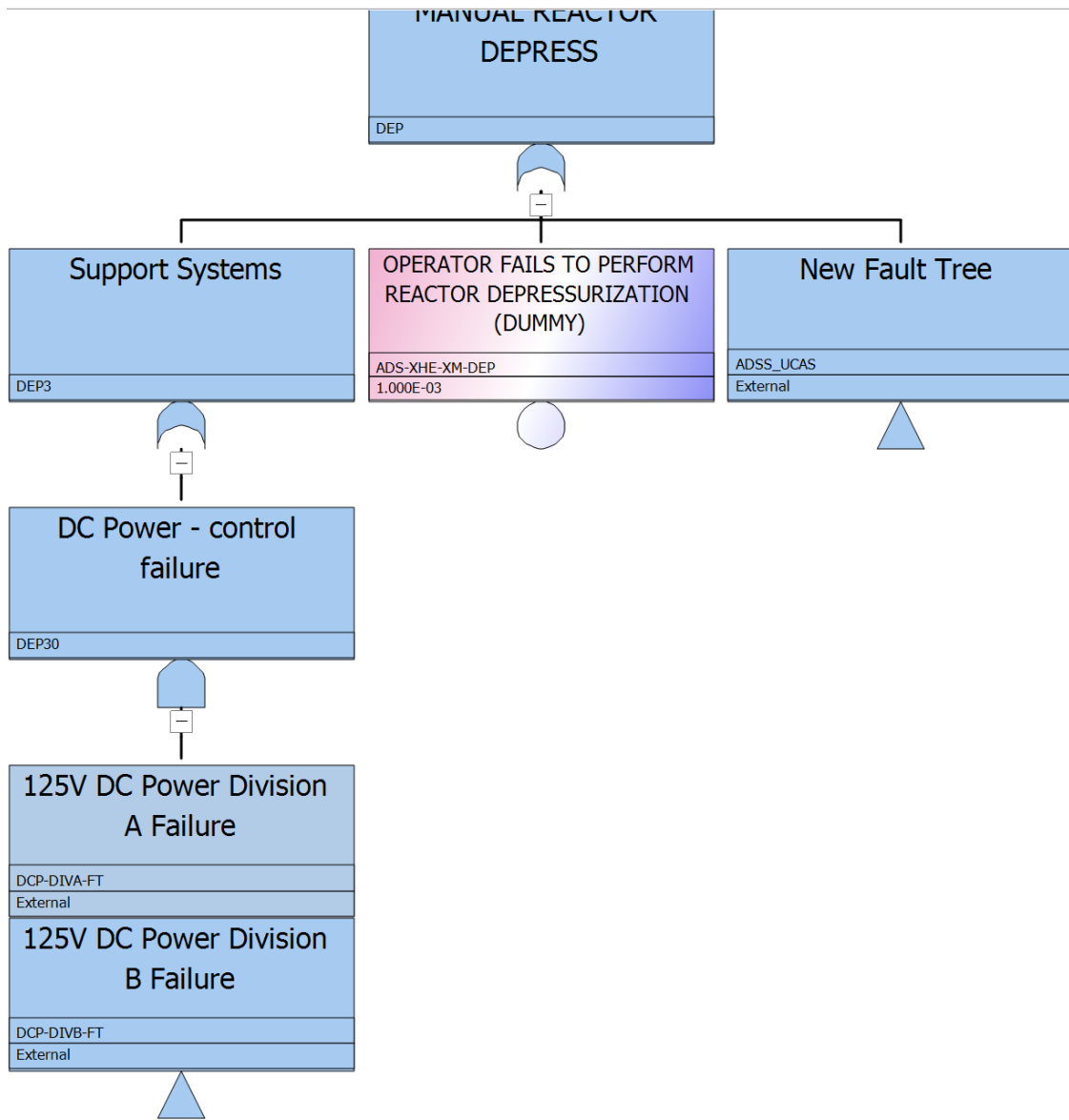


Figure A.20. ADS Restructured Gate

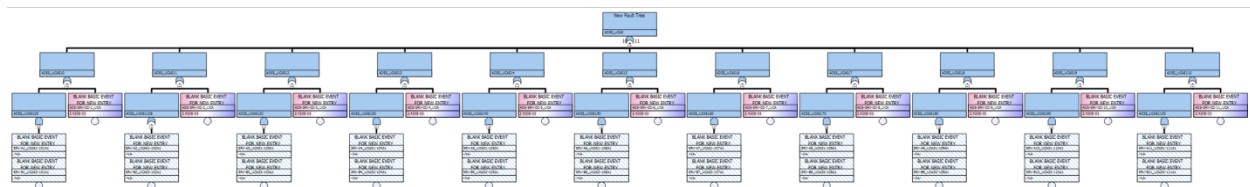


Figure A.21. ADS UCAs Expanded

F.2. High Pressure Injection SIFTs

Table A.4 contains the list of UCAs that were added to the ADS fault tree, all UCAs were set to 1.0. A comprehensive list of UCA dispositions and control actions is in Appendix D.

