B.23 LER Number 388/92-001

Event Description: Reactor Trip with Emergency Diesel Generator and Vital Bus Unavailable

Date of Event: March 18, 1992

Plant: Susquehanna 2

B.23.1 Summary

Susquehanna 2 was operating at 100% power on March 18, 1992 when emergency diesel generator (EDG) B failed during surveillance testing, preparations were begun to align the spare diesel, EDG E, in its place. During the course of these preparations, ESF bus C suddenly isolated. Since this isolated the containment instrument gas supply required for control of the main steam isolation valves (MSIVs), the reactor was manually scrammed in anticipation of an automatic scram on MSIV closure. The conditional core damage probabilty estimated for this event is 6.6×10^{-6}. The relative significance of this event to other postulated events at Susquehanna is shown in Fig. B.48.

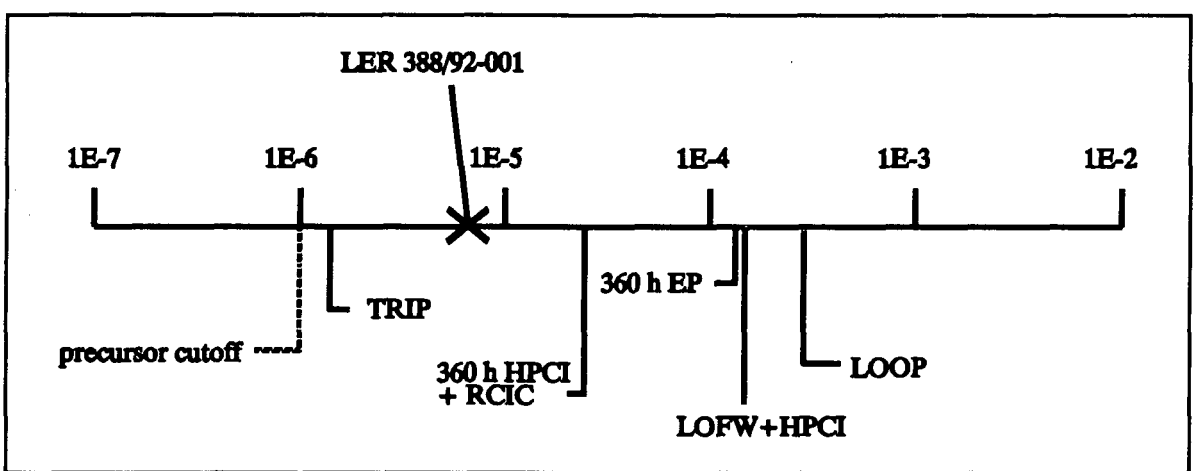

Fig. B.48. Relative event significance of LER 388/92-001 compared with other potential events at Susquehanna 2.

B.23.2 Event Description

Susquehanna Unit 2 was operating at 100% power on March 18, 1992, and EDG B was being run for its monthly surveillance test. During this test, the EDG tripped on loss of field, apparently due to failure of a diode in its field rectifier circuitry. EDG B was declared inoperable and procedures were begun to align the spare, EDG E, in its place. These procedures required operators to check all protective relay "targets" (actuation indicators) on the 4kV ESF buses and to reset the targets as necessary. When an

operator found a bus differential relay target dropped on ESF bus 2C and attempted to reset it, the bus tripped and locked out.

This resulted in unavailablity of normal and emergency power to a number of loads including a core spray (CS) pump, a residual heat removal (RHR) pump, and several drywell coolers. In addition, several containment isolations occurred, including the containment instrument gas (CIG) system. As the CIG system is required for MSIV control, plant operators manually scrammed the reactor in anticipation of an automatic scram on MSIV closure.

B.23.3 Additional Event-Related Information

Susquehanna's emergency power system consists of four EDGs (A, B, C, and D) and one spare EDG (E) that are shared by two plants. EDG E is capable of being substituted for any of the other EDGs without violating the independence of the redundant safety-related load groups.

ESF bus 2C supplies the following loads: one of four core spray pumps, one of four core spray pump room coolers, one of four residual heat removal (RHR) pumps, one of four RHR room coolers, seven of 14 drywell coolers, one of two instrument air compressors, one of two reactor building chillers, one of two reactor core isolation cooling (RCIC) room coolers, both standby liquid control heaters, one of two standby liquid control injection pumps, one of three battery chargers, one of four containment hydrogen recombiners, and the main condenser vacuum pump.

