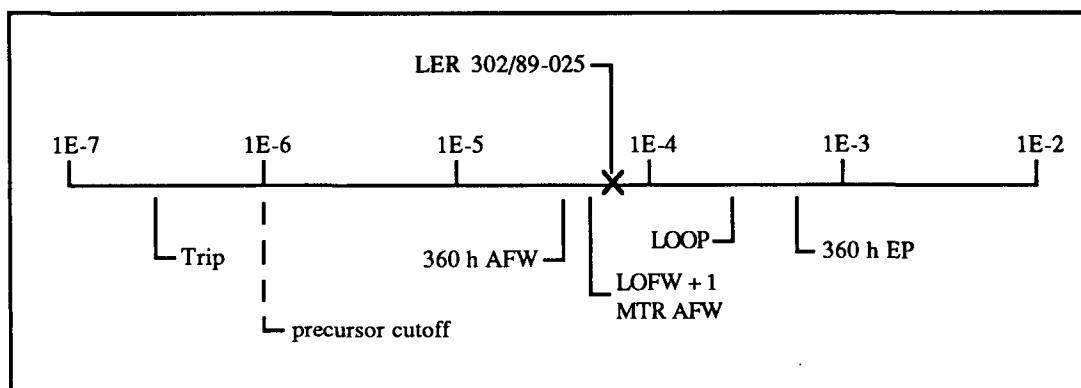


## ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No: 302/89-025  
 Event Description: Loss of offsite power in hot shutdown with one DG unavailable and degraded emergency feedwater  
 Date of Event: June 29, 1989  
 Plant: Crystal River 3

### Summary

An electric fault in the 230-kV switchyard caused the circuit breakers to the Crystal River 3 startup transformer to open, resulting in the interruption of normal offsite power to the engineered safeguards (ES) buses 3A and 3B. The plant was in hot shutdown, cooling down to perform maintenance on one of the two diesel generators. Emergency power to 3A ES bus was provided by the 3A diesel generator (DG). Backup power was supplied to 3B ES bus within 2 min by manually lining up the Unit 1 and 2 startup transformer. The motor-driven emergency feedwater pump had to be manually started once the diesel generator repowered bus 3A. Approximately 1.25 h after the event, operators restored power to the plant via the startup transformer. The conditional core damage probability estimated for this event is  $6.3 \times 10^{-5}$ . The relative significance of this event compared with other postulated events at Crystal River 3 is shown below.



### Event Description

On June 29, 1989, Crystal River 3 was in hot shutdown for maintenance on DG 3B. An electrical storm in the area is believed to have caused an electric fault in the 230-kV switchyard, causing an interruption in the power supply to the startup transformer. DG 3A automatically started and reenergized the 3A 4160-V engineered safeguards (ES) bus.

Because of the unavailability of DG 3B, bus 3B was not initially repowered. Two minutes after the loss of power the Crystal River Unit 1 and 2 startup transformer was lined up to power the 3B 4160-V ES bus. As a result of the loss of power to the startup transformer, the three operating reactor coolant pumps tripped off, the operating main feedwater pump tripped off, the condenser circulating water pumps tripped off, and one of a group of control rods that were being held withdrawn to provide trippable reactivity inserted into the reactor. The loss of the condenser circulating water pumps caused a loss of vacuum in the main condenser and eliminated the condenser as a heat sink. This forced the operators to relieve steam from the steam generators to atmosphere. The operators manually started the motor-driven EFW pump and manually controlled the feedwater flow and steam generator fill rates during the event. Approximately 1.25 h after the interruption, the Crystal River 3 startup transformer was returned to service and used to power plant loads.

### **Additional Event-Related Information**

Crystal River 3's normal offsite source of power to ES buses 3A and 3B is from the 230-kV switchyard (five possible sources) stepped down through the Unit 3 startup transformer. Alternate offsite power to the ES buses is from the Unit 3 auxiliary transformer supplied by the Unit 3 main generator. Backup offsite power to the ES Buses is from the Units 1 and 2 startup transformer. DGs 3A and 3B supply emergency power to the ES buses in the event that all other sources of power are lost. In this event, the plant was in hot shutdown, and the main generator was separated from the grid. Thus, the alternate source of power to the ES buses was unavailable. The event began with the interruption of the normal source of offsite power to the ES buses. Since DG 3B was out of service for maintenance, power was initially unavailable on bus 3B. The backup source of power for 3B ES bus was manually lined up, which took ~2 min.

