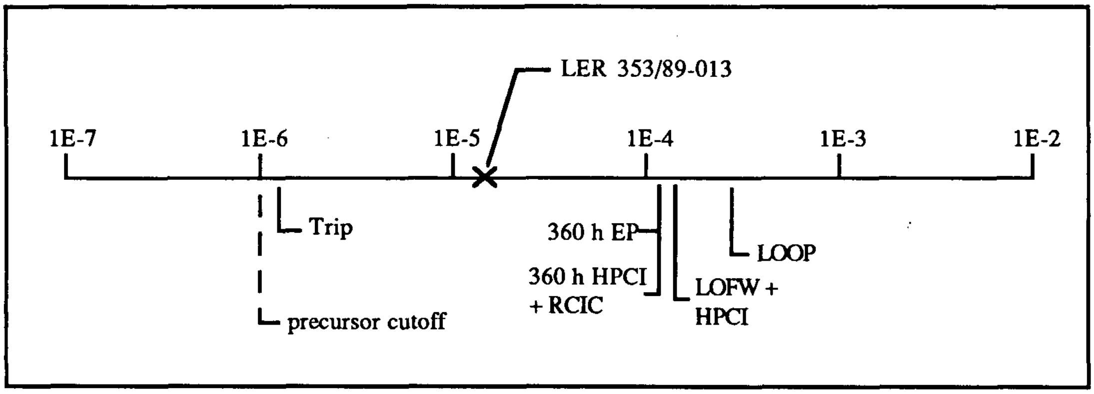
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No: 353/89-013
Event Description: Reactor scram with degraded HPCI
Date: December 11, 1989
Plant: Limerick 2

Summary

An incorrectly set generator differential relay caused a turbogenerator trip that resulted in a reactor scram. After the scram, fluctuations in reactor vessel level provided initiation signals to the reactor core isolation cooling system (RCIC) and the high-pressure coolant injection (HPCI) system. RCIC did not initiate, and HPCI did not initiate correctly. The core damage probability estimated for the event is 1.5×10^{-5}. The relative significance of this event compared with potential events at Limerick 2 is shown below.



Event Description

While at 98% power, during startup power ascension testing, Limerick Unit 2 experienced a main generator trip. The trip was caused by an incorrectly set generator differential relay and resulted in turbine trip and reactor scram. As expected after a scram resulting from turbine control valve fast closure while at high power, the reactor vessel was subjected to moderate level and pressure transients. Shortly after the scram, vessel level instrumentation momentarily spiked below the -38-in. instrument level, at which point RCIC and HPCI initiate. However, RCIC did not initiate, and HPCI did not correctly initiate. The utility concluded that the short duration of the low level signal (approximately 50 ms) prevented proper RCIC and HPCI initiation. It was believed that RCIC could have initiated had the initiation signal remained present.

The HPCI barometric condenser vacuum pump and auxiliary oil pump started, and the turbine steam admission valve opened. The valve that supplies cooling water to the HPCI lube oil cooler and barometric condenser failed to open as did HPCI discharge valves to the feedwater and core spray systems. As a result, HPCI initiated and tripped in this incorrect configuration six times in the next 3 min before operators noticed and shut down the system.

Additional Event-Related Information

The following FSAR information is relevant to the assessment of the event:

- FSAR Fig. 7.3-7 indicates that the circuits for the following pumps and valves simultaneously receive the HPCI (one-out-of-two-taken-twice logic) initiation signal: outboard steam supply isolation valve (F003), test bypass to CST (F008), redundant shutoff to suppression pool (F071), pump discharge (F006), pump discharge (F007), pump suction from CST (F004), steam supply to turbine (F001), cooling water supply (F059), valve F105, vacuum pump, and auxiliary oil pump.

- Following the logic diagram (FSAR Fig. 7.3-7) the HPCI injection valve (F006) should open automatically (and seal-in) upon receipt of an HPCI initiation signal if the TSV and F001 are not full closed and when no test switch is in. Plus, there is a seal-in initiation signal until reseat.