Table A.4. Modeled HPCI UCAs

UCA	New Gate	Basic Event
UCA11-102B	HPCIS235_MOV41_UCA	HPCI-MOV-OC-41_UCA11-102B
UCA11-102C2	HPCIS235_MOV41_UCA	HPCI-MOV-OC-41_UCA11-102C2
UCA11-102D	HPCIS235_MOV41_UCA	HPCI-MOV-OC-41_UCA11-102D
UCA11-103A1	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-103A1
UCA11-103A2	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-103A2
UCA11-103C2	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-103C2
UCA11-103C3	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-103C3
UCA11-104B	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-104B
UCA11-104C2	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-104C2
UCA11-104D	HPCIS235_MOV42_UCA	HPCI-MOV-CC-42_UCA11-104D
UCA11-301A	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301A
UCA11-301B	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301B
UCA11-301C1	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301C1
UCA11-301C2	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301C2
UCA11-301D1	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301D1
UCA11-301D2	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-301D2
UCA11-302A	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-302A
UCA11-302C1	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-302C1
UCA11-302C2	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-302C2
UCA11-302D1	HPCIS235_HOV52_UCA	HPCI-HOV-CC-52_UCA11-302D1
UCA13-101A	HPCIS0_MOV35_UCA	HPCI-MOV-CC-35_UCA13-101A
UCA13-101C2	HPCIS0_MOV35_UCA	HPCI-MOV-CC-35_UCA13-101C2
UCA13-103A	HPCIS11_MOV32_UCA	HPCI-MOV-CC-32_UCA13-103A
UCA13-103C2	HPCIS11_MOV32_UCA	HPCI-MOV-CC-32_UCA13-103C2

Figure A.22 and Figure A.23 show the additions of the HPCI UCAs into the fault tree.

