

# ASP Screening Analysis - REJECT

Accident Sequence Precursor Program – Office of Nuclear Regulatory Research

<b>Browns Ferry Nuclear Plant, Unit 3</b>	High Pressure Coolant Injection and Reactor Core Isolation Cooling Inoperable Due to No Suction Source Aligned		
<b>Event Date:</b> 02/11/2015	<b>LER:</b> 296-2015-001	<b>IR:</b> 50-296/15-02	
<b>Plant Type:</b> Boiling Water Reactor (BWR); General Electric Type 4 with Wet, Mark I Containment			
<b>Plant Operating Mode (Reactor Power Level):</b> Mode 1 (100% Reactor Power)			
<b>Analyst:</b> Candace Pfefferkorn	<b>Reviewer:</b> Keith Tetter	<b>Contributors:</b> David Aird/Chris Hunter	<b>BC Approved Date:</b> 05/11/16

**Event Description.** On February 11, 2015, at 08:20 am, the High Pressure Coolant Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems at Browns Ferry Nuclear Plant (BFN) Unit 3 were declared inoperable after operations personnel performing a HPCI system valve position verification monthly surveillance test closed supply breaker 3-BKR-2-166 to flow control isolation valve 3-FCV-2-166 causing the valve to inadvertently close and isolate the normal condensate storage tank (CST) suction source for HPCI and RCIC. At 08:24 am operations personnel opened valve 3-FCV-2-166 remotely using a hand switch in the BFN Unit 1 control room restoring the normal CST suction source. With valve 3-FCV-2-166 open, an operator in the field manually opened breaker 3-BKR-2-166 to prevent the possibility of further valve movement.

The direct cause of the inadvertent valve closure was found to be faulty stuck contacts on a control room hand switch. The apparent cause of the event was found to be an inadequate design change review that introduced a latent design vulnerability to the plant. Specifically, the design change altered the configuration of breaker 3-BKR-2-166 from normally closed to normally open to address fire concerns. The design change review assumed that the breaker would remain open at all times eliminating the requirement for additional protective measures against spurious valve closure. However, a requirement for operations personnel to close breaker 3-BKR-2-166 in order to verify valve 3-FCV-2-166 position was nonetheless included in an update to surveillance procedure 3-SR-3.5.1.2 (HPIC), titled "High Pressure Coolant Injection System Monthly Valve Position Verification" when the design change was implemented in 2010.

**SDP Result.** In Inspection Report 50-296/15-02 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15223A508), the inspectors documented their review of License Event Report (LER) 296-2015-001 (ADAMS Accession No. ML15114A289). The inspectors determined that the LER adequately documented the summary of the event including the cause of the event and the potential safety consequences. The inspectors noted that the licensee made design changes to prevent spurious operation of the CST discharge valves when pertinent breakers are closed for testing. No findings were identified and the inspectors closed the LER.

**Analysis Type.** The BFN Unit 3 Standardized Plant Analysis Risk (SPAR) model, Revision 8.18, created May 20, 2014, was used for this event analysis. The event was modeled as a condition assessment.

**Analysis Rules.** The ASP program uses Significance Determination Process (SDP) results for degraded conditions when available. However, the ASP Program performs independent analyses for events involving reactor trips. In addition, any system, structure, or component that was determined to be degraded, failed, or unavailable due to test/maintenance during the event is factored into the ASP analysis (regardless of whether the failures or degradations are due to licensee performance deficiency).

**Key Modeling Assumptions.** The following modeling assumptions were determined to be vital to this event analysis:

- In this event, the loss of CST suction to HPIC and RCIC lasted for only four minutes; however, the smallest time unit option in the Events and Conditions Assessment (ECA) workspace within the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) is one hour. Therefore, the event duration for this analysis was set to one hour and thus values generated for the change in core damage probability ( $\Delta CDP$ ) reflect a conservative estimate of the actual  $\Delta CDP$ .
- Default SAPHIRE ECA solution settings were used (e.g. cut set truncation,  $1.00 \times 10^{-11}$ ; size truncation, none; solve method, multiple pass; etc.)