According to the FSAR there are five automatic initiating signals for the EFW system: (1) all four reactor coolant pumps tripped; (2) both main feed pumps tripped and reactor power is greater than 20%; (3) low level in either steam generator; (4) low pressure in either steam generator; or (5) SI actuation on both A and B ESAS channels. There is not enough information in this LER to establish whether an automatic initiation signal for EFW existed.

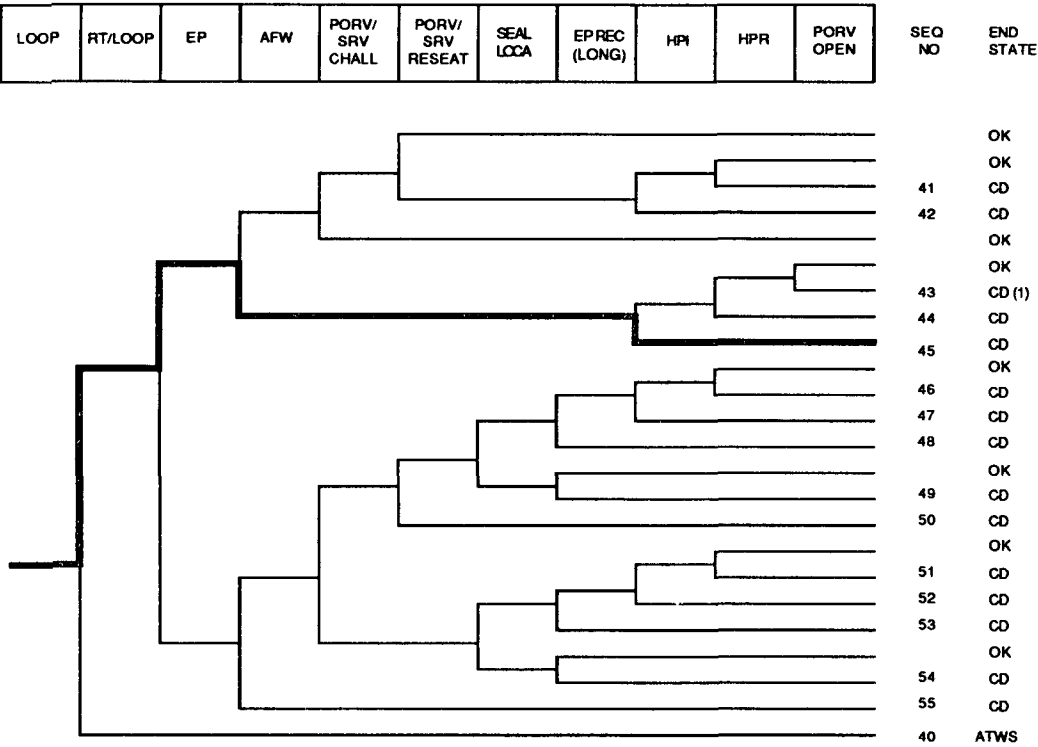
However, LER 302/89-023 describes a loss of offsite power one-half month earlier during which the motor-driven EFW pump failed to automatically start because of two faulty relays. That LER notes that one of the faulty relays was not discovered until sometime after the plant had been returned to power.

### **ASP Modeling Assumptions and Approach**

This event has been modeled as a plant-centered loss of offsite power with one diesel generator unavailable and the motor-driven EFW pump initially unavailable. Two calculations were performed to estimate a core damage probability for the event. In the first calculation, DG 3B and the motor-driven EFW pump were assumed to be unavailable. In the second, power to the ES bus 3B was assumed available. The probability of not recovering AC power to bus 3B via the Unit 1 and 2 startup transformer was assumed to be 0.1, and the two core damage probability estimates were normalized by this value to develop an overall estimate.

