B.24 LER No. 324/82-005

Event Description: Scram with both RHRSW Loops Inoperable

Date of Event: January 16, 1982

Plant: Brunswick 2

B.24.1 Summary

After a reactor scram, operators attempted to align suppression pool cooling but were unable to do so because both residual heat removal (RHR) system service water (SW) loops were found to be inoperable. The conditional core damage probability estimated for the event is 2.3×10^{-4}.

B.24.2 Event Description

On January 16, 1982, Brunswick 2 experienced a scram due to low condenser vacuum. After the scram, a group 1 isolation occurred and the main steam isolation valves (MSIVs) closed. Operators aligned the reactor core isolation cooling system (RCIC) to supply makeup water to the reactor. Later, when operators attempted to align suppression pool cooling, they discovered that both RHRSW loops were inoperable. Low suction header pressure lockout signals prevented start of pumps in both loops. Operators reset the group 1 isolation, reopened the MSIVs, re-established condenser vacuum, and realigned the main feedwater power conversion system (PCS) for makeup and decay heat removal.

An inspection of the suction header pressure switches found that their sensing lines were partially plugged with sediment, which may have prevented the switches from sensing the actual header pressure, which was within acceptable limits. The suction header pressure switch for the A loop was also found to be damaged. In addition, the power supply of the B loop suction header pressure switch was found to be switched off, apparently having been left that way after prior maintenance work. The pressure switch power feed breaker was reclosed, the RHRSW B loop interlock cleared, and the associated RHR train was started and aligned for suppression pool cooling. RHRSW train B was tested and declared operable approximately 4 hours after the scram. The A service water loop was made operable approximately 8 hours after the scram.

B.24.3 Additional Event-Related Information

"Operating Experience Feedback Report - Service Water System Failures and Degradations," NUREG-1275, V. 3, and "Brunswick Nuclear Power Station Unit 2 Loss of Residual Heat Removal Service Water on January 16, 1982," AEOD/Engineering Evaluation Report E236, USNRC, provide additional detail about this event.

B.24.4 Modeling Assumptions

This event was modeled as a scram with both trains of RHRSW initially unavailable. The RHRSW pumps at Brunswick maintain a positive pressure differential between the tube and shell side of the RHR heat

exchangers, which prevents leakage of primary coolant into the service water (SW) system. Adequate decay heat removal can be provided in the event of RHRSW pump unavailability using the SW pumps to directly supply the RHR heat exchangers, if one valve (FO68A/B) in each train is locally opened. This action is addressed in the Brunswick IPE, and an operator failure probability of 0.01 was estimated. Because of the unavailability of the RHRSW trains, all modes of RHR, except low-pressure coolant injection (LPCI), were modeled as initially failed.

As this event involved a loss of condenser vacuum and MSIV isolation, the power conversion system was assumed to be failed and nonrecoverable in the short term (PCS was assumed to be recoverable in the long term).

To recover decay heat removal capability using RHR, operators needed to either recover the inoperable RHRSW pumps or align the service water system to supply the RHR heat exchangers. In the event, since the PCS had been recovered and was being used for decay heat removal, the operators focused on correcting the RHRSW suction header pressure switch problems and restoring RHRSW.

If the PCS had not been recovered, RHR could have been recovered by locally opening SW valves FO68A and B.

To address this action, the nonrecovery probability for RHR was revised to 0.01 to reflect the probability of the operators failing to open FO68A and B.

For sequences involving potential RHR and PCS recovery, the nonrecovery estimate was revised to 0.01 x 0.017 [probability of not aligning SW multiplied by PCS long-term nonrecovery given MSIV closure (see Appendix A)], or 1.7E-4.

B.24.5 Analysis Results

The conditional core damage probability estimated for this event is 2.3×10^{-4}. The dominant core damage sequence, highlighted on the event tree in Figure B.24.1, involves the observed scram, failure of the power conversion system, and RHR failure.

