B.4 LER No. 254/82-007, -009

Event Description: Transient with RHRSW Train B Inoperable

Date of Event: April 15, 1982

Plant: Quad Cities 1

B.4.1 Summary

During normal operation on April 15, 1982, residual heat removal service water (RHRSW) pump D outboard bearing was found to be failed due to excessive leakage of water from the adjacent packing to the oil in the bearing. On April 30, RHRSW pump C was taken out of service for maintenance on the pump seal packing. Water which leaked from adjacent seal packing was found in the bearing oil reservoir. Three plant trips had occurred around the time of the faults in the pumps (April 17, 19, and 30). The conditional core damage probability estimated for this event is 1.7×10^{-4}.

B.4.2 Event Description

During normal operation on April 15, 1982, RHRSW pump D outboard bearing was found to be failed during a surveillance test. Investigation revealed that the pump bearing failed due to excessive leakage of water from the adjacent packing to the oil in the bearing. The bearing and packing was replaced and the pump was returned to service on April 22. A few days later, on April 30, RHRSW pump C was taken out of service for maintenance on the pump seal packing. Water which leaked from adjacent seal packing was found in the bearing oil reservoir. The licensee stated that while there was insufficient water to cause bearing damage due to a loss of lubrication, continued operation could have possibly resulted in bearing damage. The pump was declared inoperable. The pump seals were repacked and the oil in the bearing oil reservoir was replaced. The pump was returned to service later that day.

Three plant trips occurred around the time of the discovery of the bearing faults in the pumps (April 17, 19, and 30). The plant trip on April 17 involved a reactor scram due to low condenser vacuum due to a condensate demineralizer valve failure. The plant trip on April 19 involved a reactor scram due to high main steam line flow. The plant trip on April 30 (Licensed Operating Reactors, Status Summary Report, NUREG-0020, published monthly, hereafter referred to as NUREG-0020) involved a trip on low reactor water level due to a B reactor feedpump discharge valve closure.

B.4.3 Additional Event-Related Information

The residual heat removal service water system provides cooling water to the residual heat removal (RHR) system heat exchangers. RHR is a two-train system (A and B) which provides three functions: suppression pool cooling, containment spray, and shutdown cooling. Each train has two RHR pumps and one heat exchanger. Suppression pool cooling is used to remove heat from the suppression pool whenever the water temperature exceeds 95°F. Containment spray is used in the event of a nuclear system break within the primary containment to prevent excessive containment pressure and temperature by condensing steam and

cooling noncondensable gases. Shutdown cooling can be used during normal shutdown and cooldown to remove decay heat, once the reactor coolant temperature is low enough that the steam supply pressure is not sufficient to maintain turbine shaft gland seals or vacuum in the main condensers. RHR requires the use of one pump and one functioning heat exchanger (and thus one train of RHRSW) for suppression pool cooling, containment spray, and shutdown cooling. RHRSW is a two-train system (A and B). Each RHRSW train has two pumps and one heat exchanger. Pumps A and B supply heat exchanger A for RHR train A. Pumps C and D supply heat exchanger B for RHR train B. RHRSW also has a crosstie which enables the RHRSW pumps to provide coolant to the RHR system for use as an alternative injection system. Two RHRSW pumps supplying flow to one heat exchanger are sufficient for all RHR modes. One RHRSW pump is sufficient to provide the alternative injection source for RHR.

B.4.4 Modeling Assumptions

RHRSW (and thus RHR) were assumed to be degraded at the time of the trip on April 17, 1982. The event was modeled as a transient with PCS initially unavailable due to main steam isolation valve (MSIV) closure. The demineralizer valve failure was assumed to be recoverable on the same time scale as the MSIVs. Assuming that the water was present in the lube oil for both pumps C and D at the time of the transient, two of the four RHRSW pumps were assumed to fail during their mission time, and potential failure of the other two pumps from similar causes was assumed. The potential for common cause failure exists, even when a component is failed. Therefore, the conditional probability of a common cause failure was included in the analysis for those components that were assumed to have been failed as part of the postulated event. Since the ASP model assumes that common cause failure of the RHR pumps dominates the failure of RHR and does not directly account for the failure of RHRSW pumps leading to RHR failure, the RHR failure probability was modified to reflect the degraded state of RHRSW in this event. The conditional train probabilities for RHRSW pumps shown in Table 1 were combined and added to the probability of RHR failure as follows

