B.33 LER No. 331/83-017 and -018

Event Description: HPCI and RHRSW Loop B Inoperable

Date of Event: May 23, 1983

Plant: Duane Arnold

B.33.1 Summary

During normal operation on May 23, 1983, the pressure differential across the residual heat removal service water (RHRSW) system strainer 1S-90B increased. The strainer jammed with river water debris, causing the drive motor coupling shear pins to shear. On the same day, during routine surveillance testing, the high-pressure coolant injection (HPCI) pump did not meet Technical Specification output pressure flow requirements. Investigation revealed that the HPCI speed indication circuit for the turbine was out of calibration. The estimated increase in core damage probability, or importance, over the duration of the event is 1.7×10^{-5}. The base-case core damage probability (CDP) over the duration of the event is 1.0×10^{-7}, resulting in an estimated conditional core damage probability (CCDP) of 1.7×10^{-5}.

B.33.2 Event Description

During normal operation on May 23, 1983, the pressure differential across the residual heat removal service water system strainer 1S-90B increased. The strainer jammed with river water debris, causing the drive motor coupling shear pins to shear as per design. The B loop of RHRSW was declared inoperable, and the redundant loop was satisfactorily tested. The strainers were cleaned and the shear pins were replaced. On the same day, during routine surveillance testing, the HPCI pump did not meet Technical Specification output pressure flow requirements. Technical Specifications require an output pressure of 1,050 psig at 3,700 RPM and 3000 gpm. The test measured an output pressure of 780 psig. Investigation revealed that the HPCI speed indication circuit for the turbine was out of calibration. The turbine speed was actually lower than indicated. The speed circuit was recalibrated and the pump tested satisfactorily.

B.33.3 Additional Event-Related Information

The RHRSW system provides cooling water to the residual heat removal (RHR) system heat exchangers. The RHR system provides three functions: suppression pool cooling, containment spray, and shutdown cooling. 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 condenser. RHR requires the use of at least one heat exchanger (and thus RHRSW) for all three modes.

RHRSW is a two-loop system (A and B). Each loop has two pumps (1P22A and 1P22C, and 1P22B and 1P22D, respectively) and one heat exchanger (1E201A and 1E201B). Each pair of pump discharge lines connects to a common line which flows through a self-cleaning strainer and then to an RHR heat exchanger. If the strainers become clogged, flow to the RHR heat exchangers is degraded. One pump supplying one heat exchanger is sufficient to cool all RHR.

RHRSW also has a crosstie which enables the RHRSW pumps to provide coolant to the RHR system for use as an alternative injection system. Flow from the RHRSW common lines proceeds through the strainers to the crosstie line. The crosstie line contains two motor-operated valves in series, which must be opened for injection. One pump is sufficient to provide the alternative injection source for RHR.

B.33.4 Modeling Assumptions

HPCI was assumed to be inoperable for half its surveillance period, 360 hours. Since HPCI did not pass Technical Specification requirements due to a miscalibrated turbine speed indication circuit, the HPCI pump was assumed to be failed and nonrecoverable. The clogged strainers were assumed to lead to degraded RHR. Since the RHR system model is composed of four pump trains and two of the four trains flow through one heat exchanger which is cooled by RHRSW, two of the four trains were assumed to be failed. Since it is likely that the RHRSW loop A strainer could also get clogged with river debris, the first two trains of RHR and RHR (SPCOOL) were set to failed to reflect the potential for a common cause failure due to river debris in loop A. The probability of RHRSW injection failure was also revised to reflect the potential failure of both RHRSW loops. 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. It is unlikely that clogged strainers would go unnoticed for more than 24 hours, so this event was modeled as the unavailability of HPCI, two RHR pump trains, and degraded RHRSW injection for a period of 24 hours. The nonrecovery probability for RHR was revised to 0.054 to reflect the RHRSW failures (see Appendix A). For sequences involving potential RHR or power conversion system (PCS) recovery, the nonrecovery estimates were revised to 0.054 x 0.52 (PCS nonrecovery), or 0.028.

B.33.5 Analysis Results

The estimated increase in core damage probability over the duration of this event is 1.7×10^{-5}. The base-case CDP (not shown in calculation) is 1.0×10^{-7}, resulting in an estimated CCDP of 1.7×10^{-5}. The dominant sequence is a postulated transient with a successful reactor shutdown, failure of PCS, successful feedwater, and failure of RHR, and is shown in Figure B.33.1.