**SPAR Model Modifications.** Fault tree modifications and basic event additions were made within the BFN Unit 3 SPAR model as described below:

- A new house event, titled CST-FCV-166 (*Isolation Flow Control Valve 3-FCV-2-166 Fails Closed*) was created to model the operational state of valve 3-FCV-2-166. The normal state of this valve is open and therefore CST-FCV-166 was set to FALSE.
- In the HCI (*HPCI*) fault tree, the HCI02 (*CST-LOCHS FLAG*) “OR” logic gate and its associated basic house event, titled HE-LOCHS (*House Event – Total Loss of Condenser Heat Sink Initiator*) were deleted because the CST remains available during a loss of condenser heat sink event.
- The HCI fault tree was modified to include the basic house event CST-FCV-166 under a newly added “OR” gate, titled HCI03 (*CST Suction Fails*). The basic event CDS-TNK-HW-CST (*Condensate Storage Tank Fails*), originally located under the HCI02 “OR” logic gate, is now located under HCI03. HCI was modified as described since failure of the CST or closure of valve 3-FCV-2-166 would result in a loss of CST suction to HPCI.
- The RCI (RCIC) fault tree was modified to include the basic house event CST-FCV-166 under a newly added “OR” gate, titled RCI12 (*CST Suction Fails*). The basic event CDS-TNK-HW-CST is now located under RCI12. RCI was modified as described since failure of the CST or closure of valve 3-FCV-2-166 would result in a loss of CST suction to RCIC.
- The HPCI fault tree related to specific station black out (SBO) scenarios, titled HCI01 (*Browns Ferry 3 HPCI System Fault Tree*) was modified to include the basic house event CST-FCV-166 under a newly added OR gate, HCI0122 (*CST Suction Fails*). The basic event CDS-TNK-HW-CST is now located under HCI0122. HCI01 was modified as described since failure of the CST or closure of valve 3-FCV-2-166 would result in a loss of CST suction to HPCI.

- The RCIC fault tree related to specific SBO scenarios, titled RCI01 (*RCIC*), was modified to include the basic house event CST-FCV-166 under a newly added “OR” gate, RCI0132 (*CST Suction Fails*). The basic event CDS-TNK-HW-CST is now located under RCI0132. RCI01 was modified as described since failure of the CST or closure of valve 3-FCV-2-166 would result in a loss of CST suction to RCIC.
- The “OR” gate associated with RCI01-1 (*RCIC Water Supplies Are Unavailable*) in the RCI01 fault tree was changed to an “AND” gate to reflect RCIC water supply availability given either CST or Torus suction.

**Basic Event Probability Changes.** At the time of the event BFN Unit 3 was at full power and no components were reported as being out of service for test and maintenance. However, valve 3-FCV-2-166 was closed in the February 11, 2015, event, and thus the basic event titled CST-FCV-166 was set to TRUE for this event analysis.

**Rejection Basis.** The  $\Delta CDP$  for this analysis is  $8.7 \times 10^{-12}$  which is below the ASP Program  $\Delta CDP$  threshold of  $1 \times 10^{-6}$ . Therefore, this event is not a precursor and is screened out of the ASP Program.

## Appendix A: SAPHIRE 8 Worksheet

### Summary of Conditional Event Changes

Event	Description	Cond Value	Nominal Value
CST-FCV-166	Isolation Flow Control Valve 3-FCV-2-166 Fails Closed	True	False

### Event Tree Dominant Results

Only items contributing at least 1.0% to the total CCDP are displayed.

