

# Final ASP Program Analysis - Reject

Accident Sequence Precursor Program – Office of Nuclear Regulatory Research			
<b>Fermi, Unit 2</b>	Reactor Scram Due to Loss of Turbine Building Closed Cooling Water		
<b>Event Date:</b> 9/13/2015	<b>LER:</b> <a href="#">341-2015-006</a> <b>IR(s):</b> <a href="#">50-341/2015-003</a> and <a href="#">50-341/2016-001</a>	<b>CCDP=</b> 1×10 <sup>-6</sup>	
<b>Plant Type:</b> General Electric BWR-4 with a Wet Mark I Containment			
<b>Plant Operating Mode (Reactor Power Level):</b> Mode 1 (100 Percent Reactor Power)			
<b>Analyst:</b> Keith Tetter	<b>Reviewer:</b> David Aird	<b>Contributors:</b> N/A	<b>BC Approved Date:</b> 6/30/2016

## EVENT DETAILS

**Event Description.** At 11:05 pm on September 13, 2015, a manual reactor scram was initiated in response to a loss of all Turbine Building Closed Cooling Water (TBCCW) in accordance with plant procedures. All control rods were fully inserted and the lowest Reactor Water Level (RWL) reached was 137 inches above the top of active fuel. Decay heat was initially removed through the Main Turbine Bypass System to the Main Condenser; however, as a result of the loss of TBCCW, the Reactor Feed Pumps lost cooling and had to be secured. At 11:10 pm, the Standby Feedwater System was initiated.

A field investigation later verified that a tube leak occurred in the East TBCCW heat exchanger, causing General Service Water (GSW) to flow into the lower pressure TBCCW system. This resulted in a TBCCW head tank level increase and water flowing from the TBCCW head tank relief valve. The interaction of TBCCW system pressure fluctuations with the TBCCW tank instrumentation ultimately caused a trip of the running TBCCW pumps and a loss of TBCCW.

The loss of TBCCW also caused all Station Air Compressors (SACs) to trip on loss of cooling. The loss of SACs caused the Instrument Air header pressure to degrade to the point at which the Secondary Containment (SC) isolation dampers drifted closed. This resulted in the reactor building pressure going positive and exceeding the Technical Specification minimum requirement of -0.125 inches water column. At 11:25 pm, operators started the Standby Gas Treatment System (SGTS) and manually inserted a SC isolation signal. SC vacuum was restored to within Technical Specification limits. The Technical Specification limit was exceeded for approximately 3 minutes and 43 seconds and the maximum pressure recorded was 1.932 inches water column. Additionally, operators were monitoring for expected Main Steam Isolation Valve (MSIV) drift due to the degraded, but operable, Instrument Air header pressure. The air system is composed of two subsystems; station air and control air (interruptible and noninterruptible). A station air connection supplies the interruptible control air system, which consists of two 100 percent redundant dryers, each capable of supplying the same quality of instrument air as the noninterruptible control air system. At 11:45 pm, when the outboard MSIVs were observed to be drifting, operators closed the outboard and inboard MSIVs. At 11:52 pm, Low-Low Set Safety Relief Valves (SRVs) reached their setpoint and began automatic cycling to control reactor pressure. The manual closure of MSIVs led to an expected loss of Main Condenser vacuum at 12:01 am on September 14, 2015.

**Cause.** The primary failure cause of the TBCCW heat exchanger tube leak was stress corrosion cracking. The root cause evaluation determined that important internal equipment operating history and industry operating experience were not identified and implemented in the TBCCW heat exchanger monitoring requirements during the development of the site Balance of Plant Heat Exchanger Program.