B.23.4 Modeling Assumptions

This event was modeled as a scram with one train of CS and RHR/LPCI unavailable. This is slightly conservative. The turbine-driven main feedwater pumps and power conversion systems are unavailable following the expected MSIV closure.

RCIC was assumed to be capable of supplying adequate makeup for sequences involving a single stuck-open relief valve. (The BWR nonspecific reactor trip event tree was modified to reflect this – see Fig. B.49). This probability was estimated as:

p(RCIC) + p(2 or more valves fail open | 1 or more valves fail open)

The ASP RCIC assumed failure rate is 0.06. A value of 0.027 was estimated for p(2 or more valves fail open | 1 or more valves fail open), based on an estimated probability for two or more SRVs stuck open of 0.0015 (see NUREG/CR-4550, Vol. 1, Rev. 1, *Analysis of Core Damage Frequency: Internal Events Methodology*, January 1990, p.6-10) and an estimated probability of one or more SRVs stuck open of 0.056 (developed as described in Appendix A, Sect. A.4). The probability of RCIC/SRV is then 0.06 + 0.027 = 0.09.

It was noted that, during this event, one EDG was unavailable and the distribution bus associated with another was unavailable, leaving only two EDG/bus pairs available to immediately supply power in event of a loss of offsite power (LOOP). The Susquehanna FSAR indicates that three EDGs are required for

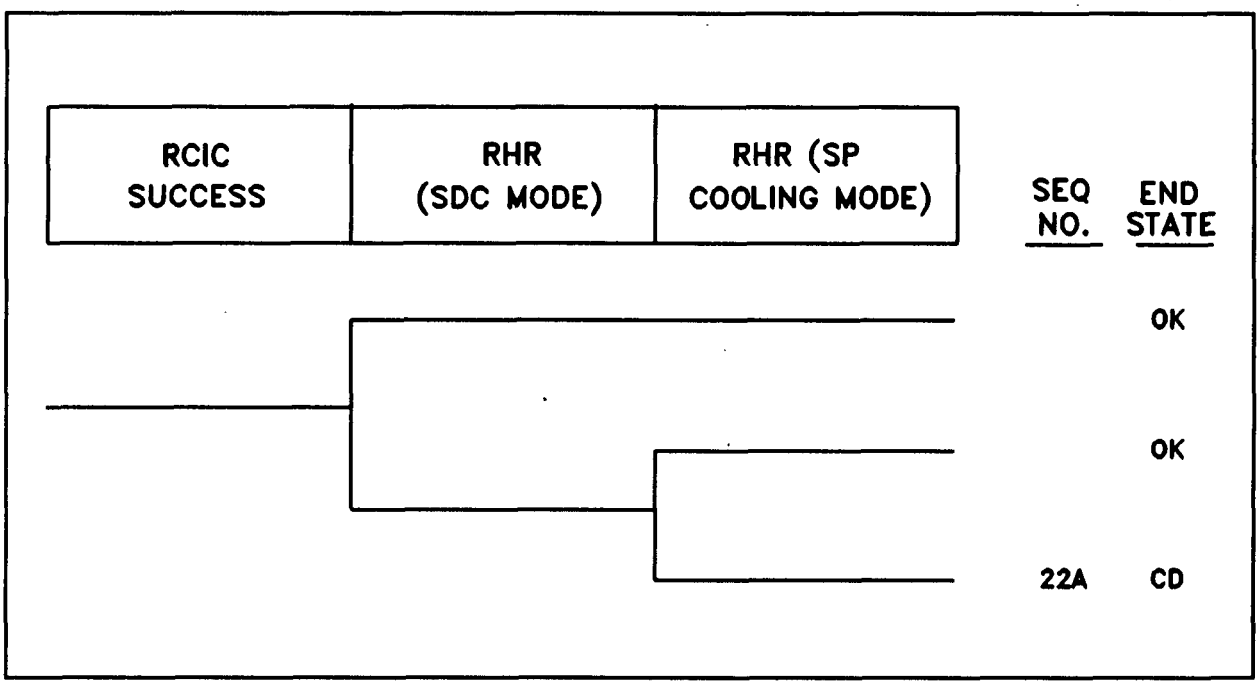

Fig. B.49. Modification to event tree when power conversion, feedwater, and HPCI systems are unavailable and an SRV has opened but failed to close.

safe plant shutdown under accident conditions. It is possible that two EDGs would be sufficient for ordinary plant shutdown during a LOOP. The spare EDG was always available for tie in which requires less than 2 h. This LOOP condition was modeled for a duration of 2 h. The core damage probability that resulted was less than 1.0×10^{-6}. Therefore, these LOOP concerns were not included in this analysis.