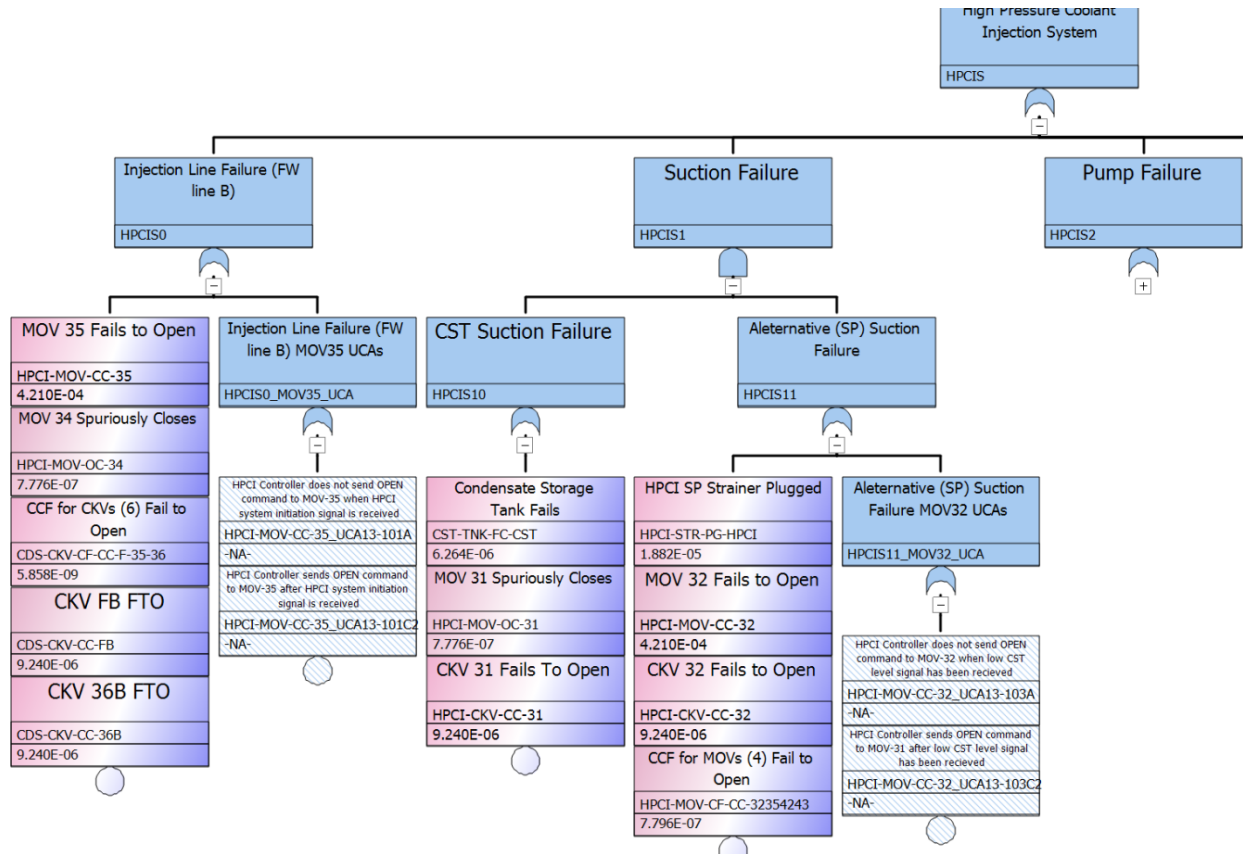


Figure A.22. HPCIS0 and HPCIS1 HPCI UCAs

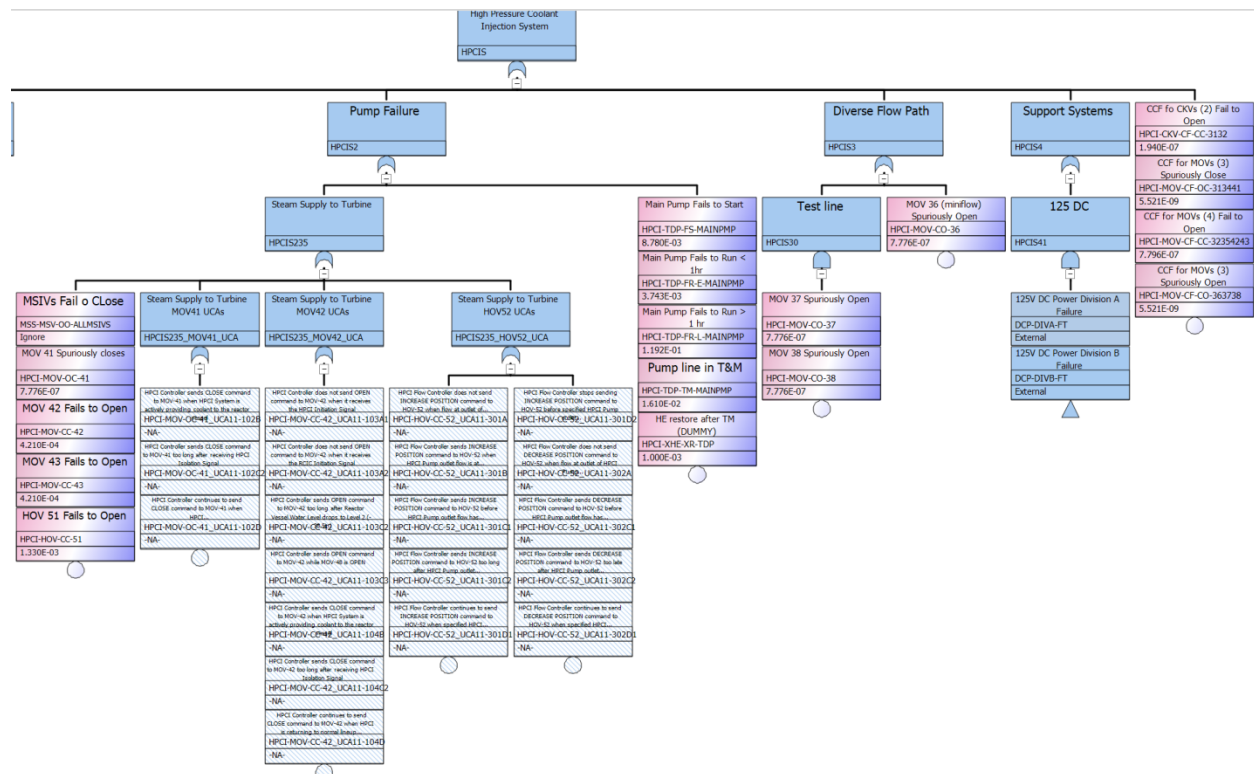


Figure A.23. HPCI5235 HPCI UCAs

F.3. Residual Heat Removal SIFTs

Only the LPCI mode of RHR was in the scope of this analysis. UCAs were only added for this mode of operation of RHR. Table A.5 contains the list of UCAs that were added to the RHR, all UCAs were set to 1.0. A comprehensive list of UCA dispositions and control actions is in Appendix D.