## MODELING

**Basis for ASP Analysis/SDP Results.** The ASP Program uses Significance Determination Process (SDP) results for degraded conditions when available and applicable. The ASP Program performs independent analyses for initiating events. ASP analyses of initiating events account for all failures/degraded conditions and unavailabilities (e.g., equipment out for test/maintenance) that occurred during the event, regardless of licensee performance.<sup>1</sup>

In Inspection Report (IR) 05000341/2016001 (Ref. 1), Section 1R12.b(3), the inspectors reviewed the event and follow-up actions by the licensee. A Green finding was identified based on the licensee's failure to incorporate industry operating experience in order to perform adequate preventative maintenance on the TBCCW heat exchanger. This finding was self-revealed when the failure of a tube inside the TBCCW heat exchanger caused a trip of the TBCCW pumps and a manual reactor scram. A detailed risk evaluation was performed by an NRC Senior Reactor Analyst (SRA) with a resultant conditional core damage probability (CCDP) of about  $5 \times 10^{-7}$ . Additional event information is available in LER 341-2015-006 (Ref. 2) and IR 05000341/2015003 (Ref. 3). This LER is not yet closed.

An independent ASP analysis was performed because this was an initiating event (reactor scram due to loss of TBCCW) with the failure of MSIVs to remain open and the increase in the potential for SRV failure (due to cycling) was not accounted for in the analysis performed for the SDP.

**Analysis Type.** An initiating event analysis was performed using the Fermi Unit 2 Standardized Plant Analysis Risk (SPAR) model Revision 8.21, created in April 2016. This revised SPAR model included two recent modifications by Idaho National Laboratory, which maintains the SPAR models for the NRC. The first modification of the SPAR model was performed to remove the assumed dependency between the operator action to vent containment and the operator action to start/control the Residual Heat Removal (RHR) System in the suppression pool cooling mode. This change was made consistent with the current SPAR model 26 philosophy that these two actions are separate enough in time such that the failure to vent the containment is independent from the failure to start/control RHR. The second modification allowed continued core injection using the Standby Feedwater System (with a probability of 91 percent) and the Control Rod Drive System (with a probability of 19 percent), even after containment vent system failure. These probabilities of Standby Feedwater System and Control Rod Drive System success after containment failure are based on the types and probabilities of drywell and suppression pool failures that could occur to the containment and the effects on each type of failure on the systems.

**SPAR Model Modifications.** No additional SPAR model modifications were needed to perform this analysis other than those mentioned above that were already included in the model.

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<sup>1</sup> ASP analyses also account for any degraded condition(s) that were identified after the initiating event occurred if the failure/degradation exposure period(s) overlapped the initiating event date.

**Key Modeling Assumptions.** The following assumptions were determined to be significant to the modeling of this event:

- The probability of IE-TRANS (*General Transient Initiating Event*) was set to 1.0; all other initiating event probabilities were set to zero.
- Basic event MSS-MSV-OC-STEAM (*Steam Loop Valves Fail to Remain Open*) was set to TRUE because the MSIVs were closed by operators due to low air system pressure.
- Basic event TBC-MDP-CF-RUN (*TBCCW Pumps Fail from Common Cause to Run*) was set to TRUE because east TBCCW heat exchanger tube failure caused GSW to leak into the TBCCW system resulting in the overfilling of the TBCCW expansion tank, lifting the expansion tank relief valve, and eventually the loss of both operating TBCCW pumps.
- Basic event ZT-BWR-SRV-OO-P1 (*BWR ADS/SRV Fails to Reclose*) was changed because operators cycled the SRVs about every 5 minutes throughout the event. Therefore, a binomial expansion was used to adjust the failure probability for basic event ZT-BWR-SRV-OO-P1 (*BWR ADS/SRV Fails to Reclose*) to 0.18 to account for the increased probability that the valves could stick open. This is a conservative basic event change since it assumes that the SRVs were cycled every 5 minutes for the entire 24 hour mission time.
- All other safety systems responded as designed.

## ANALYSIS RESULTS

**CCDP/Rejection Basis.** The CCDP for this analysis is  $1.0 \times 10^{-6}$ . The ASP Program threshold is a CCDP of greater than  $1 \times 10^{-6}$ . Therefore, this event is not a precursor and is screened out of the ASP Program.

**Dominant Sequence.** The dominant accident sequence is Transient (TRANS) Sequence 62-7 (2SORVS) (CCDP =  $2.9 \times 10^{-7}$ ) that contributes approximately 28% of the total internal events CCDP. Figure 1 in Appendix B illustrates this sequence showing the 2SORVS event subtree. The cut sets/sequences that contribute to the top 95% and/or at least 1% of the total internal events CCDP are provided in Appendix A.

