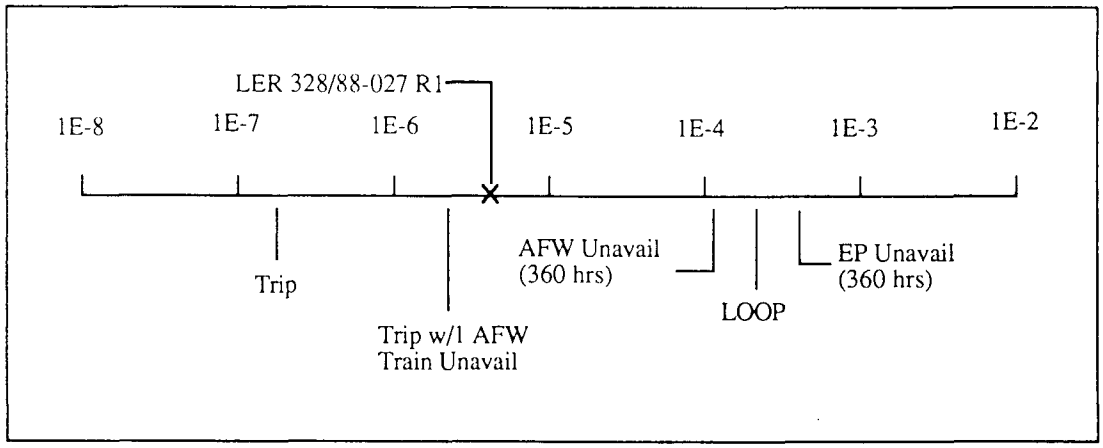
Accident Sequence Precursor Program Event Analysis

LER No: 328/88-027 R1
Event Description: Reactor trip following loss of main feedwater with turbine-driven AFW pump unavailable
Date of Event: June 6, 1988
Plant: Sequoyah Unit 2

Summary

A reactor trip occurred because of a loss of main feedwater caused by closure of a feedwater control valve during testing as a result of a missing diode in a blocking circuit. The turbine-driven auxiliary feedwater pump was also unavailable. The conditional probability of severe core damage estimated for this event is 4.5×10^{-6}. The relative significance of this event compared with other potential events at Sequoyah 2 is shown below.



Event Description

At approximately 14:15 EDT with unit 2 at 98% power, a reactor trip occurred due to a steam/feedwater flow mismatch coincident with a low steam generator level in loop 4. The steam/flow mismatch and low steam generator level were both caused by the closure of the loop 4 feedwater flow control valve (2-FCV-3-103). The valve closed during the performance of surveillance instruction 618, "Engineered Safety Features Actuation System Block Tests." A missing diode in the blocking circuit caused the flow control valve to close.

During the recovery from the trip, several variations from the normal trip recovery occurred. These variations were:

(1) Flow control valves 2-FCV-1-139 (MSR-C2) and 2-FCV-1-153 (MSR-B1) would not close while trying to isolate steam to the moisture separator reheaters. The torque switch settings for these valves were too low to close against the high pressure steam.

(2) A condenser vacuum breaker was erroneously opened by an assistant unit operator and resulted in a loss of condenser vacuum and disabling of the steam dump valves. High noise levels in the area contributed to the miscommunication that caused the operator to open the vacuum breaker. The intent was to open the extraction low-point drain valves using the handswitch near the condenser vacuum breaker.

(3) Because the main control room operator was unaware of the vacuum breaker being opened locally, two vacuum pumps were turned off in an attempt to stabilize condenser vacuum.

(4) The assistant unit operator noted that the condenser vacuum breaker was open from the local handswitch and immediately closed the vacuum breaker. The vacuum breaker was open for approximately 2 min. Condenser vacuum restabilized, and the " B" vacuum pump was restarted.

(5) Unit operators noted that the number 3 steam generator level was rising and reverted to manual control. The turbine-driven auxiliary feedwater control valve (2-LCV-3-172) was not closing completely on demand, and the turbine-driven auxiliary feedwater pump was continuing to fill steam generator number 3. The valve was not closing properly because of a stem maladjustment. Manual control of auxiliary feedwater was undertaken, and the turbine-driven auxiliary feedwater pump was shut off.

(6) The power-operated relief valve for steam generator number 2 opened prematurely at approximately 1005 psig instead of 1040 psig. This valve opened prematurely because of an out-of-calibration condition on the pressure switch.

None of the above variances from normal responses prevented the operators from recovering safely from the reactor trip. Changes to the FSAR have made it unnecessary to perform surveillance instruction 618; therefore, this surveillance test will no longer be performed.

