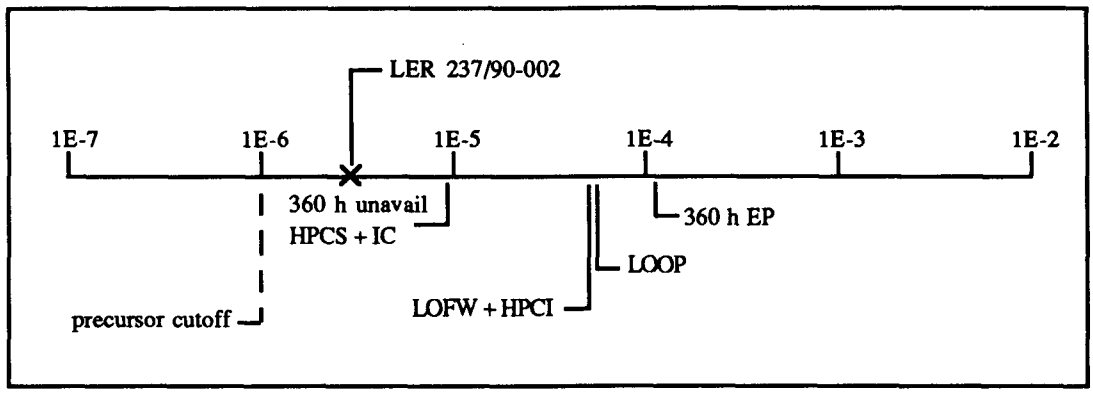
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 237/90-002
Event Description: Reactor scram followed by a loss of offsite power
Date of Event: January 16, 1990
Plant: Dresden 2

Summary

Dresden 2 scrammed from 100% power on January 16, 1990. Following the scram the reserve auxiliary transformer (RAT-22) tripped off causing a loss of offsite power (LOOP). Just prior to the LOOP the operator, anticipating the LOOP, had manually started emergency diesel generator (EDG) #2, which placed the EDG in a potential overload condition. The LOOP lasted until offsite power was restored 12 h and 39 min later. Additionally, it took more than 2 h to establish shutdown cooling (SDC) through loop B because of a failed isolation valve. The conditional core damage probability estimated for this event is 3.1×10^{-6}. The relative significance of this event compared to other postulated events at Dresden 2 is shown below.



Event Description

Dresden 2 tripped from 100% power on January 16, 1990, following failure of the 2D condensate pump due to a probable internal fault. The two operating reactor feed pumps tripped on low suction pressure, followed by scram on low water level approximately 10 s later. Standby feed pump 2B started on trip of the two operating pumps, and pump 2A was restarted by the operator after the scram. Both operating main feed pumps and the turbine tripped on high reactor water level.

One minute later RAT-22 tripped off due to an internal fault. Loads supplied by the RAT

transferred to the unit auxiliary transformer (UAT), supplied by the main generator. When the generator field breaker opened, a LOOP occurred since power was unavailable to both vital AC buses. The LOOP lasted until offsite power was restored 12 h 39 min later.

Just prior to the LOOP the operator, anticipating the LOOP, had manually started DG #2 to power bus 24-1. Since automatic load sequencing is not performed during manual start, the potential for DG overload existed [operating procedure requirements to place emergency core cooling system (ECCS) pumps in pull-to-lock, which minimized this likelihood, were followed]. Swing DG 2/3 auto-started and loaded bus 23-1.

Main steam isolation valve (MSIV) 2C closed when AC power was interrupted. The cause of the valve closing was a previously failed DC solenoid. The MSIVs on Dresden use a DC- and an AC-powered solenoid, both of which must deenergize to close the valve. Momentary interruption of AC power prior to the DG's powering the vital buses, in combination with the failed DC solenoid, caused the valve to close. All other MSIVs were closed shortly thereafter to conserve reactor inventory.

Two minutes after the MSIVs were closed, indication of a fire was received from the condensate pump room. Flames were observed coming from the 2D condensate pump vents. The fire was extinguished with a dry chemical fire extinguisher.

The isolation condenser and HPCI were used for decay heat removal. When the operator opened electromatic relief valve 2-203-3B to help control reactor pressure, the "open" lamp shorted and emitted sparks and smoke. Valve 2-203-3B was closed and valve 2-203-3C was used instead.

While taking the plant to cold shutdown, SDC pump discharge valve MO2-1001-4B failed to open because of a failed pinion gear in the valve motor. (The valve had been successfully operated on January 6, 1990, during cooldown following a scram on that date.)

Additional Event-Related Information

Dresden 2 has two independent sources of off-site power, RAT-22 and unit auxilary transformer 21 (UAT-21). Normally, five separate sources of 138-kV power feed RAT-22, which, in turn, feeds 4.16-kV Buses 22 and 24. Bus 24 supplies 4.16-kV vital Bus 24-1. The emergency supply for Bus 24-1 is EDG #2. A cross-tie also exists that can provide power to bus 24-1 via the Unit 3 RAT.

