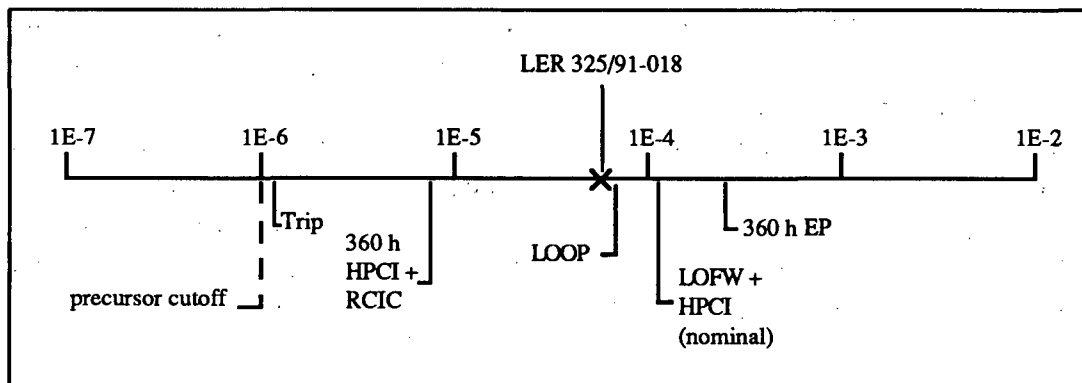


## ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 325/91-018  
 Event Description: Loss of feedwater with degraded HPCI system  
 Date of Event: July 18, 1991  
 Plant: Brunswick 1

### Summary

The reactor scrammed from 100% power during surveillance on a reactor water level transmitter. A spurious low water level signal resulted in main steam isolation valve (MSIV) closure and initiated the high-pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) systems, which provided reactor vessel makeup. HPCI had an oil leak that would have degraded HPCI performance if left uncorrected. The conditional core damage probability estimated for this event is  $6.0 \times 10^{-5}$ . The relative significance of this event compared to other postulated events at Brunswick is shown below.



### Event Description

Brunswick 1 scrammed from 100% power on July 18, 1991. The scram occurred while preparing to return a reactor vessel level transmitter to service. Leakage by the instrument manifold isolation valve for the transmitter resulted in a pressure transient on the common instrument variable leg header, which serves instruments for both reactor protection divisions, when the transmitter's drain valve was opened. The erroneous level signal closed all MSIVs and actuated the HPCI, core spray (CS), RCIC, and emergency power systems. The MSIV closure generated a full reactor scram, and all control rods fully inserted. The reactor power decrease and MSIV closure caused an actual momentary reactor water level decrease due to steam void collapse. Safety relief valves (SRVs) operated as designed to control reactor pressure. During the event, an ~0.4 gpm oil leak

on the HPCI turbine oil filter inlet pressure gage drained ~10 gal of oil before being isolated by closing a manual isolation valve. HPCI operation was not affected by the loss of oil (78 of 88 gals of oil were still available). However, if the oil leak had not been detected and isolated, HPCI would have been rendered unavailable.