The events and important component/system failures in TRANS Sequence 62-7 are:

- A plant transient occurs,
- Reactor protection system succeeds,
- Offsite power recovery succeeds,
- Two or more stuck open SRVs,
- Low pressure injection (Core Spray or Low Pressure Core Injection) fails.

## REFERENCES

1. U.S. Nuclear Regulatory Commission, "Fermi Nuclear Power Plant, Unit 2 – NRC Integrated Inspection Report 05000341/2016001," dated May 9, 2015 (ML16130A752).
2. Fermi 2, "LER 341-2015-006-01 – Reactor Scram Due to Loss of Turbine Building Closed Cooling Water," dated April 15, 2016 (ML16109A091).
3. U.S. Nuclear Regulatory Commission, "Fermi Power Plant, Unit 2 – NRC Integrated Inspection Report 05000341/2015003," dated November 5, 2015 (ML15309A680).

## Appendix A: SAPHIRE 8 Worksheet

### Summary of Conditional Event Changes

Event	Description	Cond Value	Nominal Value
IE-TRANS	GENERAL PLANT TRANSIENT	1.00E+0 <sup>a</sup>	7.62E-1
MSS-MSV-OC-STEAM	STEAM LOOP VALVES FAIL TO REMAIN OPEN	True	9.22E-6
TBC-MDP-CF-RUN	TBCCW PUMPS FAIL FROM COMMON CAUSE TO RUN	True	2.68E-7
ZT-BWR-SRV-OO-P1	BWR ADS/SRV Fails To Reclose	1.80E-1	8.56E-4

a. All other initiating event probabilities were set to zero.

### Event Tree Dominant Results

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

EVENT TREE	CCDP	% CONTRIBUTION	DESCRIPTION
TRANS	1.04E-6	100.0%	GENERAL PLANT TRANSIENT
<b>Total</b>	<b>1.04E-6</b>	<b>100.0%</b>	

### Dominant Sequence Results

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

EVENT TREE	SEQUENCE	CCDP	% CONTRIBUTION	DESCRIPTION
TRANS	62-7	2.92E-7	28.1%	/RPS, /OEP, P2, LPI
TRANS	62-4	2.11E-7	20.3%	/RPS, /OEP, P2, /LPI, SPC, CSS, /CVS, LI02
TRANS	07	1.78E-7	17.1%	/RPS, /OEP, /SRV, PCS, /SFW, RHR, PCSR, CVS, LI04A
TRANS	60	6.48E-8	6.2%	/RPS, /OEP, /SRV, PCS, SFW, HPI, DEP
TRANS	64-07	6.10E-8	5.9%	RPS, /PPR, /RRS, PCS, /SLC, /NX, TAF
TRANS	62-6	5.92E-8	5.7%	/RPS, /OEP, P2, /LPI, SPC, CSS, CVS, LI04
TRANS	64-09	5.37E-8	5.2%	RPS, /PPR, /RRS, PCS, SLC
TRANS	59	3.81E-8	3.7%	/RPS, /OEP, /SRV, PCS, SFW, HPI, /DEP, CDS, LPI, VA
TRANS	14	3.52E-8	3.4%	/RPS, /OEP, /SRV, PCS, SFW, /HPI, SPC, /DEP, /CR2, RHR, PCSR, CVS, LI04B
TRANS	64-06-07	2.44E-8	2.3%	RPS, /PPR, /RRS, PCS, /SLC, /NX, /TAF, /DE3, /LCI, LVL
TRANS	64-10	1.19E-8	1.1%	RPS, /PPR, RRS
<b>Total</b>		<b>1.04E-6</b>	<b>100.0%</b>	