<u>EVENT TREE</u>	<u>CCDP</u>	<u>CDP</u>	<u>Δ CDP</u>	<u>DESCRIPTION</u>
LOCHS	6.88E-11	6.48E-11	3.96E-12	BROWNS FERRY 3 - LOSS OF CONDENSER HEAT SINK
IORV	6.19E-11	5.92E-11	2.75E-12	BROWNS FERRY 3 - INADVERTENT OPEN RELIEF VALVE
MLOCA	2.04E-11	1.98E-11	6.34E-13	BROWNS FERRY 3 - MEDIUM LOSS-OF-COOLANT ACCIDENT
LOOPGR	6.29E-11	6.23E-11	5.24E-13	BROWNS FERRY 3 - LOSS OF OFFSITE POWER - GRID RELATED
LOOPSC	4.36E-11	4.33E-11	3.61E-13	BROWNS FERRY 3 - LOSS OF OFFSITE POWER - SWITCHYARD CENTERED
LOPCA	8.53E-12	8.33E-12	2.04E-13	BROWNS FERRY 3 - LOSS OF PLANT CONTROL AIR
LOOPWR	4.51E-11	4.50E-11	1.42E-13	BROWNS FERRY 3 - LOSS OF OFFSITE POWER - WEATHER RELATED
SLBOC	1.81E-11	1.80E-11	9.47E-14	BROWNS FERRY 3 - STEAM LINE BREAK OUTSIDE CONTAINMENT
<b>Total</b>	<b>3.68E-10</b>	<b>3.59E-10</b>	<b>8.72E-12</b>	

### Dominant Sequence Results

Only items contributing at least 1.0% to the total CCDP are displayed.

<u>EVENT TREE</u>	<u>SEQUENCE</u>	<u>CCDP</u>	<u>CDP</u>	<u>Δ CDP</u>	<u>DESCRIPTION</u>
LOCHS	59	5.58E-11	5.18E-11	3.96E-12	/RPS, /SRV, HPI, DEP, CR2
IORV	46	6.06E-11	5.78E-11	2.75E-12	/RPS, PCS, HPI, DEP
MLOCA	51	1.38E-11	1.32E-11	6.16E-13	/RPS, /VSS, HCI, DEP
LOOPGR	25	4.86E-12	4.54E-12	3.24E-13	/RPS, /EPS, /SRV, HPI, DEP
LOOPSC	25	4.14E-12	3.87E-12	2.74E-13	/RPS, /EPS, /SRV, HPI, DEP
LOPCA	54	2.98E-12	2.78E-12	1.95E-13	/RPS, /SRV, HPI, DEP, CR2
LOOPGR	24	2.02E-12	1.86E-12	1.61E-13	/RPS, /EPS, /SRV, HPI, /DEP, LPI, VA
LOOPWR	25	1.55E-12	1.45E-12	9.93E-14	/RPS, /EPS, /SRV, HPI, DEP
SLBOC	59	1.47E-12	1.38E-12	9.47E-14	/RPS, /MSIV, HPI, DEP, CR2
<b>Total</b>		<b>3.68E-10</b>	<b>3.59E-10</b>	<b>8.72E-12</b>	

**Referenced Fault Trees**

<b>Fault Tree</b>	<b>Description</b>
CR2	BROWNS FERRY 3 CRD SYSTEM FAULT TREE
DEP	MANUAL REACTOR DEPRESS
HCI	HPCI
HPI	HIGH PRESSURE INJECTION (RCIC or HPCI)
LPI	LOW PRESSURE INJECTION (CS or LPCI)
PCS	POWER CONVERSION SYSTEM
VA	ALTERNATE LOW PRESS INJECTION

**Cut Set Report - LOCHS 59**

Only items contributing at least 1% to the total are displayed.

<b>#</b>	<b>PROB/FREQ</b>	<b>TOTAL%</b>	<b>CUT SET</b>
	4.89E-7	100	Displaying 146 Cut Sets. (146 Original)
1	1.09E-7	22.38	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	5.24E-8	10.72	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	4.96E-8	10.16	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	3.12E-8	6.39	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	3.02E-8	6.18	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	2.38E-8	4.87	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	1.79E-8	3.66	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
8	1.79E-8	3.66	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
9	1.50E-8	3.06	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	1.37E-8	2.80	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	8.57E-9	1.75	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	8.27E-9	1.69	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	8.12E-9	1.66	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	5.49E-9	1.12	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	5.11E-9	1.05	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	4.94E-9	1.01	IE-LOCHS,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN

