Final Accident Sequence Precursor (ASP) Analysis

Office of Nuclear Regulatory Research

Catawba Units 1 and 2		**Duel Unit Loss of Offsite Power Event**			
Event Date:	05/20/2006	LER:	413/2006-001-00	CCDP (Unit 1):	9E-05
				CCDP (Unit 2):	6E-05

09/25/2006

Event Summary

Description. On May 20, 2006, at 2:01 p.m., an electrical fault in the Catawba 230kV switchyard caused several power circuit breakers (PCB's) to open resulting in a loss of all offsite power (LOOP) and a subsequent reactor trip of both units from 100 percent power. All reactor trip breakers opened as expected and all control rods fully inserted into the core on the two units. Both main turbines tripped upon receipt of the P4 protective signals following the reactor trips. Control room operators responded to the event using normal, abnormal and emergency operating procedures.

Following the LOOP, the four (4) emergency diesel generators started and supplied power to the 4.16kV vital busses. Designated vital equipment was re-energized in accordance with the plant design through the diesel generator load sequencers. During the LOOP events, two pressurizer power-operated relief valves (PORVs) in Unit 1 cycled for a total of 62 times; one PORV in Unit 2 cycled 35 times. The PORVs on both units operated as designed to control primary plant pressure.

Power was restored to the Unit 2 6.9kV busses at 8:27 p.m. on May 20, 2006, and to the Unit 1 6.9kV busses at 8:40 p.m. Due to existing lockouts on the 1A and 2B main transformers, full realignment of breakers to provide offsite power to the vital busses and securing of all four diesel generators did not occur until approximately 1:10 a.m. on May 21, 2006.

Recovery assumption. Offsite power to the first vital bus could have been restored within one hour given a postulated station blackout.

Analysis Results

Conditional Core Damage Probability (CCDP). The mean CCDP for the loss of offsite event is 9E-05 for Unit 1 and 6E-05 for unit 2. The uncertainty distribution is as follows:

	5th percentile	mean	95th percentile
Unit 1	8E-06	9E-05	3E-04
Unit 2	6E-06	6E-05	2E-04

ASP Program thresholds (CCDP). This event is a precursor in the ASP program. However, since the CCDP is less than 1.0E-03, this event is NOT a *significant* precursor.

Dominating sequences. The two top dominant core damage sequences for this assessment are loss of offsite power (LOOP)/station blackout (SBO) sequence 20-74 and LOOP sequence 13 (81% of the total CCDP). The LOOP and SBO event trees are shown in Figures 1 and 2.

The events and important component failures in LOOP/SBO Sequence 20-74 are:

- o Loss of offsite power occurs
- o Reactor shutdown succeeds
- o Emergency power fails
- o Auxiliary feedwater succeeds
- o Pressurizer power-operated relief valve sticks open
- o Offsite power is not recovered in 1 hour
- o An emergency diesel generator is not recovered in 1 hour

The events and important component failures in LOOP Sequence 13 are:

- o Loss of offsite power occurs
- o Reactor shutdown succeeds
- o Emergency power is unavailable (at least one of two trains)
- o Auxiliary feedwater succeeds
- o Pressurizer power-operated relief valve sticks open
- o High pressure injection fails
- o Offsite power is not recovered in 1 hour

Sensitivity analysis results. A sensitivity analysis was performed assumes that no pressurizer PORV opens during the event. The resultant CCDP for both units still exceeds the ASP program threshold of a precursor (i.e., CCDP > 1E-06).

An additional sensitivity analysis was performed that assumes (1) offsite power can not be restored to required vital buses within one hour, but was recoverable within two hours, and (2) multiple pressurizer PORVs cycles. The resultant CCDP for either unit does not exceed the ASP Program threshold of a *significant* precursor (i.e., CCDP < 1E-03).

Attachments - Analysis Background Documents

1. Analysis Worksheet
2. GEM Reports: Units 1 and 2

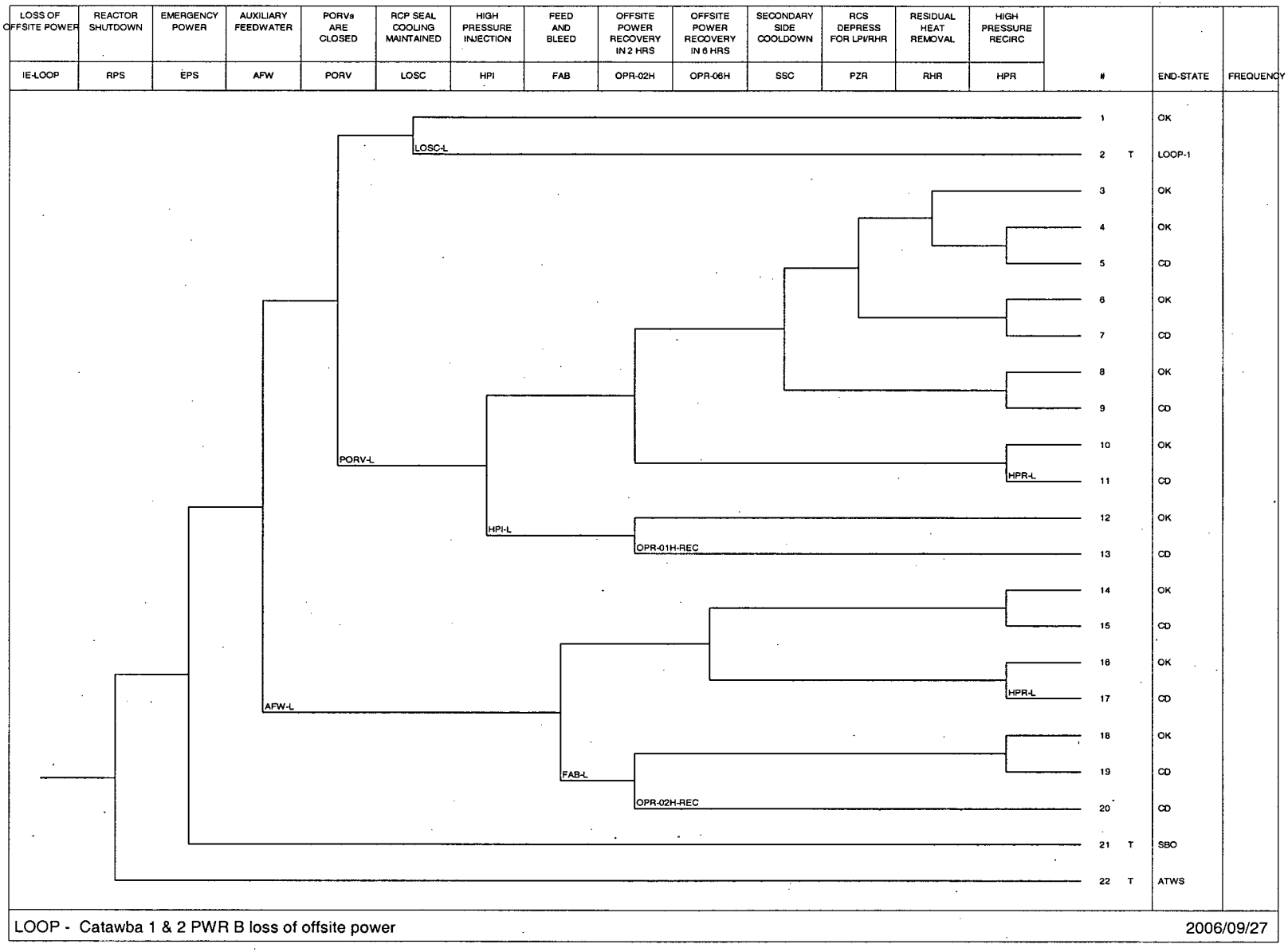
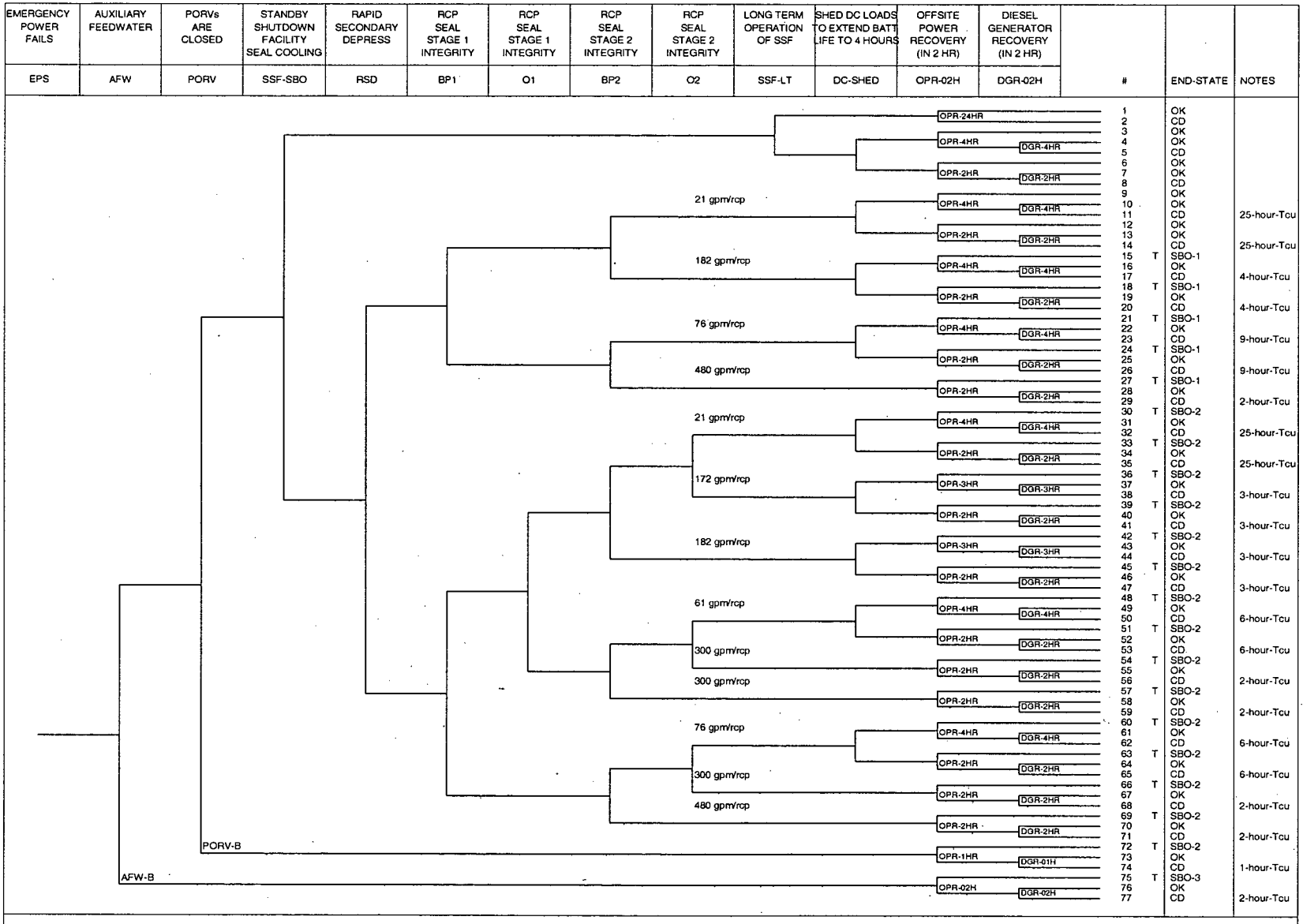


Figure 1. Loss of Offsite Power Event Tree



SBO - Catawba 1 & 2 PWR B station blackout 2006/06/12

Figure 2. Station Blackout Event Tree

Accident Sequence Precursor (ASP) Analysis Worksheet	
Office of Nuclear Regulatory Research	
Worksheet Date:	09/25/2006
Analysis Status:	Final
Plant Name:	**Catawba**
Affected Unit Number(s):	**Units 1 and 2**
Event Title:	**Duel Unit Loss of Offsite Power Event**
Occurrence/Discovery Date:	**05/20/2006**
Licensee:	Duke Energy Nuclear, LLC
Docket Number(s):	05000413, 414
Inspection Report Number(s):	05000413/2006-009 and 05000414/2006-009 (AIT), 06/29/2006
Enforcement Action Number:	na
LER Number(s):	413/2006-001-00
LER Date:	07/19/2006
ASP Analysis Number	
Unit 1:	413-06-001
Unit 2:	414-06-001
ASP Analysis Type:	Initiating Event - Loss of Offsite Power
Lead Analyst:	Don Marksberry
SRA Reviewer(s):	Walt Rogers
ASP Reviewer(s):	Gary DeMoss
MD 8.3 Result:	na
ASP Results	
Unit 1:	**CCDP = 9E-5**
Unit 2:	**CCDP = 6E-5**
Table of Contents:	Title Page
	Facts
	Assumptions
	SPAR Model Changes
	Results
	Attachment 1 - Sequence of Events
	Attachment 2 - SPAR-H Adjustments
	End Notes
	References
	Figures

DESCRIPTION OF EVENT (FACTS)		
Worksheet Date:	09/25/2006	
(Loss of Offsite Power Version)		
Plant Response		Reference
1. Reactor Trip:	Both units	(1) IR
2. Trip initiator:	Loss of Offsite Power (LOOP) to reactor coolant pumps (RCPs)	(1) IR
3. Time of trip/LOOP:	14:01:45	(1) IR
4. Pressurizer power-operated relief valve (PORV) lift		
a. Unit 1:	1NC-32B stroked 5 times; 1NC-34A stroked 57 times	(1) IR
b. Unit 2:	2NC-34A stroked 35 times	(1) IR
5. Status of balance-of-plant (BOP) systems	Full LOOP; BOP not available	(2) LER
6. Automatic/Manual actuation of safety systems		
a. Safety injection pump(s):	Not demanded	(1) IR
b. Auxiliary feedwater (AFW) pump(s):	All AFW pumps auto started (2 motor-driven pumps, 1 turbine-driven pumps) each unit	(1) IR
c. Other systems:	None reported in inspection report or Licensee Event Report (LER)	
7. Emergency diesel generator (EDG) operations during the event		
a. EDGs automatically started and load:	All EDGs operated as designed (2-EDGs per unit)	(1) IR
b. Run time of longest running EDG:	11 hrs 9 min	(1) IR
c. Any problems with an EDG reported?	No problems reported during the LOOP event	IR/LER
8. Alternate ac power source operations		
a. Alt. ac source started and load:	Standby Shutdown Facility (SSF) diesel generator not needed given that all EDGs operated successfully through out the event	(1) IR
b. Start time (after LOOP initiator):	na	
c. Run time of longest running generator:	na	
d. Any problems reported?	na	
9. Electrical grid and switchyard status	Offsite power sources to the switchyard were only momentary lost during the event. Power to the Yellow and Red buses was automatically restored within a fraction of a second after the fault was isolated. See note 3.	(8) SRI
Complications, Failures, Degradations	**Cause**	Reference
Failed equipment		
1. (Unit 1) Main transformer 1A not available to provide offsite power to vital bus 1ETA (feed from main transformer 1B was available)	Zone 1A lockout of Power Circuit Breakers (PCBs) 18 and 17	(1) IR