### Referenced Fault Trees

Fault Tree	Description
CDS	CONDENSATE
CSS	CONTAINMENT SPRAY
CVS	CONTAINMENT VENTING FAILS
DEP	MANUAL REACTOR DEPRESS
HPI	HIGH PRESSURE INJECTION (RCIC or HPCI)
LI02	LATE INJECTION
LI04	LATE INJECTION AFTER CONTAINMENT VENTING FAILURE
LI04A	LATE INJECTION AFTER CONTAINMENT VENTING FAILURE (FW)
LI04B	LATE INJECTION AFTER CONTAINMENT VENTING FAILURE (CRD)
LPI	LOW PRESSURE INJECTION (CS or LPCI)
LVL	RESTORE LEVEL AND PREVENT OVER-FILL
P2	TWO OR MORE STUCK OPEN SRVs
PCS	POWER CONVERSION SYSTEM
PCSR	POWER CONVERSION SYSTEM RECOVERY FAILS

RHR	RESIDUAL HEAT REMOVAL
RPS	REACTOR SHUTDOWN
RRS	RECIRC PUMP TRIP
SFW	STANDBY FEEDWATER
SLC	STANDBY LIQUID CONTROL FAILS TO INJECT
SPC	SUPPRESSION POOL COOLING
TAF	OPERATOR FAILS TO CONTROL LEVEL AT TAF
VA	ALTERNATE LOW PRESS INJECTION

**Cut Set Report - TRANS 62-7**

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

#	CDDP	TOTAL%	CUT SET
	2.92E-7	100	Displaying 104 Cut Sets. (104 Original)
1	2.86E-7	98.09	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-STR-CF-NLOCA
2	3.11E-9	1.07	IE-TRANS,DCP-BAT-CF-260V,PPR-SRV-OO-2VLVS

**Cut Set Report - TRANS 62-4**

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

#	CDDP	TOTAL%	CUT SET
	2.11E-7	100	Displaying 469 Cut Sets. (469 Original)
1	7.38E-8	34.95	IE-TRANS,PPR-SRV-OO-2VLVS,RSW-MDP-CF-RUN
2	3.90E-8	18.46	IE-TRANS,PPR-SRV-OO-2VLVS,RSW-MDP-CF-START
3	1.43E-8	6.78	IE-TRANS,OPR-XHE-XM-ALPI2,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR
4	1.38E-8	6.53	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-MOV-OO-F010,RHR-XHE-XM-ERROR
5	1.38E-8	6.53	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR,RSW-MOV-CC-F075
6	1.38E-8	6.53	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR,RSW-MOV-CC-F073
7	1.38E-8	6.53	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-MOV-CC-F015B,RHR-XHE-XM-ERROR
8	7.88E-9	3.73	IE-TRANS,ADS-XHE-XM-MDEPR5,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR
9	4.84E-9	2.29	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-MOV-CC-F007A,RSW-MDP-TM-TRNB,RSW-MDP-TM-TRND
10	2.51E-9	1.19	IE-TRANS,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR,RSW-MDP-TM-TRNB,RSW-MDP-TM-TRND

**Cut Set Report - TRANS 07**

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

#	CDDP	TOTAL%	CUT SET
	1.78E-7	100	Displaying 186 Cut Sets. (186 Original)
1	4.50E-8	25.30	IE-TRANS,CVS-XHE-XM-VENT,DW-SHELL-RUPT,RHR-XHE-XM-ERROR
2	4.28E-8	24.06	IE-TRANS,CVS-AOV-OO-F407,DW-SHELL-RUPT,RHR-XHE-XM-ERROR
3	4.28E-8	24.06	IE-TRANS,CVS-AOV-OO-F408,DW-SHELL-RUPT,RHR-XHE-XM-ERROR
4	4.28E-8	24.06	IE-TRANS,CVS-AOV-OO-F409,DW-SHELL-RUPT,RHR-XHE-XM-ERROR

**Cut Set Report - TRANS 60**

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

#	CDDP	TOTAL%	CUT SET
	6.48E-8	100	Displaying 201 Cut Sets. (201 Original)
1	1.73E-8	26.68	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN,SFW-XHE-XA-MISALIGN
2	8.76E-9	13.52	IE-TRANS,ACP-XHE-XM-64T65T,DCP-BCH-CF-ALL
3	7.85E-9	12.11	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FR-TRAIN,SFW-XHE-XA-MISALIGN
4	5.00E-9	7.72	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-TM-TRAIN,RCI-TDP-FR-TRAIN,SFW-XHE-XA-MISALIGN

