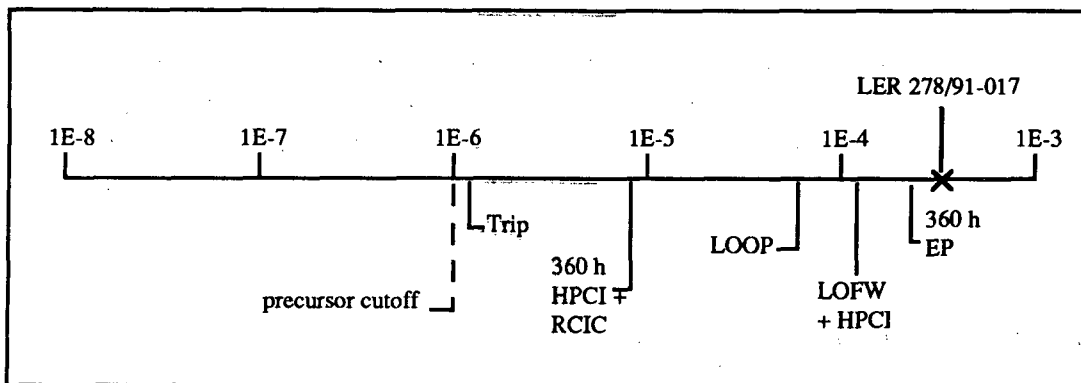


ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 278/91-017
 Event Description: Control wiring for ADS/relief valves found damaged
 Date of Event: September 24, 1991
 Plant: Peach Bottom 3

Summary

Improperly installed insulation on the automatic depressurization system (ADS) / safety relief valves (SRVs) resulted in damage to SRV control wiring. This condition existed throughout the refueling cycle. The high-pressure coolant injection (HPCI) system was also unavailable for periods of time during that interval. The conditional core damage probability estimated for this event is 3.3×10^{-4} . The relative significance of this event compared to other postulated events at Peach Bottom 3 is shown below.



Event Description

Following shutdown for refueling in September 1991, three SRVs were removed for preventive maintenance. On examination, the control solenoid valve wiring insulation was found to be degraded on each SRV. The electrical cable insulation between the solenoid coil and its junction box was cracked and hardened on all three valves. A termination splice between the solenoid and the junction box was melted on two of the valves.

An investigation determined that the damage occurred because SRV insulation was improperly installed during the previous refueling outage, which was completed in December 1989. The installed configuration left a significant portion of the piping

around the valve and adjacent to the solenoid uncovered. This allowed the solenoid and its wiring to experience temperatures in excess of 400°F. These high temperatures resulted in accelerated thermal aging — qualified lifetimes were exceeded within 3 d after startup.

The solenoids for the eight remaining SRVs were operated and verified to function as expected under shutdown conditions. The valves were then removed and sent to a test facility to determine how well they could perform under accident conditions. Initial results of that testing indicated that some failures occurred, but final results were unavailable at the time that the LER and an associated Nuclear Regulatory Commission (NRC) inspection report were written.

The SRVs associated with the ADS system, in conjunction with low-pressure makeup sources, are intended to back up the HPCI system in maintaining vessel inventory during small-break loss-of-coolant accidents (LOCAs). The HPCI system was unavailable for an estimated total of ~510 h during the 21-month period that the SRV control circuits were compromised (NRC Inspection Reports 50-277/91-33 and 50-278/91-33, dated December 23, 1991).

Additional Event-Related Information

The SRVs at Peach Bottom are Target Rock two-stage, pilot-operated valves. As installed, high main steamline pressure will operate a pilot valve that will, in turn, operate the main valve in the unit to relieve steam to the suppression pool. An electrically operated solenoid valve can also be used to align compressed gas to open the main valve. This allows remote operation of the valve either by the operator or by the ADS.

ASP Modeling Assumptions and Approach

Wiring for 8 of the 11 SRVs (including 4 of 5 dedicated to ADS) was shown to be still functional under normal conditions; the concern is that the valves might not have functioned under small-break LOCA conditions. As reactor core isolation cooling (RCIC) is assumed unable to provide sufficient makeup during a small-break LOCA in the Accident Sequence Precursor (ASP) models, HPCI provides the only reliable high-pressure source of makeup. Should HPCI be unavailable in this circumstance, the ADS system is required to rapidly depressurize the reactor vessel to permit makeup by low-pressure sources.

Small-break LOCAs may be classified into two categories: those involving relief valves that operate and fail to reseal correctly and those involving other reactor pressure boundary failures. Failures of the first type could be expected not to result in significant changes to the containment atmosphere. In accidents of this type, the

information available indicates that the ADS system would have worked.

Failures of the second type could result in release of steam to the containment atmosphere, and it is unclear whether the control circuits for the SRVs could have continued to function. For the purposes of this analysis, it was assumed that the SRVs would have failed in the event of a small-break LOCA other than those involving relief valve leakage.