2. (Unit 2) Main transformer 2B not available to provide offsite power to vital bus 2ETB (feed from main transformer 2A was available)	Zone 2B lockout of Power Circuit Breakers (PCBs) 23 and 24	(1) IR
3. (Unit 1) Excess letdown control valve fail to open on demand	Variable orifice control valve fail to close	(1) IR
4. (Unit 1) Pressurizer heaters did not energize	Blown control circuit fuse	(2) LER
5. Train A control room area chilled water system chiller did not automatically start once signal from load sequencer was received. Chiller was manually started.	Loose wire on the program timer within the chiller control panel	(2) LER
Equipment performance degradations/complications		
6. (Unit 1) 2 days later - Water overflow from cooling tower spreads into EDG Room 1A. Both sump pumps failed following being submerged.	Due to unsealed electrical conduits	(1) IR
7. (Unit 1) 2 days later - High RCP stator winding temps on two pumps resulted in the decision to cool down to Mode 5 using natural circulation.	Cause due to biological debris swept into the motor coolers when the source of cooling water swapped from normal containment chilled water system to backup nuclear service water system on the loss of offsite power.	(1) IR
Operator response issues		
8. Initial notification to the NRC Operations Center was made 61 min. late	The senior reactor operator normally available to make the notifications was tasked with plant recovery and procedure implementation responsibilities; and failure to task a non-licensed operator to make the call.	(2) LER
Recovery Actions Taken During Event		Reference
1. Offsite power restored to first vital bus		
a. Unit 1:	9 hrs 1 min (4 kV Bus 1ETB)	(1) IR
b. Unit 2:	9 hrs 29 mins (4 kV Bus 2ETA)	(1) IR
2. Offsite power restored to all vital buses		
a. Unit 1:	11 hrs 9 mins	(1) IR
b. Unit 2:	9 hrs 51 mins	(1) IR
3. Offsite power recovered past electrical fault to first (usually non-vital) bus	Power restored to 6.9kV buses: 6 hrs 38 mins (Unit 1); 6 hrs 25 mins (Unit 2)	(1) IR
4. Problems in restoring offsite power:		
No operator action was needed to restore power to the Yellow and Red switchyard buses. Paths with no faults were available from Zone 1A (Unit 1) and Zone 2B (Unit 2) to vital loads. Emergency operating procedure (EOP) ECA-0.0 provides instructions for restoring offsite power from the switchyard to vital loads using a zone from either unit. The expansive time actually taken during the event to restore power to vital buses was due to precautions and not complications experienced in the event.		(8) SRI
5. Failed or out-of-service equipment restored during event		
None		

Plant Configuration Prior to Reactor Trip		Reference
1. Equipment out of service	None reported in inspection report or LER	
2. Unusual electrical power lineups	None reported in inspection report or LER	
3. Power history (last plant shutdown)		
Cause of LOOP		Reference
Licensee has concluded the initiating event was the X phase of the current transformer to PCB 18. Losing PCB 18 should have caused only a 50% runback on Catawba Unit 1 and nothing on Unit 2. However, because the switchyard differential relays were not set correctly (since initial construction), several switchyard breakers to trip sooner than they should have, on undercurrent. In the end, enough breakers tripped to cause a total loss of offsite power to both units.		(1) IR
Unique Plant Design Features		Reference
1. Number of EDGs per unit:	2	(3) FSAR
2. Alternate ac power source(s):	One diesel generator (non-safety) in SSF with limited capability (see below description)	(3) FSAR
3. Rated battery depletion times		
a. Station batteries:	2 hours (w/o load shedding); 4 hours (w/ load shedding)	(3) FSAR
b. SSF batteries:		
c. Switchyard batteries:	4 hours (EOP ECA-0.0, Enclosure 22)	
d. Procedures for load shedding:	Yes, EOP ECA-0.0 (Enclosure 12 for station batteries and Encl. 22 for switchyard batteries)	
4. Reactor Coolant Pump Seal Design:		
a. Seal design type	High temperature seals on all pumps	SRA
b. Coping time w/o seal injection/cooling	13 mins. ECA-0.0, Enclosure 2, provides instructions for establishing seal injection from the SSF during SBO.	
5. Cross ties between units		
a. Shared EDG?	No	(4) IPE
b. Bus cross connect(s):	No	(4) IPE
c. AFW:	No	(4) IPE
d. Other event-important cross ties:	Each 4 kV vital bus can be powered from a designated main transformer from the other unit. ECA-0.0, Enclosure 7 provides the necessary instructions to perform this crosstie.	(9) EOP
6. Diesel driven pumps	None	
7. PZR PORV block valves closed at power:	No	
8. Delineation of owner controlled breakers in switchyard and alternate ac power source(s)	No alternate ac blackout power source other than the SSF	(4) FSAR

a. Plant control boundary	Hardwired controls are provided in the control room for eight PCB's and four motor operated disconnects associated with the unit feeder. The remaining breakers are controlled from the area operating center via a supervisory system.	(4) FSAR
b. Breaker controls and start capability in control room	(U1) PCBs 14, 15, 17, 18. (U2) PCBs 20, 21, 23, 24.	(9) EOP
c. Communications needed with outside organization (including another control room of a multi-unit site)	Transmission Control Center available 24-hours, 7 days a week (24/7)	(9) EOP
d. Availability of outside organizations (24/7)	Transmission Control Center available 24/7	(9) EOP
9. Standby Shutdown Facility (SSF) - designed to provide an alternate and independent means to achieve and maintain hot standby conditions for one or both units. SSF features include: one diesel generator, SSF heating, ventilation, and air conditioning (HVAC) system, ac and dc power supplies to key components and instrumentation, one standby makeup pump for each unit (26 gpm), instrumentation and controls for remote operation of the turbine-driven AFW pump, manual action required to start the SSF.		(4) IPE
10. AFW turbine-driven pump (TDP). Features include: one TDP per unit; each AFW pump mounted in a separate pit for NPSH requirements; cooling water from the turbine oil cooler empties directly into the TDP pit (if the sump is not drained, failure of the TDP could occur as early as 3 hours); one of the two sump pumps for the TDP is power from the SSF; HVAC is not needed for the operation of the TDP; air-operated flow throttle valve for the TDP fails in the 50% position upon the loss of air (a handjack provides local operation of the air-operated valve).		(4) IPE
Reference List ()		

ANALYSIS ASSUMPTIONS				
Worksheet Date:	09/25/2006			
Key Event-Related Fact	**Assumption**	**Basis**	**Fault Tree/Basic Event/Project Rule**	**Model Change**
Note: The SPAR model changes discussed below are made to reflect the modeling of the actual event.				
Duel unit loss of offsite (LOOP) event due to fault in switchyard	Model as switchyard centered dual unit LOOP initiating event	Reflect the actual event	GEM initiating event selection	Switchyard centered LOOP
			DUEL-UNIT-LOOP	Set to True. This function limits the power cross-ties from the opposite unit, since this event is a loss of offsite power event.
The earliest time that offsite power was restored to the first vital bus in either unit was 9 hrs following the LOOP initiator (Unit 1); however, power to the 6.9kV buses were restored at 6 hrs 25 mins (Unit 2).	**Assumption:** Power to the first vital bus could have been restored within 1 hour given a postulated station blackout. **Bases:** One-hour restoration possible: (1) switchyard energized---no action needed, (2) only one of two zones (main transformers locked out); no fault in the electrical success paths, (4) Emergency operating procedure (EOP) ECA-0.0, Enclosure 6, provided instructions for energizing vital loads from the switchyard to vital buses, (5) 30 mins needed to restore power from switchyard to vital loads, based on procedures and practice, and (6) lockouts identified during the actual event within 20 mins (would be idetnified sooner once ECA-0.0, Enclosure 6 is entered). Assume an extra 30 minutes to respond to initial transient and understand switchyard conditions (Ref. 8). See SPAR-H human reliability analysis (HRA) worksheets for SPAR model "OEP" events. Use same nonrecovery prob. for 6 hrs and 24 hrs. No other "OEP" basic events modeled in the Catawba SPAR model, other than 1, 2, 4, 6, and 24 hours.		OEP-XHE-XL-NR01H (see below for additional adjustment)	2.0E-01
			OEP-XHE-XL-NR02H	2.5E-02
			OEP-XHE-XL-NR04H	2.5E-02
			OEP-XHE-XL-NR06H	5.0E-04
			OEP-XHE-XL-NR024H	5.0E-04

Emergency operating procedure (EOP) abnormality: EOP for restoration of offsite power (ECA-0.0, Enclosure 6, Step 6) requires that **all** 6.9kV motor load breakers are open before the 6.9kV bus is energized. ("Do not continue in this procedure until all 6.9 KV motor load breakers are open.")	Assume offsite power can not be restored within 1 hour given that 1 of 42 breakers fail-to-close. Probability of 1 of 42 breakers fail-to-close is 2.6E-5/demand (Ref. 10) x 42 breakers (=0.11). For simplicity, add probability to OEP-XHE-XL-NR01H.	No credit given for intentional procedure violation. If a breaker fails to open on LOOP, then the operators would be procedurally held up. Time to locally open a 6.9kV breaker would most likely exceed the 1 hour that is needed to bring offsite power to the required vital loads (see SPAR-H HRA worksheet).	OEP-XHE-XL-NR01H	3.1E-01
Presssurizer power-operated relief valve (PORV) 1NC-32B stroked 5 times (Unit 1 PORV); 1NC-34A stroked 57 times (Unit 1 PORV); 2NC-34A stroked 35 times (Unit 2 PORV)	Model Pressurizer PORV fail to close (FTC) probability given the number of demands (see modeling uncertainty discussion below)	SPAR model top event. Reflect that PORVs were challenged during event.	PPR-SRV-CO-L	Set to True
			PPR-SRV-CO-SBO	Set to True
		ASP modeling method (FTC/demand x no. of demands). Reflect the potential increase in FTC probability given multiple demands; use updated PORV FTC probability of 1.6E-03/demand (Ref. 10). Note: GEM Calculation Type No. 9 (Base probability * Probability Field) selected in the "Event probability Change" Window with Probability Field = no. of demands.	PPR-SRV-OO-NC34A (Unit 1)	Prob. Field = 57 (GEM calculated total FTC prob. = 9.1E-2)
			PPR-SRV-OO-NC32B (Unit 1)	Prob. Field = 5; (GEM calculated total FTC prob. = 8.0E-3)
			PPR-SRV-OO-NC34A (Unit 2)	Prob. Field = 35; (GEM calculated total FTC prob. = 5.6E-2)
No equipment in test and maintenance (T/M) during the event	Use nominal T/M.	ASP modeling method	No changes required.	

Offsite power was recovered to the last vital bus 11 hours following the LOOP initiator	Emegency diesel generator (EDG), Standby Shutdown Facility (SSF) diesel generator (SSF-DG), and turbine-driven auxiliary feedwater (AFW) pump mission times are bounded by the longer of: (a) the 95th percentile of the industry average potential bus recovery time for switchyard-centered LOOPs or (b) the actual offsite power recovery time to the last vital bus plus 30 minutes for lineups.	ASP modeling method. Used longest EDG run time for both units. From NUREG/CR-6890, Vol. 1, Table 4.1, the 95th percentile is 5.3 hours (Ref. 11). Note: mission time set in GEM "Event Probability Change" Window in the "Mission Time" field	ZT-DGN-FR-L (for run times > 1 hr)	Set SPAR event mission time to 10.5 hrs (=11 hrs - 1 hr + 0.5 hr)
			ZT-TDP-FR-L (for run times > 1 hr)	Set SPAR event mission time to 10.5 hrs (=11 hrs - 1 hr + 0.5 hr)
Other complications: letdown system, pressurizer heaters, control room chillers	No additional changes to the model necessary.	Treated as distractions already factored into HRA of offsite power recovery [performance shaping factor (PSF) for complexity assumed to be highly complex]		
Complications occurring a day later: EDG room flooding, clams in the reactor coolent pump (RCP) motor cooler	Not modeled	Events occurred following 24-hour mission time of the LOOP initiating event		
Unknowns	**Key Information Needed**		**Temporary Resolution**	
See uncertainties				

Key Uncertainties	Reason	Resolution
PORV fail-to-close (FTC) probability	Pressurizer PORV fail-to-close parameter has high importance in dominating sequences. PORVs at Catawba (and McGuire) are unique in the industry in both design and operation. They are similar to a steam generator PORV (see note 4). The inspection of the PORVs during the LOOP event in 1996 showed no wear after 74 cycles---31 times passing water. Appling the standard method for calculating total failure probability given x demands may be conservative. Industry generic pressurizer PORV fail-to-close probability may not apply.	Perform sensitivity analyses to determine if ASP reject (<1E-6) or significant precursor (>1E-3). See results section. Relevant considerations to use existing ASP modeling method (no. of demands x failure to close probability) in best estimate analysis: (1) operating experience show that steam generator PORVs do fail to close on demand (Ref. 10), (2) operating experience show that pressurizer PORVs do fail on multiple cycles (Salem 1994), although of different design, (3) pressurizer PORVs are subject to higher pressure and boric acid environment; therefore, may be subject to a higher probability of initial sticking than steam generator PORVs, (4) operating experience with multiple cycling not documented in EPIX, and (5) NRC study on SRV/PORV reliability just underway and no other publicly available industry study to support justification of a lower failure probability given multiple cycles.
EDG room exhaust fan success criteria	Both exhaust fans are required for success in the SPAR model and Individual Plant Examination (IPE). Both fans are required when ambient temperature in EDG room exceeds 85 degrees F. Room temperature during the event was 78 degrees F with the EDG and both exhaust fans running (Ref. 8).	Use 2 of 2 success criteria. Given the lack of analysis to determine postulated room temperature with one fan and the importance of EDG room cooling is only about 9% of the CCDP.

