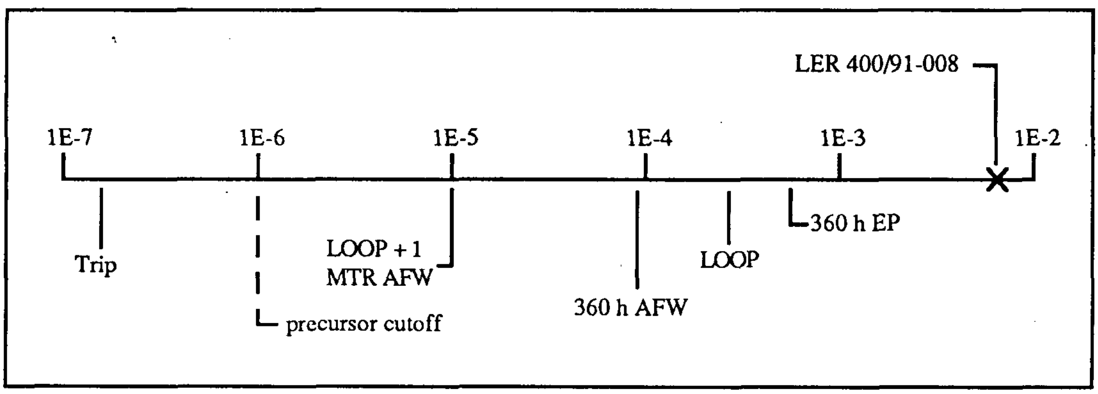
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.:	400/91-008
Event Description:	HPI unavailability for one refueling cycle because of inoperable miniflow lines
Date of Event:	April 3, 1991
Plant:	Harris 1

Summary

Harris is equipped with three charging/safety injection pumps (CSIPs) that provide charging and seal flow during normal operation and provide high-pressure injection (HPI) during accidents. Each pump is provided with a normal minimum flow path and an alternate minimum flow path for pump protection. During normal operations, the minimum flow path is via the seal water heat exchanger back to the pump suction. During safety injection (SI) operation, this path is isolated, and two alternate paths via relief valves to the reactor water storage tank (RWST) are aligned. Tests conducted during a refueling outage revealed that both relief valves were failed, as well as associated piping. Had HPI been demanded during the operating cycle, sufficient flow would have been diverted via the alternate miniflow system to fail the injection function. Under some circumstances, pump runout and failure could also have resulted.

The conditional core damage probability estimated for this event is 6.3×10^{-3}. The relative significance of the event compared to other postulated events at Harris 1 is shown below.



Event Description

The CSIPs provide charging and reactor coolant pump seal injection flow during normal operation at Harris. Under accident conditions the CSIPs act as HPI pumps, providing

high-pressure makeup to the reactor coolant system (RCS). While acting as charging pumps, the CSIPs are protected against deadhead operation by normal minimum flow lines that are capable of returning 60 gpm through the seal water heat exchanger to the pump suction. On an SI, these lines are automatically isolated, and two alternate minimum flow lines are aligned. Relief valves 1CS-744 and 1CS-755 are located respectively in these lines. They are designed to lift at approximately 2300 psig to recirculate water back to the RWST.

During outage testing, these relief valves were both found to be damaged, along with associated piping. Relief valve 1CS-755 failed to hold any pressure during bench testing, and 1CS-744 lifted at 1100 psig. Piping upstream of valve 1CS-755 was found to be cracked; this piping failed during testing. In addition, a weld indication was identified upstream of 1CS-744. Utility investigation determined that the damage was a result of water-hammer effects. Gas accumulations, believed to be air, were thought to have developed in the alternate miniflow lines during previous testing or maintenance. Displacement of this air during earlier system testing apparently resulted in water-hammer and damage to the piping and valves.

The utility reported that, had HPI been demanded, the failures in the alternate miniflow lines would have diverted sufficient flow that the system would not have been able to perform its safety function. It was also reported that, in the event of a large-break loss-of-coolant accident (LOCA), the additional flow through the alternate miniflow system would have resulted in CSIP runout.

Additional Event-Related Information

A drawing of the Harris charging/SI system is shown in Fig. 1.

EOP-FRP-C.2, "Response to Degraded Core Cooling," provides instructions for RCS depressurization and use of the accumulators and low-pressure injection (LPI) pumps if the high-pressure system is unavailable. This alternate mitigation method would only be effective if secondary-side cooling were available and if the RCS could be depressurized prior to core uncovery. The Accident Sequence Precursor (ASP) models, described in Appendix A, do not currently address the potential use of secondary-side depressurization and LPI for core cooling success.