### **Analysis Results**

The conditional probability of severe core damage for this event is  $6.3 \times 10^{-5}$ . The dominant core damage sequence involves successful emergency power with failure of EFW and feed and bleed. This sequence is highlighted on the following event tree. Note that if neither the AC bus nor the EFW train are assumed to be failed, then the core damage probability for the event is estimated to be  $1.3 \times 10^{-5}$ .



Dominant core damage sequence for LER 302/89-025

# B-85

## CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 302/89-025  
 Event Description: LOOP in hot shutdown with one DG OOS and degraded EFW  
 Event Date: 06/29/89  
 Plant: Crystal River 3

### INITIATING EVENT

#### NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 1.5E-01

#### SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	3.1E-04
Total	3.1E-04

#### ATWS

LOOP	0.0E+00
Total	0.0E+00

#### SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
55 LOOP -rt/loop EMERG.POWER afw/emerg.power	CD	1.2E-04	4.1E-02
54 LOOP -rt/loop EMERG.POWER -afw/emerg.power -porv.or.srv.chall - SEAL.LOCA EP.REC	CD	9.7E-05	1.2E-01
45 LOOP -rt/loop -EMERG.POWER AFW HPI(F/B)	CD	3.4E-05	3.2E-02
53 LOOP -rt/loop EMERG.POWER -afw/emerg.power -porv.or.srv.chall SEAL.LOCA EP.REC(SL)	CD	2.6E-05	1.2E-01
44 LOOP -rt/loop -EMERG.POWER AFW -HPI(F/B) HPR/-HPI	CD	2.0E-05	3.9E-02
49 LOOP -rt/loop EMERG.POWER -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power -SEAL.LOCA EP.REC	CD	8.4E-06	1.2E-01
50 LOOP -rt/loop EMERG.POWER -afw/emerg.power porv.or.srv.chall porv.or.srv.reseat/emerg.power	CD	5.4E-06	1.2E-01

\*\* non-recovery credit for edited case

#### SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
44 LOOP -rt/loop -EMERG.POWER AFW -HPI(F/B) HPR/-HPI	CD	2.0E-05	3.9E-02
45 LOOP -rt/loop -EMERG.POWER AFW HPI(F/B)	CD	3.4E-05	3.2E-02
49 LOOP -rt/loop EMERG.POWER -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power -SEAL.LOCA EP.REC	CD	8.4E-06	1.2E-01
50 LOOP -rt/loop EMERG.POWER -afw/emerg.power porv.or.srv.chall porv.or.srv.reseat/emerg.power	CD	5.4E-06	1.2E-01
53 LOOP -rt/loop EMERG.POWER -afw/emerg.power -porv.or.srv.chall SEAL.LOCA EP.REC(SL)	CD	2.6E-05	1.2E-01
54 LOOP -rt/loop EMERG.POWER -afw/emerg.power -porv.or.srv.chall - SEAL.LOCA EP.REC	CD	9.7E-05	1.2E-01
55 LOOP -rt/loop EMERG.POWER afw/emerg.power	CD	1.2E-04	4.1E-02

\*\* non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrdsal.cmp  
 BRANCH MODEL: c:\asp\1989\crystal3.sll  
 PROBABILITY FILE: c:\asp\1989\pwr\_bsll.pro