Table A.5. Modeled RHR UCAs

UCA	New Gate	Basic Event
UCA21-401A	RHR-MDP-A_RHRA_FS_UCA	RHR-MDP-FS-A_UCA21-401A
UCA21-401B2	RHR-MDP-A_RHRA_FS_UCA	RHR-MDP-FS-A_UCA21-401B2
UCA21-401C1	RHR-MDP-A_RHRA_FS_UCA	RHR-MDP-FS-A_UCA21-401C1
UCA21-401C4	RHR-MDP-A_RHRA_FS_UCA	RHR-MDP-FS-A_UCA21-401C4
UCA21-402B	RHR-MDP-A_RHRA_FR_UCA	RHR-MDP-FR-A_UCA21-402B
UCA21-402C1	RHR-MDP-A_RHRA_FR_UCA	RHR-MDP-FR-A_UCA21-402C1
UCA21-402C3	RHR-MDP-A_RHRA_FR_UCA	RHR-MDP-FR-A_UCA21-402C3
UCA21-403A	RHR-MDP-A_NSIG_UCA	RHR-MDP-A_NSIG_UCA21-403A
UCA21-403C2	RHR-MDP-A_LSIG_UCA	RHR-MDP-A_LSIG_UCA21-403C2
UCA21-404A	RHR-MDP-C_RHRC_FS_UCA	RHR-MDP-FS-C_UCA21-404A

UCA	New Gate	Basic Event
UCA21-404B2	RHR-MDP-C_RHRC_FS_UCA	RHR-MDP-FS-C_UCA21-404B2
UCA21-404C1	RHR-MDP-C_RHRC_FS_UCA	RHR-MDP-FS-C_UCA21-404C1
UCA21-404C4	RHR-MDP-C_RHRC_FS_UCA	RHR-MDP-FS-C_UCA21-404C4
UCA21-405B	RHR-MDP-C_RHRA_FR_UCA	RHR-MDP-FR-C_UCA21-405B
UCA21-405C1	RHR-MDP-C_RHRA_FR_UCA	RHR-MDP-FR-C_UCA21-405C1
UCA21-405C3	RHR-MDP-C_RHRA_FR_UCA	RHR-MDP-FR-C_UCA21-405C3
UCA21-406A	RHR-MDP-C_NSIG_UCA	RHR-MDP-C_NSIG_UCA21-406A
UCA21-406C2	RHR-MDP-C_LSIG_UCA	RHR-MDP-C_LSIG_UCA21-406C2
UCA21-410B	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-410B
UCA21-410C1	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-410C1
UCA21-410C3	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-410C3
UCA21-411A	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-411A
UCA21-411C1	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-411C1
UCA21-411C2	LPIMSUCTIONA_MOV31A_UCA	RHR-MOV-OC-31A_UCA21-411C2
UCA21-413B	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-413B
UCA21-413C1	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-413C1
UCA21-413C3	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-413C3
UCA21-414A	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-414A
UCA21-414C1	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-414C1
UCA21-414C2	LPIMSUCTIONC_MOV31C_UCA	RHR-MOV-OC-31C_UCA21-414C2
UCA21-418B	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-418B
UCA21-418C1	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-418C1
UCA21-418C2	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-418C2
UCA21-420A	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-420A
UCA21-420C1	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-420C1
UCA21-420C2	LPI-A113_UCA	RHR-MOV-CO-40A_UCA21-420C2
UCA21-421B	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-421B
UCA21-421C1	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-421C1
UCA21-421C2	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-421C2