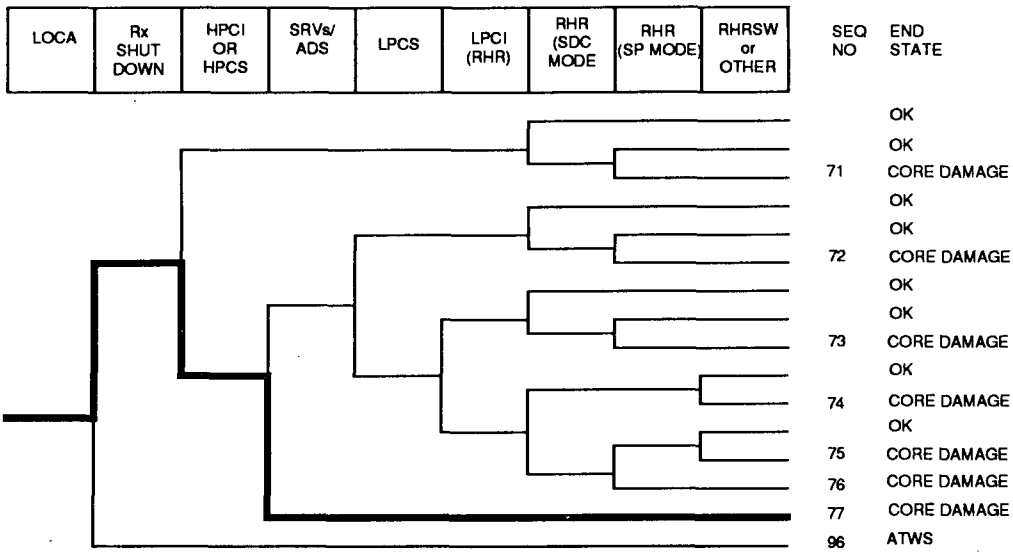
The ASP Program estimates the small-break LOCA frequency at $3.3 \times 10^{-6}/\text{h}$, with a nonrecovery probability of 0.5, and these values were used in this analysis. The ASP Program normally estimates a HPCI failure-on-demand probability of 0.029. In this case, however, data regarding HPCI unavailability during the event were available, which suggested that a higher value should be employed. As noted earlier, the HPCI system was unavailable for ~510 h during the 21 months of operation with degraded SRVs. Assuming the plant was at power or in hot shutdown for 70% of the 21-month period results in an estimated HPCI unavailability of 0.047. (LER 278/91-017 reports an HPCI unavailability of ~0.036 for the entire 21-month period.) The nonrecovery probability of 0.7 normally employed was used in this case.

This event was modeled as an unavailability of SRVs for the ADS function during a LOCA. HPCI was modeled as having a higher than usual failure probability. 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 time).

Analysis Results

The estimated core damage probability associated with this event is 3.3×10^{-4} . The dominant core-damage sequence, highlighted on the following event tree, involves a postulated LOCA with HPCI and ADS failures.

Additional information concerning this event is included in combined inspection reports 50-277/91-33 and 50-278/91-33 dated December 23, 1991.



Dominant core damage sequence for LER 278/91-017

B-121

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 278/91-017
 Event Description: Control wiring for SRVs found damaged (TI LOCAs)
 Event Date: 09/24/91
 Plant: Peach Bottom 3

UNAVAILABILITY, DURATION= 6132

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	3.4E+00
LOOP	2.3E-02

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.5E-07
LOOP	1.5E-07
Total	3.0E-07
ATWS	
TRANS	0.0E+00
LOOP	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
28	trans -rx.shutdown pcs/trans srv.chall/trans.-scram srv.close fw/pcs.trans HPCI srv.ads	CD	1.5E-07	1.7E-01
55	loop -emerg.power -rx.shutdown srv.chall/loop.-scram srv.close HPCI srv.ads	CD	1.3E-07	1.2E-01
67	loop emerg.power -rx.shutdown/ep -ep.rec srv.chall/loop.-scram -srv.close HPCI rcic	CD	9.7E-09	9.4E-02
69	loop emerg.power -rx.shutdown/ep -ep.rec srv.chall/loop.-scram srv.close HPCI	CD	8.7E-09	1.3E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
28	trans -rx.shutdown pcs/trans srv.chall/trans.-scram srv.close fw/pcs.trans HPCI srv.ads	CD	1.5E-07	1.7E-01
55	loop -emerg.power -rx.shutdown srv.chall/loop.-scram srv.close HPCI srv.ads	CD	1.3E-07	1.2E-01
67	loop emerg.power -rx.shutdown/ep -ep.rec srv.chall/loop.-scram -srv.close HPCI rcic	CD	9.7E-09	9.4E-02
69	loop emerg.power -rx.shutdown/ep -ep.rec srv.chall/loop.-scram srv.close HPCI	CD	8.7E-09	1.3E-01