$$P(RHRSW) = P(A|DC)*P(B|ADC)$$

$$P(RHR)_{NEW} = P(RHR)_{OLD} + P(RHRSW)$$

$$P(RHR)_{NEW} = P(RHR)_{OLD} + 0.15.$$

Table 1. RHRSW Pump Train Failure to Start and Run Conditional Failure Probabilities

Train	Conditional Failure Probability
P(1)	0.01
P(2|1)	0.1
P(3|12)	0.3
P(4|123)	0.5

The suppression pool cooling mode of RHR would also be affected in the same manner. Thus, P(RHRSW) was added to the branch probability for RHR(SPCOOL) in the same manner as described above. The same modifications were made to RHR/-LPCI and RHR(SPCOOL)/-LPCI. Since there would still be ample time to recover RHR given LPCI success, the nonrecovery probability for RHR/-LPCI was set to the same nominal nonrecovery probability as that for RHR.

The nonrecovery probability for RHR was revised to 0.054 to reflect the RHRSW failure (see Appendix A). For sequences involving potential RHR or power conversion system (PCS) recovery, the nonrecovery estimate was revised to 0.054 x 0.017 (PCS nonrecovery given MSIV closure), or 9.2E-4.

A sensitivity study was performed assuming that the water leak into the bearing oil reservoir for pump C was not sufficient to cause pump C to fail. RHR, RHR(SPCOOL), RHR/-LPCI, and RHR(SPCOOL)/-LPCI were modified to reflect only one failed RHRSW pump (p = 0.015).

B.4.5 Analysis Results

The estimated conditional core damage probability is 1.7×10^{-4}. The dominant sequence involves a successful reactor shutdown, failure of the power conversion system, successful feedwater recovery, and failure of RHR, and is highlighted in the event tree in Figure B.4.1. The estimated conditional core damage probability for the sensitivity study (with RHRSW pump C operable) is 2.8×10^{-5}. The dominant sequence remains the same.