UCA	New Gate	Basic Event
UCA21-423A	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-423A
UCA21-423C1	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-423C1
UCA21-423C2	LPI-A1132_41A_UCA	RHR-MOV-CO-41A_UCA21-423C2
UCA21-424A	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-424A
UCA21-424B	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-424B
UCA21-424C1	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-424C1
UCA21-424C2	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-424C2
UCA21-425B	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-425B
UCA21-425C1	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-425C1
UCA21-425C2	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-425C2
UCA21-426A	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-426A
UCA21-426C1	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-426C1
UCA21-426C2	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-426C2
UCA21-442A	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-442A
UCA21-442C1	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-442C1
UCA21-442C2	MOV-37A_UCA	RHR-MOV-CC-37A_UCA21-442C2
UCA22-401A	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-401A
UCA22-401B2	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-401B2
UCA22-401C1	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-401BC1
UCA22-401C4	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-401BC4
UCA22-402B	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-402B
UCA22-402C1	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-402C1
UCA22-402C3	RHR-MDP-B_RHRB_FS_UCA	RHR-MDP-FS-B_UCA22-402C3
UCA22-403A	RHR-MDP-B_NSIG_UCA	RHR-MDP-B_NSIG_UCA22-403A
UCA22-403C2	RHR-MDP-B_LSIG_UCA	RHR-MDP-B_LSIG_UCA22-403C2
UCA22-404A	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-404A
UCA22-404B2	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-404B2
UCA22-404C1	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-404C1
UCA22-404C4	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-404C4

UCA	New Gate	Basic Event
UCA22-405B	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-405B
UCA22-405C1	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-405C1
UCA22-405C3	RHR-MDP-D_RHRD_FS_UCA	RHR-MDP-FS-D_UCA22-405C3
UCA22-406A	RHR-MDP-D_NSIG_UCA	RHR-MDP-D_NSIG_UCA22-406A
UCA22-406C2	RHR-MDP-D_LSIG_UCA	RHR-MDP-D_LSIG_UCA22-406C2
UCA22-410B	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-410B
UCA22-410C1	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-410C1
UCA22-410C3	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-410C3
UCA22-411A	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-411A
UCA22-411C1	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-411C1
UCA22-411C2	LPIMSUCTIONB_MOV31B_UCA	RHR-MOV-OC-31B_UCA22-411C2
UCA22-413B	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-413B
UCA22-413C1	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-413C1
UCA22-413C3	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-413C3
UCA22-414A	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-414A
UCA22-414C1	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-414C1
UCA22-414C2	LPIMSUCTIOND_MOV31D_UCA	RHR-MOV-OC-31D_UCA22-414C2
UCA22-418B	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-418B
UCA22-418C1	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-418C1
UCA22-418C2	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-418C2
UCA22-420A	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-420A
UCA22-420C1	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-420C1
UCA22-420C2	LPI-B105_UCA	RHR-MOV-CO-40B_UCA22-420C2
UCA22-421B	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-421B
UCA22-421C1	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-421C1
UCA22-421C2	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-421C2
UCA22-423A	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-423A
UCA22-423C1	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-423C1
UCA22-423C2	LPI-B1052_41B_UCA	RHR-MOV-CO-41B_UCA22-423C2

UCA	New Gate	Basic Event
UCA22-424A	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-424A
UCA22-424B	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-424B
UCA22-424C1	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-424C1
UCA22-424C2	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-424C2
UCA22-425B	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-425B
UCA22-425C1	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-425C1
UCA22-425C2	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-425C2
UCA22-426A	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-426A
UCA22-426C1	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-426C1
UCA22-426C2	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-426C2
UCA22-445A	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-445A
UCA22-445C1	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-445C1
UCA22-445C2	MOV-37B_UCA	RHR-MOV-CC-37B_UCA22-445C2
UCA21-448A	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-448A
UCA21-448B	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-448B
UCA21-448C1	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-448C1
UCA21-448C2	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-448C2
UCA21-449B	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-449B
UCA21-449C1	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-449C1
UCA21-449C2	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-449C2
UCA21-450A	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-450A
UCA21-450C1	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-450C1
UCA21-450C2	LPI12541041_UCA	RHR-MOV-CC-32A_UCA21-450C2
UCA21-451A	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-451A
UCA21-451B	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-451B
UCA21-451C1	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-451C1
UCA21-451C2	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-451C2
UCA21-452B	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-452B
UCA21-452C1	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-452C1

