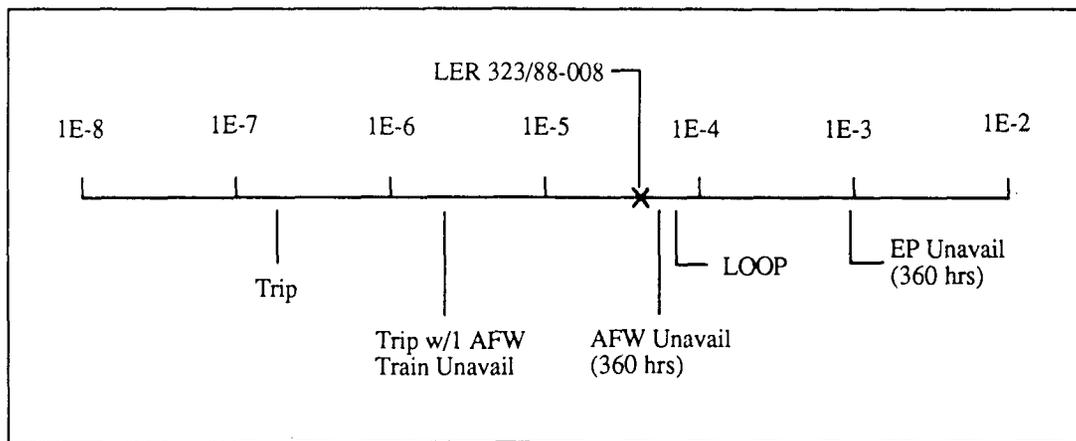


Accident Sequence Precursor Program Event Analysis

LER No.: 323/88-008
 Event Description: Loss of offsite power with safety injection
 Date of Event: July 17, 1988
 Plant: Diablo Canyon Unit 2

Summary

While at 100% power, an electrical connection on a reactor coolant pump feeder line arced to ground causing ground alarms to the pump and various other 12-kV electrical equipment. An operator attempted to isolate the ground by transferring one of the 12-kV buses from the auxiliary transformer to the startup transformer; however, the event was aggravated when the startup transformer caught on fire due to an unrelated failure. On subsequent loss of offsite power, all safety-related systems responded as designed. The conditional core damage probability estimated for the event is 4.1×10^{-5} . The relative significance of the event compared with other potential transients at Diablo Canyon is shown below.



Event Description

While at 100% power, feeder ground alarms actuated on reactor coolant pump 2-2 (Bus D), circulating water pump 2-1 (Bus D), and circulating water pump 2-2 (Bus E). Due to a poor electrical connection, insulation around a power feeder to RCP 2-2 had deteriorated, allowing arcing to ground and activating the feeder ground alarms. A minute after the feeder ground alarms, the 1-1 12-kV auxiliary transformer ground over-current alarm annunciated. Eight minutes into the event, the operator received a report that the associated ground resistor bank to the 1-1

auxiliary transformer was hot. In an attempt to isolate the ground, an operator transferred 12-kV Bus D (with the faulted RCP) from the 1-1 auxiliary transformer to the 12-kV startup bus. This bus was powered by the 2-1 startup transformer. The 2-1 startup transformer subsequently caught on fire due to an unrelated maintenance error in which a sheet of micarta-type material had been inadvertently left on the resistor banks. Thirty-four minutes into the event, an RCP 2-2 phase unbalance alarm was received. Four minutes later, operators initiated power reduction to 50% and tripped the circulating water pump 2-1 breaker in a further attempt to isolate the ground. One hour and 5 min after operators transferred power to the startup bus, a fire was reported at the 2-1 startup transformer. Subsequently the operators manually tripped the reactor, which caused 12-kV Bus E to transfer to the startup bus powered by the burning startup transformer. At this point, all the RCPs were powered from the startup bus.

Within 29 min, the operators had tripped all the RCPs and placed the unit on natural circulation. Coincident with but unrelated to tripping the last RCP, the fire in the startup transformer caused a phase-to-phase fault causing breaker OCB 212 to open, resulting in a loss of startup power to both units 1 and 2. On loss of startup power, all five emergency diesel generators for units 1 and 2 started, but only the unit 2 diesels and the swing diesel (1-3) loaded per design. One hour and 55 min into the event (1 min after the LOOP), safety injection initiated from a high steam line pressure differential pressure resulting from secondary system transients. One of the pressurizer PORVs was challenged several times during the event. The valve was challenged because of loss of normal and auxiliary spray, with subsequent high RCS pressure. Auxiliary power was restored at 2 h and 22 min into the event, and the plant was in natural circulation cooldown to RHR within 4 h from the event start.

Event-Related Design Information

The 12-kV loads for either unit may be powered from two sources, a 12-kV startup bus, which is common to both units and each unit's respective #1 auxiliary transformer. Equipment required for safe shutdown of the plant is located on the vital 4.16-kV buses or below. These buses have three sources, the 12-kV startup bus, the unit's #2 auxiliary transformer, and the emergency diesel generators. There are three vital 4.16-kV buses on each plant. Of five diesel generators for both units, two are dedicated to each unit and one may swing between units.