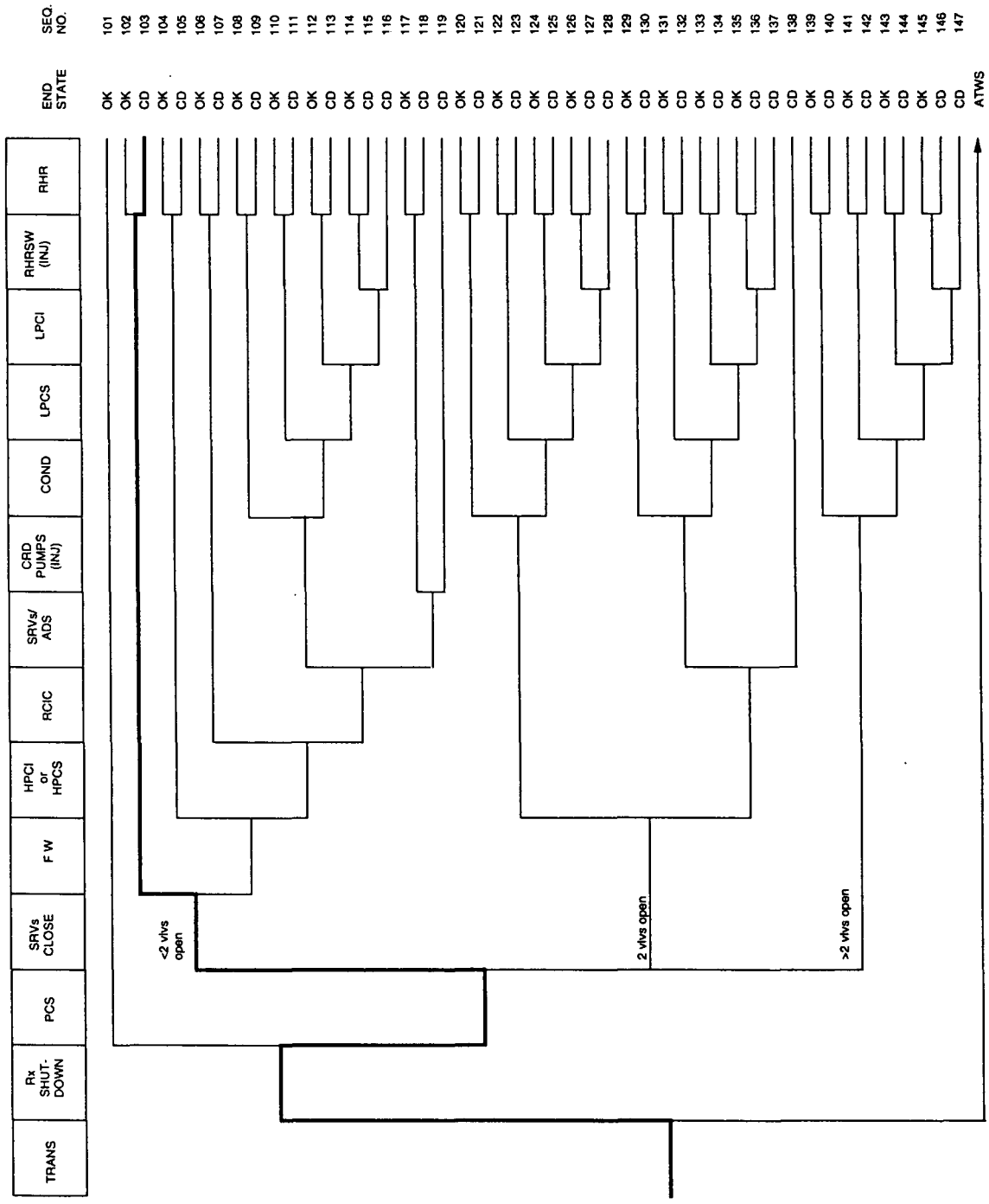

Figure B.33.1 Dominant core damage sequence for LER 331/83-017 and -018

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 331/83-017
Event Description: HPCI and RHRSW loop B inop
Event Date: May 23, 1983
Plant: Duane Arnold

UNAVAILABILITY, DURATION= 24

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	2.3E-02
LOOP	1.4E-04
LOCA	5.3E-05

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.6E-05
LOOP	1.2E-06
LOCA	7.3E-08
Total	1.7E-05

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	1.4E-05	2.6E-02
107	trans -rx.shutdown pcs srv.ftc.<2 mfw HPCI -rcic RHR.AND.PCS.NREC	CD	1.5E-06	9.4E-03
204	loop -rx.shutdown -ep srv.ftc.<2 HPCI -rcic RHR	CD	1.1E-06	1.9E-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	1.4E-05	2.6E-02
107	trans -rx.shutdown pcs srv.ftc.<2 mfw HPCI -rcic RHR.AND.PCS.NREC	CD	1.5E-06	9.4E-03
204	loop -rx.shutdown -ep srv.ftc.<2 HPCI -rcic RHR	CD	1.1E-06	1.9E-02

** 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: d:\asp\models\bwrc8283.cmp

BRANCH MODEL: d:\asp\models\duarnold.82
PROBABILITY FILE: d:\asp\models\bwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	9.5E-04	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	
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	3.4E-01	
HPCI	2.9E-02 > 1.0E+00	7.0E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-02 > 1.0E+00		
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 > 0.012	1.0E+00	1.0E-02
Branch Model: 1.OF.1+opr			
Train 1 Cond Prob:	2.0E-02 > 0.012		
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 > 2.8E-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/-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 > 5.4E-02	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-03
ep	2.9E-03	8.7E-01	
ep.rec	6.6E-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