The other Dresden 2 vital 4.16-kV Bus, 23-1, is supplied by Bus 23, which, along with

Bus 21, is supplied by the main generator via UAT-21. The common Unit 2 and Unit 3 EDG (EDG #2/3 or swing EDG) provides emergency backup power to Bus 23-1. With this arrangement, the auxiliary power for Unit 2 is supplied by UAT-21 and RAT-22 with the loads divided equally between them.

On a loss of auxiliary power the reactor will scram; conversely, the UAT is the on-site power source from the main generator and by design it is lost following a turbine trip. In this event, the RAT tripped about 1 min after the turbine tripped but before the generator tripped. Buses 22 and 24, which were being carried by the RAT, automatically transferred to the UAT. (Bus 22 made four attempts to close onto the UAT before it was successful.) Consequently, when the main generator tripped the UAT tripped off and caused the LOOP.

Two other occurrences at this site (LERs 237/85-034 and 249/89-001) involved a LOOP plus a scram. All three events (this LER and the previous two) involved a failed RAT.

When EDG #2 receives an automatic start signal, the feeder breaker supplying normal 4.16-kV power from Bus 24 to Bus 24-1 is opened, thus shedding the loads on Bus 24. After the EDG is at rated speed and voltage, it is automatically loaded onto its emergency bus, Bus 24-1, and vital loads required for safe shutdown of the plant are sequenced onto the bus. If the EDG is manually started, the feeder breaker from Bus 24 to Bus 24-1 is not opened. In this case, the EDG could potentially attempt to power Buses 24 and 24-1. Additional potential loads on Bus 24 would include two service water pumps, one circulating water pump, one control rod drive pump, and two condensate pumps.

In this event (LER 237/90-002), the operator was preparing to synchronize the EDG with the bus when he noticed that the swing EDG had automatically started. He then placed the control switch back to the auto position to allow EDG #2 to auto synchronize onto the dead bus. Had the EDG been manually loaded, anticipated loads would be expected to have been less than design basis loads since an ECCS signal did not exist and Dresden operating procedures require the low-pressure ECCS pumps to be placed in pull-to-lock during manual loading to minimize the likelihood of DG overload. The operators are also trained to avoid DG overload conditions.

SDC is comprised of three 50% capacity loops, each consisting of one pump and one heat exchanger. Shutdown heat loads require that two loops be operational for 24 h, and after that only one loop is necessary to maintain the reactor cooled below 125°F.