SPAR MODEL CHANGES & UPDATES		
Worksheet Date:	09/25/2006	
SPAR Model Revision:	3.12	
SAPHIRE Code Revision:	7.26	
SPAR Model Changes to the Base Case Model (Enhancements and Fixes)		
Note: The SPAR model changes discussed below are made to update the model to reflect actual plant design/operations and parameters. These generic changes are made to the base case model.		
Fault Tree/Basic Event/Project Rule	**Model Change**	**Basis**
Basic Event: SSF-XHE-XM-LT	Update basic event SSF-XHE-XM-LT, "Operator Controls SSF in Long Term," assign HEP = 1.2E-2	HEP based on SPAR-H method. See SPAR-H HRA worksheet.
Basic event: ZT-FAN-FR-E	Lambda = 3.1E-04/hr	Update parameter using EPIX data for EDG exhaust fans (see Note 2). Mission run times are adjusted to that of the longest running emergency diesel generator (EDG) during the event (see assumption section). Note: mission time set in GEM "Event Probability Change" Window in the "Mission Time" field.
Basic event: ZT-FAN-FR-L	Lambda = 1.2E-04/hr	
Basic event: ZT-FAN-FS	7.1E-04/demand	

ANALYSIS RESULTS					
Worksheet Date	09/25/2006				
Run Cases	**Key assumptions**	**Results (Include Nominal TM)**			
		Point Est.	**5%tile**	**mean**	**95%tile**
Unit 1					
Best estimate	Offsite power restoration possible within 1 PORV fail to close model (cycling: 1.6E-3/demand x no. demands) SSF DG reliability same as EDG 10.5-hr mission times: EDG, SSF-DG, AFW TDP	9.1E-05	7.6E-06	8.6E-05	2.7E-04
Sensitivity A	Only one cycle each PORV	1.5E-05			
Sensitivity B	Only five cycles each PORV	2.4E-05			
Sensitivity C	SPAR model "OEP" HEPs: Stress and Complexity PSF level reduced to x2	4.5E-05			
Sensitivity D	SPAR model"OEP" HEPs: Stress or Complexity PSF level reduced to x2	5.9E-05			
Sensitivity E	Offsite power recovery NOT possible within	2.6E-04			
Sensitivity F	Sensitivity E & five cycles each PORV	4.8E-05			
Unit 2					
Best estimate	Offsite power restoration possible within 1 hr PORV fail to close model (cycling: 1.6E-3/demand x no. demands) SSF DG reliability same as EDG 10.5-hr mission times: EDG, SSF-DG, AFW TDP	5.9E-05	5.6E-06	5.6E-05	1.7E-04

Sequence of Events (Source: AIT report)

Catawba Unit 1

TIME	EVENT DESCRIPTION
20-May-06	
14:01:45	An internal fault occurred in a current transformer associated with power circuit breaker (PCB) 18. This fault resulted in a loss of the 230 kV Yellow and Red busses and a 1A Zone lockout.
14:01:49	The first-out annunciator was "NI Hi Flux Rate – Power Range"; however, a review of reactor power traces do not show any valid increase or change in reactor power at this time (NOTE: The licensee is reviewing data to determine the cause of this signal). Both reactor trip breakers open and control rods insert. The main turbine trips on receipt of the reactor trip signal.
14:02:13	Diesel generators 1A and 1B start and re-energize the 1ETA and 1ETB 4.16kV emergency busses as designed.
14:02:30	Both main feedwater pumps trip on Lo-Lo suction pressure as a result of the loss of the hotwell and condensate booster pumps. The auxiliary feedwater pumps (two motor-driven and one turbine-driven) start automatically and provide inventory makeup to the steam generators.
14:07:34	Letdown isolation occurs when pressurizer level reaches 17%. Excess letdown could not be established due to the failure of the excess letdown control valve to open on demand. Normal letdown was subsequently re-established through the fixed orifice line due to the variable orifice control valve failing closed following the LOOP and not re-opening.
14:08:02	Main Steam Isolation signal is received when the 1C steam generator pressure reached 775 psig on 2/3 channels. Secondary pressure control transitions to the steam generator PORV's.
14:12	Intermediate Range nuclear instrumentation drops below 1E-10 amps (P6 setpoint).
14:14	Operations Shift Manager declared a Notice of Unusual Event (Emergency Action Level 4.5.U.1, "AC electrical power from all offsite sources has been lost for more than 15 minutes with onsite power available") due to the dual unit loss of offsite power. Emergency Response Organization page sent to activate the Technical Support Center (TSC) and Operations Support Center (OSC) (See Emergency Event Notification timeline for details on the licensee's response to the event).
14:22	Due to the loss of pressurizer spray (no forced circulation following the loss of the reactor coolant pumps), two of three pressurizer PORV's begin to cycle to control primary system pressure. (See section 4OA5.4 for details on the pressurizer PORV lifts). No pressurizer safety valves opened during the event.

14:55	Normal letdown is restored through the fixed orifice line.
20:34	Unit is stabilized on natural circulation using emergency, abnormal and normal operating procedures. Primary system parameters are being controlled through the use of auxiliary feedwater and steam generator PORV's.
20:40	Offsite power is restored to the 6.9kV non-vital busses. Work is in-progress to energize the 4.16kV vital busses from offsite power and secure the diesel generators.
21:55	Final pressurizer PORV actuation. Total number of actuations during event on PORV 1NC-34A was 57 cycles and on PORV 1NC-32B, five cycles.
23:03	4.16kV vital bus 1ETB is aligned to offsite power.
23:06	1B diesel generator output breaker is opened. Actions initiated to secure the 1B diesel generator and place it in stand-by.
21-May-06	
1:11	4.16kV vital bus 1ETA is aligned to offsite power. Due to the 1A Zone lockout, power is being supplied from the Unit 2 A SAT using procedural guidance to establish the required alignment.
1:14	1A diesel generator output breaker is opened. Actions initiated to secure the 1A diesel generator and place it in stand-by.
1:40	Notice of Unusual Event is terminated following restoration of offsite power to all unit busses.
15:17	The 1B reactor coolant pump is placed in service restoring forced circulation in the primary system and providing normal pressurizer sprays for pressure control if required. Primary system is stabilized at 475 F and 1850 psig in Mode 3.
22-May-06	
6:03	The 1B reactor coolant pump motor stator winding temperatures increase to 295°F requiring the pump to be secured. The 1A reactor coolant pump is started.
8:35	Stator winding temperatures on the 1A reactor coolant pump motor increase and approach the 300°F operating limit. The pump is secured and the decision made to cool down to Mode 5 using natural circulation in order to place residual heat removal in service. (NOTE: The elevated temperatures were determined to have been caused by biological debris being swept into the motor coolers when the source of cooling water swapped from the normal containment chilled water system to the backup nuclear service water system on the loss of offsite power).
8:49	Briefing conducted to initiate a natural circulation Cooldown to Mode 5.
16:07	Unit 1 enters Mode 4
23-May-06	

9:09	Unit 1 enters Mode 5
---	The unit is stabilized at 170°F and 295 psig in Mode 5. The A train of residual heat removal is placed in-service for decay heat removal. The B train is placed in-service at 21:17. Repair and recovery actions are initiated.

Catawba Unit 2

TIME	EVENT DESCRIPTION
20-May-06	
14:01:45	An internal fault occurred in a current transformer associated with power circuit breaker (PCB) 18. This fault resulted in a loss of the 230 kV Yellow and Red busses and a 2B Zone lockout.
14:01:46	The first-out annunciator is "Under Frequency Conditions on the Reactor Coolant Pump Busses" as sensed by the reactor coolant pump monitoring circuit. Both reactor trip breakers open and control rods insert. The main turbine trips on receipt of the reactor trip signal.
14:02	Diesel generators 2A and 2B start and re-energize the 2ETA and 2ETB 4.16kV emergency busses as designed.
14:02	Both main feedwater pumps trip on Lo-Lo suction pressure as a result of the loss of the hotwell and condensate booster pumps. The auxiliary feedwater pumps (two motor-driven and one turbine-driven) start automatically and provide inventory makeup to the steam generators.
14:08:05	Letdown isolation occurs when pressurizer level reaches 17%. Excess letdown is placed in service. Normal letdown was subsequently re-established.
14:08:21	Main Steam Isolation signal is received when the 2A steam generator pressure reached 775 psig on 2/3 channels. Secondary pressure control transitioned to the steam generator PORV's.
14:27	Due to the loss of pressurizer spray (no forced circulation following the loss of the reactor coolant pumps), one of three pressurizer PORV's begins to cycle to control primary system pressure. (See section 4OA5.4 for details on the pressurizer PORV lifts). No pressurizer safety valves opened during the event.
14:13	Intermediate Range nuclear instrumentation drops below 1E-10 amps (P6 setpoint).
14:14	Operations Shift Manager declares a Notice of Unusual Event (Emergency Action Level 4.5.U.1, "AC electrical power from all offsite sources has been lost for more than 15 minutes with onsite power available") due to the dual unit loss of offsite power. Emergency Response Organization page is sent to activate the Technical Support Center (TSC) and Operations Support Center (OSC). (See Emergency Event Notification timeline for details on the licensee's response to the event)

18:10	Final pressurizer PORV actuation. Total number of actuations during event on PORV 2NC-34A was 35 cycles.
----------	Unit is stabilized on natural circulation using emergency, abnormal and normal operating procedures. Primary system parameters are being controlled through the use of auxiliary feedwater and steam generator PORV's.
20:27	Offsite power is restored to the 6.9kV non-vital busses. Work is in-progress to re-energize the 4.16kV vital busses from offsite power and secure the diesel generators.
23:31	4.16kV vital bus 2ETA is aligned to offsite power.
23:36	2A diesel generator output breaker is opened. Actions initiated to secure the 2A diesel generator and place it in stand-by.
23:53	4.16kV vital bus 2ETB is aligned to offsite power. Due to the 2B Zone lockout, power is being supplied from the Unit 1 B SAT using procedural
21-May-06	
23:57	2B diesel generator output breaker is opened. Actions initiated to secure the 2B diesel generator and place it in stand-by.
1:40	Notice of Unusual Event terminated following restoration of offsite power to all unit busses.
11:06	The 2B reactor coolant pump was placed in service restoring forced circulation in the primary system and providing normal pressurizer sprays for pressure control if required. Exited Natural Circulation EP and transitioned to OP/2/A/6100/002; Controlling Procedure for Unit Shutdown
12:00	The unit was stabilized at 460 F and 1900 psig in Mode 3. Recovery actions are initiated.
22-May-06	
11:00	Vacuum is reestablished in the main condenser allowing secondary pressure control to be transferred from the steam generator PORV's to the steam dumps and conserve inventory required to feed the steam generators.

SPAR-H HRA Worksheet			SSF-XHE-XM-SYSLT
Worksheet Date:	09/25/2006		
Basic Event:	**Operator Fails to Operate SSF in Long Term**		
Basic Event Context. After the manual initiation of Standby Shutdown Facility (SSF) during a station blackout (already modeled), operators must maintain steam generator (SG) level using the TDAFW pump from two locations: SG level indications in the SSF and at the auxiliary feedwater (AFW) flow control/block valves.			
Part I: Diagnosis		None	
Emergency operating procedure (EOP) provides instructions for maintaining SG levels from the SSF			
Part II: Action			
PSFs	**PSF Level**	**Multiplier**	**Basis for change from nominal**
Available Time	Nominal time (x1)	1.00	Four hours to battery depletion and low decay heat levels provide adequate time to prepare for local SG level control with the SSF indications
Stress/Stressors	High (x2)	2.0	SBO in progress; however, knowing power is available in switchyard, successful SSF operation, and staffed TSC/EOF does not present extreme stress
Complexity	Moderately complex (x2)	2.0	Must regulate AFW flow control locally while communicating with SSF for SG level indication; however, routine nature of these actions do not present a highly complex operation
Experience/ Training	Low (x3)	3.0	Local SG level control at the turbine-driven AFW pump while communicating with SSF for level indications is not an EOP action routinely practiced
Procedures	Nominal (x1)	1.0	All actions covered in EOP ECA-0.0
Ergonomics/HMI	Nominal (x1)	1.0	
Fitness for Duty	Nominal (x1)	1.0	
Work Processes	Nominal (x1)	1.0	
	Composite PSF	12	
	Nominal HEP	1.0E-03	
	Action HEP	1.2E-02	If no more than 2 negative PSFs are present
	HEP w/ Adjustment Factor	1.2E-02	If 3 or more negative PSFs are present
	Final Action HEP	**1.2E-02**	
Part III: HEP without Dependency			
	Diagnosis HEP	0	
	Action HEP	1.2E-02	
	Total HEP	**1.2E-02**	

Part III: Dependency		None	
	HEP w/ dependency	1.2E-02	Zero dependence
Part IV: Uncertainty Parameter			
	Alpha parameter	0.5	From SPAR-H Figure 2.6 (Ref. 7)
	Beta parameter	41.6	Beta = alpha*(1-HEP)/HEP

SPAR-H HRA Worksheet			OEP-XHE-XL-NR01H
Worksheet Date:	09/25/2006		
Basic Event:	**Operator Fails to Restore Offsite Power within 1 Hour**		
Basic Event Context: Station blackout sequences where the pressurizer PORV fails to close given demand results in the start of core uncovery in 1 hour. Offsite power sources to the switchyard were available throughout the LOOP event. Protective lockouts actuated on Unit 1 Zone A (trips PCB's 17 and 18, GCB 1A) and Unit 2 Zone B (trips PCB's 23 and 24, and GCB 2B); however, the other zone in each unit did not received a lockout. A zone lockout basically prevents the use of one of two main step-up transformers in each unit, until the lockout has been reset (and the cause of the lockout been determined). A zone lockout would prevent power from being restored to one of two vital bus divisions; however, that division could be powered from the other unit's main transformer (e.g., Unit 1 4 kV bus 1ETA powered from Unit 2 zone 2B; Unit 2 4 kV bus 2ETB powered from Unit 1 zone 1A).			
No faults or lockouts would have prevented restoration of power from the unaffected zone path in each unit. Operators identified the zone lockouts in 20 minutes (Ref. 8) following the LOOP initiator. Emergency operating procedure (Ref. 9) provided sufficient instructions to restore power to the vital bus. Other relevant information provided in the basis for the performance shaping factors (PSFs), below.			
Part I: Diagnosis		None	
No diagnosis required. Emergency operating procedures (EOPs) will alert the operators of station blackout conditions and loss of RCS inventory			
Part II: Action			
PSFs	**PSF Level**	**Multiplier**	**Basis for change from nominal**
Available Time	Time available is about the time required (x10)	10.00	Just enough time to restore offsite power to vital loads within one hour: (1) zone lockout was actually discovered 20 min. into the event (Ref. 8), (2) about 25-30 minutes needed to implement ECA-0.0 and ECA-0.2 to restore offsite power from the switchyard (already energized), through the main transformer of the available zone, and to required vital loads (Ref. 8); (3) weekend staffing level would take longer to perform actions; and (4) other control room activities, such as offsite notifications, declaration of an emergency (SAE or GE), taking calls from offsite organizations, site evacuation, etc., would further reduce staffing.
Stress/Stressors	Extreme (x5)	5.0	Extreme stress: (1) blackout conditions; (2) core uncovery imminent without immediate operator action; (3) operators may not be aware that power restoration would work, given that the origin of the faults in the switchyard was not known; and (4) distractions from offsite notifications and emergency declaration activities.

