B.8 LER No. 261/83-004, -007 and -016

Event Description: Transient with One AFW Pump and One PORV Inoperable

Date of Event: April 19, 1983

Plant: Robinson 2

B.8.1 Summary

On April 19, 1983, following a reactor trip, A and B motor-driven auxiliary feedwater (AFW) pumps started automatically. The B AFW pump tripped due to low discharge pressure caused by pump cavitation resulting from buildup of vapor in the pump's casing. On April 29, 1983, a pressurizer power operated relief valve (PORV) failed to meet required cycle time and also on a third attempt to cycle, the valve failed to fully open. The estimated conditional core damage probability for this event is 9.2×10^{-4}.

B.8.2 Event Description

On April 19, 1983, following a reactor trip caused by failure of the turbine electro-hydraulic oil pumps, A and B motor-driven AFW pumps started automatically. Within five minutes of the auto-start, pump B tripped. Visual inspection of the B pump breaker revealed no damage, and the breaker did not appear to have tripped on overcurrent. The periodic AFW component test was performed. The test requires that the pump casing be vented prior to running the pump. When the casing was vented, a significant amount of vapor was released from the pump casing. Thus, it was determined that the pump tripped due to low discharge pressure caused by pump cavitation resulting from vapor buildup inside the pump casing. Following the test on pump B, the same test was performed on pump A. Pump A casing did not release any vapor when vented. A later examination of the pumps on April 20, 1983 revealed high pump temperatures. The temperature indicated that a slight backleakage of hot water through the discharge gate valves into the pump casings existed. Both pumps were again vented, but no vapor was released.

A similar occurrence of backleakage through the discharge valves resulted in the binding of the turbine-driven AFW pump on July 21, 1983 (LER 261/83-016). The plant was operating at 79% power when the turbine-driven AFW pump was declared inoperable due to steam binding. The plant was shut down when the limiting condition for operation time limit expired, seven days later. The pump discharge valves were repaired and a leakage evaluation was performed with satisfactory results.

On April 29, 1983, during testing of the PORVs, valve RC-455C failed to meet the required cycle time, and on a subsequent attempt to cycle the valve, the valve failed to fully open. Inspections revealed that the cause of the PORV failure was galling of the valve plug to the cage. The valve was rebuilt and returned to service approximately thirteen days later. A stem and valve plug manufactured from materials designed to reduce the chance of galling and a stem guide bushing intended to improve the valve plug's ability to seat were installed.

B.8.3 Additional Event-Related Information

The AFW system at Robinson 2 is a three-train system consisting of two motor-driven pumps and a turbine-driven pump. Either motor-driven pump or the turbine-driven pump is capable of supplying secondary side cooling to any of three steam generators.

In addition to providing overpressure protection, the PORVs are used in conjunction with the safety injection system to provide bleed and feed cooling should the AFW and main feedwater (MFW) systems fail.

B.8.4 Modeling Assumptions

AFW pump B was declared inoperable following a reactor trip. Assuming the PORV was faulted at the time of the trip as well (which is likely since these valves are usually cycled only when shutdown), this event was modeled as a transient with one train of AFW set to failed and the feed-and-bleed (FEED.BLEED) branch probability set to 1.0.

The mechanism which failed AFW pump B could have occurred in the other pumps as well. LER 261/83-016 reported a similar problem with the turbine-driven pump three months later. To reflect the potential impact of this failure mode in all three pumps, the serial component probability (which represents common cause effects among the three different design pumps in the AFW model) was revised to 3.0E-2 [p(pump A fails from steam binding given pump B failed from steam binding)*p(pump C fails given pump B and pump A failed)], 0.1*0.3, using typical ASP Program conditional failure probabilities). Because potential common cause effects were addressed using the serial component failure probability, the AFW train failure probabilities were revised to reflect the unavailability of pump B (independent faults).