Event-Related Design Information

There are two turbine-driven, variable-speed main feedwater pumps that are capable of delivering feedwater to the four steam generators. The feedwater system normally operates at full load with three hotwell, three demineralized condensate, three condensate heater, and two main feedwater pumps in service.

The auxiliary feedwater system consists of two motor-driven pumps and one turbine-driven pump. Each of the motor-driven pumps serves two steam generators; the turbine-driven pump serves all four.

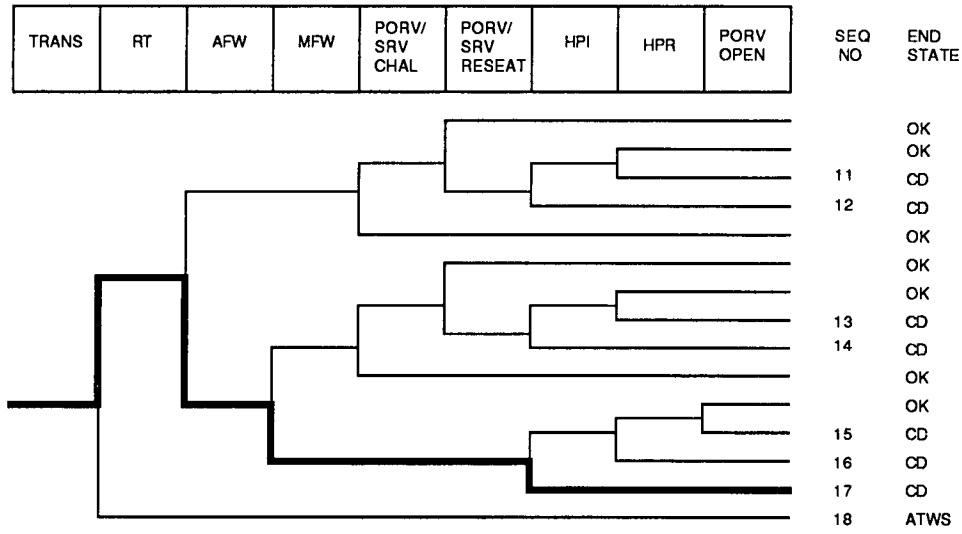
ASP Modeling Assumptions and Approach

The event has been modeled as a loss of main feedwater and failure of the turbine-driven feedwater pump in the auxiliary feedwater system.

Analysis Results

The conditional probability of severe core damage estimated for this event is 4.5×10^{-6}.

Dominant sequences leading to core damage for this event involve the initiating transient and successful scram, failure of AFW ($p = 6.0 \times 10^{-4}$), failure to recover main feedwater ($p = 0.34$), and failure of feed and bleed ($p = 0.02$, including failure to initiate). The dominant sequence associated with the event is highlighted on the following event tree.



Dominant Core Damage Sequence for LER 328/88-027 R1

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 328/88-027
Event Description: Trip from steam/feedwater flow mismatch and low SG level
Event Date: 06/06/88
Plant: Sequoyah 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	4.5E-06
Total	4.5E-06
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
17	trans -rt AFW MFW hpi(f/b)	CD	2.2E-06	7.4E-02
15	trans -rt AFW MFW -hpi(f/b) -hpr/-hpi porv.open	CD	2.1E-06	8.8E-02
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
15	trans -rt AFW MFW -hpi(f/b) -hpr/-hpi porv.open	CD	2.1E-06	8.8E-02
17	trans -rt AFW MFW hpi(f/b)	CD	2.2E-06	7.4E-02
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: a:\sealmod\pwrbseal.cmp
BRANCH MODEL: a:\sealmod\sequoyah.sll
PROBABILITY FILE: a:\sealmod\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	7.7E-04	1.0E+00	
loop	1.6E-05	5.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
emerg.power	2.9E-03	8.0E-01	
AFW	3.8E-04 > 2.3E-03	2.6E-01	
Branch Model: 1.OF.3+ser			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	5.0E-02 > Failed		

Serial Component Prob:	2.8E-04		
AFW/EMERG.POWER	5.0E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	5.0E-02 > Failed		
MFW	1.0E+00 > 1.0E+00	7.0E-02 > 3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.0E+00 > Failed		
porv.or.srv.chall	4.0E-02	1.0E+00	
porv.or.srv.reseat	2.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	2.0E-02	1.0E+00	
seal.loca	2.7E-01	1.0E+00	
ep.rec(s1)	5.7E-01	1.0E+00	
ep.rec	0.0E+00	1.0E+00	
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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