**Cut Set Report - IORV 46**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	5.31E-7	100	Displaying 18 Cut Sets. (18 Original)
1	3.23E-7	60.92	IE-IORV,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN
2	9.23E-8	17.40	IE-IORV,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN
3	5.29E-8	9.97	IE-IORV,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN
4	1.39E-8	2.61	IE-IORV,ADS-XHE-XM-MDEPR,HCI-XHE-XE-MISCAL
5	8.15E-9	1.54	IE-IORV,ADS-XHE-XM-MDEPR,HCI-XHE-XO-ERROR
6	7.85E-9	1.48	IE-IORV,ADS-XHE-XM-MDEPR,HCI-MOV-CC-F027
7	7.85E-9	1.48	IE-IORV,ADS-XHE-XM-MDEPR,HCI-MOV-OO-F040
8	7.85E-9	1.48	IE-IORV,ADS-XHE-XM-MDEPR,HCI-MOV-CC-F026
9	7.85E-9	1.48	IE-IORV,ADS-XHE-XM-MDEPR,HCI-MOV-CC-F016
10	7.85E-9	1.48	IE-IORV,ADS-XHE-XM-MDEPR,HCI-MOV-CC-F044

**Cut Set Report - MLOCA 51**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	1.21E-7	100	Displaying 10 Cut Sets. (10 Original)
1	7.38E-8	61.04	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-TDP-FR-TRAIN
2	2.11E-8	17.44	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-TDP-TM-TRAIN
3	1.21E-8	9.99	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-TDP-FS-TRAIN
4	3.16E-9	2.62	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-XHE-XE-MISCAL
5	1.86E-9	1.54	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-XHE-XO-ERROR
6	1.79E-9	1.48	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-MOV-CC-F027
7	1.79E-9	1.48	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-MOV-OO-F040
8	1.79E-9	1.48	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-MOV-CC-F026
9	1.79E-9	1.48	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-MOV-CC-F016
10	1.79E-9	1.48	IE-MLOCA,ADS-XHE-XM-MLOCA,HCI-MOV-CC-F044

**Cut Set Report - LOOPGR 25**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	4.26E-8	100	Displaying 88 Cut Sets. (88 Original)
1	9.59E-9	22.52	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	4.60E-9	10.79	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	4.35E-9	10.22	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	2.74E-9	6.43	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	2.65E-9	6.22	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	2.09E-9	4.90	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	1.57E-9	3.69	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
8	1.57E-9	3.69	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
9	1.31E-9	3.08	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	1.20E-9	2.82	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	7.53E-10	1.77	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	7.26E-10	1.70	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	7.13E-10	1.67	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	4.82E-10	1.13	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	4.49E-10	1.05	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	4.34E-10	1.02	IE-LOOPGR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN

**Cut Set Report - LOOPSC 25**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	3.63E-8	100	Displaying 83 Cut Sets. (83 Original)
1	8.18E-9	22.55	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	3.92E-9	10.80	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	3.71E-9	10.24	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	2.34E-9	6.44	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	2.26E-9	6.23	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	1.78E-9	4.90	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	1.34E-9	3.69	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
8	1.34E-9	3.69	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
9	1.12E-9	3.09	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	1.02E-9	2.83	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	6.42E-10	1.77	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	6.19E-10	1.71	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	6.08E-10	1.68	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	4.11E-10	1.13	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	3.83E-10	1.05	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	3.70E-10	1.02	IE-LOOPSC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN



**Cut Set Report - LOPCA 54**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	2.61E-8	100	Displaying 80 Cut Sets. (80 Original)
1	5.89E-9	22.57	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	2.82E-9	10.81	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	2.67E-9	10.24	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	1.68E-9	6.45	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	1.63E-9	6.23	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	1.28E-9	4.91	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	9.64E-10	3.70	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
8	9.64E-10	3.70	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
9	8.06E-10	3.09	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	7.38E-10	2.83	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	4.62E-10	1.77	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	4.46E-10	1.71	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	4.38E-10	1.68	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	2.96E-10	1.13	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	2.76E-10	1.06	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	2.66E-10	1.02	IE-LOPCA,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN

**Cut Set Report - LOOPGR 24**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	1.77E-8	100	Displaying 216 Cut Sets. (216 Original)
1	1.91E-9	10.78	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
2	9.64E-10	5.43	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
3	9.16E-10	5.16	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
4	8.68E-10	4.89	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-MOV-CC-IVFRO, HCI-MULTIPLE-INJECT, HCI-XHE-XL-INJECT, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
5	5.46E-10	3.08	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-TM-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
6	5.30E-10	2.99	IE-LOOPGR, DCP-XHE-XM-BB3, EPS-DGN-FR-DGC, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
7	5.28E-10	2.98	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-TM-TRAIN
8	4.62E-10	2.60	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
9	4.37E-10	2.47	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-MOV-CC-IVFRO, HCI-MULTIPLE-INJECT, HCI-XHE-XL-INJECT, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
10	4.16E-10	2.34	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-MOV-CC-IVFRO, HCI-MULTIPLE-INJECT, HCI-XHE-XL-INJECT, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
11	3.13E-10	1.76	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-FS-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
12	3.13E-10	1.76	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FS-TRAIN
13	2.75E-10	1.55	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-TDP-TM-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
14	2.67E-10	1.51	IE-LOOPGR, DCP-XHE-XM-BB3, EPS-DGN-TM-DGC, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN
15	2.66E-10	1.50	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-TM-TRAIN
16	2.62E-10	1.48	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-TDP-TM-TRAIN, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
17	2.54E-10	1.43	IE-LOOPGR, DCP-XHE-XM-BB3, EPS-DGN-FR-DGC, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
18	2.40E-10	1.35	IE-LOOPGR, EPS-DGN-FR-DGC, HCI-MOV-CC-IVFRO, HCI-MULTIPLE-INJECT, HCI-XHE-XL-INJECT, OPR-XHE-XR-CASLT, RCI-TDP-TM-TRAIN
19	2.10E-10	1.18	IE-LOOPGR, EPS-DGN-TM-DGC, HCI-MOV-CC-IVFRO, HCI-MULTIPLE-INJECT, HCI-XHE-XL-INJECT, OPR-XHE-XR-CASLT, RCI-XHE-XE-MISCAL
20	1.94E-10	1.09	IE-LOOPGR, EPS-DGN-FS-DGC, HCI-TDP-FR-TRAIN, OPR-XHE-XR-CASLT, RCI-TDP-FR-TRAIN

**Cut Set Report - LOOPWR 25**

Only items contributing at least 1% to the total are displayed.

#	PROB/FREQ	TOTAL%	CUT SET
	1.36E-8	100	Displaying 72 Cut Sets. (72 Original)
1	3.08E-9	22.66	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	1.47E-9	10.85	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	1.40E-9	10.28	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	8.78E-10	6.47	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	8.49E-10	6.26	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	6.69E-10	4.93	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	5.03E-10	3.71	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
8	5.03E-10	3.71	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
9	4.21E-10	3.10	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	3.85E-10	2.84	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	2.41E-10	1.78	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	2.33E-10	1.71	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	2.28E-10	1.68	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	1.54E-10	1.14	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	1.44E-10	1.06	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	1.39E-10	1.02	IE-LOOPWR,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN

**Cut Set Report - SLBOC 59**

Only items contributing at least 1% to the total are displayed.