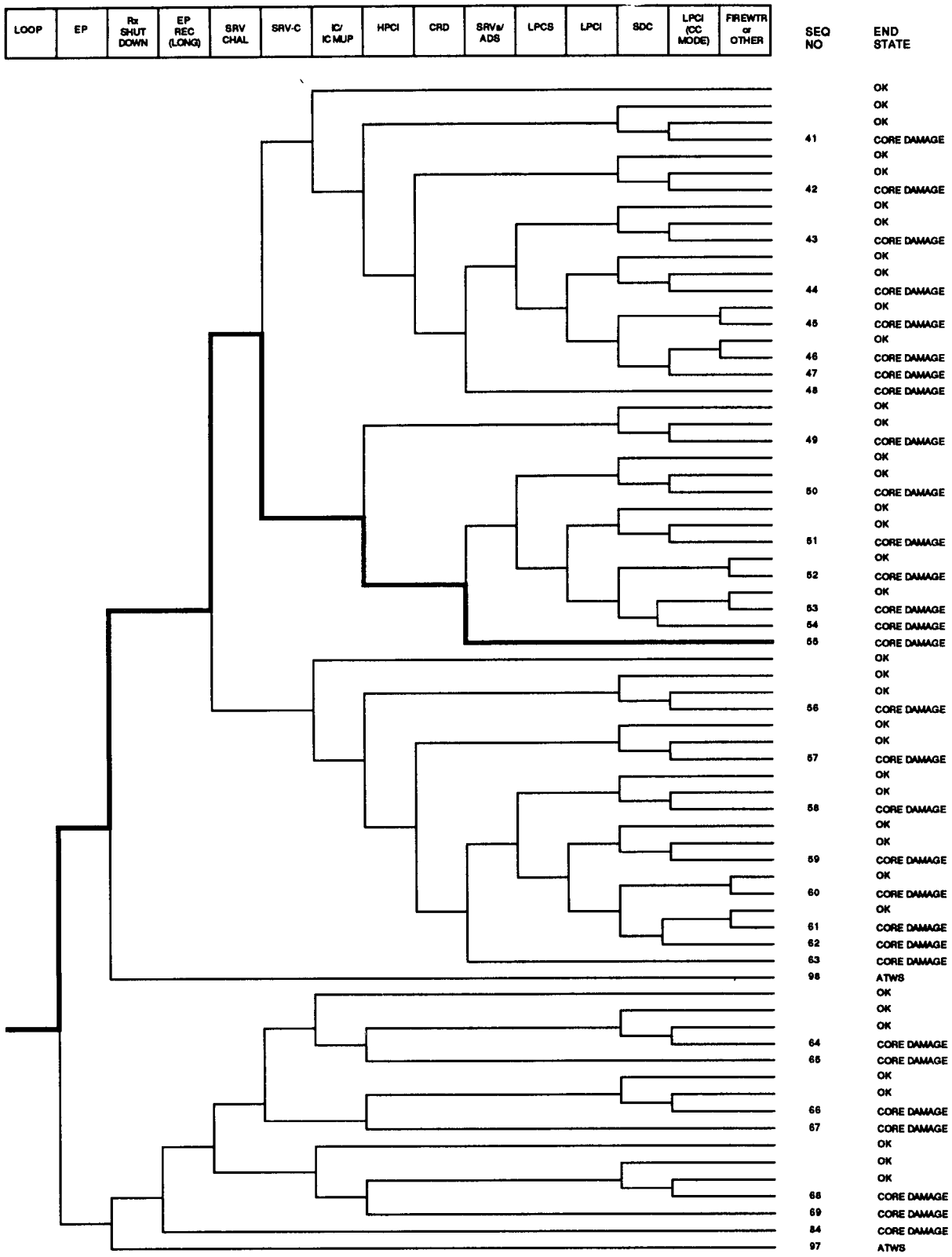
ASP Modeling Assumptions and Approach

This event was modeled as a reactor scram and plant-centered LOOP with one of three SDC loops unavailable. Manual loading of DG #2 was not assumed to impact reliability of the DG during this event.

Analysis Results

The conditional probability of severe core damage estimated for this event is 3.1×10^{-6}. The dominant sequence to core damage, highlighted on the following event tree, involves a potential transient-induced LOCA due to relief valve failure to close, followed by HPCI failure and failure to depressurize using ADS.

Additional information concerning this event is provided in AIT report 50-237/90-004.



Dominant core damage sequence for LER 237/90-002

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 237/90-002
Event Description: Reactor scram and LOOP with SDC train unavailable
Event Date: 01/16/90
Plant: Dresden 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP	3.0E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	3.1E-06
Total	3.1E-06
ATWS	
LOOP	9.2E-06
Total	9.2E-06

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
55	LOOP -emerg.power -rx.shutdown srv.chall/loop.-scram srv.close hpci srv.ads	CD	1.3E-06	1.5E-01
84	LOOP emerg.power -rx.shutdown/ep EP.REC	CD	9.6E-07	2.4E-01
65	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram -srv.close isol.cond hpci	CD	2.7E-07	1.7E-01
67	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram srv.close hpci	CD	2.3E-07	1.7E-01
64	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram -srv.close isol.cond -hpci SDC lpci(cc)/lpci	CD	1.6E-07	8.1E-02
66	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram srv.close -hpci SDC lpci(cc)/lpci	CD	1.3E-07	8.1E-02
98	LOOP -emerg.power rx.shutdown	ATWS	9.0E-06	3.0E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
55	LOOP -emerg.power -rx.shutdown srv.chall/loop.-scram srv.close hpci srv.ads	CD	1.3E-06	1.5E-01
98	LOOP -emerg.power rx.shutdown	ATWS	9.0E-06	3.0E-01
64	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram -srv.close isol.cond -hpci SDC lpci(cc)/lpci	CD	1.6E-07	8.1E-02
65	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram -srv.close isol.cond hpci	CD	2.7E-07	1.7E-01
66	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram	CD	1.3E-07	8.1E-02

	srv.close -hpci SDC lpci(cc)/lpci				
67	LOOP emerg.power -rx.shutdown/ep -EP.REC srv.chall/loop.-scram	CD		2.3E-07	1.7E-01
	srv.close hpci				
84	LOOP emerg.power -rx.shutdown/ep EP.REC	CD		9.6E-07	2.4E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\bwrbseal.cmp
BRANCH MODEL: c:\asp\1989\dresden.sll
PROBABILITY FILE: c:\asp\1989\bwr_csll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	3.4E-04	1.0E+00	
LOOP	1.6E-05 > 1.6E-05	3.6E-01 > 3.0E-01	
Branch Model: INITOR			
Initiator Freq:	1.6E-05		
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	1.6E-02	1.0E+00	
emerg.power	2.9E-03	8.0E-01	
EP.REC	6.6E-02 > 1.4E-03	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	6.6E-02 > 1.4E-03		
fw/pcs.trans	2.9E-01	3.4E-01	
hpci	2.9E-02	7.0E-01	
isol.cond	2.0E-02	1.0E+00	
crd	1.0E-02	1.0E+00	1.0E-02
srv.ads	3.7E-03	7.1E-01	1.0E-02
lpcs	2.0E-03	3.4E-01	
lpci	1.0E-03	7.1E-01	
SDC	2.9E-03 > 3.2E-02	3.4E-01	1.0E-03
Branch Model: 1.OF.3+ser+opr			
Train 1 Cond Prob:	3.0E-02 > Failed		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01		
Serial Component Prob:	2.0E-03		
lpci(cc)	1.0E-03	3.4E-01	
lpci(cc)/lpci	1.0E+00	1.0E+00	
lpci(cc)/-lpci	0.0E+00	1.0E+00	
firewater	1.0E+00	1.0E+00	2.0E-03

* branch model file
** forced

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Event Identifier: 237/90-002