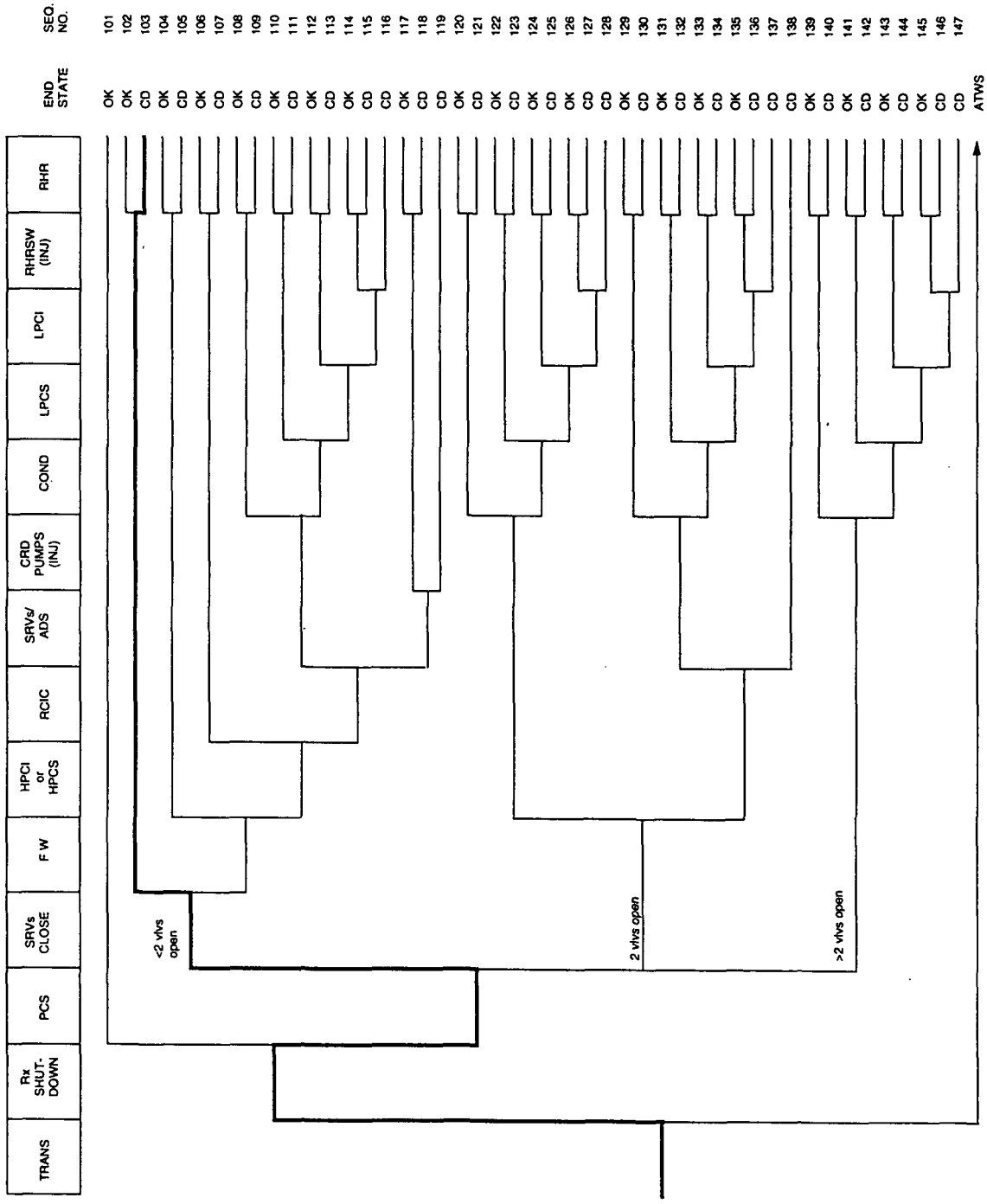

Figure B.4.1 Dominant core damage sequence for LER 254/82-007, -009

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 254/82-007
Event Description: Transient with RHRSW train B inoperable
Event Date: April 15, 1982
Plant: Quad Cities 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.7E-04
Total	1.7E-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	9.8E-05	6.1E-04
105	trans -rx.shutdown PCS srv.ftc.<2 MFW -hpci RHR.AND.PCS.NREC	CD	4.9E-05	3.1E-04
121	trans -rx.shutdown PCS srv.ftc.2 -hpci -cond RHR	CD	6.8E-06	3.5E-02
403	trans rx.shutdown -rpt -slcs PCS -ads.inhibit -hpci RHR(SPCOOL)	CD	5.0E-06	9.9E-02
123	trans -rx.shutdown PCS srv.ftc.2 -hpci cond -lpcs RHR	CD	3.5E-06	1.8E-02

** 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	9.8E-05	6.1E-04
105	trans -rx.shutdown PCS srv.ftc.<2 MFW -hpci RHR.AND.PCS.NREC	CD	4.9E-05	3.1E-04
121	trans -rx.shutdown PCS srv.ftc.2 -hpci -cond RHR	CD	6.8E-06	3.5E-02
123	trans -rx.shutdown PCS srv.ftc.2 -hpci cond -lpcs RHR	CD	3.5E-06	1.8E-02
403	trans rx.shutdown -rpt -slcs PCS -ads.inhibit -hpci RHR(SPCOOL)	CD	5.0E-06	9.9E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1982-83\bwrc8283.cmp
BRANCH MODEL: c:\asp\1982-83\quadcit1.82
PROBABILITY FILE: c:\asp\1982-83\bwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.5E-03	1.0E+00	
loop	1.6E-05	5.3E-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	2.9E-01 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-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-02
RHR	1.5E-04 > 1.5E-01 **	1.6E-02 > 5.4E-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 > 1.5E-01 **	8.3E-03 > 9.2E-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 > 1.5E-01 **	1.0E+00 > 5.4E-02	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 > 1.5E-01 **	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 > 1.5E-01 **	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	4.9E-02	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