UCA	New Gate	Basic Event
UCA21-452C2	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-452C2
UCA21-453A	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-453A
UCA21-453C1	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-453C1
UCA21-453C2	LPI1254104110_UCA	RHR-MOV-CC-32C_UCA21-453C2
UCA22-448A	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-448A
UCA22-448B	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-448B
UCA22-448C1	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-448C1
UCA22-448C2	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-448C2
UCA22-449B	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-449B
UCA22-449C1	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-449C1
UCA22-449C2	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-449C2
UCA22-450A	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-450A
UCA22-450C1	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-450C1
UCA22-450C2	LPI1254104111_UCA	RHR-MOV-CC-32B_UCA22-450C2
UCA22-451A	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-451A
UCA22-451B	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-451B
UCA22-451C1	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-451C1
UCA22-451C2	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-451C2
UCA22-452B	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-452B
UCA22-452C1	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-452C1
UCA22-452C2	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-452C2
UCA22-453A	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-453A
UCA22-453C1	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-453C1
UCA22-453C2	LPI1254104112_UCA	RHR-MOV-CC-32D_UCA22-453C2
UCA21-455B	LPI-A1022_UCA	RHR-MOV-OC-33A_UCA21-455B
UCA21-455C1	LPI-A1022_UCA	RHR-MOV-OC-33A_UCA21-455C1
UCA21-455C2	LPI-A1022_UCA	RHR-MOV-OC-33A_UCA21-455C2
UCA22-455B	LPI-B1132_UCA	RHR-MOV-OC-33B_UCA22-455B
UCA22-455C1	LPI-B1132_UCA	RHR-MOV-OC-33B_UCA22-455C1