#	CCDP	TOTAL%	CUT SET
5	4.44E-9	6.84	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-TDP-TM-TRAIN,SFW-XHE-XA-MISALIGN
6	2.83E-9	4.37	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-TDP-FS-TRAIN,SFW-XHE-XA-MISALIGN
7	2.01E-9	3.11	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-TM-TRAIN,SFW-XHE-XA-MISALIGN
8	1.58E-9	2.44	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-XHE-XO-ERROR1,RCI-XHE-XO-ERROR,SFW-XHE-XA-MISALIGN
9	1.31E-9	2.02	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT,SFW-XHE-XA-MISALIGN
10	1.29E-9	1.98	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-MOV-CC-IVFRO,HCI-MULTIPLE-INJECT,HCI-XHE-XL-INJECT,RCI-TDP-FS-TRAIN,SFW-XHE-XA-MISALIGN
11	8.69E-10	1.34	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER,SFW-XHE-XA-MISALIGN
12	8.65E-10	1.33	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN,SFW-XHE-XM-INITIATE
13	8.33E-10	1.28	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-FR-TRAIN,RCI-TDP-FR-TRAIN,SFW-MOV-CC-F001
14	8.19E-10	1.26	IE-TRANS,ADS-XHE-XM-MDEPR5,HCI-TDP-TM-TRAIN,RCI-TDP-FS-TRAIN,SFW-XHE-XA-MISALIGN

### Cut Set Report - TRANS 64-07

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

#	CCDP	TOTAL%	CUT SET
	6.10E-8	100	Displaying 5 Cut Sets. (5 Original)
1	4.25E-8	69.67	IE-TRANS,OPR-XHE-XM-CTRLTAF,RPS-SYS-FC-PSOVS
2	9.50E-9	15.57	IE-TRANS,OPR-XHE-XM-CTRLTAF,RPS-SYS-FC-RELAY
3	6.25E-9	10.25	IE-TRANS,OPR-XHE-XM-CTRLTAF,RPS-SYS-FC-CRD
4	2.75E-9	4.51	IE-TRANS,OPR-XHE-XM-CTRLTAF,RPS-SYS-FC-HCU

### Cut Set Report - TRANS 62-6

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

#	CCDP	TOTAL%	CUT SET
	5.92E-8	100	Displaying 138 Cut Sets. (138 Original)
1	1.43E-8	24.17	IE-TRANS,CVS-XHE-XM-VENT,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR
2	1.36E-8	22.99	IE-TRANS,CVS-AOV-OO-F407,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR
3	1.36E-8	22.99	IE-TRANS,CVS-AOV-OO-F408,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR
4	1.36E-8	22.99	IE-TRANS,CVS-AOV-OO-F409,PPR-SRV-OO-2VLVS,RHR-XHE-XM-ERROR

### Cut Set Report - TRANS 64-09

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

#	CCDP	TOTAL%	CUT SET
	5.37E-8	100	Displaying 87 Cut Sets. (87 Original)
1	2.55E-8	47.51	IE-TRANS,RPS-SYS-FC-PSOVS,SLC-XHE-XR-SYS
2	8.50E-9	15.84	IE-TRANS,RPS-SYS-FC-PSOVS,SLC-XHE-XM-INJ
3	5.70E-9	10.62	IE-TRANS,RPS-SYS-FC-RELAY,SLC-XHE-XR-SYS
4	3.75E-9	6.99	IE-TRANS,RPS-SYS-FC-CRD,SLC-XHE-XR-SYS
5	2.79E-9	5.19	IE-TRANS,RPS-SYS-FC-PSOVS,RWC-ISO-TM-DIV1&2
6	1.90E-9	3.54	IE-TRANS,RPS-SYS-FC-RELAY,SLC-XHE-XM-INJ
7	1.65E-9	3.07	IE-TRANS,RPS-SYS-FC-HCU,SLC-XHE-XR-SYS
8	1.25E-9	2.33	IE-TRANS,RPS-SYS-FC-CRD,SLC-XHE-XM-INJ
9	6.23E-10	1.16	IE-TRANS,RPS-SYS-FC-RELAY,RWC-ISO-TM-DIV1&2
10	5.50E-10	1.02	IE-TRANS,RPS-SYS-FC-HCU,SLC-XHE-XM-INJ