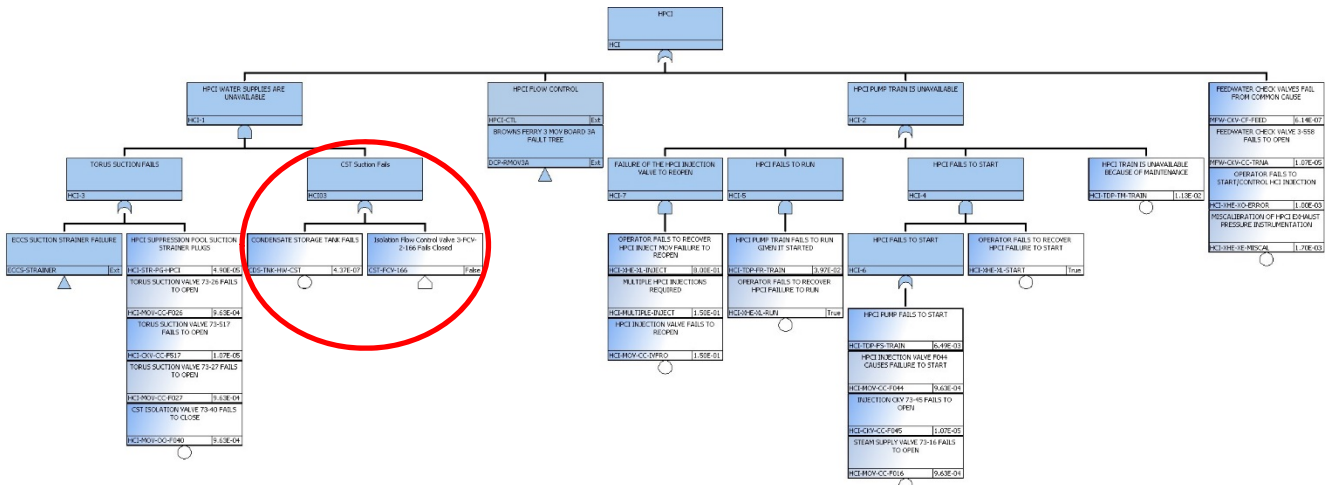
#	PROB/FREQ	TOTAL%	CUT SET
	1.29E-8	100	Displaying 72 Cut Sets. (72 Original)
1	2.93E-9	22.66	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN
2	1.40E-9	10.85	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-XHE-XE-MISCAL
3	1.33E-9	10.28	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN
4	8.36E-10	6.47	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN
5	8.08E-10	6.26	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN
6	6.36E-10	4.93	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-XHE-XE-MISCAL
7	4.79E-10	3.71	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-FR-TRAIN
8	4.79E-10	3.71	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN
9	4.00E-10	3.10	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-XHE-XE-MISCAL
10	3.67E-10	2.84	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN
11	2.29E-10	1.78	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-XHE-XE-MISCAL
12	2.21E-10	1.71	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
13	2.17E-10	1.68	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN
14	1.47E-10	1.14	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
15	1.37E-10	1.06	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN
16	1.32E-10	1.02	IE-SLBOC,ADS-XHE-XM-MDEPR,HCI-TDP-FS-TRAIN,RCI-TDP-TM-TRAIN