Complexity	Highly complex (x5)	5.0	Highly complex: many multiple, concurrent steps required---communications with the load dispatcher and operators in the switchyard and plant will be required.
Experience/ Training	Nominal (x1)	1.0	Offsite power recovery actions in EOPs are routinely practiced (Ref. 8).
Procedures	Nominal (x1)	1.0	All actions covered in EOP ECA-0.0
Ergonomics/HMI	Nominal (x1)	1.0	
Fitness for Duty	Nominal (x1)	1.0	
Work Processes	Nominal (x1)	1.0	
	Composite PSF	250	
	Nominal HEP	1.0E-03	
	Action HEP	2.5E-01	If no more than 2 negative PSFs are present
	HEP w/ Adjustment Factor	2.0E-01	If 3 or more negative PSFs are present
	Final Action HEP	**2.0E-01**	
Part III: HEP without Dependency			
	Diagnosis HEP	0	
	Action HEP	2.0E-01	
	Total HEP	**2.0E-01**	
Part III: Dependency		None	
	HEP w/ dependency	2.0E-01	Zero dependence
Part IV: Uncertainty Parameter			
	Alpha parameter	0.435	From SPAR-H Figure 2.6 (Ref. 7)
	Beta parameter	1.7	Beta = alpha*(1-HEP)/HEP

SPAR-H Worksheet			OEP-XHE-XL-NR02H
Worksheet Date:	09/25/2006		
Basic Event:	**Operator Fails to Restore Offsite Power within 2 Hours**		
Basic Event Context: SBO sequences where the turbine-driven AFW pump fails resulting in the start of core uncovery in 2 hours. Refer to context description for OEP-XHE-XL-NR01H. Other relevant information provided in the basis for the performance shaping factors (PSFs), below.			
Part I: Diagnosis		None	
No diagnosis required. Emergency operating procedures will alert the operators of station blackout conditions and loss of secondary cooling			
Part II: Action			
PSFs	**PSF Level**	**Multiplier**	**Basis for change from nominal**
Available Time	Nominal time (x1)	1.00	Nominal time to restore offsite power to vital loads: (1) zone lockout was actually discovered 20 min. into the event (Ref. 8), (2) about 25-30 minutes needed to implement ECA-0.0 and ECA-0.2 to restore offsite power through the switchyard, through the main transformer of the available zone, and to required vital loads (Ref. 8); and (3) Technical Support Center activated 1 hour 37 minutes into the event (pagers set off within 12 minutes following the LOOP initiator, so additional staffing would be arriving at the site soon thereafter).
Stress/Stressors	Extreme (x5)	5.0	Same as for OEP-XHE-XL-NR01H.
Complexity	Highly complex (x5)	5.0	Same as for OEP-XHE-XL-NR01H.
Experience/Training	Nominal (x1)	1.0	Same as for OEP-XHE-XL-NR01H.
Procedures	Nominal (x1)	1.0	Same as for OEP-XHE-XL-NR01H.
Ergonomics/HMI	Nominal (x1)	1.0	
Fitness for Duty	Nominal (x1)	1.0	
Work Processes	Nominal (x1)	1.0	
	Composite PSF	25	
	Nominal HEP	1.0E-03	
	Action HEP	2.5E-02	If no more than 2 negative PSFs are present
	HEP w/ Adjustment Factor	2.4E-02	If 3 or more negative PSFs are present
	Final Action HEP	**2.5E-02**	
Part III: HEP without Dependency			
	Diagnosis HEP	0	
	Action HEP	2.5E-02	
	Total HEP	**2.5E-02**	

Part III: Dependency		None	
	HEP w/ dependency	2.5E-02	Zero dependence
Part IV: Uncertainty Parameter			
	Alpha parameter	0.495	From SPAR-H Figure 2.6 (Ref. 7)
	Beta parameter	19.3	Beta = alpha*(1-HEP)/HEP

SPAR-H Worksheet			OEP-XHE-XL-NR04H
Worksheet Date:	09/25/2006		
Basic Event:	**Operator Fails to Restore Offsite Power within 4 Hours**		
Basic Event Context: Station blackout (SBO) sequences where the station batteries deplete (with load shedding) resulting in the start of core uncovery in 4 hours. Plant staff would take diligent actions to restore ac power. Refer to context description for OEP-XHE-XL-NR01H. Other relevant information provided in the basis for the performance shaping factors (PSFs), below.			
Part I: Diagnosis		None	
No diagnosis required. Emergency operating procedures will alert the operators of station blackout conditions and loss of dc power			
Part II: Action			
PSFs	**PSF Level**	**Multiplier**	**Basis for change from nominal**
Available Time	Nominal time (x1)	1.00	Same as for OEP-XHE-XL-NR02H. Not quite 5 times the time required to justify a lower PSF level multiplier.
Stress/Stressors	Extreme (x5)	5.0	Same as for OEP-XHE-XL-NR01H.
Complexity	Highly complex (x5)	5.0	Same as for OEP-XHE-XL-NR01H.
Experience/Training	Nominal (x1)	1.0	Same as for OEP-XHE-XL-NR01H.
Procedures	Nominal (x1)	1.0	Same as for OEP-XHE-XL-NR01H.
Ergonomics/HMI	Nominal (x1)	1.0	
Fitness for Duty	Nominal (x1)	1.0	
Work Processes	Nominal (x1)	1.0	
	Composite PSF	25	
	Nominal HEP	1.0E-03	
	Action HEP	2.5E-02	If no more than 2 negative PSFs are present
	HEP w/ Adjustment Factor	2.4E-02	If 3 or more negative PSFs are present
	Final Action HEP	**2.5E-02**	
Part III: HEP without Dependency			
	Diagnosis HEP	0	
	Action HEP	2.5E-02	
	Total HEP	**2.5E-02**	
Part III: Dependency		None	
	HEP w/ dependency	2.5E-02	Zero dependence
Part IV: Uncertainty Parameter			
	Alpha parameter	0.495	From SPAR-H Figure 2.6 (Ref. 7)
	Beta parameter	19.3	Beta = alpha*(1-HEP)/HEP

SPAR-H Worksheet			OEP-XHE-XL-NR06H
Worksheet Date:	09/25/2006		
Basic Event:	**Operator Fails to Restore Offsite Power within 6 Hours**		
Basic Event Context: Non-station blackout LOOP sequence where high-pressure feed & bleed cooling is successful and operators were able to restore offsite power with sufficient time to recover secondary side cooling prior to FWST depletion and recirculation sump switchover. Most likely, important cutsets will include an EDG failure in one train and a AFW pump failure in the other train. Refer to context description for OEP-XHE-XL-NR01H. Other relevant information provided in the basis for the performance shaping factors (PSFs), below.			
Part I: Diagnosis		None	
No diagnosis required. Emergency operating procedures (EOPs) will alert operators for the need to recover power given unavailability of important equipment.			
Part II: Action			
PSFs	**PSF Level**	**Multiplier**	**Basis for change from nominal**
Available Time	Time available > 5x the time required (x0.1)	0.10	Offsite power could be restored to vital load(s) within one hour, See basis for OEP-XHE-XL-NR01H.
Stress/Stressors	Nominal (x1)	1.0	Failure to restore power within 6 hours does not mean core uncovery. Failure to establish high-pressure recirculation is also needed to complete the core damage sequence.
Complexity	Highly complex (x5)	5.0	Same as for OEP-XHE-XL-NR01H. May require offsite power feed through other unit's main transformer, depending on the train needing to be restored.
Experience/Training	Nominal (x1)	1.0	Same as for OEP-XHE-XL-NR01H.
Procedures	Nominal (x1)	1.0	All actions covered in EOP ECA-0.0
Ergonomics/HMI	Nominal (x1)	1.0	
Fitness for Duty	Nominal (x1)	1.0	
Work Processes	Nominal (x1)	1.0	
	Composite PSF	0.5	
	Nominal HEP	1.0E-03	
	Action HEP	5.0E-04	If no more than 2 negative PSFs are present
	HEP w/ Adjustment Factor	5.0E-04	If 3 or more negative PSFs are present
	Final Action HEP	**5.0E-04**	
Part III: HEP without Dependency			
	Diagnosis HEP	0	
	Action HEP	5.0E-04	
	Total HEP	**5.0E-04**	

Part III: Dependency		None	
	HEP w/ dependency	5.0E-04	Zero dependence
Part IV: Uncertainty Parameter			
	Alpha parameter	0.5	From SPAR-H Figure 2.6 (Ref. 7)
	Beta parameter	1000	Beta = alpha*(1-HEP)/HEP

Worksheet Date:	09/25/2006

Note 1. EDG and AFW TDP Unreliability Parameters for Catawba

06/20/2006
S.A.Eide, INL

Plant-specific estimates for EDGs and AFWS TDP for Catawba Units 1 and 2 (EPIX data for Catawba for 1997 - 2005)

EDG mission time (h)	24
TDP mission time (h)	24

		Industry Average			Industry Average CNID			Plant-Specific Data (both units)			Updated Plant-Specific Distributions: Industry Average Prior			Updated Plant-Specific Distributions: Industry Average CNID Prior			Distribution
Component	Failure Mode	Mean	Alpha	Beta	Mean	Alpha	Beta	Failures	Demands	Hours	Mean	Alpha	Beta	Mean	Alpha	Beta	Type
EDG	FTS	4.53E-03	1.075	236.2	4.53E-03	0.500	109.9	1	1413		1.26E-03	2.075	1648.2	9.85E-04	1.500	1521.9	Beta
	FTLR (note a	2.90E-03	1.445	498.3	2.90E-03	0.500	171.9	5	1177		3.84E-03	6.445	1670.3	4.08E-03	5.500	1343.9	Beta
	FTR	8.48E-04	2.016	2377.0	8.48E-04	0.500	589.6	1		4729	4.24E-04	3.016	7106.0	2.82E-04	1.500	5318.6	Gamma
	UA	9.01E-03	5.880	236.2	9.01E-03	0.500	55.0	9.8E-3 (ROP SSU 2003 - 2005)			9.80E-03			9.80E-03			Beta
									(note b)								
TDP (AFW)	FTS	6.88E-03	0.414	59.8	6.88E-03	0.500	72.2	1	200		5.43E-03	1.414	258.8	5.50E-03	1.500	271.2	Beta
	FTR≤1H	2.64E-03	0.805	304.9	2.64E-03	0.500	189.4	0		115	1.92E-03	0.805	419.9	1.64E-03	0.500	304.4	Gamma
	FTR>1H	7.35E-05	0.500	6803.0	7.35E-05	0.500	6802.7	0		0	7.35E-05	0.500	6803.0	7.35E-05	0.500	6802.7	Gamma
	UA	5.05E-03	3.330	59.8	5.05E-03	0.500	59.8	8.0E-3 (ROP SSU 2003 - 2005)			8.00E-03			8.00E-03			Beta
									(note c)								

a. Includes output circuit breaker
b. Planned and unplanned outages
c. Planned and unplanned outages. Average of MDPs and TDPs (data do not indicate which trains are TDPs).

Recommended Distributions

EDG total UR = FTS + FTLR + FTR*23h + UA =	3.59E-02	Industry average
	2.47E-02	Updated plant-specific
	2.13E-02	Updated plant-specific using CNID prior
TDP total UR = FTS + FTR≤1H*1h + FTR>1H*23h + UA =	1.63E-02	Industry average
	1.70E-02	Updated plant-specific
	1.68E-02	Updated plant-specific using CNID prior

Note 2. Industry-average EPS FAN unreliability estimates (no plant-specific data in EPIX for Catawba EPS FANS)

The draft data NUREG/CR generated FAN unreliability estimates using FAN data from a variety of systems. A more detailed look at the data would investigate whether unreliability estimates could be generated for each system. This analysis looks at FAN data (EPIX, 1998 - 2002) only within the EPS. Catawba did not report such data to EPIX, so only industry-average results are generated here.

		Industry Data - All Systems (EPIX, 1998 - 2002)			Industry Data - EPS Only (EPIX, 1998 - 2002)			All FANs			EPS FANs Only			
Component	Failure Mode	Failures	Demands	Hours	Failures	Demands	Hours	Mean	Alpha	Beta	Mean (MLE)	Alpha	Beta	Distribution Type
FAN	FTS	33	25099.0		5	7073.8		2.89E-03	0.300	103.9	7.07E-04	0.500	706.9	Beta
	FTR≤1H	19		17019.0	1		3234.2	1.91E-03	0.348	181.8	3.09E-04	0.500	1617.1	Gamma
	FTR>1H	8.00		76434.0	1.18		9880.1	1.11E-04	8.480	76430.0	1.19E-04	0.500	4186.5	Gamma
	UA				Included in EDG UA									

Recommended Distributions

FAN total UR = FTS + FTR≤1H*1h + FTR>1H*23h + UA =	7.35E-03	FAN data for all systems
	3.76E-03	FAN data for EPS only

The EPS FAN total UR of 3.76E-3 (24-h mission) is 20% of the EDG total UR of 2.13E-2 (24-h mission). The EPIX data indicated that EDG failures resulting from the HVAC support system are probably less than 5% of the total EDG failures, so the results generated here for EPS FAN unreliability estimates may be conservatively high.