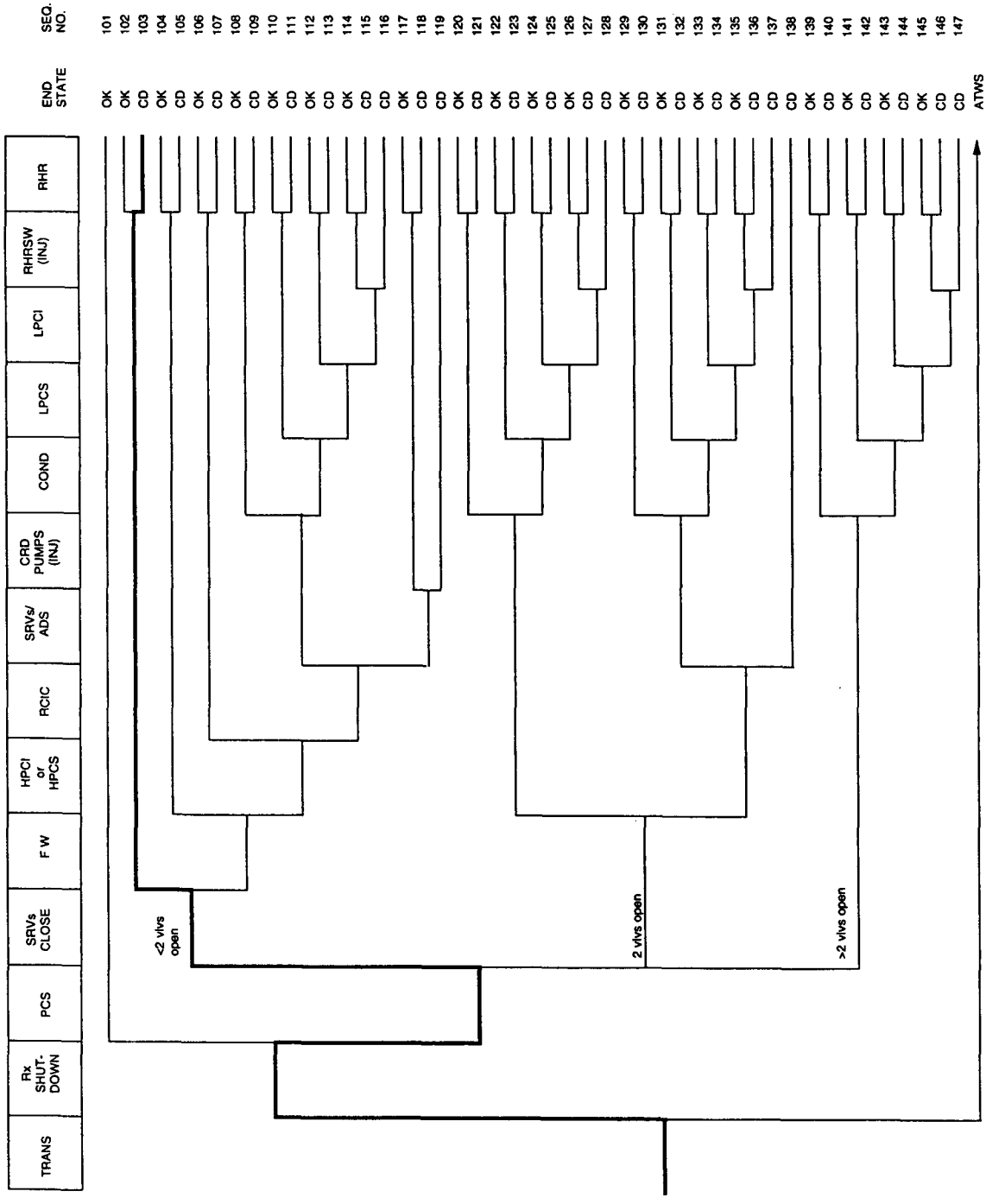

Figure B.24.1 Dominant core damage sequence for LER 324/82-005

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 324/82-005
Event Description: Scram with both RHRSW loops inoperable
Event Date: January 16, 1982
Plant: Brunswick 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	2.3E-04
Total	2.3E-04

