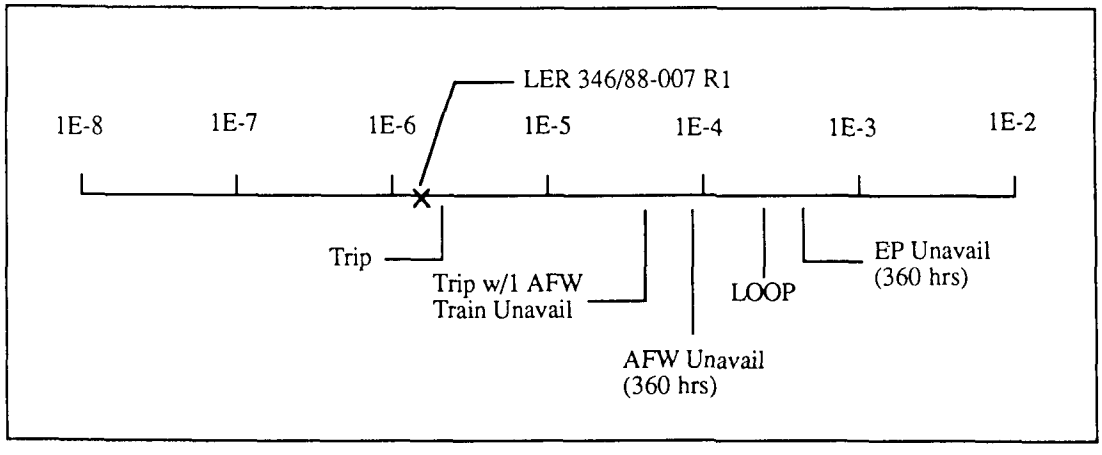
Accident Sequence Precursor Program Event Analysis

LER No: 346/88-007 R1
Event Description: Component cooling valves drift closed on loss of air
Date of Event: March 4, 1988
Plant: Davis Besse

Summary

During maintenance, it was discovered that a prolonged loss of instrument air would cause three service water valves to close. This closure results in isolation of service water to the component cooling water heat exchangers, which faults the heat removal capability of this system. This event has been modeled as a potential unavailability of CCW during a long-term loss of instrument air. The conditional probability of core damage associated with the event is estimated to be 1.6×10^{-6}. The relative significance of this event compared with other potential events at Davis Besse is shown below.



Event Description

During troubleshooting, operations personnel isolated instrument air from service water air-operated valve SW1434 (service water heat exchanger temperature control valve) with the understanding that the valve would remain in its fail-safe full open position. Approximately 1.5 h after the valve was isolated from instrument air, a control room alarm indicated that the valve was not fully open. The valve drifted closed due to air leakage of its accumulator system. Further investigation revealed five other valves with similar problems. The valves were the temperature control valves (SW1424 and SW1429) for the other two component cooling water heat exchangers, the temperature control valves

(CC1467 and CC1469) for the decay heat removal heat exchangers, and the component cooling nonessential header isolation valve CC 1495.

Upon discovery of the potential failure mode of valves CC1467 and CC1469, valve CC1469 was placed in the open position by engaging its manual operator. There was, however, no corrective action immediately identified for the remaining valves. Long-term corrective action was identified to modify the valves' actuator design and implement the modifications during the sixth refueling outage.

Event-Related Plant Design Information

The air-operated valves impacted by this event utilize two safety-grade accumulators as a backup pneumatic supply source. One accumulator allows the valve to open on demand by providing pressurized air to the bottom of the valve's actuator piston, forcing the valve open as air is vented from above the piston. Similarly, when closing the valve, the other accumulator provides pressurized air to the top of the valve's actuator piston, forcing the valve to close as air is vented from below the piston.

Valves SW1424, SW1429, and SW1434 are the service water heat exchanger temperature control valves to the respective E22-1, E22-2, and E22-3 component cooling water heat exchangers. The component cooling water loops serviced by these heat exchangers provide cooling to many components, some of which are shown below:

(1) the high-pressure-injection-bearing oil coolers
(2) the decay-heat-pump-bearing housing coolers
(3) the emergency diesel generator jacket heat exchangers
(4) the make-up pump gear and pump lube oil coolers
(5) the seal return coolers
(6) the letdown coolers
(7) the control rod drive coolers

If the three valves close, component cooling water will be able to circulate; however, heat removal capability for the system would be lost and would eventually render the above components inoperable if not corrected.