- FSAR section 6.3.2.2.1 states "The HPCI controls automatically start the system and bring it to design flow within 30 seconds from receipt of a reactor pressure vessel (RPV) low water level signal . . .", "If an initiation signal is received after the turbine is shut down, the system restarts automatically . . .", and "HPCI operation automatically actuates the following valves: (a) HPCI pump discharge shutoff valves, (b) HPCI steam supply shutoff valve, (c) HPCI turbine stop valve, (d) HPCI turbine control valves, (e) HPCI steam line drain isolation valve, (f) HPCI test valve, if open , and (g) minimum flow bypass valve."

All of the above verify that when an initiation signal is received (i.e., completion of the one-out-of-two-taken-twice logic for either RPV low water level or high drywell pressure), the HPCI system should start and inject water into the RPV.

ASP Modeling Assumptions and Approach

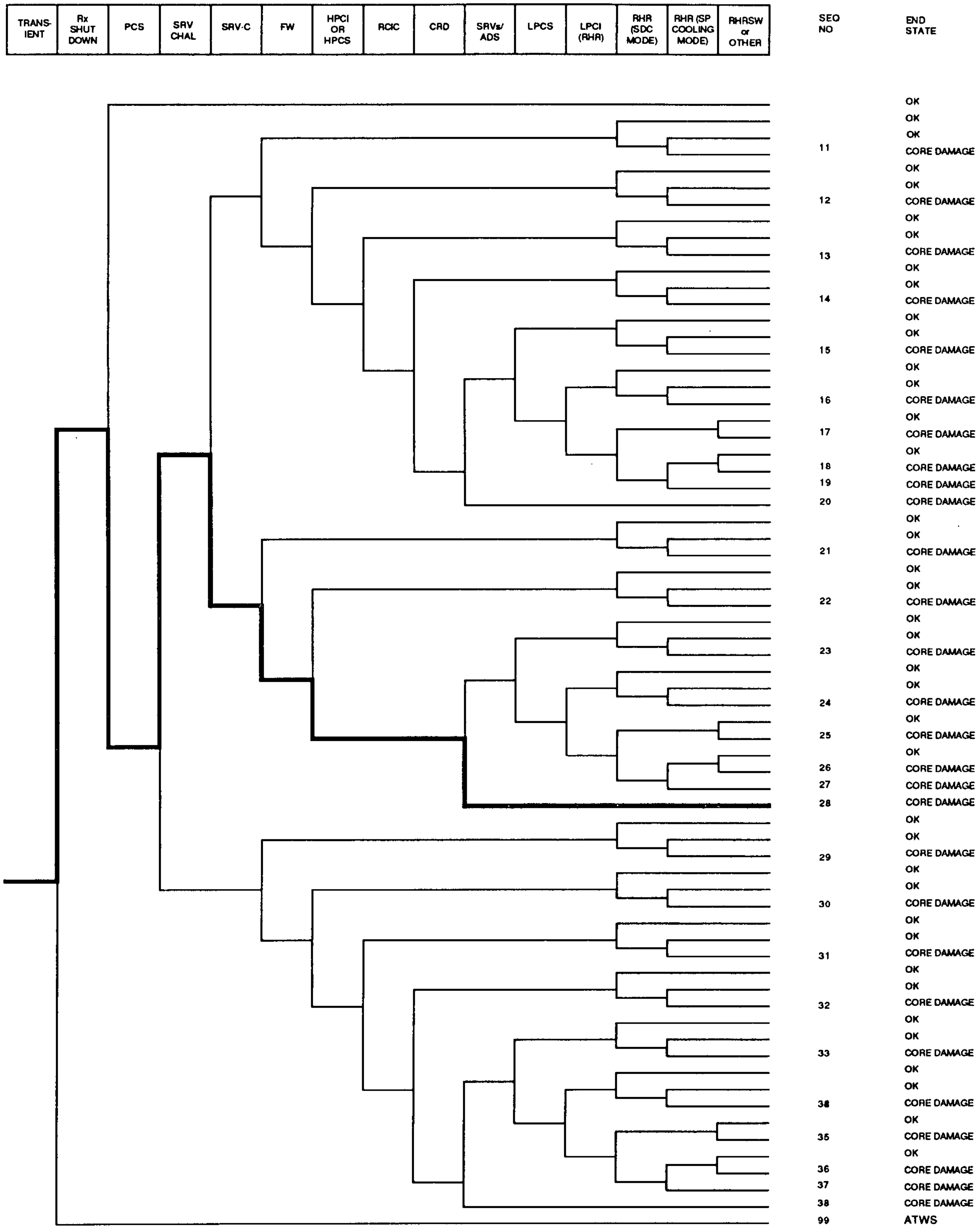
The event has been modeled as a reactor scram with degraded HPCI (local recovery assumed possible). To bound the impact of the potentially unavailable RCIC, two calculations were performed, one assuming RCIC was available and the other assuming RCIC was unavailable (with local recovery also assumed possible).