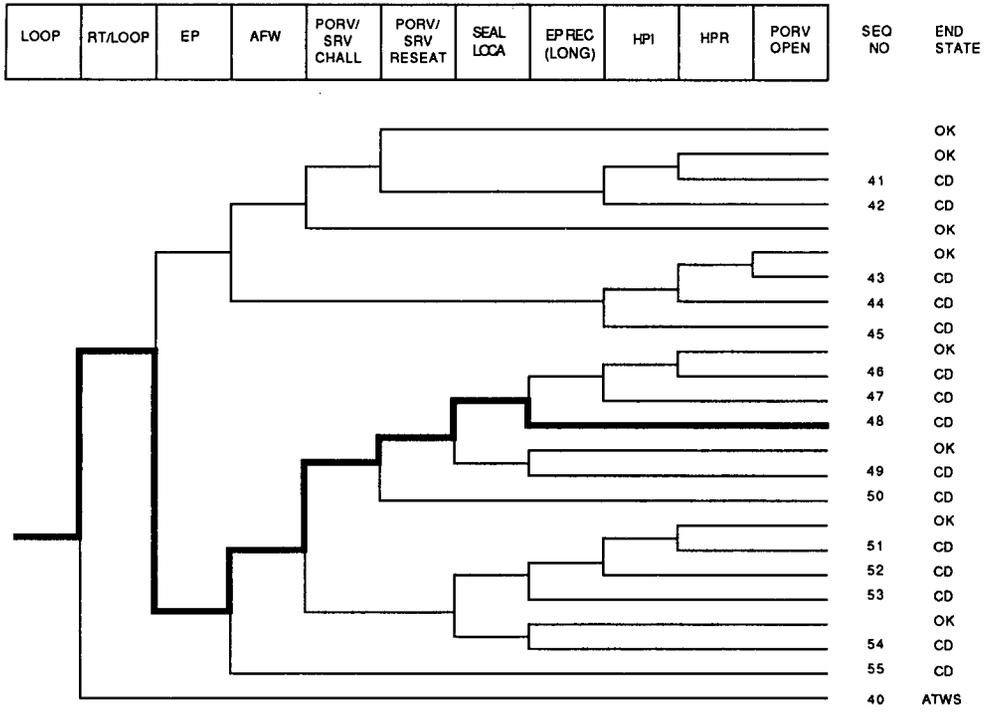
ASP Modeling Assumptions and Approach

The event is modeled as a loss of offsite power with pressurizer PORV challenge. A nominal value for not recovering offsite power within a 30-min period was assumed.

Analysis Results

The conditional probability of core damage is estimated to be 4.1×10^{-5} . The dominant core damage sequence (highlighted on the following event tree) is associated with RCP seal failure following station blackout: failure to recover from the LOOP ($p = 0.5$), potential emergency power failure (4.3×10^{-4}), seal LOCA ($p = 0.23$), and failure to recover AC power prior to core uncovering ($p = 0.48$). Within the set of all 1984-1987 precursors with conditional probabilities $\geq 1.0 \times 10^{-6}$, this event ranks as a mid-range event.

The lift of the PORV does not substantially impact event significance (its importance is a factor of 1.09). The assumption that offsite power is nominally recoverable in the short term has a greater impact. If the LOOP is not recoverable, the event conditional probability is increased by a factor of 2.



Dominant Core Damage Sequence for LER 323/88-008

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 323/88-008
 Event Description: Loss of offsite power with safety injection
 Event Date: 07/17/88
 Plant: Diablo Canyon 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 5.0E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	4.1E-05
Total	4.1E-05

ATWS

LOOP	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
48 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power SEAL.LOCA EP.REC(SL)	CD	2.3E-05	4.0E-01
49 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power -SEAL.LOCA EP.REC	CD	6.8E-06	4.0E-01
50 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL porv.or.srv.reseat/emerg.power	CD	6.4E-06	4.0E-01
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	3.7E-06	1.4E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
48 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power SEAL.LOCA EP.REC(SL)	CD	2.3E-05	4.0E-01
49 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power -SEAL.LOCA EP.REC	CD	6.8E-06	4.0E-01
50 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL porv.or.srv.reseat/emerg.power	CD	6.4E-06	4.0E-01
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	3.7E-06	1.4E-01

** non-recovery credit for edited case

SEQUENCE MODEL: a:\sealmod\pwrbaseal.cmp
 BRANCH MODEL: a:\sealmod\diablo2.s11
 PROBABILITY FILE: a:\sealmod\pwr_bs11.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.5E-04	1.0E+00	
LOOP	2.0E-05 > 2.0E-05	5.8E-01 > 5.0E-01	
Branch Model: INITOR			

Event Identifier: 323/88-008

Initiator Freq:	2.0E-05		
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
emerg.power	5.4E-04	8.0E-01	
afw	3.8E-04	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	1.0E+00	7.0E-02	
PORV.OR.SRV.CHALL	4.0E-02 > 1.0E+00 **	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.0E-02		
porv.or.srv.reseat	3.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	3.0E-02	1.0E+00	
SEAL.LOCA	3.2E-01 > 2.3E-01 **	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	3.2E-01 > 2.3E-01		
EP.REC(SL)	6.5E-01 > 4.8E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	6.5E-01 > 4.8E-01		
EP.REC	1.1E-01 > 4.3E-02	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.1E-01 > 4.3E-02		
hpi	1.0E-03	8.4E-01	
hpi(f/b)	1.0E-03	8.4E-01	1.0E-02
hpr/-hpi	1.5E-04	1.0E+00	1.0E-03
porv.open	1.0E-02	1.0E+00	4.0E-04
* branch model file			
** forced			

Minarick
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