**Cut Set Report - TRANS 59**

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

#	CCDP	TOTAL%	CUT SET
	3.82E-8	100	Displaying 12 Cut Sets. (12 Original)
1	3.51E-8	91.89	IE-TRANS,DCP-BCH-CF-ALL
2	2.17E-9	5.70	IE-TRANS,DCP-BAT-CF-260V,SFW-XHE-XA-MISALIGN
3	6.36E-10	1.67	IE-TRANS,DCP-BAT-CF-BATT,SFW-XHE-XA-MISALIGN

**Cut Set Report - TRANS 14**

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

#	CCDP	TOTAL%	CUT SET
	3.52E-8	100	Displaying 190 Cut Sets. (190 Original)
1	7.20E-9	20.45	IE-TRANS,CVS-XHE-XM-VENT,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN,WWDW-LK-RUPT
2	6.85E-9	19.45	IE-TRANS,CVS-AOV-OO-F409,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN,WWDW-LK-RUPT
3	6.85E-9	19.45	IE-TRANS,CVS-AOV-OO-F408,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN,WWDW-LK-RUPT
4	6.85E-9	19.45	IE-TRANS,CVS-AOV-OO-F407,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN,WWDW-LK-RUPT
5	9.00E-10	2.56	IE-TRANS,CVS-XHE-XM-VENT,DW-SHELL-RUPT,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN
6	8.56E-10	2.43	IE-TRANS,CVS-AOV-OO-F409,DW-SHELL-RUPT,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN
7	8.56E-10	2.43	IE-TRANS,CVS-AOV-OO-F408,DW-SHELL-RUPT,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN
8	8.56E-10	2.43	IE-TRANS,CVS-AOV-OO-F407,DW-SHELL-RUPT,RHR-XHE-XM-ERROR,SFW-XHE-XA-MISALIGN
9	3.60E-10	1.02	IE-TRANS,CVS-XHE-XM-VENT,RHR-XHE-XM-ERROR,SFW-XHE-XM-INITIATE,WWDW-LK-RUPT

**Cut Set Report - TRANS 64-06-07**

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

#	CCDP	TOTAL%	CUT SET
	2.44E-8	100	Displaying 5 Cut Sets. (5 Original)
1	1.70E-8	69.67	IE-TRANS,OPR-XHE-XM-NOOVRFIL,RPS-SYS-FC-PSOVS
2	3.80E-9	15.57	IE-TRANS,OPR-XHE-XM-NOOVRFIL,RPS-SYS-FC-RELAY
3	2.50E-9	10.25	IE-TRANS,OPR-XHE-XM-NOOVRFIL,RPS-SYS-FC-CRD
4	1.10E-9	4.51	IE-TRANS,OPR-XHE-XM-NOOVRFIL,RPS-SYS-FC-HCU

**Cut Set Report - TRANS 64-10**

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

#	CCDP	TOTAL%	CUT SET
	1.19E-8	100	Displaying 10 Cut Sets. (10 Original)
1	4.07E-9	34.30	IE-TRANS,RPS-SYS-FC-PSOVS,RRS-CRB-CC-PUMP1
2	4.07E-9	34.30	IE-TRANS,RPS-SYS-FC-PSOVS,RRS-CRB-CC-PUMP2
3	9.09E-10	7.67	IE-TRANS,RPS-SYS-FC-RELAY,RRS-CRB-CC-PUMP1
4	9.09E-10	7.67	IE-TRANS,RPS-SYS-FC-RELAY,RRS-CRB-CC-PUMP2
5	5.98E-10	5.04	IE-TRANS,RPS-SYS-FC-CRD,RRS-CRB-CC-PUMP1
6	5.98E-10	5.04	IE-TRANS,RPS-SYS-FC-CRD,RRS-CRB-CC-PUMP2
7	2.63E-10	2.22	IE-TRANS,RPS-SYS-FC-HCU,RRS-CRB-CC-PUMP1
8	2.63E-10	2.22	IE-TRANS,RPS-SYS-FC-HCU,RRS-CRB-CC-PUMP2