09/25/2006

NOTES

3 **E-mail from senior resident inspector (08/08/2006).** All of power circuit breakers (PCBs) in the switchyard automatically reclose when the fault is cleared, except for the zoned breakers associated with the main transformers. Auto closure actually occurred that day (of the event) on all of those breakers and takes a few hundredsth of a second. The zoned breakers could be operated by the operators in the control room located on the control room panels, based on conditions. None of this requires action from the Transmission Control Center (TCC).

4 **E-mail from senior resident inspector (06/23/2006).** Both Catawba and McGuire are set up the same when it comes to PORV operation. These two plants are the only plants in the country that have the type of valve that is installed. They are similiar to a steam generator PORV. One of the two PORVs in the system are set up to operate using a proportional controller. One PORV will use the proportional controller set at 2235 and the other is set at 2335 and will not use the proportional controller. Either valve can be setup to use the propotional controller. The proportional controller uses Pref as a setpoint and has a 20# blowdown to restore pressure back to Pref, with a 7 cycle time constant whenever the actual pressure is above Pref. This means that whenever the pressure is above Pref the valve will cycle about 7 times to get the pressure back to Pref. This provides for a very controlled parabolic pressure control curve. The proportional controller was setup to replace and act similar to the pressurizer spray valve in this scenario; i.e.- natural circulation which is when the spray valve doesn't work.

5 Parameter uncertainties for "OEP" human error probability (HEP) events are based SPAR-H method (Ref. 7). SAPHIRE/GEM code uses the beta distribution. The beta distribution requires two parameters, alpha and beta. Figure 2-6 in Ref. 7 shows the numerical value of a as a function of the HEP. For example, using the SPAR-H HRA worksheet, if one determines that the HEP has a value of 0.3, the value of alpha (from the curve) is 0.42. The second parameter, beta, is found via the equation:

$$\beta = \frac{\alpha(1 - HEP)}{HEP}$$

In the case where the HEP is 0.3, b is found to be 0.98. The beta factor is entered in the "Event Probability Changes" Window, under the Uncertainty Data section with the beta value entered in the "b" field. The alpha value is not entered.

References

(1) IR — Catawba Nuclear Station - NRC Augmented Inspection Team (AIT) Report 05000413/2006009 and 050000414/2006006, June 29, 2006

(2) LER — LER 413/2006-001-00, Loss of Offsite Power Event Resulted in Reactor Trip of Both Catawba Units from 100% Power, July 19, 2006

(3) SPAR — Catawba SPAR Model, Revision 3.31, March 2006

(4) FSAR — Catawba Undated Final Safety Analysis Report, Revision 10, March 27, 2003

(5) IPE — Catawba Individual Plant Examination

(6) IPEEE — na

(7) SPAR-H — NUREG/CR-6883, "The SPAR-H Human Reliability Analysis Method," August 2005.

(8) SRI — Various telephone discussions with Gene Guthrie, Senior Resident Inspector at Catawba

(9) EOPs — EP/1/A/5000/ECA-0.0, Loss of All AC Power, Revision 28

EP/1/A/5000/ECA-0.2, Loss of All AC Power Recovery With S/I Required, Revision 17

(10) — Draft NUREG/CR-XXXX (INL/EXT-06-11119), "Industry Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants," May 2006.

(11) — NUREG/CR-6890, Vol. 1, "Reevaluation of Station Blackout Risk at Nuclear Power Plants---Analysis of Loss of Offsite Power Events: 1986-2004," December 2005.

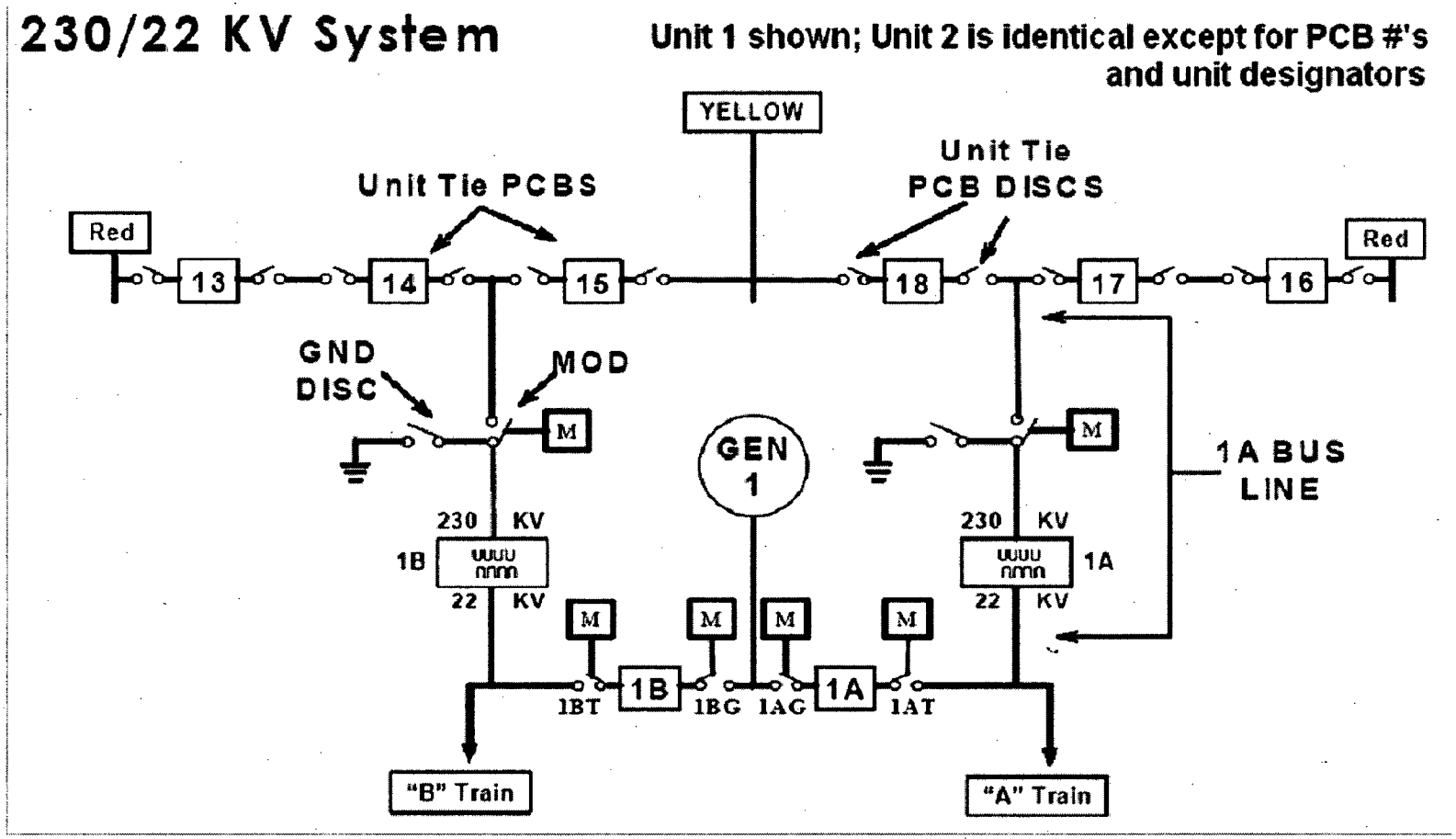


Figure 3. Main Generator and Switch Yard
(Source: AIT Report)

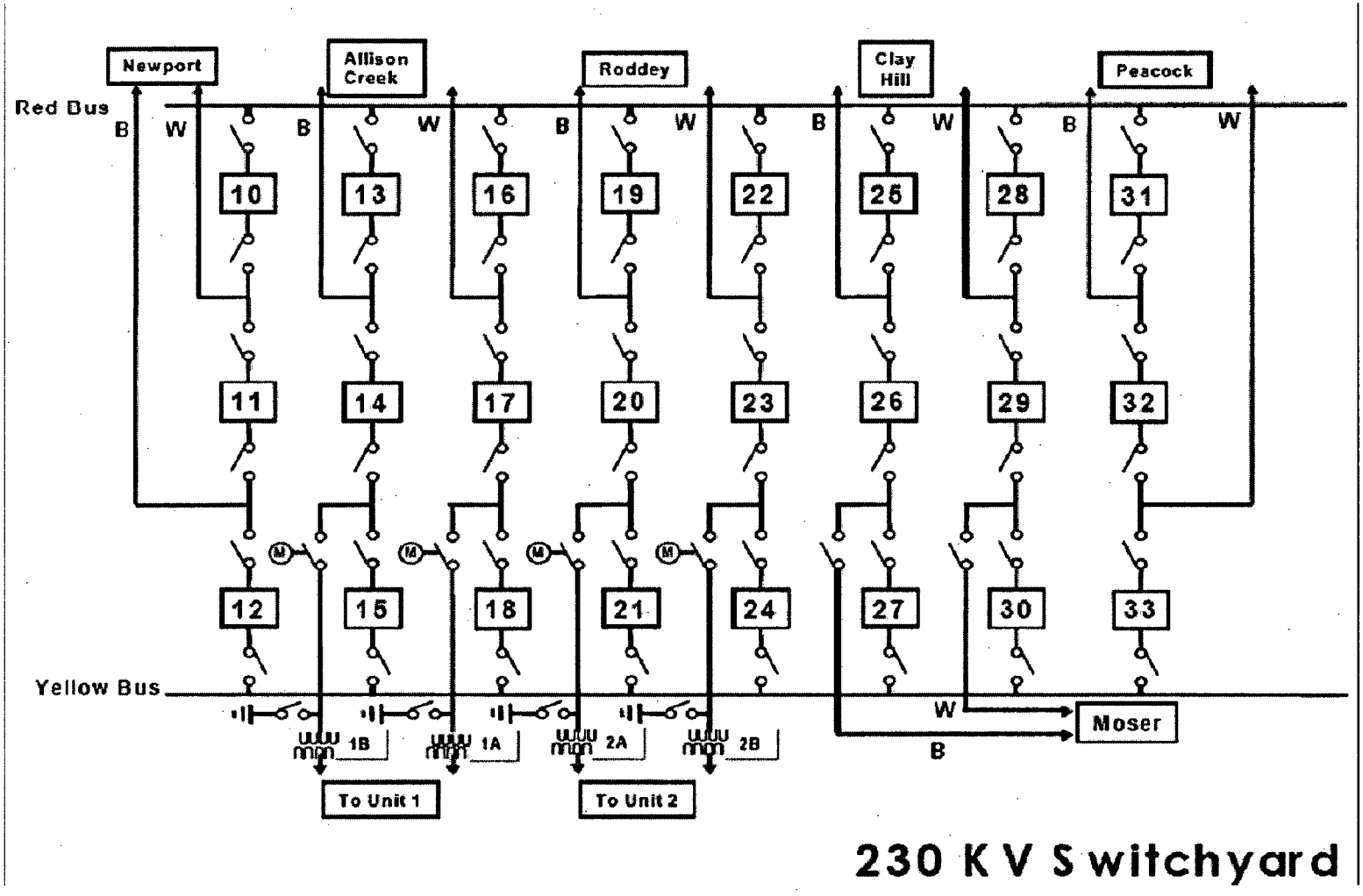


Figure 4. Switchyard
(Source: AIT Report)

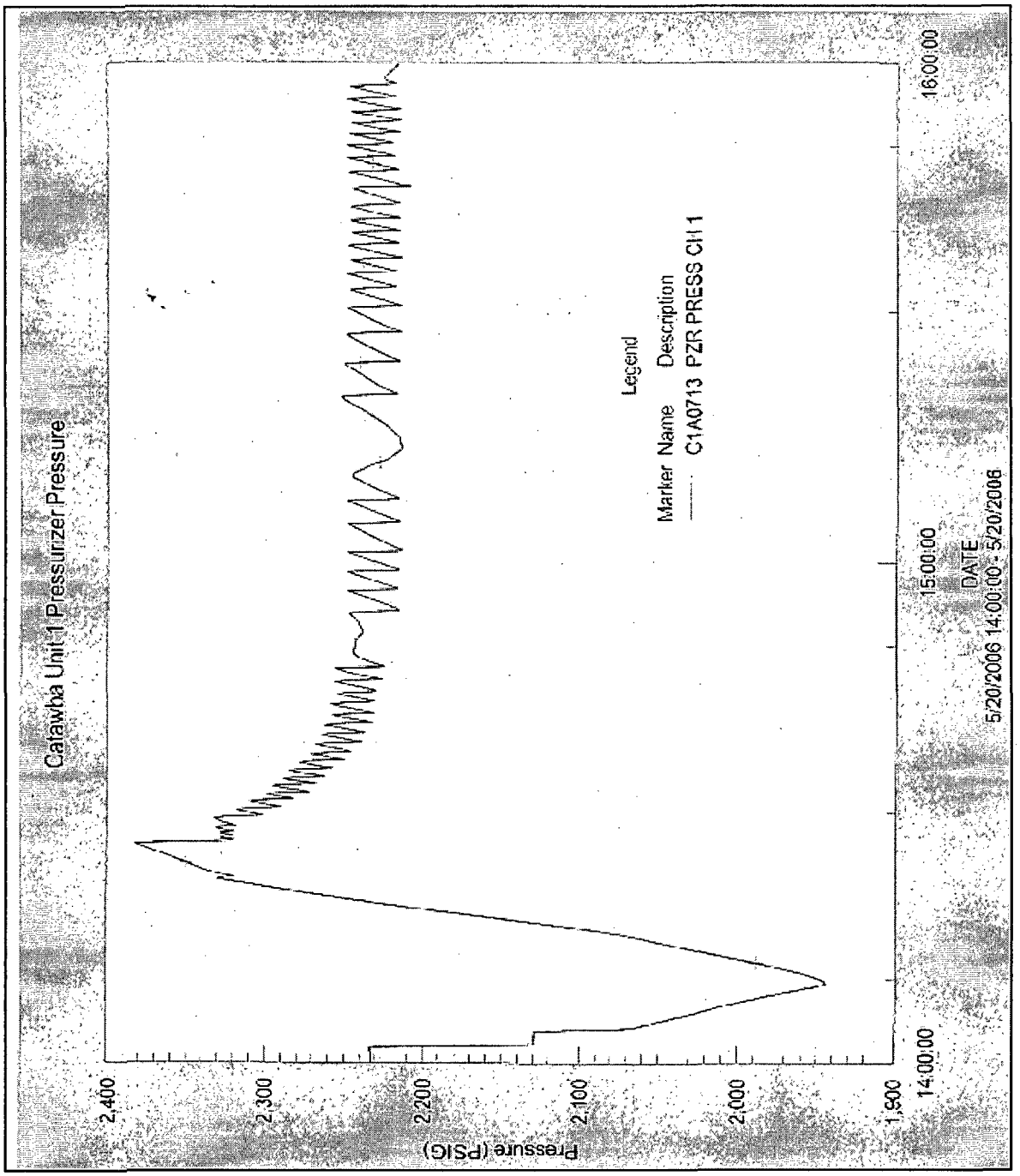


Figure 5a. Unit 1 Primary pressure showing response from pressureizer PORV cycling.
(Source: AIT Report)