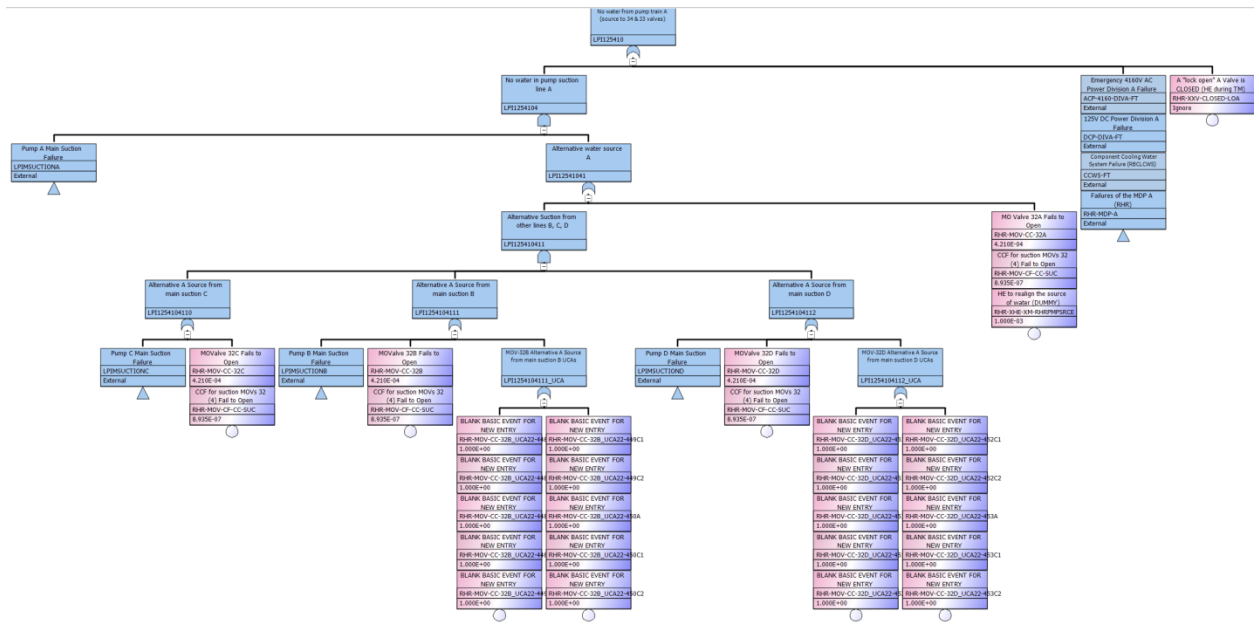


Figure A.25. RHR Alternate Injection UCAs

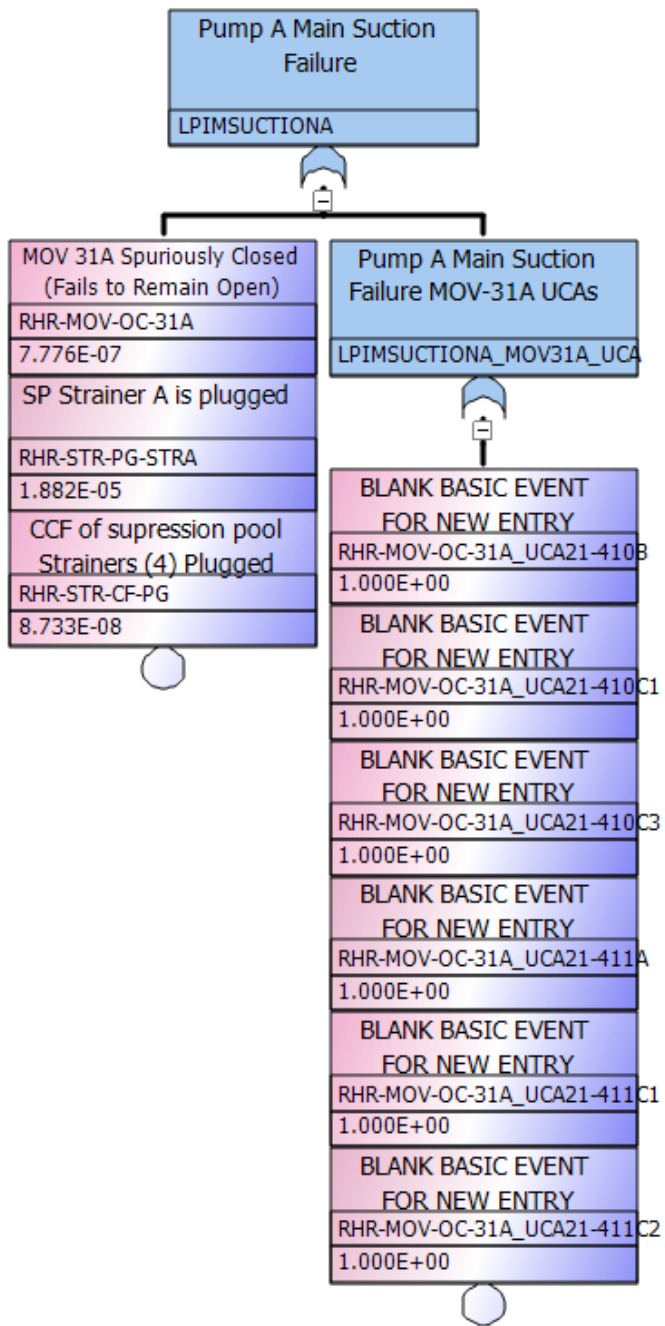


Figure A.26. RHR Suction UCAs

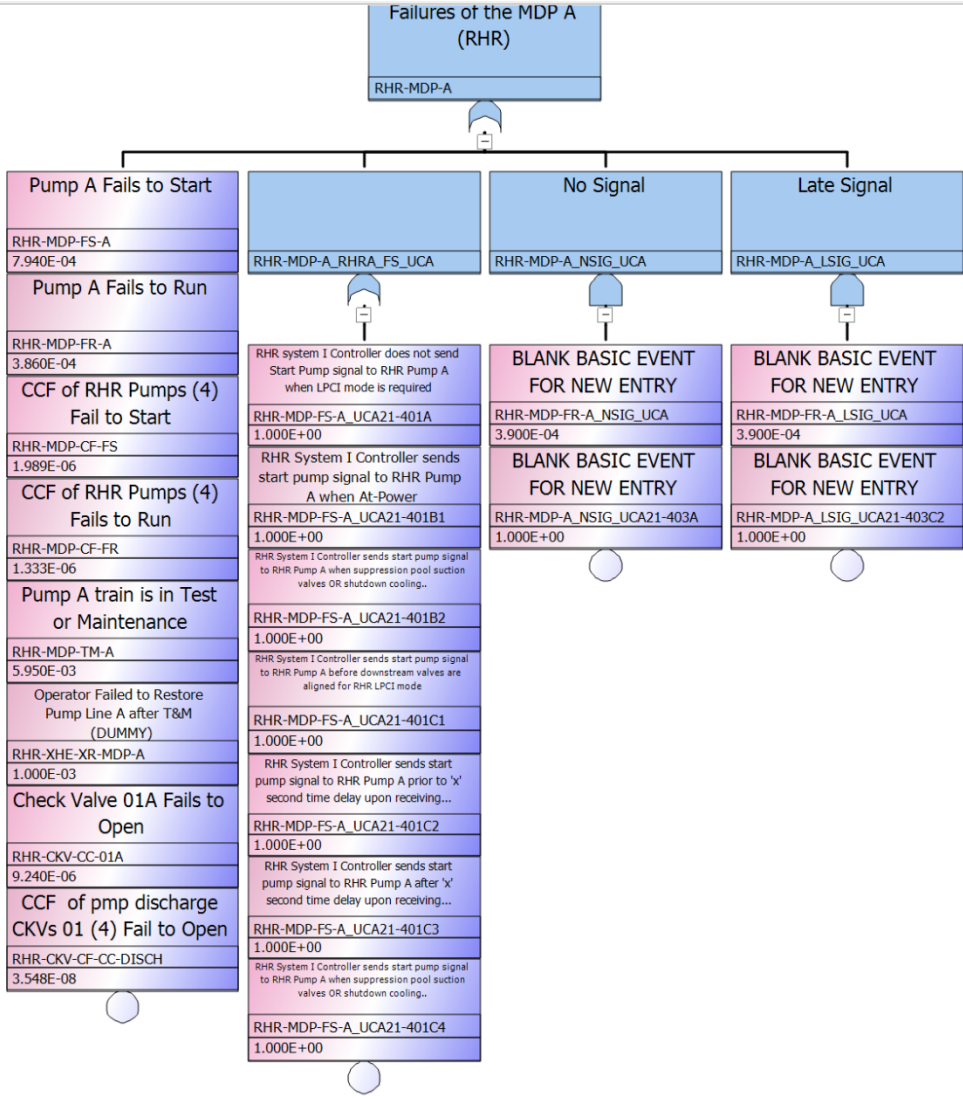


Figure A.27. RHR Pump UCAs

F.4. SIFTs not Modeled

Appendix D includes the complete list of UCAs that were analyzed and provides a disposition on if the UCA was added or omitted from the model. Unmodeled UCAs are listed in Appendix E.

Table A.6. UCA Dispositions

Modeled	Description
Done	Added to Model
N/A	UCA not developed
No - Assessing electrical bus failures is deferred to STPA analysis on those electrical systems	Outside the bounds of the analysis
No - Cleanup Wording	Fix this
No - Component Not Modeled	Component not modeled in the PRA
No - Loss scenario	Does not lead to core damage
No - No Impact	Does not lead to core damage
No - Operator Action	Operator Actions are outside the bounds of the analysis
No - Operator Feedback	Operator Feedback is outside the bounds of the analysis
No - Upon initiation all trains are activated, RHR-LPCI is independent of controller communication	Controller communication does not impact system success in this scenario
Removed - UCA aligns with normal operating state	UCA does not impact core damage

F.5. SIFT Quantification Results