**Referenced Events**

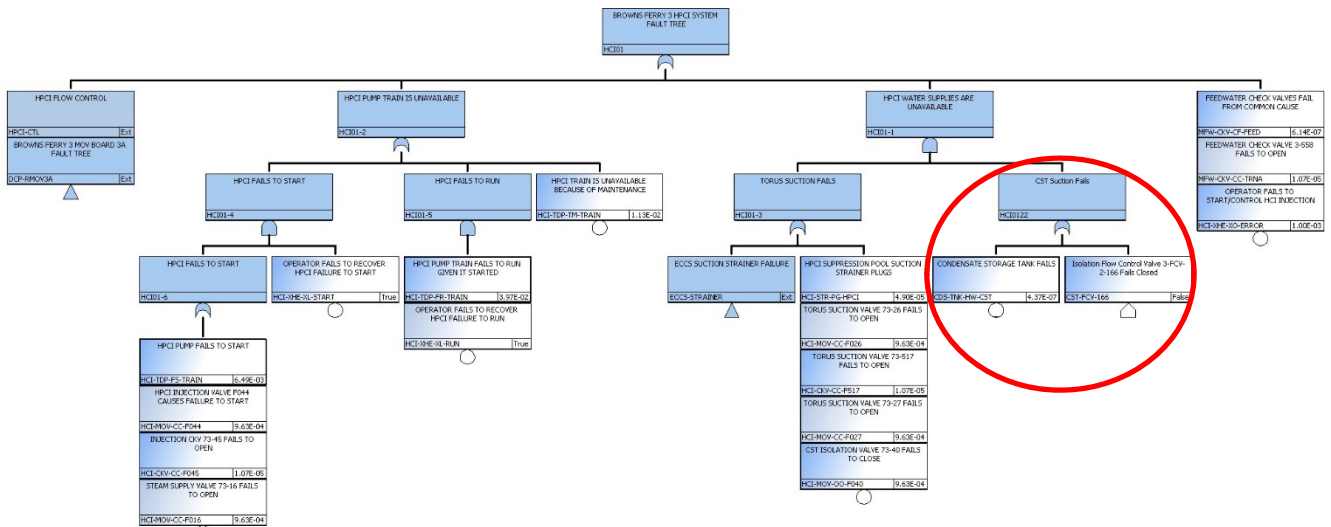
<b>Event</b>	<b>Description</b>	<b>Probability</b>
ADS-XHE-XM-MDEPR	OPERATOR FAILS TO DEPRESSURIZE THE REACTOR	5.00E-4
ADS-XHE-XM-MLOCA	OPERATOR FAILS TO DEPRESSURIZE THE REACTOR - MLOCA (PSA)	1.86E-2
DCP-XHE-XM-BB3	OPERATOR FAILS TO ALIGN BACKUP POWER TO DC-BATBD3	1.10E-2
EPS-DGN-FR-DGC	DIESEL GENERATOR C FAILS TO RUN	2.85E-2
EPS-DGN-FS-DGC	DIESEL GENERATOR C FAILS TO START	2.89E-3
EPS-DGN-TM-DGC	DG C IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.43E-2
HCI-MOV-CC-F016	STEAM SUPPLY VALVE 73-16 FAILS TO OPEN	9.63E-4
HCI-MOV-CC-F026	TORUS SUCTION VALVE 73-26 FAILS TO OPEN	9.63E-4
HCI-MOV-CC-F027	TORUS SUCTION VALVE 73-27 FAILS TO OPEN	9.63E-4
HCI-MOV-CC-F044	HPCI INJECTION VALVE F044 CAUSES FAILURE TO START	9.63E-4
HCI-MOV-CC-IVFRO	HPCI INJECTION VALVE FAILS TO REOPEN	1.50E-1
HCI-MOV-OO-F040	CST ISOLATION VALVE 73-40 FAILS TO CLOSE	9.63E-4
HCI-MULTIPLE-INJECT	MULTIPLE HPCI INJECTIONS REQUIRED	1.50E-1
HCI-TDP-FR-TRAIN	HPCI PUMP TRAIN FAILS TO RUN GIVEN IT STARTED	3.97E-2
HCI-TDP-FS-TRAIN	HPCI PUMP FAILS TO START	6.49E-3
HCI-TDP-TM-TRAIN	HPCI TRAIN IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.13E-2
HCI-XHE-XE-MISCAL	MISCALIBRATION OF HPCI EXHAUST PRESSURE INSTRUMENTATION	1.70E-3
HCI-XHE-XL-INJECT	OPERATOR FAILS TO RECOVER HPCI INJECT MOV FAILURE TO REOPEN	8.00E-1
HCI-XHE-XO-ERROR	OPERATOR FAILS TO START/CONTROL HCI INJECTION	1.00E-3
IE-IORV	INADVERTENT OPEN RELIEF VALVE	1.63E-2
IE-LOCHS	LOSS OF CONDENSER HEAT SINK	1.39E-1
IE-LOOPGR	LOSS OF OFFSITE POWER INITIATOR (GRID-RELATED)	1.22E-2
IE-LOOPSC	LOSS OF OFFSITE POWER INITIATOR (SWITCHYARD-CENTERED)	1.04E-2
IE-LOOPWR	LOSS OF OFFSITE POWER INITIATOR (WEATHER-RELATED)	3.91E-3
IE-LOPCA	LOSS OF PLANT CONTROL AIR	7.49E-3
IE-MLOCA	MEDIUM LOCA	1.00E-4
IE-SLBOC	STEAM LINE BREAK OUTSIDE CONTAINMENT	3.72E-3
OPR-XHE-XR-CASLT	MISALIGNMENT AFTER COMMON ACCIDENT SIGNAL LOGIC TEST (PSA)	3.50E-3
RCI-MOV-FC-XFER	RCIC FAILS TO TRANSFER DURING RECIRCULATION	7.97E-3
RCI-RESTART	RESTART OF RCIC IS REQUIRED	1.50E-1
RCI-TDP-FR-TRAIN	RCIC PUMP FAILS TO RUN GIVEN THAT IT STARTED	3.97E-2
RCI-TDP-FS-RSTRT	RCIC FAILS TO RESTART GIVEN START AND SHORT-TERM RUN	8.00E-2
RCI-TDP-FS-TRAIN	RCIC PUMP FAILS TO START	6.49E-3
RCI-TDP-TM-TRAIN	RCIC PUMP TRAIN IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.09E-2
RCI-XHE-XE-MISCAL	RCIC FAILS FROM MISCALIBRATION OF RUPTURE DISC	1.90E-2
RCI-XHE-XL-RSTRT	OPERATOR FAILS TO RECOVER RCIC FAILURE TO RESTART	2.50E-1
RCI-XHE-XL-XFER	OPERATOR FAILS TO RECOVER SUCTN XFER FAILURE	2.50E-1