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
103	trans -rx.shutdown PCS srv.ftc.<2 -MFW RHR.AND.PCS.NREC	CD	1.2E-04	1.1E-04
105	trans -rx.shutdown PCS srv.ftc.<2 MFW -hpci RHR.AND.PCS.NREC	CD	6.0E-05	5.7E-05
403	trans rx.shutdown -rpt -slcs PCS -ads.inhibit -hpci RHR(SPCOOL)	CD	3.3E-05	9.9E-02
121	trans -rx.shutdown PCS srv.ftc.2 -hpci -cond RHR	CD	8.4E-06	6.6E-03
123	trans -rx.shutdown PCS srv.ftc.2 -hpci cond -lpcs RHR	CD	4.3E-06	3.4E-03

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
103	trans -rx.shutdown PCS srv.ftc.<2 -MFW RHR.AND.PCS.NREC	CD	1.2E-04	1.1E-04
105	trans -rx.shutdown PCS srv.ftc.<2 MFW -hpci RHR.AND.PCS.NREC	CD	6.0E-05	5.7E-05
121	trans -rx.shutdown PCS srv.ftc.2 -hpci -cond RHR	CD	8.4E-06	6.6E-03
123	trans -rx.shutdown PCS srv.ftc.2 -hpci cond -lpcs RHR	CD	4.3E-06	3.4E-03
403	trans rx.shutdown -rpt -slcs PCS -ads.inhibit -hpci RHR(SPCOOL)	CD	3.3E-05	9.9E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1982-83\bwrc8283.cmp
BRANCH MODEL: c:\asp\1982-83\bruns2.82
PROBABILITY FILE: c:\asp\1982-83\bwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.1E-03	1.0E+00	
loop	1.6E-05	3.6E-01	
loca	3.3E-06	6.7E-01	
rx.shutdown	3.5E-04	1.0E-01	
PCS	1.7E-01 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.7E-01 > 1.0E+00		
srv.ftc.<2	1.0E+00	1.0E+00	
srv.ftc.2	1.3E-03	1.0E+00	
srv.ftc.>2	2.2E-04	1.0E+00	
MFW	4.6E-01 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.6E-01 > 1.0E+00		
hpci	2.9E-02	7.0E-01	
rcic	6.0E-02	7.0E-01	
srv.ads	3.7E-03	7.0E-01	1.0E-02
crd(inj)	1.0E-02	1.0E+00	1.0E-02
cond	1.0E+00	3.4E-01	1.0E-03
lpcs	2.0E-03	1.0E+00	
lpci	1.1E-03	1.0E+00	
RHRSW(INJ)	2.0E-02 > 1.0E+00	1.0E+00	1.0E-02
Branch Model: 1.OF.1+opr			
Train 1 Cond Prob:	2.0E-02 > 1.0E+00		
RHR	1.5E-04 > 1.0E+00 **	1.6E-02 > 1.0E-02	1.0E-05
Branch Model: 1.OF.4+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01		
Train 4 Cond Prob:	5.0E-01		
RHR.AND.PCS.NREC	1.5E-04 > 1.0E+00 **	8.3E-03 > 1.7E-04	1.0E-05
Branch Model: 1.OF.4+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01		
Train 4 Cond Prob:	5.0E-01		
RHR/-LPCI	0.0E+00 > 1.0E+00 **	1.0E+00	1.0E-05
Branch Model: 1.OF.1+opr			
Train 1 Cond Prob:	0.0E+00		
rhr/lpci	1.0E+00	1.0E+00	1.0E-05
RHR(SPCOOL)	2.1E-03 > 1.0E+00 **	1.0E+00	1.0E-03
Branch Model: 1.OF.4+ser+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01		
Train 4 Cond Prob:	5.0E-01		
Serial Component Prob:	2.0E-03		
RHR(SPCOOL)/-LPCI	2.0E-03 > 1.0E+00 **	1.0E+00	1.0E-03
Branch Model: 1.OF.1+ser+opr			
Train 1 Cond Prob:	0.0E+00		
Serial Component Prob:	2.0E-03		
ep	2.9E-03	8.7E-01	
ep.rec	1.6E-01	1.0E+00	
rpt	1.9E-02	1.0E+00	

slcs	2.0E-03	1.0E+00	1.0E-02
ads.inhibit	0.0E+00	1.0E+00	1.0E-02
man.depress	3.7E-03	1.0E+00	1.0E-02

* branch model file
** forced