## Referenced Events

Event	Description	Probability
ACP-XHE-XM-64T65T	OPERATOR FAILS TO ALIGN 4160V MAINT CROSS TIE 65T/64T	2.50E-1
ADS-XHE-XM-MDEPR5	OPERATOR FAILS TO DEPRESSURIZE THE REACTOR	5.50E-4
CVS-AOV-OO-F407	REACTOR BUILDING HVAC ISOLATION FAILS	9.51E-4
CVS-AOV-OO-F408	SBGT ISOLATION FAILS	9.51E-4
CVS-AOV-OO-F409	SBGT ISOLATION FAILS	9.51E-4
CVS-XHE-XM-VENT	OPERATOR FAILS TO VENT CONTAINMENT	1.00E-3
DCP-BAT-CF-260V	COMMON CAUSE FAILURE OF DIVISION I, II 260V BATTERIES	1.09E-7
DCP-BAT-CF-BATT	COMMON CAUSE FAILURE OF DIVISION I, II BATTERIES	3.18E-8
DCP-BCH-CF-ALL	CCF OF BATTERY CHARGERS	3.51E-8
DW-SHELL-RUPT	LARGE DRYWELL SHELL RUPTURE FAILS ALL INJECTION	9.00E-2
HCI-MOV-CC-IVFRO	HPCI INJECTION VALVE FAILS TO REOPEN	1.50E-1
HCI-MULTIPLE-INJECT	PROBABILITY OF MULTIPLE HPCI INJECTIONS	1.50E-1
HCI-TDP-FR-TRAIN	HPCI PUMP TRAIN FAILS TO RUN GIVEN IT STARTED	3.97E-2
HCI-TDP-TM-TRAIN	HPCI TRAIN IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.15E-2
HCI-XHE-XL-INJECT	OPERATOR FAILS TO RECOVER HPCI INJECTION VALVE REOPENING	8.00E-1
HCI-XHE-XO-ERROR1	OPERATOR FAILS TO START/CONTROL HPCI INJECTION	1.44E-1
IE-TRANS	GENERAL PLANT TRANSIENT	1.00E+0
OPR-XHE-XM-ALPI2	OPERATOR FAILS TO START/CONTROL ALT LOW PRESS INJECTION	1.00E-3
OPR-XHE-XM-CTRLTAF	OPERATOR FAILS TO CONTROL LEVEL TO TAF	2.50E-2
OPR-XHE-XM-NOOVRFIL	OPERATOR FAILS TO CONTROL RPV LEVEL - BWR	1.00E-2
PPR-SRV-OO-2VLVS	TWO OR MORE SRVS FAIL TO CLOSE	2.86E-2
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	1.02E-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
RCI-XHE-XO-ERROR	OPERATOR FAILS TO START/CONTROL RCIC INJECTION	1.00E-3
RHR-MOV-CC-F007A	RHR LOOP A MINFLOW MOV F007A FAILS TO OPEN	9.63E-4
RHR-MOV-CC-F015B	LPCI TRAIN B INJECT MOV F015B FAILS TO OPEN	9.63E-4
RHR-MOV-OO-F010	RHR LOOP CROSS-TIE VALVE FAILS TO CLOSE	9.63E-4
RHR-STR-CF-NLOCA	SUPPRESSION POOL STRAINERS FAIL FROM COMMON CAUSE (NON-LOCA)	1.00E-5
RHR-XHE-XM-ERROR	OPERATOR FAILS TO START/CONTROL RHR	5.00E-4
RPS-SYS-FC-CRD	CONTROL ROD DRIVE MECHANICAL FAILURE	2.50E-7
RPS-SYS-FC-HCU	HCU COMPONENTS FAIL	1.10E-7
RPS-SYS-FC-PSOVS	HCU SCRAM PILOT SOVS FAIL	1.70E-6
RPS-SYS-FC-RELAY	TRIP SYSTEM RELAYS FAIL	3.80E-7
RRS-CRB-CC-PUMP1	RECIRC PUMP 1 FIELD BREAKER FAILS TO OPEN	2.39E-3
RRS-CRB-CC-PUMP2	RECIRC PUMP 2 FIELD BREAKER FAILS TO OPEN	2.39E-3
RSW-MDP-CF-RUN	RHRSW PUMPS FAIL FROM COMMON CAUSE TO RUN	2.58E-6
RSW-MDP-CF-START	RHRSW PUMPS FAIL FROM COMMON CAUSE TO START	1.36E-6
RSW-MDP-TM-TRNB	RHRSW PUMP B IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.32E-2
RSW-MDP-TM-TRND	RHRSW PUMP D IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.32E-2
RSW-MOV-CC-F073	RHRSW/LPCI CROSS-TIE VALVE FAILS TO OPEN	9.63E-4
RSW-MOV-CC-F075	RHRSW/LPCI CROSS-TIE VALVE FAILS TO OPEN	9.63E-4