ASP Modeling Assumptions and Approach

This event was modeled as an unavailability of the CSIPs for SI. The failures were assumed to be nonrecoverable. Since the procedures require SI to be initiated prior to opening the PORVs for feed and bleed, the failed relief valves would also have resulted in a failure of that function as well as SI in the event of a LOCA.

The unavailability existed throughout the refueling cycle. To estimate the relative significance of the event within a 1-yr observation period (the interval between precursor reports), a 1-yr unavailability period was utilized in the analysis (6132 h, assuming the plant was critical or at hot shutdown for 70% of the year).

Two sensitivity analyses were also performed. The first involved the potential use of steam generator (SG) depressurization and the LPI system for sequences in which secondary-side cooling was available. A failure probability of 0.12 was assumed for this alternate core cooling method. As described in Appendix A, a failure probability of 0.12 is used in the ASP Program for situations in which action could be taken from the control room, but which are not routine or involve substantial operator burden. (Use of SG depressurization and LPI as an alternate to HPI is not addressed in the current ASP models.) The second sensitivity analysis addressed the possibility that two CSIPs would be effective in providing high-pressure makeup.

Analysis Results

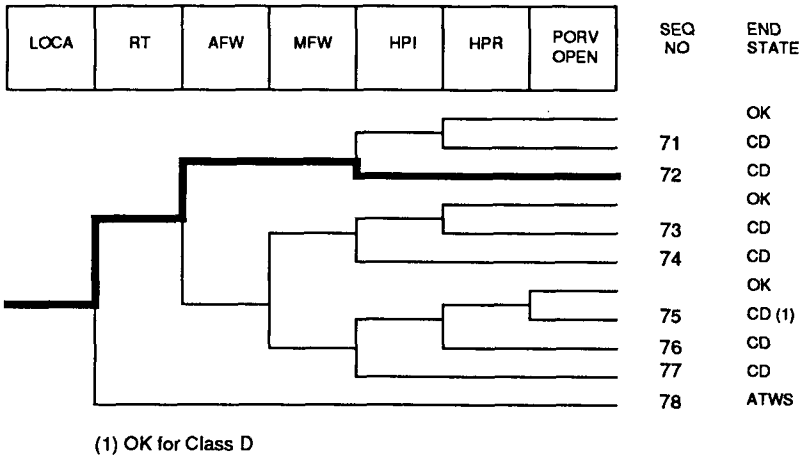
The conditional core damage probability associated with this event was estimated to be 6.3×10^{-3}. The dominant core damage sequence, highlighted on the following event tree, involves a LOCA, reactor trip and auxiliary feedwater success, and failure of HPI.

If SG depressurization and LPI is assumed to provide successful core cooling with a failure probability of 0.12, then the conditional probability for the event is reduced to 7.8×10^{-4}, still a significant event.

It is possible that use of two charging pumps would provide adequate injection flow even with the failed relief valves, but no information is available that would permit this to be confirmed. If this were the case, the conditional probability estimated for the event would be $\sim 1.3 \times 10^{-4}$ without the use of SG depressurization, and 2.3×10^{-5} if SG depressurization and LPI were effective in providing core cooling.

Figure removed during SUNSI review.

Fig. 1. Harris 1 charging/safety injection system



Dominant core damage sequence for LER 400/91-008

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 400/91-008
Event Description: HPI unavailable due to inoperable mini-flow lines
Event Date: 04/03/91
Plant: Harris 1

UNAVAILABILITY, DURATION= 6132

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	3.4E+00
LOOP	5.3E-02
LOCA	6.3E-03

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.5E-05
LOOP	1.8E-05
LOCA	6.3E-03
Total	6.3E-03
ATWS	
TRANS	0.0E+00
LOOP	0.0E+00
LOCA	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
72	loca -rt -afw HPI	CD	6.3E-03	4.3E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
72	loca -rt -afw HPI	CD	6.3E-03	4.3E-01

** non-recovery credit for edited case

Note: For unavailabilities, conditional probability values are differential values which reflect the added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

SEQUENCE MODEL: c:\asp\1989\pwrbseal.cmp
BRANCH MODEL: c:\asp\1989\harris.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

Event Identifier: 400/91-008

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	5.5E-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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	1.0E+00	7.0E-02	1.0E-03
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(sl)	5.7E-01	1.0E+00	
ep.rec	7.0E-02	1.0E+00	
HPI	3.0E-04 > 1.0E+00	8.4E-01 > 1.0E+00	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPI(F/B)	3.0E-04 > 1.0E+00	8.4E-01 > 1.0E+00	1.0E-02
Branch Model: 1.OF.3+opr			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
Train 3 Cond Prob:	3.0E-01 > Failed		
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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Event Identifier: 400/91-008