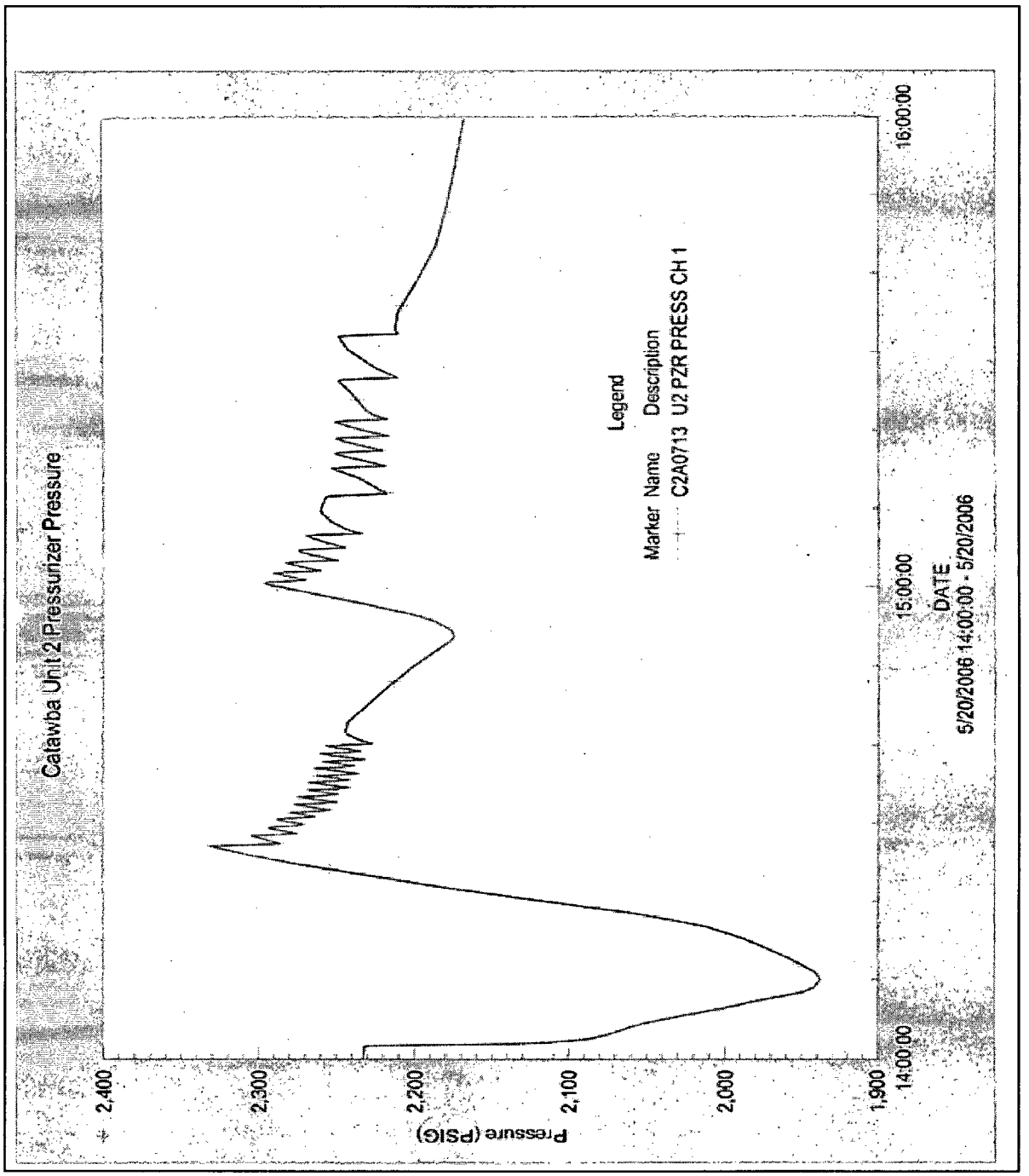


Figure 5b. Unit 2 Primary pressure showing response from pressureizer PORV cycling.
(Source: AIT Report)

CATAWBA (Unit 1) LOOP Initiating Event - Final ASP Analysis

Code Ver : 7:26
Fam : CATA_3P
Model Ver : 2006/03/10
User : INEEL
Init Event: IE-LOOP
Ev ID: U1-LOOP-BEST-ESTIMATE
Total CCDP: 9.0E-005
Desc : Best estimate - W/ TM, credit recovery at 1 h (0.3)

BASIC EVENT CHANGES

Event Name	Description	Base Prob	Curr Prob	Type
AFW-XHE-XL-SUMPPUMPS	OPERATOR FAILS TO RECOVER SU	1.0E+000	1.0E+000	TRUE
CCW-MDP-TM-1A1	CCW MDP 1A1 Unavailable due	8.0E-003	+0.0E+000	IGNORE
CCW-MDP-TM-1A2	CCW MDP 1A2 Unavailable due	8.0E-003	+0.0E+000	IGNORE
CCW-TRN-TM-TRAINA	CCW Train A Unavailable due	+0.0E+000	+0.0E+000	IGNORE
DUAL-UNIT-LOOP	Probability that a LOOP is a	5.8E-001	1.0E+000	TRUE
IE-ISL-HPI	ISLOCA IE 2-CKV HPI interfac	4.6E-006	+0.0E+000	
IE-ISL-LPI	ISLOCA IE 2-CKV LPI interfac	4.6E-006	+0.0E+000	
IE-ISL-RHR	RHR pipe ruptures	7.9E-006	+0.0E+000	
IE-LLOCA	Large Loss of Coolant Accide	5.0E-006	+0.0E+000	
IE-LOACA	Loss of Essential ac Bus A i	9.0E-003	+0.0E+000	
IE-LOCCW	Loss of Component Cooling Wa	4.0E-004	+0.0E+000	
IE-LOCHS	LOSS OF CONDENSOR HEAT SIN	9.0E-002	+0.0E+000	
IE-LODCEDF	Loss of DC Bus EDF Initiatin	8.0E-004	+0.0E+000	
IE-LOIA	LOSS OF INSTRUMENT AIR INITI	8.0E-003	+0.0E+000	
IE-LOMFW	LOSS OF MAIN FEEDWATER	1.0E-001	+0.0E+000	
IE-LONSR	Loss of Nuclear Service Wate	4.0E-004	+0.0E+000	
IE-LOOP	LOSS OF OFFSITE POWER	3.6E-002	1.0E+000	
IE-MLOCA	MEDIUM LOCA	4.0E-005	+0.0E+000	
IE-RXVRUPT	REACTOR VESSEL RUPTURE INIT	1.0E-007	+0.0E+000	
IE-SGTR	STEAM GENERATOR TUBE RUPTU	4.0E-003	+0.0E+000	
IE-SLOCA	SMALL LOCA	4.0E-004	+0.0E+000	
IE-SORV	STUCK-OPEN PZR SAFETY VALVE	3.0E-003	+0.0E+000	
IE-TRANS	TRANSIENT	7.0E-001	+0.0E+000	
OEP-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER OF	5.3E-001	3.1E-001	
OEP-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER OF	3.2E-001	2.5E-002	
OEP-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER OF	1.6E-001	2.5E-002	
OEP-XHE-XL-NR06H	OPERATOR FAILS TO RECOVER OF	9.6E-002	5.0E-004	
OEP-XHE-XL-NR24H	OPERATOR FAILS TO RECOVER OF	1.8E-002	5.0E-004	
PPR-SRV-CO-L	PORVs/SRVs Open during LOOP	1.6E-001	1.0E+000	TRUE
PPR-SRV-CO-SBO	PORVs/SRVs Open during STATI	3.7E-001	1.0E+000	TRUE
PPR-SRV-OO-NC32B	PORV NC32B Fails to Reclose	1.6E-003	8.0E-003	
PPR-SRV-OO-NC34A	PORV NC34A Fails to Reclose	1.6E-003	9.1E-002	
ZT-DGN-FR-L	DIESEL GENERATOR FAILS TO RU	1.8E-002	8.4E-003	
ZT-FAN-FR-E	HVAC FAN FAILS TO RUN	1.2E-003	3.2E-003	
ZT-FAN-FR-L	HVAC FAN FAILS TO RUN	3.4E-003	1.3E-003	
ZT-FAN-FS	HVAC FAN FAILS TO START	2.5E-003	7.1E-004	
ZT-TDP-FR-L	TURBINE DRIVEN PUMP FAILS TO	1.4E-003	6.3E-004	
ZV-LOOP-GR-LAMBDA	GRID RELATED LOSS OF OFFSITE	1.9E-002	+0.0E+000	
ZV-LOOP-PC-LAMBDA	PLANT CENTERED LOSS OF OFFSI	2.1E-003	+0.0E+000	
ZV-LOOP-SC-LAMBDA	SWITCHYARD CENTERED LOSS OF	1.0E-002	1.0E+000	
ZV-LOOP-WR-LAMBDA	WEATHER RELATED LOSS OF OFFS	4.8E-003	+0.0E+000	

SEQUENCE PROBABILITIES

Truncation : Cummulative : 100.0% Individual : 2.0%

Event Tree Name	Sequence Name	CCDP	%Cont
LOOP	21-74	4.6E-005	
LOOP	13	2.9E-005	
LOOP	21-77	2.5E-006	
LOOP	21-11	2.1E-006	
LOOP	19	1.8E-006	
LOOP	11	1.8E-006	

SEQUENCE LOGIC

Event Tree	Sequence Name	Logic	
LOOP	21-74	/RPS	EPS
		/AFW-B	PORV-B
		OPR-01H	DGR-01H
LOOP	13	/RPS	/EPS
		/AFW-L	PORV-L
		HPI-L	OPR-01H-REC
LOOP	21-77	/RPS	EPS
		AFW-B	OPR-02H
		DGR-02H	
LOOP	21-11	/RPS	EPS
		/AFW-B	/PORV-B
		SSF-SBO	/RSD
		/BP1	/BP2
		/DC-SHED	OPR-04H
		DGR-04H	
LOOP	19	/RPS	/EPS
		AFW-L	FAB-L
		/OPR-02H-REC	HPR
LOOP	11	/RPS	/EPS
		/AFW-L	PORV-L
		/HPI-L	OPR-02H
		HPR-L	

Fault Tree Name	Description
AFW-B	AUXILIARY FEEDWATER-SBO
AFW-L	AUXILIARY FEEDWATER-LOOP
BP1	RCP SEAL STAGE 1 INTEGRITY
BP2	RCP SEAL STAGE 2 INTEGRITY
DC-SHED	SHED DC LOADS TO EXTEND BATT LIFE TO 4 HOURS
DGR-01H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN 1 HOUR
DGR-02H	DIESEL GENERATOR RECOVERY (IN 2 HR)
DGR-04H	DIESEL GENERATOR RECOVERY (IN 4 HR)
EPS	EMERGENCY POWER
FAB-L	EMERGENCY POWER
HPI-L	HIGH PRESSURE INJECTION
HPR	HIGH PRESSURE RECIRC
HPR-L	HIGH PRESSURE RECIRC
OPR-01H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1 HOUR
OPR-01H-REC	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1 HOUR
OPR-02H	OFFSITE POWER RECOVERY IN 2 HRS
OPR-02H-REC	FAILURE TO RECOVER OFFSITE POWER IN 2 HRS (AFW + F&B)
OPR-04H	OFFSITE POWER RECOVERY (IN 4 HR)
PORV-B	PORVs ARE CLOSED-SBO
PORV-L	PORVs ARE CLOSED-LOOP
RPS	REACTOR SHUTDOWN
RSD	RAPID SECONDARY DEPRESS
SSF-SBO	STANDBY SHUTDOWN FACILITY SEAL COOLING

SEQUENCE CUT SETS

Truncation: Cummulative: 100.0% Individual: 2.0%

Event Tree: LOOP CCDP: 4.6E-005
Sequence: 21-74

CCDP	% Cut Set	Cut Set Events	
6.6E-006	14.25	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR01H
		PPR-SRV-OO-NC34A	OEP-XHE-XL-NR01H
		EPS-DGN-XX-RR1H	
3.7E-006	7.97	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-CF-FRU1	OEP-XHE-XL-NR01H
2.6E-006	5.58	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-RR1H
2.3E-006	4.96	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-CF-FSU1	OEP-XHE-XL-NR01H
2.1E-006	4.63	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-TM-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
2.1E-006	4.63	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-TM-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.2E-006	2.57	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-FS-1B

		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.2E-006	2.57	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FS-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.0E-006	2.27	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-FAN-FR-EX1B1
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.0E-006	2.27	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-FR-EX1A1	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.0E-006	2.27	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-FR-EX1A2	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.0E-006	2.27	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-FAN-FR-EX1B2
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
9.8E-007	2.14	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FS-1A	EPS-DGN-TM-1B
		OEP-XHE-XL-NR01H	
9.8E-007	2.14	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-TM-1A	EPS-DGN-FS-1B
		OEP-XHE-XL-NR01H	

Event Tree: LOOP CCDP: 2.9E-005
Sequence: 13

CCDP	% Cut Set	Cut Set Events	
6.4E-006	22.34	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R1H	
3.0E-006	10.30	PPR-SRV-OO-NC34A	EPS-DGN-FS-1A
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
2.6E-006	9.08	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A2
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
2.6E-006	9.08	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A1
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
1.2E-006	4.26	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-MDP-RUNA1A2
		CCW-MDP-TM-1B2	EPS-DGN-XX-R1H
1.2E-006	4.26	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-MDP-TM-1B1
		CCW-MDP-RUNA1A2	EPS-DGN-XX-R1H
5.9E-007	2.06	PPR-SRV-OO-NC34A	OEP-XHE-XL-NR01H
		CCW-TRN-TM-TRAINB	EPS-MOV-CC-1RN232A

Event Tree: LOOP CCDP: 2.5E-006
Sequence: 21-77

CCDP	% Cut Set	Cut Set Events	
1.5E-007	5.88	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR02H