### **Additional Event-Related Information**

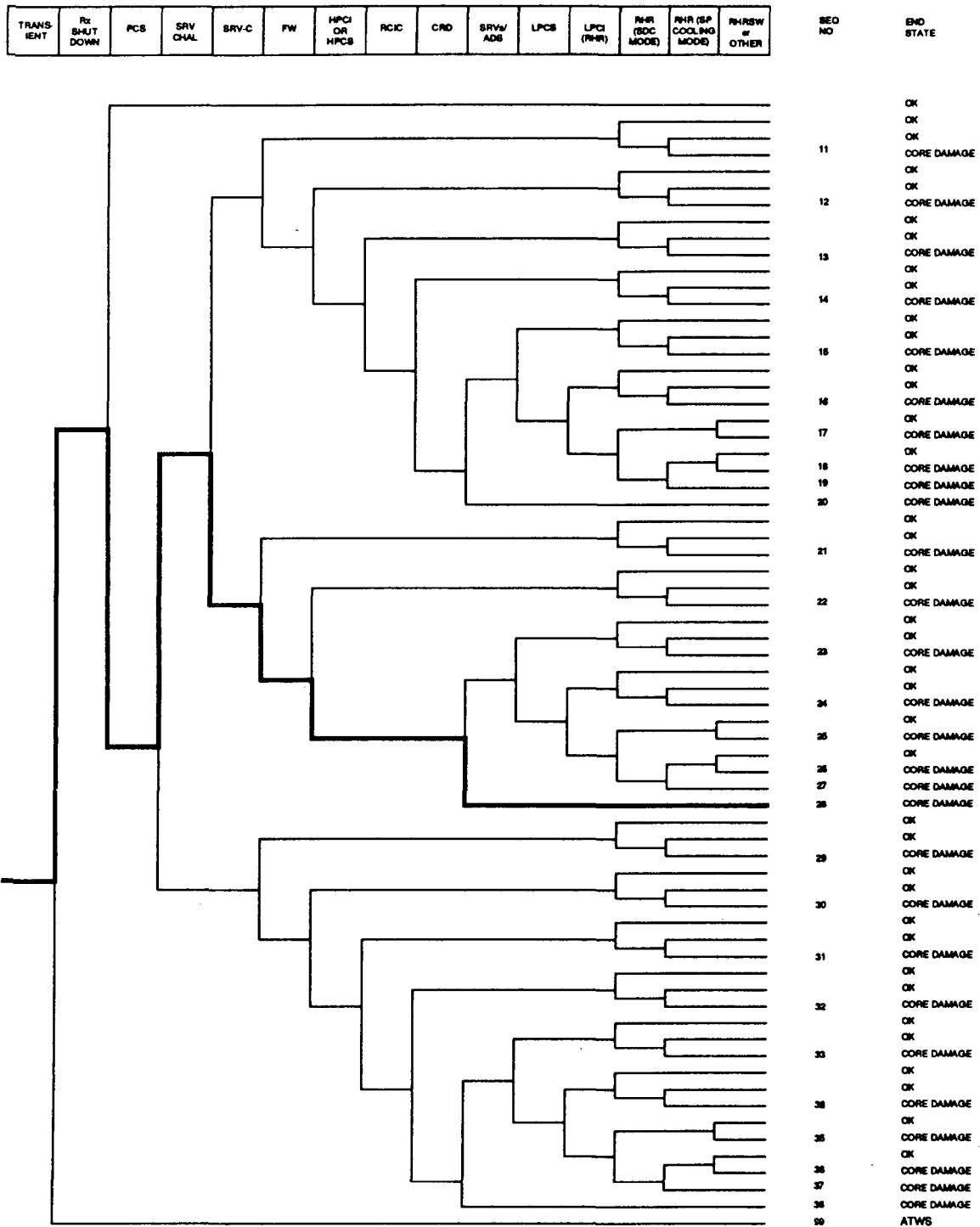
The HPCI system is a high-pressure injection system designed for small-break loss-of-coolant accidents (LOCAs) that do not depressurize the reactor. HPCI maintains sufficient reactor vessel inventory during plant shutdown until the vessel is depressurized. HPCI is an independent system, uses a turbine-driven pump, and automatically initiates on reactor low water level. HPCI can deliver 4250 gpm of makeup water to the vessel through the feedwater piping. There are two sources of water for the HPCI system. Initially, the system uses demineralized water from the condensate storage tank (CST). When the CST reaches a low level, the system automatically transfers to the suppression pool.

### **ASP Modeling Assumptions and Approach**

In this event, if the HPCI oil leak had not been isolated, the oil-operated trip valve would have closed due to low oil pressure, and the HPCI turbine would have stopped prior to bearing damage. However, at the leakage rate for this event, it would take more than 60 min for the oil level in the reservoir to drain down to the low level alarm setpoint and more than 1 h and 20 min for the level to drop to the point where the oil pressure was low enough to close the trip valve. This assumes that nothing is done by the operators or that the HPCI room is inaccessible. This event was modeled as a loss of feedwater (due to MSIV closure) with HPCI inoperable but with a nonrecovery factor of 0.34.

### **Analysis Results**

The conditional probability of core damage estimated for this event is  $6.0 \times 10^{-5}$ . The dominant core damage sequence, highlighted on the following event tree, involves a loss of feedwater, a stuck-open SRV (transient-induced LOCA), failure of HPCI, and failure to depressurize using the automatic depressurization system to allow use of the low-pressure injection systems.



Dominant core damage sequence for LER 325/91-018

# B-304

## CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 325/91-018  
 Event Description: Loss of feedwater with degraded HPCI system  
 Event Date: 07/18/91  
 Plant: Brunswick 1

### INITIATING EVENT

#### NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS 1.0E+00

#### SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	6.0E-05
Total	6.0E-05
ATWS	
TRANS	3.0E-05
Total	3.0E-05

#### 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	5.3E-05	8.2E-02
11 trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close -FW/PCS.TRANS rhr(sdc) rhr(spcool)/rhr(sdc)	CD	3.5E-06	7.6E-02
99 trans rx.shutdown	ATWS	3.0E-05	1.0E+00

\*\* non-recovery credit for edited case

#### SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
11 trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close -FW/PCS.TRANS rhr(sdc) rhr(spcool)/rhr(sdc)	CD	3.5E-06	7.6E-02
28 trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram srv.close FW/PCS.TRANS HPCI srv.ads	CD	5.3E-05	8.2E-02
99 trans rx.shutdown	ATWS	3.0E-05	1.0E+00

\*\* non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\bwrceal.cmp  
 BRANCH MODEL: c:\asp\1989\brunswck.sll  
 PROBABILITY FILE: c:\asp\1989\bwr\_csll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Event Identifier: 325/91-018

# B-305

Branch	System	Non-Recov	Opr Fail
trans	2.3E-04	1.0E+00	
loop	1.6E-05	3.6E-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	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
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	1.6E-01	1.0E+00	
FW/PCS.TRANS	4.6E-01 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
fw/pcs.loca	1.0E+00	3.4E-01	
HPCI	2.9E-02 > 1.0E+00	7.0E-01 > 3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
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	
hrsw	2.0E-02	3.4E-01	2.0E-03
* branch model file			
** forced			

Minarick  
06-07-1992  
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Event Identifier: 325/91-018