The failure probability for AFW following ATWS was also revised to reflect the potential common cause failure of all three pumps. The potential for common cause failure exists, even when a component is failed. Therefore, the conditional probability of a common cause failure was included in the analysis for those components that failed as part of the event.

The serial component of the feed-and-bleed branch probability represents the failure of the PORVs. In the models, both PORVs are assumed to be needed for proper accident mitigation using feed and bleed. Thus, to represent the effect of one PORV inoperable, the serial component of FEED.BLEED was set to 1.0. Because PORV RC-455C partially opened, the PORVs were assumed to be available to support pressure relief.

B.8.5 Analysis Results

The estimated conditional core damage probability for this event is 9.2×10^{-4}. The dominant sequence, highlighted on the event tree in Figure B.8.1, involved the observed trip, failure of AFW, failure of main feedwater, and failure of feed and bleed.

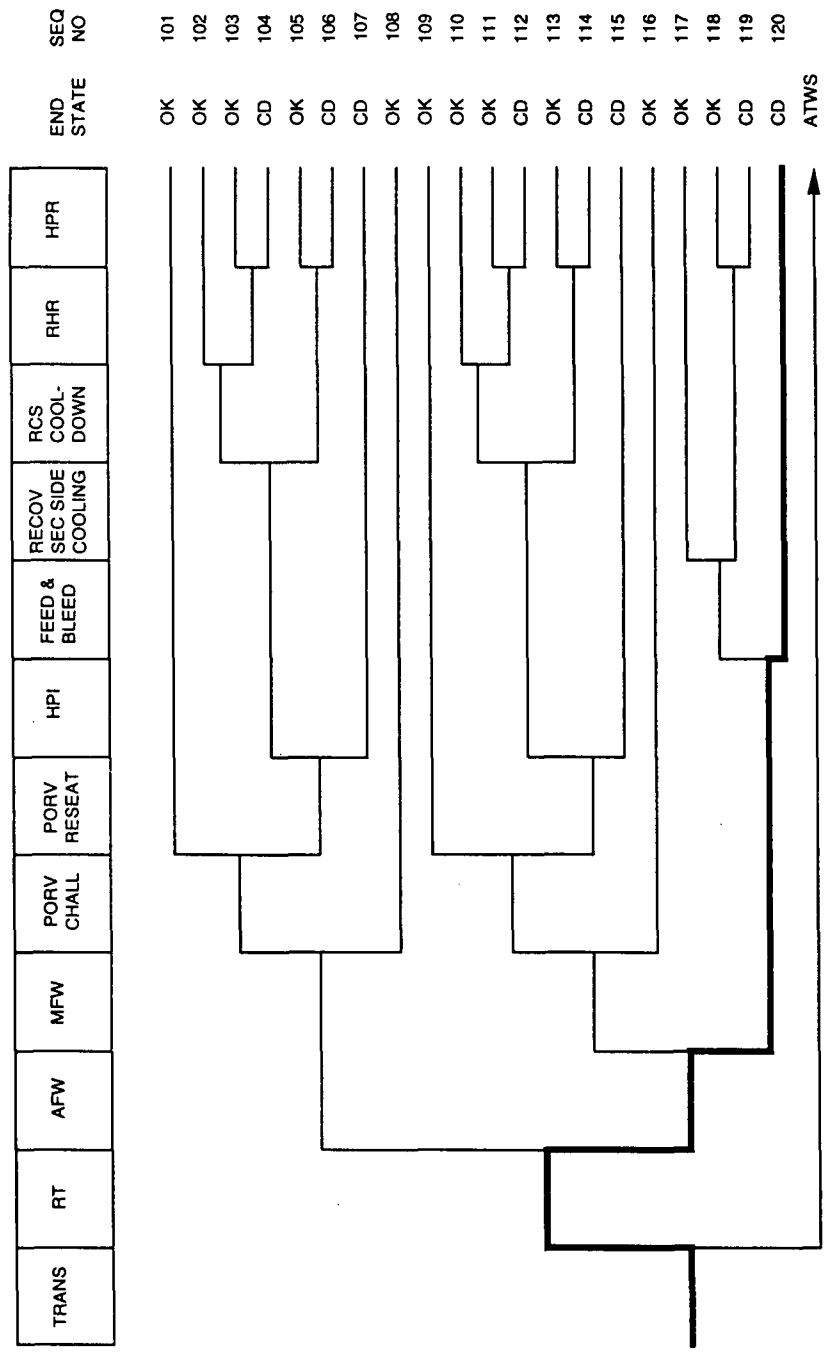

Figure B.8.1 Dominant core damage sequence for LER 261/83-004, -007, and -016

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 261/83-004, -005, -007, and -016
Event Description: Transient with one AFW pump and one PORV inoperable
Event Date: April 19, 1983
Plant: Robinson

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	9.2E-04
Total	9.2E-04

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
120	trans -rt AFW mfw FEED.BLEED	CD	9.1E-04	1.5E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
120	trans -rt AFW mfw FEED.BLEED	CD	9.1E-04	1.5E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\aspcode\models\pwrb8283.cmp