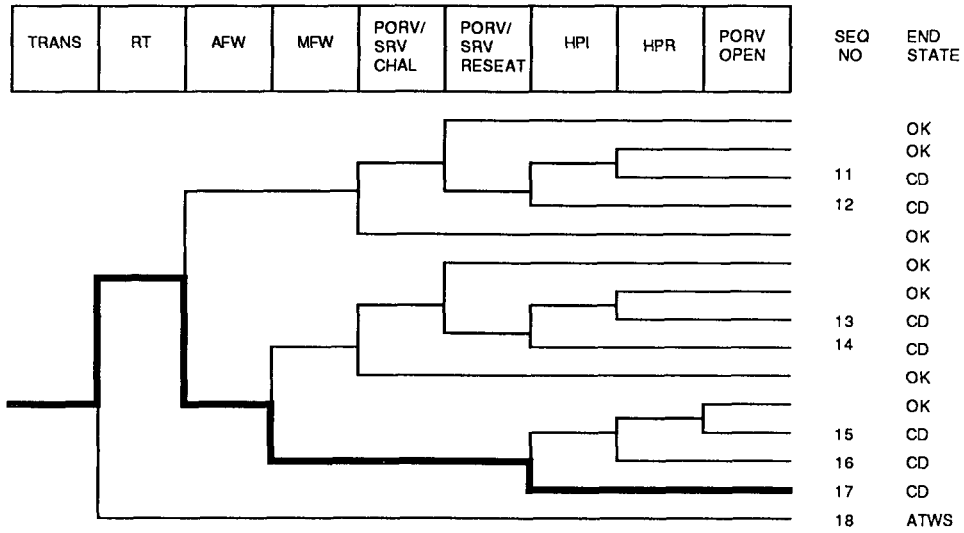
Valves CC1467 and CC1469 are the temperature control valves for the respective E27-1 and E27-2 decay heat removal heat exchangers. Closure of these valves would render both trains of decay heat removal inoperable. However, closure of the CCW heat exchanger valves results in the same impact.

ASP Modeling Assumptions and Approach

This event has been modeled a long-term unavailability of instrument air. Loss of instrument air results in a loss of feedwater due to unavailability of air to the feedwater control valves. The frequency of loss of instrument air was assumed to be 0.01/yr (this is consistent with valves assumed in plant-specific PRAs). The probability of not recovering instrument air prior to depletion of the individual valve accumulators at ~1.5 h was assumed to be 0.34. In addition, operator action to restore service water to the heat exchangers [p(nonrecovery) = 0.34] has been included in the analysis.

Analysis Results

The core damage frequency estimated for the event is 1.6×10^{-6}. This value was developed from the probability of loss of instrument air over a 1-year period (p = 0.01), failure to recover instrument air before 1.5 h (p = 0.34), failure to recover CCW once the valves have closed on loss of instrument air (p = 0.34, included in transient calculation), and p(core damage | LOFW and loss of HPI, feed and bleed, and HPR). The dominant sequence (highlighted on the following event tree) involves loss of secondary-side cooling and failure of feed and bleed. Note that this assessment may be conservative in that relaxed system success criteria resulting from 1.5 h of successful decay heat removal has not been factored into the analysis.



Dominant Core Damage Sequence for LER 346/88-007 R1

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 346/88-007
Event Description: Component cooling valves drift close on loss of air
Event Date: 03/04/88
Plant: Davis-Besse

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	3.4E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	4.6E-04
Total	4.6E-04
ATWS	
TRANS	1.1E-05
Total	1.1E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
17	TRANS -rt afw MFW HPI(F/B)	CD	4.6E-04	9.2E-02
18	TRANS rt	ATWS	1.1E-05	4.1E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
17	TRANS -rt afw MFW HPI(F/B)	CD	4.6E-04	9.2E-02
18	TRANS rt	ATWS	1.1E-05	4.1E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\sealmod\pwrbseal.cmp
BRANCH MODEL: c:\asp\sealmod\davis.sll
PROBABILITY FILE: c:\asp\sealmod\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	6.3E-04 > 1.0E+00	1.0E+00 > 3.4E-01	
Branch Model: INITOR			
Initiator Freq:	6.3E-04 > 1.0E+00		
loop	1.6E-05	2.4E-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	5.0E-03	2.7E-01	
afw/emerg.power	5.0E-03	2.7E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		

porv.or.srv.chall	8.0E-02	1.0E+00	
porv.or.srv.reseat	1.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	1.0E-02	1.0E+00	
seal.loca	0.0E+00	1.0E+00	
ep.rec(sl)	0.0E+00	1.0E+00	
ep.rec	4.5E-01	1.0E+00	
HPI	1.0E-03 > 1.0E+00	8.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
HPI(F/B)	1.0E-03 > 1.0E+00	8.4E-01 > 1.0E+00	1.0E-02
Branch Model: 1.OF.2+opr			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
HPR/-HPI	1.5E-04 > 1.0E+00	1.0E+00	1.0E-03
Branch Model: 1.OF.2+opr			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
** forced

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