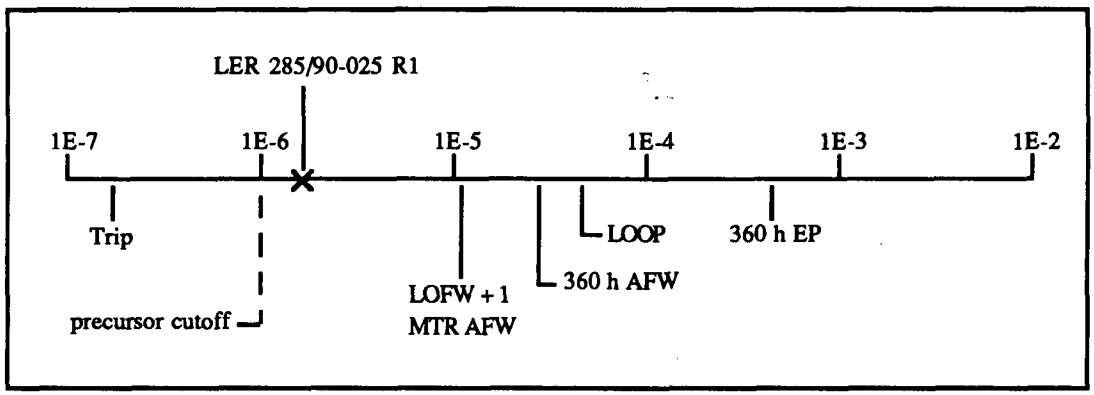
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 285/90-025 R1
Event Description: Component cooling water would fail on loss of control air
Date of Event: September 29, 1990
Plant: Fort Calhoun 1

Summary

It was discovered that the component cooling water (CCW) system would be rendered inoperable by failure of the instrument air (IA) system. In addition, it was discovered that the capability of the raw water system to back up the CCW system was inadequate. The conditional probability of core damage associated with this event is 1.7×10^{-6}. The relative significance of the event compared to other postulated events at Fort Calhoun is shown below.



Event Description

Vital functions of the CCW system are backed up by the raw water system at Fort Calhoun. The two systems are cross-tied at various points by normally closed, air-operated valves. It was realized that, if the IA system failed, these valves would open. This would permit the high-pressure CCW to drain via the raw water system to the Missouri River. At the same time, it was realized that the raw water discharge pressure was inadequate to back up the CCW system in supplying the containment coolers.

At Fort Calhoun, the raw water system normally provides cooling to the CCW system. In event of a failure of the CCW system, air-operated valves are opened to route raw water directly to the containment air cooling coils, control room air conditioners,

shutdown cooling heat exchangers, safety injection pump seal and bearing coolers, and containment spray pump seal and bearing coolers. The air-operated crosstie valves are equipped with accumulators, but they are nonsafety grade, and the utility assumes that they could not be relied upon. A loss of IA would then allow the crosstie valves to open between the systems, allowing CCW to drain.

By design, the raw water system should supply the vital CCW loads when CCW is unavailable. It was realized, however, that the discharge pressure supplied by the raw water pumps was insufficient to permit them to properly supply the containment coolers during accident conditions.

Other analysis efforts identified a potential single-failure mode for the containment spray (CS) system. One CS pump is aligned to receive emergency power from emergency diesel generator (EDG) 1, and two CS pumps are aligned to EDG 2. In the event of a design basis accident involving a loss of offsite power (LOOP) and failure of EDG 2, one CS pump would attempt to feed both containment spray headers. Depending on containment pressure and other factors, the sole pump could run out and fail.

Additional Event-Related Information

The CCW system consists of three pumps and four heat exchangers. Raw water is supplied to the heat exchangers to cool the closed-loop CCW system. CCW loads include: letdown heat exchangers, reactor coolant pump lube oil and coolers, control room air conditioners, safety injection pump seal and bearing coolers, charging pump lube oil coolers, and CS pump seal and bearing coolers.

Backup raw water is supplied to the following CCW loads: containment spray pumps and heat exchangers, low-pressure safety injection (LPSI) and high-pressure safety injection (HPSI) pumps, and the containment fan coolers (which were found to be faulted on loss of IA in this event). Backup raw water is not provided to the reactor coolant pump (RCP) lube oil and seal coolers, SI leakage coolers, storage pool heat exchanger, letdown heat exchanger, and charging pump lube oil coolers.