RWC-ISO-TM-DIV1&2	REACTOR WATER CLEANUP ISOLATION SYSTEM BOTH DIVISIONS IN TM (PSA)	1.64E-3
SFW-MOV-CC-F001	BOUNDARY VALVE F001 FAILS TO OPEN	9.63E-4
SFW-XHE-XA-MISALIGN	FERMI STANDBY FEEDWATER MISALIGNMENT ERROR FOLLOWING 24_107_03	2.00E-2
SFW-XHE-XM-INITIATE	OPERATOR FAILS TO INITIATE SBFW INJECTION	1.00E-3
SLC-XHE-XM-INJ	OPERATOR FAILS TO START/CONTROL SLC INJECTION DURING ATWS	5.00E-3
SLC-XHE-XR-SYS	SLCS UNAVAIL DUE TO MISALIGNMENT AFTER PUMP/VALVE TEST (PRA)	1.50E-2
WWDW-LK-RUPT	SMALL WW OR DW SHELL FAILURE OR LARGE WW RUPT FAILS ALL INJECTION EXCEPT SBFW	7.20E-1

## Appendix B: Key Event Tree

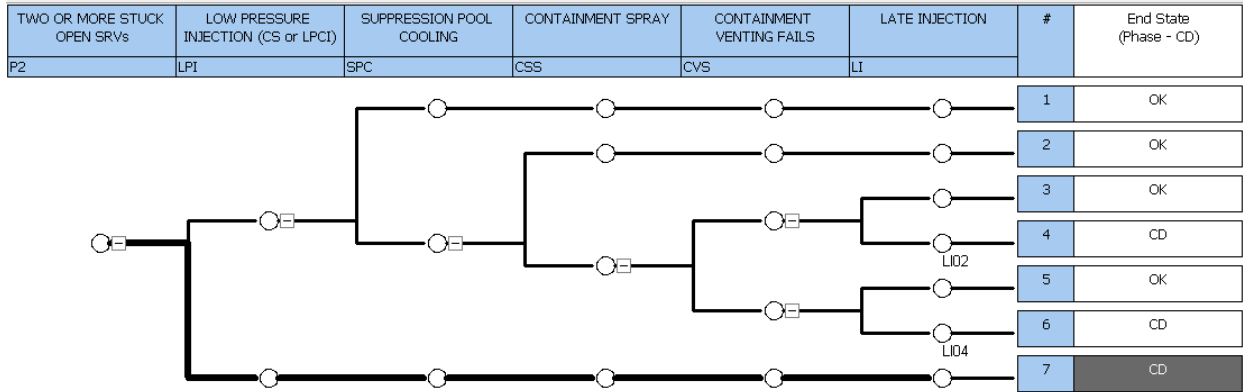


Figure 1: Fermi 2 2SORVS Event Tree (Sequence 7 Bolded)