		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H
		EPS-DGN-XX-RR2H	
8.2E-008	3.29	EPS-XHE-XL-NR02H	EPS-FAN-CF-FRU1
		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H
5.7E-008	2.30	EPS-XHE-XL-NR02H	EPS-DGN-FR-1A
		EPS-DGN-FR-1B	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	EPS-DGN-XX-RR2H
5.3E-008	2.13	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR02H
		OEP-XHE-XL-NR02H	SSF-DGN-FR-DGN
		EPS-DGN-XX-RR2H	
5.1E-008	2.05	EPS-XHE-XL-NR02H	EPS-DGN-CF-FSU1
		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H

Event Tree: LOOP
Sequence: 21-11

CCDP: 2.1E-006

CCDP	% Cut Set	Cut Set Events	
2.9E-007	14.16	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR04H
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2
		SSF-XHE-XM-SYSL	EPS-DGN-XX-RR4H
1.6E-007	7.91	EPS-XHE-XL-NR04H	EPS-FAN-CF-FRU1
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2
		SSF-XHE-XM-SYSL	
1.1E-007	5.54	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-RR4H	
1.0E-007	4.93	EPS-XHE-XL-NR04H	EPS-DGN-CF-FSU1
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2
		SSF-XHE-XM-SYSL	
9.4E-008	4.60	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-TM-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
9.4E-008	4.60	EPS-XHE-XL-NR04H	EPS-DGN-TM-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
5.2E-008	2.56	EPS-XHE-XL-NR04H	EPS-DGN-FS-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
5.2E-008	2.56	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-FS-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
4.6E-008	2.25	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-FAN-FR-EX1B2	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
4.6E-008	2.25	EPS-XHE-XL-NR04H	EPS-FAN-FR-EX1A2

		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
4.6E-008	2.25	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-FAN-FR-EX1B1	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
4.6E-008	2.25	EPS-XHE-XL-NR04H	EPS-FAN-FR-EX1A1
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
4.4E-008	2.12	EPS-XHE-XL-NR04H	EPS-DGN-FS-1A
		EPS-DGN-TM-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
4.4E-008	2.12	EPS-XHE-XL-NR04H	EPS-DGN-TM-1A
		EPS-DGN-FS-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL

Event Tree: LOOP CCDP: 1.8E-006
Sequence: 19

CCDP	% Cut Set	Cut Set Events	
3.0E-007	16.91	AFW-XHE-XM-CR	CCW-HTX-CF-HTXS
2.8E-007	15.48	AFW-XHE-XM-CR	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
2.8E-007	15.48	AFW-XHE-XM-CR	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
7.1E-008	3.94	AFW-TDP-FS-TDP	CCW-HTX-CF-HTXS
6.5E-008	3.61	AFW-TDP-FS-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
6.5E-008	3.61	AFW-TDP-FS-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
5.1E-008	2.82	AFW-TDP-TM-TDP	CCW-HTX-CF-HTXS
4.7E-008	2.60	AFW-TDP-FR-TDP	CCW-HTX-CF-HTXS
4.6E-008	2.58	AFW-TDP-TM-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
4.6E-008	2.58	AFW-TDP-TM-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
4.3E-008	2.38	AFW-TDP-FR-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
4.3E-008	2.38	AFW-TDP-FR-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	

Event Tree: LOOP CCDP: 1.8E-006
Sequence: 11

CCDP	% Cut Set	Cut Set Events	
1.5E-007	8.37	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR02H	RHR-MDP-TM-1B
		EPS-DGN-XX-R2H	

6.8E-008	3.86	PPR-SRV-OO-NC34A	EPS-DGN-FS-1A
		OEP-XHE-XL-NR02H	RHR-MDP-TM-1B
6.2E-008	3.49	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR02H	RHR-HTX-TM-HTX1B
		EPS-DGN-XX-R2H	
6.0E-008	3.40	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A1
		OEP-XHE-XL-NR02H	RHR-MDP-TM-1B
6.0E-008	3.40	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A2
		OEP-XHE-XL-NR02H	RHR-MDP-TM-1B
4.9E-008	2.79	HPR-XHE-XM-RECIRC	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	OEP-XHE-XL-NR02H
		EPS-DGN-XX-R2H	
4.1E-008	2.32	HPR-XHE-XM-RECIRC	PPR-SRV-OO-NC34A
		EPS-DGN-TM-1A	OEP-XHE-XL-NR02H
3.7E-008	2.09	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR02H	RHR-MDP-FS-1B
		EPS-DGN-XX-R2H	

BASIC EVENTS (Cut Sets Only)

Event Name	Description	Curr Prob
AFW-TDP-FR-TDP	AFW TURBINE DRIVEN PUMP FAILS TO RUN (INCLUDI	4.6E-003
AFW-TDP-FS-TDP	AFW TURBINE DRIVEN PUMP FAILS TO START (INCLU	7.0E-003
AFW-TDP-TM-TDP	AFW TDP UNAVAILABLE DUE TO TEST AND MAINTENAN	5.0E-003
AFW-XHE-XM-CR	OPERATOR FAILS TO THROTTLE AND CONTROL AFW FL	3.0E-002
CCW-HTX-CF-HTXS	CCF OF CCW HTXS 1A/1B	1.0E-005
CCW-MDP-CF-FSALL	CCF OF ALL CCWS TO START	1.9E-005
CCW-MDP-RUNA1A2	FRACTION OF TIME 1A1 AND 1A2 ARE RUNNING	5.0E-001
CCW-MDP-RUNB1B2	FRACTION OF TIME CCW MDP 1B1 AND 1B2 ARE INIT	5.0E-001
CCW-MDP-TM-1B1	CCW MDP 1B1 UNAVAILABLE DUE TO T & M	8.0E-003
CCW-MDP-TM-1B2	CCW MDP 1B2 UNAVAILABLE DUE TO T & M	8.0E-003
CCW-TRN-TM-TRAINB	CCW TRAIN B UNAVAILABLE DUE TO T & M (PSA)	2.1E-002
EPS-DGN-CF-FRU1	CCF OF UNIT 1 DIESEL GENERATORS TO RUN	3.0E-004
EPS-DGN-CF-FSU1	CCF OF UNIT 1 DIESEL GENERATORS TO START	1.0E-004
EPS-DGN-FR-1A	DIESEL GENERATOR 1A FAILS TO RUN	1.1E-002
EPS-DGN-FR-1B	DIESEL GENERATOR 1B FAILS TO RUN	1.1E-002
EPS-DGN-FS-1A	DIESEL GENERATOR 1A FAILS TO START	5.0E-003
EPS-DGN-FS-1B	DIESEL GENERATOR 1B FAILS TO START	5.0E-003
EPS-DGN-TM-1A	DIESEL GENERATOR 1A UNAVAILABLE DUE TO TEST A	9.0E-003
EPS-DGN-TM-1B	DIESEL GENERATOR 1B UNAVAILABLE DUE TO TEST A	9.0E-003
EPS-DGN-XX-R1H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 1 HOUR	1.0E+000
EPS-DGN-XX-R2H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 2 HOUR	1.0E+000
EPS-DGN-XX-R4H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 4 HOUR	1.0E+000
EPS-DGN-XX-RR1H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-DGN-XX-RR2H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-DGN-XX-RR4H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-FAN-CF-FRU1	CCF OF UNIT DIESEL GENERATOR EXHAUST FANS TO	1.7E-004
EPS-FAN-FR-EX1A1	FAILURE OF DIESEL GENERATOR 1A FAN 1A1 TO RUN	4.4E-003
EPS-FAN-FR-EX1A2	FAILURE OF DIESEL GENERATOR 1A FAN 1A2 TO RUN	4.4E-003
EPS-FAN-FR-EX1B1	FAILURE OF DIESEL GENERATOR 1B FAN 1B1 TO RUN	4.4E-003

Event Name	Description	Curr Prob
EPS-FAN-FR-EX1B2	FAILURE OF DIESEL GENERATOR 1B FAN 1B2 TO RUN	4.4E-003
EPS-MOV-CC-1RN232A	FAILURE OF NSR/EPS MOV RN232A TO OPEN	1.0E-003
EPS-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	7.7E-001
EPS-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	6.5E-001
EPS-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	4.8E-001
HPR-XHE-XM-RECIRC	OPERATOR FAILS TO INITIATE HPR	2.0E-003
OEP-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1	3.1E-001
OEP-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 2	2.5E-002
OEP-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 4	2.5E-002
PPR-SRV-OO-NC34A	PORV NC34A FAILS TO RECLOSE AFTER OPENING	9.1E-002
RCS-MDP-LK-BP2	RCP SEAL STAGE 2 INTEGRITY (BINDING/POPPING O	2.0E-001
RHR-HTX-TM-HTX1B	RHR HTX-1B UNAVAILABLE DUE TO T & M	2.5E-003
RHR-MDP-FS-1B	RHR MDP 1B FAILS TO START	1.5E-003
RHR-MDP-TM-1B	RHR MDP 1B UNAVAILABLE DUE TO T & M	6.0E-003
SSF-DGN-FR-DGN	FAILURE OF SSF DIESEL GENERATOR TO RUN	1.1E-002
SSF-XHE-XM-SYSL	OPERATOR FAILS TO START AND ALIGN SSF DURING	1.0E-001

CATAWBA (Unit 2) LOOP Initiating Event - Final ASP Analysis

Code Ver : 7:26
Fam : CATA_3P
Model Ver : 2006/03/10
User : INEEL
Init Event: IE-LOOP
Ev ID: U2-LOOP-BEST-ESTIMATE
Total CCDP: 5.8E-005
Desc : Best estimate - W/ TM, credit recovery at 1 h (0.3)

BASIC EVENT CHANGES

Event Name	Description	Base Prob	Curr Prob	Type
AFW-XHE-XL-SUMPPUMPS	OPERATOR FAILS TO RECOVER SU	1.0E+000	1.0E-003	
CCW-MDP-TM-1A1	CCW MDP 1A1 Unavailable due	8.0E-003	+0.0E+000	IGNORE
CCW-MDP-TM-1A2	CCW MDP 1A2 Unavailable due	8.0E-003	+0.0E+000	IGNORE
CCW-TRN-TM-TRAINA	CCW Train A Unavailable due	+0.0E+000	+0.0E+000	IGNORE
DUAL-UNIT-LOOP	Probability that a LOOP is a	5.8E-001	1.0E+000	TRUE
IE-ISL-HPI	ISLOCA IE 2-CKV HPI interfac	4.6E-006	+0.0E+000	
IE-ISL-LPI	ISLOCA IE 2-CKV LPI interfac	4.6E-006	+0.0E+000	
IE-ISL-RHR	RHR pipe ruptures	7.9E-006	+0.0E+000	
IE-LLOCA	Large Loss of Coolant Accide	5.0E-006	+0.0E+000	
IE-LOACA	Loss of Essential ac Bus A i	9.0E-003	+0.0E+000	
IE-LOCCW	Loss of Component Cooling Wa	4.0E-004	+0.0E+000	
IE-LOCHS	LOSS OF CONDENSOR HEAT SIN	9.0E-002	+0.0E+000	
IE-LODCEDF	Loss of DC Bus EDF Initiatin	8.0E-004	+0.0E+000	
IE-LOIA	LOSS OF INSTRUMENT AIR INITI	8.0E-003	+0.0E+000	
IE-LOMFW	LOSS OF MAIN FEEDWATER	1.0E-001	+0.0E+000	
IE-LONSR	Loss of Nuclear Service Wate	4.0E-004	+0.0E+000	
IE-LOOP	LOSS OF OFFSITE POWER	3.6E-002	1.0E+000	
IE-MLOCA	MEDIUM LOCA	4.0E-005	+0.0E+000	
IE-RXVRUPT	REACTOR VESSEL RUPTURE INIT	1.0E-007	+0.0E+000	
IE-SGTR	STEAM GENERATOR TUBE RUPTU	4.0E-003	+0.0E+000	
IE-SLOCA	SMALL LOCA	4.0E-004	+0.0E+000	
IE-SORV	STUCK-OPEN PZR SAFETY VALVE	3.0E-003	+0.0E+000	
IE-TRANS	TRANSIENT	7.0E-001	+0.0E+000	
OEP-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER OF	5.3E-001	3.1E-001	
OEP-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER OF	3.2E-001	2.5E-002	
OEP-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER OF	1.6E-001	2.5E-002	
OEP-XHE-XL-NR06H	OPERATOR FAILS TO RECOVER OF	9.6E-002	5.0E-004	
OEP-XHE-XL-NR24H	OPERATOR FAILS TO RECOVER OF	1.8E-002	5.0E-004	
PPR-SRV-CO-L	PORVs/SRVs Open during LOOP	1.6E-001	1.0E+000	TRUE
PPR-SRV-CO-SBO	PORVs/SRVs Open during STATI	3.7E-001	1.0E+000	TRUE
PPR-SRV-OO-NC32B	PORV NC32B Fails to Reclose	1.6E-003	1.6E-003	
PPR-SRV-OO-NC34A	PORV NC34A Fails to Reclose	1.6E-003	5.6E-002	
PPR-SRV-OO-NC36B	PORV NC36B Fails to Reclose	1.6E-003	1.6E-003	
ZT-DGN-FR-L	DIESEL GENERATOR FAILS TO RU	1.8E-002	8.4E-003	
ZT-FAN-FR-E	HVAC FAN FAILS TO RUN	1.2E-003	3.2E-003	
ZT-FAN-FR-L	HVAC FAN FAILS TO RUN	3.4E-003	1.3E-003	
ZT-FAN-FS	HVAC FAN FAILS TO START	2.5E-003	7.1E-004	
ZT-TDP-FR-L	TURBINE DRIVEN PUMP FAILS TO	1.4E-003	6.3E-004	
ZV-LOOP-GR-LAMBDA	GRID RELATED LOSS OF OFFSITE	1.9E-002	+0.0E+000	
ZV-LOOP-PC-LAMBDA	PLANT CENTERED LOSS OF OFFSI	2.1E-003	+0.0E+000	

ZV-LOOP-SC-LAMBDA	SWITCHYARD CENTERED LOSS OF	1.0E-002	1.0E+000
ZV-LOOP-WR-LAMBDA	WEATHER RELATED LOSS OF OFFS	4.8E-003	+0.0E+000

SEQUENCE PROBABILITIES

Truncation : Cummulative : 100.0% Individual : 2.0%

Event Tree Name	Sequence Name	CCDP	%Cont
LOOP	21-74	2.7E-005	
LOOP	13	1.8E-005	
LOOP	21-11	2.5E-006	
LOOP	19	1.8E-006	
LOOP	21-77	1.5E-006	
LOOP	20	1.2E-006	