ASP Modeling Assumptions and Approach

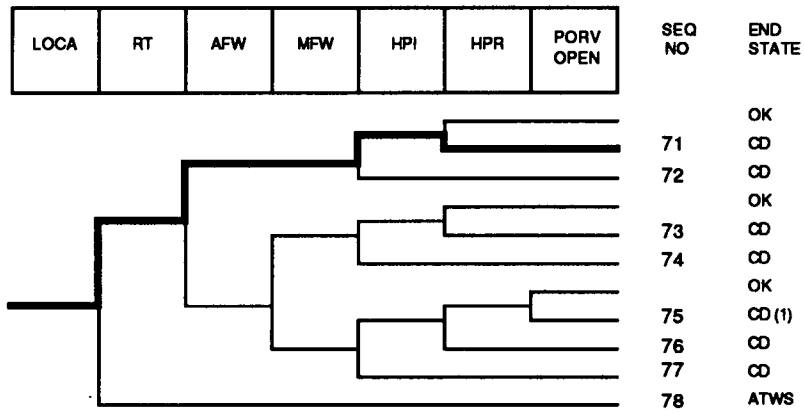
This event has been modeled as a potential loss of IA for a 1-yr period, the longest unavailability period addressed in the ASP yearly reports. Failure to recover IA within approximately 1 h is assumed to have the potential to result in an RCP seal loss-of-coolant accident (LOCA) due to unavailability of RCP seal cooling and seal injection because of the unavailability of CCW to the seals and the charging pumps.

Assuming a probability of loss of instrument air of 0.007 (0.01/yr for a typical loss of IA x 0.34 probability of not recovering within 1 h + 0.03/yr for a LOOP longer than 1 h x 0.12 probability of failing to load an air compressor on an emergency bus) and a probability of seal failure given loss of seal cooling of 0.12 (see ORNL/NRC/LTR-89/11), results in a probability of seal failure during a 1-yr vulnerability period of 8.4×10^{-4}. This probability was used, with the PWR class G event tree models (see Appendix A), to estimate a conditional core damage probability for this event.

The CS single-failure concerns and the containment cooler concerns were not addressed. While these concerns increase the probability of failure of containment cooling, they are not directly relevant to the ASP core damage models.

Analysis Results

The conditional probability of core damage estimated for this event is 1.7×10^{-6}. The dominant core damage sequence, highlighted on the following event tree, involves an RCP seal LOCA (due to the unavailability of IA for a period greater than 1 h), and successful high-pressure injection, and failure of high-pressure recirculation.



Dominant core damage sequence for LER 285/90-025

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 285/90-025
Event Description: CCW would fail on loss of instrument air
Event Date: 09/29/90
Plant: Fort Calhoun

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA	8.4E-04

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOCA	1.7E-06
Total	1.7E-06
ATWS	
LOCA	2.8E-08
Total	2.8E-08

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	LOCA -rt -afw -hpi hpr/-hpi	CD	9.6E-07	8.4E-04
72	LOCA -rt -afw hpi	CD	7.1E-07	7.1E-04
78	LOCA rt	ATWS	2.8E-08	1.0E-04

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
71	LOCA -rt -afw -hpi hpr/-hpi	CD	9.6E-07	8.4E-04
72	LOCA -rt -afw hpi	CD	7.1E-07	7.1E-04
78	LOCA rt	ATWS	2.8E-08	1.0E-04

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrgseal.cmp
BRANCH MODEL: c:\asp\1989\calhoun.sl1
PROBABILITY FILE: c:\asp\1989\pwr_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	6.0E-05	1.0E+00	

Event Identifier: 285/90-025

loop	1.6E-05	5.3E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 8.4E-04	
Branch Model: INITOR			
Initiator Freq:	2.4E-06		
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
emerg.power	2.9E-03	8.0E-01	
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	
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	4.6E-02	1.0E+00	
ep.rec(s1)	5.7E-01	1.0E+00	
ep.rec	1.4E-02	1.0E+00	
hpi	1.0E-03	8.4E-01	
hpi(f/b)	1.0E-03	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
hpr/-hpi	1.5E-04	1.0E+00	
csr	2.0E-03	3.4E-01	

* branch model file
** forced

Minarick
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Event Identifier: 285/90-025