The results reported by Sapphire do not match the sum of the cutset contributions, the sum of the cutset contributions are reported in the tables below. The comparisons done are done on a cutset basis.

F.5.1. SLOCA Results

Table A.7. SLOCA SIFT Results

Case	Event Tree	ESF	Number of Cutsets
ADS	SLOCA	2.007E-07	3269
HPCI	SLOCA	1.798E-08	443
RHR	SLOCA	Computational Issue	N/A
RHR-A	SLOCA	3.527E-06	54,503
RHR-B	SLOCA	7.721E-06	58,943

F.5.2. TRANS Results

The broken fault trees did not impact the results for any TRANS cases, the surrogate basic events were not contained in any of the cutsets. No surrogate basic event is contained in any of the associated files.

Table A.8. TRANS SIFT Results

Case	Event Tree	ESF	Number of Cutsets
ADS	TRANS	4.376E-04	137,255
HPCI	TRANS	3.013E-05	8093
RHR	TRANS	Computational Issue	N/A
RHR-A	TRANS	8.889E-05	1,280,458
RHR-B	TRANS	1.599E-04	1,305,898

APPENDIX G. BASIC EVENTS

This appendix contains the surrogate basic events used to complete the fault trees in the generic BWR-4 reactor SPAR model provided by the U.S. NRC.

Table A.9. Surrogate Basic Events.

Broken Fault Tree	New Basic Event
HCI2	HCI2_DUMMY
IASR	IASR_DUMMY
IEFT-LOIAS	IEFT-LOIAS_DUMMY
LI10	LI10_DUMMY
LI11	LI11_DUMMY
LI12	LI12_DUMMY
LVL	LVL_DUMMY
MSV	MSV_DUMMY
NX	NX_DUMMY
OEP	OEP_DUMMY
PCS1	PCS1_DUMMY
PPR	PPR_DUMMY
SLC	SLC_DUMMY
TAF	TAF_DUMMY
VA1	VA1_DUMMY

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