SEQUENCE LOGIC

Event Tree	Sequence Name	Logic	
LOOP	21-74	/RPS	EPS
		/AFW-B	PORV-B
		OPR-01H	DGR-01H
LOOP	13	/RPS	/EPS
		/AFW-L	PORV-L
		HPI-L	OPR-01H-REC
LOOP	21-11	/RPS	EPS
		/AFW-B	/PORV-B
		SSF-SBO	/RSD
		/BP1	/BP2
		/DC-SHED	OPR-04H
		DGR-04H	
LOOP	19	/RPS	/EPS
		AFW-L	FAB-L
		/OPR-02H-REC	HPR
LOOP	21-77	/RPS	EPS
		AFW-B	OPR-02H
		DGR-02H	
LOOP	20	/RPS	/EPS
		AFW-L	FAB-L
		OPR-02H-REC	

Fault Tree Name	Description
AFW-B	AUXILIARY FEEDWATER-SBO

AFW-L	AUXILIARY FEEDWATER-LOOP
BP1	RCP SEAL STAGE 1 INTEGRITY
BP2	RCP SEAL STAGE 2 INTEGRITY
DC-SHED	SHED DC LOADS TO EXTEND BATT LIFE TO 4 HOURS
DGR-01H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN 1 HOUR
DGR-02H	DIESEL GENERATOR RECOVERY (IN 2 HR)
DGR-04H	DIESEL GENERATOR RECOVERY (IN 4 HR)
EPS	EMERGENCY POWER
FAB-L	EMERGENCY POWER
HPI-L	HIGH PRESSURE INJECTION
HPR	HIGH PRESSURE RECIRC
OPR-01H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1 HOUR
OPR-01H-REC	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1 HOUR
OPR-02H	OFFSITE POWER RECOVERY IN 2 HRS
OPR-02H-REC	FAILURE TO RECOVER OFFSITE POWER IN 2 HRS (AFW + F&B)
OPR-04H	OFFSITE POWER RECOVERY (IN 4 HR)
PORV-B	PORVs ARE CLOSED-SBO
PORV-L	PORVs ARE CLOSED-LOOP
RPS	REACTOR SHUTDOWN
RSD	RAPID SECONDARY DEPRESS
SSF-SBO	STANDBY SHUTDOWN FACILITY SEAL COOLING

SEQUENCE CUT SETS

Truncation: Cummulative: 100.0% Individual: 2.0%

Event Tree: LOOP CCDP: 2.7E-005
Sequence: 21-74

CCDP	% Cut Set	Cut Set Events	
4.0E-006	14.90	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR01H
		PPR-SRV-OO-NC34A	OEP-XHE-XL-NR01H
		EPS-DGN-XX-RR1H	
2.3E-006	8.33	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-CF-FRU1	OEP-XHE-XL-NR01H
1.6E-006	5.83	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-RR1H
1.4E-006	5.19	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-CF-FSU1	OEP-XHE-XL-NR01H
1.3E-006	4.84	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-TM-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
1.3E-006	4.84	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-TM-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
7.3E-007	2.69	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FS-1A	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H

7.3E-007	2.69	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-DGN-FS-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
6.4E-007	2.37	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-FAN-FR-EX1B1
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
6.4E-007	2.37	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-FR-EX1A1	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
6.4E-007	2.37	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-FAN-FR-EX1A2	EPS-DGN-FR-1B
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
6.4E-007	2.37	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FR-1A	EPS-FAN-FR-EX1B2
		OEP-XHE-XL-NR01H	EPS-DGN-XX-R1H
6.0E-007	2.23	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-TM-1A	EPS-DGN-FS-1B
		OEP-XHE-XL-NR01H	
6.0E-007	2.23	EPS-XHE-XL-NR01H	PPR-SRV-OO-NC34A
		EPS-DGN-FS-1A	EPS-DGN-TM-1B
		OEP-XHE-XL-NR01H	

Event Tree: LOOP CCDP: 1.8E-005
Sequence: 13

CCDP	% Cut Set	Cut Set Events	
4.0E-006	22.53	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R1H	
1.8E-006	10.39	PPR-SRV-OO-NC34A	EPS-DGN-FS-1A
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
1.6E-006	9.15	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A2
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
1.6E-006	9.15	PPR-SRV-OO-NC34A	EPS-FAN-FR-EX1A1
		OEP-XHE-XL-NR01H	CCW-TRN-TM-TRAINB
7.5E-007	4.29	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-MDP-TM-1B1
		CCW-MDP-RUNA1A2	EPS-DGN-XX-R1H
7.5E-007	4.29	PPR-SRV-OO-NC34A	EPS-DGN-FR-1A
		OEP-XHE-XL-NR01H	CCW-MDP-RUNA1A2
		CCW-MDP-TM-1B2	EPS-DGN-XX-R1H
3.7E-007	2.08	PPR-SRV-OO-NC34A	OEP-XHE-XL-NR01H
		CCW-TRN-TM-TRAINB	EPS-MOV-CC-1RN232A

Event Tree: LOOP CCDP: 2.5E-006
Sequence: 21-11

CCDP	% Cut Set	Cut Set Events	
2.9E-007	11.52	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR04H
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2

		SSF-XHE-XM-SYSL	EPS-DGN-XX-RR4H
1.6E-007	6.44	EPS-XHE-XL-NR04H	EPS-FAN-CF-FRU1
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2
		SSF-XHE-XM-SYSL	
1.1E-007	4.51	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-RR4H	
1.0E-007	4.01	EPS-XHE-XL-NR04H	EPS-DGN-CF-FSU1
		OEP-XHE-XL-NR04H	/RCS-MDP-LK-BP2
		SSF-XHE-XM-SYSL	
9.4E-008	3.74	EPS-XHE-XL-NR04H	EPS-DGN-TM-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
9.4E-008	3.74	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-TM-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
5.2E-008	2.08	EPS-XHE-XL-NR04H	EPS-DGN-FS-1A
		EPS-DGN-FR-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	
5.2E-008	2.08	EPS-XHE-XL-NR04H	EPS-DGN-FR-1A
		EPS-DGN-FS-1B	OEP-XHE-XL-NR04H
		/RCS-MDP-LK-BP2	SSF-XHE-XM-SYSL
		EPS-DGN-XX-R4H	

Event Tree: LOOP CCDP: 1.8E-006
Sequence: 19

CCDP	% Cut Set	Cut Set Events	
3.0E-007	17.41	AFW-XHE-XM-CR	CCW-HTX-CF-HTXS
2.8E-007	15.94	AFW-XHE-XM-CR	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
2.8E-007	15.94	AFW-XHE-XM-CR	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
7.1E-008	4.06	AFW-TDP-FS-TDP	CCW-HTX-CF-HTXS
6.5E-008	3.72	AFW-TDP-FS-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
6.5E-008	3.72	AFW-TDP-FS-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
5.1E-008	2.90	AFW-TDP-TM-TDP	CCW-HTX-CF-HTXS
4.7E-008	2.68	AFW-TDP-FR-TDP	CCW-HTX-CF-HTXS
4.6E-008	2.66	AFW-TDP-TM-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNB1B2	
4.6E-008	2.66	AFW-TDP-TM-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
4.3E-008	2.45	AFW-TDP-FR-TDP	CCW-MDP-CF-FSALL
		CCW-MDP-RUNA1A2	
4.3E-008	2.45	AFW-TDP-FR-TDP	CCW-MDP-CF-FSALL

Event Tree: LOOP
Sequence: 21-77

CCDP: 1.5E-006

CCDP	% Cut Set	Cut Set Events	
1.5E-007	9.98	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR02H
		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H
		EPS-DGN-XX-RR2H	
8.2E-008	5.58	EPS-XHE-XL-NR02H	EPS-FAN-CF-FRU1
		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H
5.7E-008	3.90	EPS-XHE-XL-NR02H	EPS-DGN-FR-1A
		EPS-DGN-FR-1B	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	EPS-DGN-XX-RR2H
5.1E-008	3.47	EPS-XHE-XL-NR02H	EPS-DGN-CF-FSU1
		AFW-XHE-XM-CR	OEP-XHE-XL-NR02H
4.7E-008	3.24	EPS-XHE-XL-NR02H	EPS-DGN-FR-1A
		EPS-DGN-TM-1B	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	EPS-DGN-XX-R2H
4.7E-008	3.24	EPS-XHE-XL-NR02H	EPS-DGN-TM-1A
		EPS-DGN-FR-1B	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	EPS-DGN-XX-R2H
3.4E-008	2.33	EPS-DGN-CF-FRU1	EPS-XHE-XL-NR02H
		AFW-TDP-FS-TDP	OEP-XHE-XL-NR02H
		EPS-DGN-XX-RR2H	

Event Tree: LOOP
Sequence: 20

CCDP: 1.2E-006

CCDP	% Cut Set	Cut Set Events	
1.7E-007	13.97	EPS-DGN-FR-1A	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R2H	
7.9E-008	6.44	EPS-DGN-FS-1A	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
6.9E-008	5.67	EPS-FAN-FR-EX1A2	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
6.9E-008	5.67	EPS-FAN-FR-EX1A1	AFW-XHE-XM-CR
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
6.0E-008	4.87	HPI-XHE-XM-FB	AFW-XHE-XM-CR
		AFW-MDP-CF-FSAB	
4.0E-008	3.26	EPS-DGN-FR-1A	AFW-TDP-FS-TDP
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R2H	
2.9E-008	2.33	EPS-DGN-FR-1A	AFW-TDP-TM-TDP
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R2H	
2.6E-008	2.15	EPS-DGN-FR-1A	AFW-TDP-FR-TDP
		OEP-XHE-XL-NR02H	CCW-TRN-TM-TRAINB
		EPS-DGN-XX-R2H	

BASIC EVENTS (Cut Sets Only)

Event Name	Description	Curr Prob
AFW-MDP-CF-FSAB	CCF OF AFW MOTOR-DRIVEN PUMPS TO START	9.9E-005
AFW-TDP-FR-TDP	AFW TURBINE DRIVEN PUMP FAILS TO RUN (INCLUDI	4.6E-003
AFW-TDP-FS-TDP	AFW TURBINE DRIVEN PUMP FAILS TO START (INCLU	7.0E-003
AFW-TDP-TM-TDP	AFW TDP UNAVAILABLE DUE TO TEST AND MAINTENAN	5.0E-003
AFW-XHE-XM-CR	OPERATOR FAILS TO THROTTLE AND CONTROL AFW FL	3.0E-002
CCW-HTX-CF-HTXS	CCF OF CCW HTXS 1A/1B	1.0E-005
CCW-MDP-CF-FSALL	CCF OF ALL CCWS TO START	1.9E-005
CCW-MDP-RUNA1A2	FRACTION OF TIME 1A1 AND 1A2 ARE RUNNING	5.0E-001
CCW-MDP-RUNB1B2	FRACTION OF TIME CCW MDP 1B1 AND 1B2 ARE INIT	5.0E-001
CCW-MDP-TM-1B1	CCW MDP 1B1 UNAVAILABLE DUE TO T & M	8.0E-003
CCW-MDP-TM-1B2	CCW MDP 1B2 UNAVAILABLE DUE TO T & M	8.0E-003
CCW-TRN-TM-TRAINB	CCW TRAIN B UNAVAILABLE DUE TO T & M (PSA)	2.1E-002
EPS-DGN-CF-FRU1	CCF OF UNIT 1 DIESEL GENERATORS TO RUN	3.0E-004
EPS-DGN-CF-FSU1	CCF OF UNIT 1 DIESEL GENERATORS TO START	1.0E-004
EPS-DGN-FR-1A	DIESEL GENERATOR 1A FAILS TO RUN	1.1E-002
EPS-DGN-FR-1B	DIESEL GENERATOR 1B FAILS TO RUN	1.1E-002
EPS-DGN-FS-1A	DIESEL GENERATOR 1A FAILS TO START	5.0E-003
EPS-DGN-FS-1B	DIESEL GENERATOR 1B FAILS TO START	5.0E-003
EPS-DGN-TM-1A	DIESEL GENERATOR 1A UNAVAILABLE DUE TO TEST A	9.0E-003
EPS-DGN-TM-1B	DIESEL GENERATOR 1B UNAVAILABLE DUE TO TEST A	9.0E-003
EPS-DGN-XX-R1H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 1 HOUR	1.0E+000
EPS-DGN-XX-R2H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 2 HOUR	1.0E+000
EPS-DGN-XX-R4H	CONVOLUTION FACTOR FOR EDG-FR * OPR IN 4 HOUR	1.0E+000
EPS-DGN-XX-RR1H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-DGN-XX-RR2H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-DGN-XX-RR4H	CONVOLUTION FACTOR FOR EDG-FR * EDG-FR * OPR	1.0E+000
EPS-FAN-CF-FRU1	CCF OF UNIT DIESEL GENERATOR EXHAUST FANS TO	1.7E-004
EPS-FAN-FR-EX1A1	FAILURE OF DIESEL GENERATOR 1A FAN 1A1 TO RUN	4.4E-003
EPS-FAN-FR-EX1A2	FAILURE OF DIESEL GENERATOR 1A FAN 1A2 TO RUN	4.4E-003
EPS-FAN-FR-EX1B1	FAILURE OF DIESEL GENERATOR 1B FAN 1B1 TO RUN	4.4E-003
EPS-FAN-FR-EX1B2	FAILURE OF DIESEL GENERATOR 1B FAN 1B2 TO RUN	4.4E-003
EPS-MOV-CC-1RN232A	FAILURE OF NSR/EPS MOV RN232A TO OPEN	1.0E-003
EPS-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	7.7E-001
EPS-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	6.5E-001
EPS-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN	4.8E-001
HPI-XHE-XM-FB	OPERATOR FAILS TO INITIATE FEED AND BLEED COO	2.0E-002
OEP-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 1	3.1E-001
OEP-XHE-XL-NR02H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 2	2.5E-002
OEP-XHE-XL-NR04H	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 4	2.5E-002
PPR-SRV-OO-NC34A	PORV NC34A FAILS TO RECLOSE AFTER OPENING	5.6E-002
RCS-MDP-LK-BP2	RCP SEAL STAGE 2 INTEGRITY (BINDING/POPPING O	2.0E-001
SSF-XHE-XM-SYSL	OPERATOR FAILS TO START AND ALIGN SSF DURING	1.0E-001