Analysis Results

The conditional probability of severe core damage estimated for this event is 1.5×10^{-5}, assuming both HPCI and RCIC were initially unavailable. The dominant sequence to core damage involves failure of an open SRV to close, failure to recover HPCI, and failure to depressurize using ADS. Note that unavailability of RCIC does not impact this sequence. Unavailability of RCIC impacts the second most dominant sequence (a factor of three lower in probability), which involves failure of high-pressure injection (feedwater, HPCI, RCIC, and CRD pumps) and failure to depressurize using ADS.

Assuming RCIC is initially available reduces the estimated core damage probability to 1.2×10^{-5} — essentially no change in the overall event impact. This is because RCIC availability does not impact the dominant sequence, as described above.

The dominant sequence for this event is highlighted on the following event tree.



Dominant core damage sequence for LER 353/89-013

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 353/89-013
Event Description: Reactor scram with degraded HPCI
Event Date: 12/11/89
Plant: Limerick 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.5E-05
Total	1.5E-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	1.1E-05	1.7E-01
20	trans -rx.shutdown pcs/trans srv.chall/trans.-scram -srv.close fw/pcs.trans HPCI RCIC crd srv.ads	CD	3.1E-06	1.2E-01
11	trans -rx.shutdown pcs/trans srv.chall/trans.-scram -srv.close -fw/pcs.trans rhr(sdc) rhr(spcool)/rhr(sdc)	CD	7.5E-07	1.0E-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**
11	trans -rx.shutdown pcs/trans srv.chall/trans.-scram -srv.close -fw/pcs.trans rhr(sdc) rhr(spcool)/rhr(sdc)	CD	7.5E-07	1.0E-01
20	trans -rx.shutdown pcs/trans srv.chall/trans.-scram -srv.close fw/pcs.trans HPCI RCIC crd srv.ads	CD	3.1E-06	1.2E-01
28	trans -rx.shutdown pcs/trans srv.chall/trans.-scram srv.close fw/pcs.trans HPCI srv.ads	CD	1.1E-05	1.7E-01
99	trans rx.shutdown	ATWS	3.0E-05	1.0E+00

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\bwrcseal.cmp
BRANCH MODEL: c:\asp\1989\limrick2.sll
PROBABILITY FILE: c:\asp\1989\bwr_csl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	8.2E-04	1.0E+00	
loop	1.6E-05	5.3E-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	
srv.chall/trans.-scram	1.0E+00	1.0E+00	
srv.chall/loop.-scram	1.0E+00	1.0E+00	
srv.close	4.6E-02	1.0E+00	
emerg.power	1.3E-02	8.0E-01	
ep.rec	4.9E-02	1.0E+00	
fw/pcs.trans	4.6E-01	3.4E-01	
fw/pcs.loca	1.0E+00	3.4E-01	
HPCI	2.9E-02 > 1.0E+00	7.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-02 > Failed		
RCIC	6.0E-02 > 1.0E+00	7.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	6.0E-02 > Failed		
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	
rhrsw	2.0E-02	3.4E-01	2.0E-03

* branch model file
** forced

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