Available information indicates that the RHR outboard suction isolation valve is dc powered and the RHR inboard isolation valve is powered by division 1 ac. Therefore, the loss of bus C would not render the RHR shutdown cooling valves inoperable. The continued availability of ESF bus A from normal ac or emergency power (EDG A) would allow operation of the inboard isolation valve and thus would ensure availability of RHR sutdown cooling.

B.23.5 Analysis Results

The conditional probability of core damage for this event is estimated to be 6.6×10^{-6}. The dominant core damage sequence for this event, shown in Fig. B.50, involves scram with feedwater and power conversion systems unavailable, SRV operation and successful closure, HPCI success and failure of RHR shutdown cooling and suppression pool cooling modes.

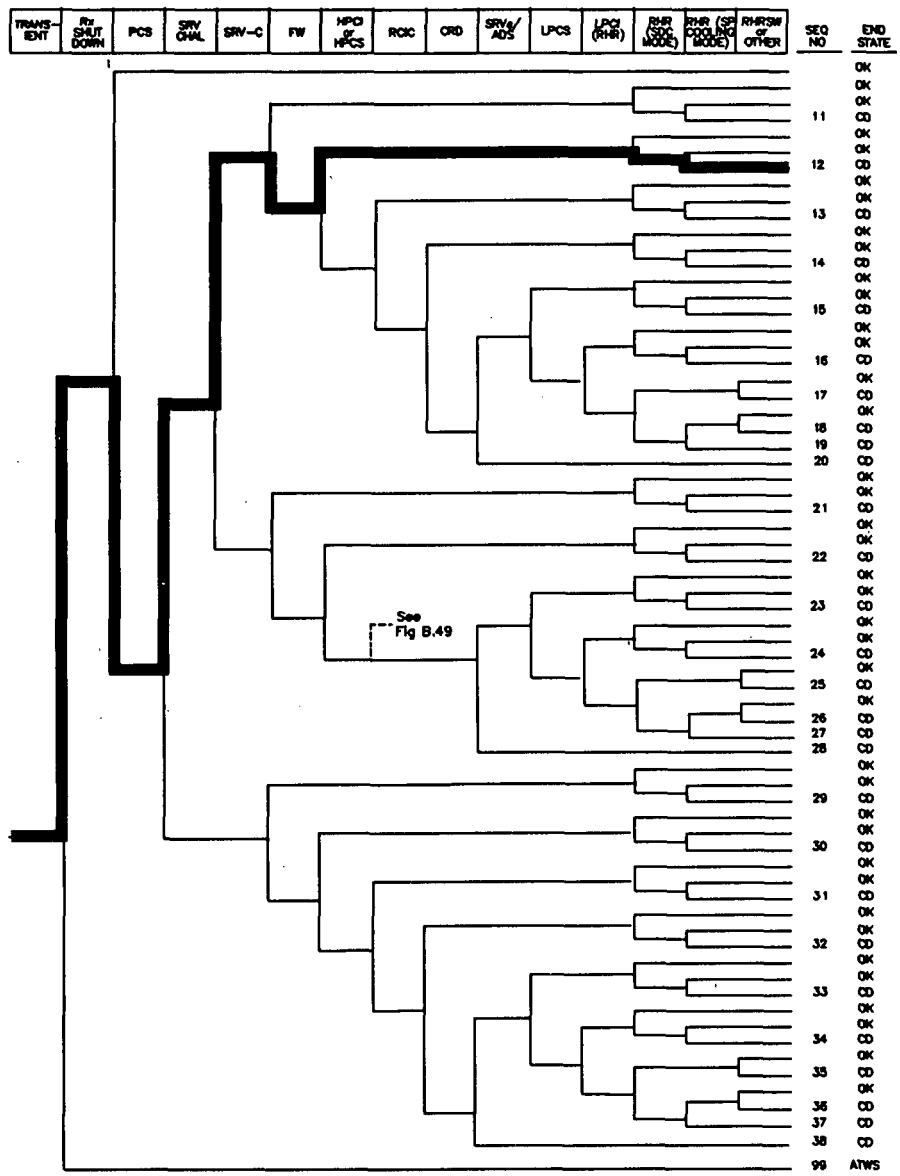

Fig. B.50. Dominant core damage sequence for LER 388/92-001.