BRANCH MODEL: c:\aspcode\models\robinson.82
PROBABILITY FILE: c:\aspcode\models\pwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.0E-03	1.0E+00	
loop	1.6E-05	5.3E-01	
loca	2.4E-06	5.4E-01	
sgtr	1.6E-06	1.0E+00	
rt	2.8E-04	1.0E-01	

rt(loop)	0.0E+00	1.0E+00	
AFW	3.8E-04 > 3.1E-02	4.5E-01	
Branch Model: 1.OF.3+ser			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
Train 3 Cond Prob:	5.0E-02		
Serial Component Prob:	2.8E-04 > 3.0E-02		
AFW/ATWS	4.3E-03 > 1.9E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.3E-03 > 1.9E-01		
afw/ep	5.0E-02	3.4E-01	
mfw	1.9E-01	3.4E-01	1.0E-03
porv.chall	4.0E-02	1.0E+00	
porv.chall/afw	1.0E+00	1.0E+00	
porv.chall/loop	1.0E-01	1.0E+00	
porv.chall/sbo	1.0E+00	1.0E+00	
porv.reseat	2.0E-02	1.1E-02	
porv.reseat/ep	2.0E-02	1.0E+00	
srv.reseat(atws)	1.0E-01	1.0E+00	
hpi	1.5E-03	8.9E-01	
FEED.BLEED	2.0E-02 > 1.0E+00	1.0E+00	1.0E-02
Branch Model: 1.OF.3+ser+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01		
Serial Component Prob:	2.0E-02 > 1.0E+00		
emrg.boration	0.0E+00	1.0E+00	1.0E-02
recov.sec.cool	2.0E-01	1.0E+00	
recov.sec.cool/offsite.pwr	3.4E-01	1.0E+00	
rcs.cooldown	3.0E-03	1.0E+00	1.0E-03
rhr	3.1E-02	7.0E-02	1.0E-03
rhr.and.hpr	1.0E-03	1.0E+00	1.0E-03
hpr	4.0E-03	1.0E+00	1.0E-03
ep	2.9E-03	8.9E-01	
seal.loca	2.7E-01	1.0E+00	
offsite.pwr.rec/-ep.and.-afw	2.2E-01	1.0E+00	
offsite.pwr.rec/-ep.and.afw	6.7E-02	1.0E+00	
offsite.pwr.rec/seal.loca	5.7E-01	1.0E+00	
offsite.pwr.rec/-seal.loca	7.0E-02	1.0E+00	
sg.iso.and.rcs.cooldown	1.0E-02	1.0E-01	
rcs.cool.below.rhr	3.0E-03	1.0E+00	3.0E-03
prim.press.limited	8.8E-03	1.0E+00	

* branch model file
** forced