No Recovery Limit

Event Identifier: 302/89-025

## BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	3.9E-04	1.0E+00	
LOOP	1.8E-05 > 1.8E-05	3.3E-01 > 1.5E-01	
Branch Model: INITOR			
Initiator Freq:			
	1.8E-05		
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
EMERG.POWER	2.9E-03 > 5.7E-02	8.0E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:			
	5.0E-02 > Failed		
Train 2 Cond Prob:			
	5.7E-02		
AFW	1.3E-03 > 5.0E-02	2.6E-01	
Branch Model: 1.OF.2+ser			
Train 1 Cond Prob:			
	2.0E-02 > Failed		
Train 2 Cond Prob:			
	5.0E-02		
Serial Component Prob:			
	2.8E-04		
afw/emerg.power	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-02	1.0E+00	
porv.or.srv.reseat	1.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	1.0E-02	1.0E+00	
SEAL.LOCA	6.0E-02 > 1.5E-02	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
	6.0E-02 > 1.5E-02		
EP.REC(SL)	7.6E-01 > 2.8E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
	7.6E-01 > 2.8E-01		
EP.REC	3.1E-01 > 1.6E-02	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
	3.1E-01 > 1.6E-02		
HPI	3.0E-04 > 1.0E-02	8.4E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:			
	1.0E-02		
Train 2 Cond Prob:			
	1.0E-01 > Unavailable		
Train 3 Cond Prob:			
	3.0E-01 > Unavailable		
HPI(F/B)	3.0E-04 > 1.0E-02	8.4E-01	1.0E-02
Branch Model: 1.OF.3+opr			
Train 1 Cond Prob:			
	1.0E-02		
Train 2 Cond Prob:			
	1.0E-01 > Unavailable		
Train 3 Cond Prob:			
	3.0E-01 > Unavailable		
HPR/-HPI	1.5E-04 > 1.0E-02	1.0E+00	1.0E-03
Branch Model: 1.OF.2+opr			
Train 1 Cond Prob:			
	1.0E-02		
Train 2 Cond Prob:			
	1.5E-02 > Unavailable		

\* branch model file  
 \*\* forced

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# B-87

## CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 302/89-025  
 Event Description: LOOP in hot shutdown with one DG OOS (calc 2)  
 Event Date: 06/29/89  
 Plant: Crystal River 3

### INITIATING EVENT

#### NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 1.5E-01

#### SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	3.5E-05
Total	3.5E-05
ATWS	
LOOP	0.0E+00
Total	0.0E+00

#### SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
45 LOOP -rt/loop -emerg.power AFW hpi(f/b)	CD	2.0E-05	3.3E-02
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	5.8E-06	4.1E-02
54 LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - SEAL.LOCA EP.REC	CD	4.9E-06	1.2E-01
44 LOOP -rt/loop -emerg.power AFW -hpi(f/b) hpr/-hpi	CD	2.2E-06	3.9E-02
53 LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall SEAL.LOCA EP.REC(SL)	CD	1.3E-06	1.2E-01

\*\* non-recovery credit for edited case

#### SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
44 LOOP -rt/loop -emerg.power AFW -hpi(f/b) hpr/-hpi	CD	2.2E-06	3.9E-02
45 LOOP -rt/loop -emerg.power AFW hpi(f/b)	CD	2.0E-05	3.3E-02
53 LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall SEAL.LOCA EP.REC(SL)	CD	1.3E-06	1.2E-01
54 LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - SEAL.LOCA EP.REC	CD	4.9E-06	1.2E-01
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	5.8E-06	4.1E-02

\*\* non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrseal.cmp  
 BRANCH MODEL: c:\asp\1989\crystal3.sll  
 PROBABILITY FILE: c:\asp\1989\pwr\_bsll.pro

No Recovery Limit

#### BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	3.9E-04	1.0E+00	
LOOP	1.8E-05 > 1.8E-05	3.3E-01 > 1.5E-01	
Branch Model: INITOR			

Event Identifier: 302/89-025

# B-88

Initiator Freq:	1.8E-05		
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
emerg.power	2.9E-03	8.0E-01	
AFW	1.3E-03 > 5.0E-02	2.6E-01	
Branch Model: 1.OP.2+ser			
Train 1 Cond Prob:	2.0E-02 > Failed		
Train 2 Cond Prob:	5.0E-02		
Serial Component Prob:	2.8E-04		
afw/emerg.power	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-02	1.0E+00	
porv.or.srv.reseat	1.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	1.0E-02	1.0E+00	
SEAL,LOCA	6.0E-02 > 1.5E-02	1.0E+00	
Branch Model: 1.OP.1			
Train 1 Cond Prob:	6.0E-02 > 1.5E-02		
EP.REC(SL)	7.6E-01 > 2.8E-01	1.0E+00	
Branch Model: 1.OP.1			
Train 1 Cond Prob:	7.6E-01 > 2.8E-01		
EP.REC	3.1E-01 > 1.6E-02	1.0E+00	
Branch Model: 1.OP.1			
Train 1 Cond Prob:	3.1E-01 > 1.6E-02		
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
hpr/-hpi	1.5E-04	1.0E+00	1.0E-03
* branch model file			
** forced			

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