Event Identifier: 278/91-017

** 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\bwrseal.cmp
 BRANCH MODEL: c:\asp\1989\peach.sll
 PROBABILITY FILE: c:\asp\1989\bwr_csll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	5.5E-04	1.0E+00	
loop	1.6E-05	2.4E-01	
loca	3.3E-06	5.0E-01	
rx.shutdown	3.0E-05	1.0E+00	
rx.shutdown/ep	3.5E-04	1.0E+00	
pcs/trans	1.7E-01	1.0E+00	
srv.chall/trans.-scram	1.0E+00	1.0E+00	
srv.chall/loop.-scram	1.0E+00	1.0E+00	
srv.close	3.6E-02	1.0E+00	
emerg.power	1.4E-03	8.0E-01	
ep.rec	2.1E-01	1.0E+00	
fw/pcs.trans	4.6E-01	3.4E-01	
fw/pcs.loca	1.0E+00	3.4E-01	
HPCI	2.9E-02 > 4.7E-02	7.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-02 > 4.7E-02		
rcic	6.0E-02	7.0E-01	
crd	1.0E-02	1.0E+00	1.0E-02
srv.ads	3.7E-03	7.1E-01	1.0E-02
lpcs	3.0E-03	3.4E-01	
lpci(rhr)/lpcs	1.0E-03	7.1E-01	
rhr(sdc)	2.1E-02	3.4E-01	1.0E-03
rhr(sdc)/-lpci	2.0E-02	3.4E-01	1.0E-03
rhr(sdc)/lpci	1.0E+00	1.0E+00	1.0E-03
rhr(spcool)/rhr(sdc)	2.0E-03	3.4E-01	
rhr(spcool)/-lpci.rhr(sdc)	2.0E-03	3.4E-01	
rhr(spcool)/lpci.rhr(sdc)	9.3E-02	1.0E+00	
rhrsw	2.0E-02	3.4E-01	2.0E-03

* branch model file
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Event Identifier: 278/91-017

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 278/91-017
 Event Description: Control wiring for SRVs found damaged (non-RV LOCAs)
 Event Date: 09/24/91
 Plant: Peach Bottom 3

UNAVAILABILITY, DURATION= 6132

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA 1.0E-02

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
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CD

LOCA	3.3E-04
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Total	3.3E-04
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ATWS

LOCA	0.0E+00
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Total	0.0E+00
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SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
77 loca -rx.shutdown HPCI SRV.ADS	CD	3.3E-04	3.5E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
77 loca -rx.shutdown HPCI SRV.ADS	CD	3.3E-04	3.5E-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\bwrseal.cmp
 BRANCH MODEL: c:\asp\1989\peach.sll
 PROBABILITY FILE: c:\asp\1989\bwr_csll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	5.5E-04	1.0E+00	

Event Identifier: 278/91-017

B-124

loop	1.6E-05	2.4E-01	
loca	3.3E-06	5.0E-01	
rx.shutdown	3.0E-05	1.0E+00	
rx.shutdown/ep	3.5E-04	1.0E+00	
pcs/trans	1.7E-01	1.0E+00	
srv.chall/trans.-scram	1.0E+00	1.0E+00	
srv.chall/loop.-scram	1.0E+00	1.0E+00	
srv.close	3.6E-02	1.0E+00	
emerg.power	1.4E-03	8.0E-01	
ep.rec	2.1E-01	1.0E+00	
fw/pcs.trans	4.6E-01	3.4E-01	
fw/pcs.loca	1.0E+00	3.4E-01	
HPCI	2.9E-02 > 4.7E-02	7.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-02 > 4.7E-02		
rcic	6.0E-02	7.0E-01	
crd	1.0E-02	1.0E+00	1.0E-02
SRV.ADS	3.7E-03 > 1.0E+00	7.1E-01 > 1.0E+00	1.0E-02
Branch Model: 1.OF.1+opr			
Train 1 Cond Prob:	3.7E-03 > Failed		
lpcs	3.0E-03	3.4E-01	
lpci(rhr)/lpcs	1.0E-03	7.1E-01	
rhr(sdc)	2.1E-02	3.4E-01	1.0E-03
rhr(sdc)/~lpci	2.0E-02	3.4E-01	1.0E-03
rhr(sdc)/lpci	1.0E+00	1.0E+00	1.0E-03
rhr(spcool)/rhr(sdc)	2.0E-03	3.4E-01	
rhr(spcool)/~lpci.rhr(sdc)	2.0E-03	3.4E-01	
rhr(spcool)/lpci.rhr(sdc)	9.3E-02	1.0E+00	
rhrsw	2.0E-02	3.4E-01	2.0E-03
* branch model file			
** forced			

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Event Identifier: 278/91-017