## Appendix B: Key Fault Trees

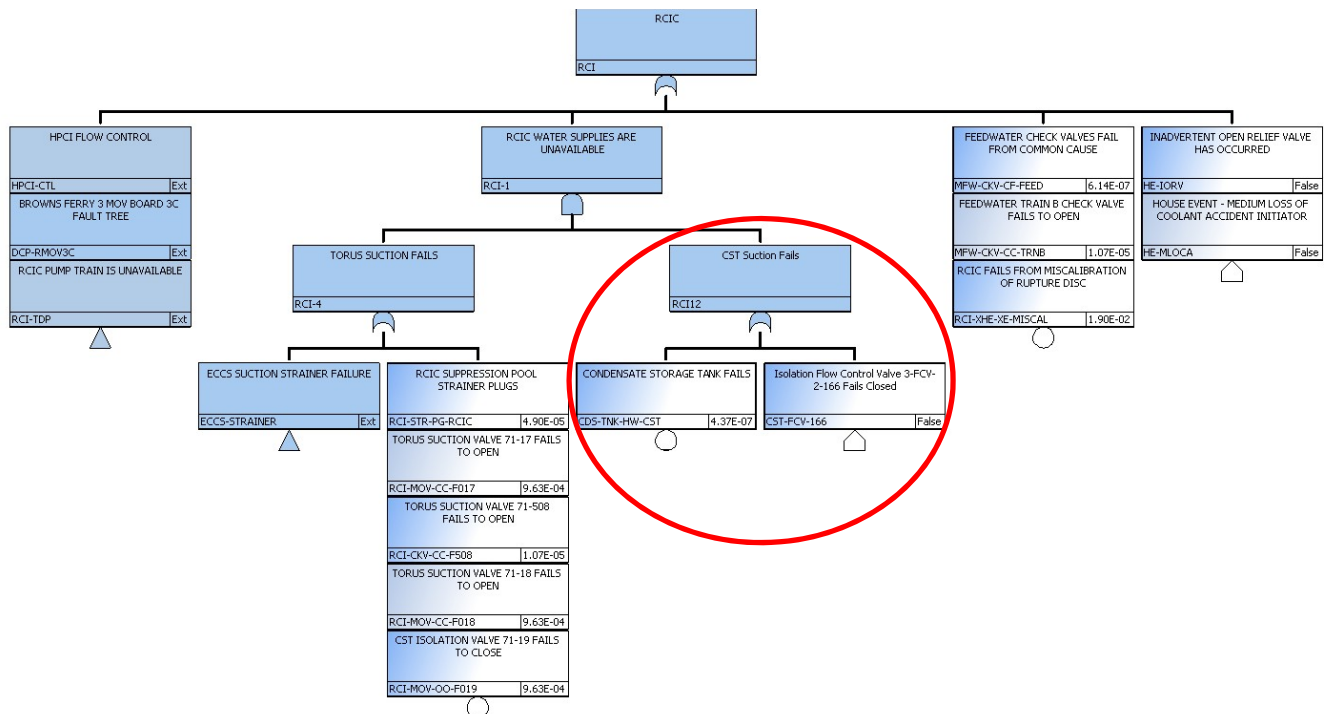
## HCI Fault Tree



## HCI01 Fault Tree



## RCI Fault Tree



## RCI01 Fault Tree