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 388/92-001
Event Description: Scram with EDG B and ESF bus C unavailable
Event Date: 3/18/92
Plant: Susquehanna 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS 1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	6.6E-06
Total	6.6E-06
ATWS	
TRANS	3.0E-05
Total	3.0E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
12	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close FW/PCS.TRANS -hpci RHR(SDC) rhr(spcool)/rhr(sdc)	CD	5.6E-06	1.1E-01
28	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram srv.close FW/PCS.TRANS hpci rcic srv.ads	CD	3.9E-07	3.5E-01
22	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram srv.close FW/PCS.TRANS -hpci RHR(SDC) rhr(spcool)/rhr(sdc)	CD	2.1E-07	1.1E-01
20	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close FW/PCS.TRANS hpci rcic crd srv.ads	CD	2.1E-07	3.5E-01
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**
12	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close FW/PCS.TRANS -hpci RHR(SDC) rhr(spcool)/rhr(sdc)	CD	5.6E-06	1.1E-01
20	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram -srv.close FW/PCS.TRANS hpci rcic crd srv.ads	CD	2.1E-07	3.5E-01
22	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram srv.close FW/PCS.TRANS -hpci RHR(SDC) rhr(spcool)/rhr(sdc)	CD	2.1E-07	1.1E-01
28	trans -rx.shutdown PCS/TRANS srv.chall/trans.-scram srv.close FW/PCS.TRANS hpci rcic srv.ads	CD	3.9E-07	3.5E-01
99	trans rx.shutdown	ATWS	3.0E-05	1.0E+00

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\models\susquhn2.cmp
BRANCH MODEL: c:\asp\models\susquhan.sl1
PROBABILITY FILE: c:\asp\models\bwr_sus1.pro

Event Identifier: 388/92-001

No Recovery Limit
BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.6E-04	1.0E+00	
loop	1.6E-05	2.4E-01	
loca	3.3E-06	5.0E-01	
rx.shutdown/ep	3.5E-04	1.0E+00	
rx.shutdown	3.0E-05	1.0E+00	
PCS/TRANS	1.7E-01 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.7E-01 > 1.0E+00[1]		
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 > 2.8E-01	8.0E-01	
Branch Model: 2.OF.4			
Train 1 Cond Prob:	5.0E-02 > 1.0E+00[3]		
Train 2 Cond Prob:	5.7E-02 > 1.0E+00[3]		
Train 3 Cond Prob:	1.9E-01		
Train 4 Cond Prob:	5.0E-01		
ep.rec	1.6E-01	1.0E+00	
FW/PCS.TRANS	4.6E-01 > 1.0E+00	3.4E-01 > 1.0E+00[1]	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.6E-01 > 1.0E+00		
FW/PCS.LOCA	1.0E+00 > 1.0E+00	3.4E-01 > 1.0E+00[1]	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.0E+00		
hpci	2.9E-02	7.0E-01	
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 > 3.0E-02	3.4E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	3.0E-02		
Train 2 Cond Prob:	1.0E-01 > 1.0E+00[2]		
LPCI(RHR)/LPCS	1.0E-03 > 1.0E-02	7.1E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01 > 1.0E+00[2]		
RHR(SDC)	2.1E-02 > 2.3E-02	3.4E-01	1.0E-03
Branch Model: 1.OF.2+ser+opr			
Train 1 Cond Prob:	3.0E-03		
Train 2 Cond Prob:	3.0E-01 > 1.0E+00[2]		
Serial Component Prob:	2.0E-02		

Event Identifier: 388/92-001

rhr(sdc)/lpci	1.0E+00	1.0E+00	1.0E-03
rhr(sdc)/-lpci	2.0E-02	3.4E-01	1.0E-03
rhr(spcool)/rhr(sdc)	2.0E-03	3.4E-01	
rhr(spcool)/lpci.rhr(sdc)	9.3E-02	1.0E+00	
rhr(spcool)/-lpci.rhr(sdc)	2.0E-03	3.4E-01	
rhrsw	2.0E-02	3.4E-01	2.0E-03

* branch model file
** forced

Notes:
1. This event began with MSIV isolation, and, since the plant has turbine driven MFW pumps, this means the turbine driven MFW are unavailable; therefore, the nonrecovery factor goes to 1.
2. The unavailability of normal ac power or emergency power to bus 2c causes the unavailability of one train of LPCS, LPCI, and SDC.
3. This failure probability was adjusted due to EDG B being declared inoperable and power to bus 2c was unavailable.

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