

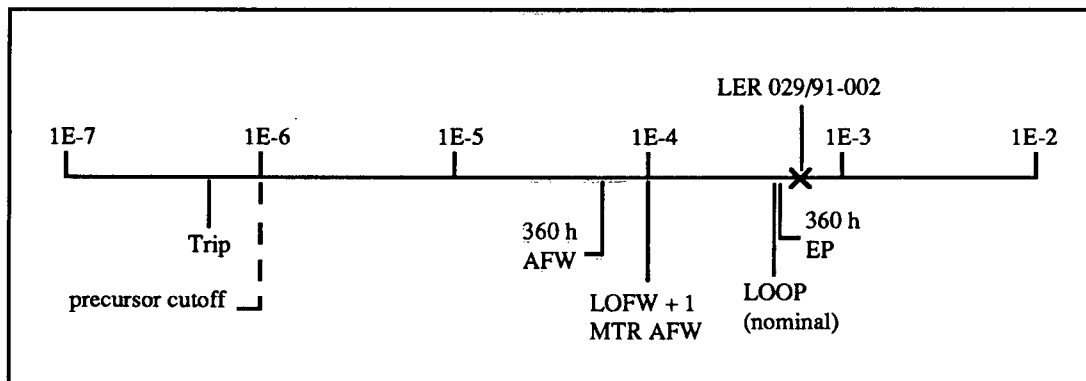
## ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 029/91-002  
 Event Description: Loss of offsite power caused by lightning strike  
 Date of Event: June 15, 1991  
 Plant: Yankee Rowe

### Summary

Yankee Rowe lost offsite power for 24 min due to a lightning strike. All three emergency diesel generators (EDGs) operated as designed. As a result of the lightning, surge protection fuses from the normal DC supplies blew on both vital power supply inverters. Both inverters transferred to their alternate (EDG-backed) AC sources. However, in the event of failure of the EDGs, 120-VAC instrument power would have been lost.

The conditional probability of core damage associated with this event is  $6.1 \times 10^{-4}$ . The relative significance of the event compared to other postulated events at Yankee Rowe is shown below:



### Event Description

Yankee Rowe experienced a lightning strike that caused a total loss of offsite AC power on June 15, 1991. The lightning strike (1) destroyed the phase A lightning arrester on station service transformer (SST) 3, which is connected to the Cabot (Y-177) 115-kV transmission line, and (2) caused a flashover of an insulator on phase A of the Harriman (Z-126) 115-kV transmission line disconnect switch. Offsite AC power was lost for 24 min.

An automatic reactor scram and turbine trip occurred as a result of the loss of offsite

power. All three EDGs operated as designed. EDGs 1 and 3 started automatically in response to the deenergization of both offsite transmission lines. EDG 2 was manually started by operators in anticipation of securing the main generator in accordance with plant procedures. Lightning also caused blown surge protection fuses in the normal DC input supplies to both vital buses. Upon deenergization, both vital bus inverters automatically transferred to and were energized by their backup sources (EDGs 1 and 3).

The nonessential uninterruptible power supply (NEUPS) failed to automatically transfer to its backup source after the lightning strike. Consequently, various plant communication systems experienced failures. The plant commercial phone system failed to operate after the NEUPS was reenergized due to lightning-induced failures of two critical circuit packs.

While attempting to realign the emergency buses to offsite power, an inadvertent safety injection (SI) actuation signal was initiated. No actual injection occurred due to adequate main coolant system pressure.

An unusual event was declared due to the loss of offsite power and a fire emergency caused by the smoldering lightning arrestor on SST 3. The unusual event was elevated to an alert based on the continued inoperability of communication systems, the deenergized NEUPS, and the existence of degraded plant equipment.

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

Yankee Rowe has two independent sources of offsite power, the 115-kV Z-126 transmission line from the Harriman station, and the 115-kV Y-177 transmission line from the Cabot station. Normal operation is with both of these lines in service. Z-126 feeds the SST 2 and Y-177 feeds the SST 3. The SST 1 is connected to the outdoor section of the generator bus.

The station service system consists of three 2400-V buses, each supplied from an SST. Each 2400-V bus, in turn, supplies a 480-V station service switchgear bus. Three emergency 480-V buses (vital bus 1, vital bus 2, and transformer A bus) are fed independently from the 480-V station service buses or, upon loss of AC power, from each of the three independent EDGs. Backup DC power consists of three 125-VDC station batteries and three associated battery chargers.

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

The event has been modeled as a plant-centered loss of offsite power (LOOP). Probabilities for LOOP nonrecovery (short term) and failure to recover AC power prior to battery depletion were revised to reflect values associated with a plant-centered LOOP

(see ORNL/NRC/LTR-89/11, *Revised LOOP Recovery and PWR Seal LOCA Models*, August 1989). Both trains of 120-VAC vital power were assumed to be unavailable if all three EDGs failed to start or run (only the backup source to the vital buses was available since the DC fuses supplying power to both inverters failed open after the lightning strike). Unavailability of both instrument buses was assumed to proceed to core damage, since steam generator (SG) and reactor coolant system (RCS) parameters would be unavailable for monitoring and control.

### **Analysis Results**

The conditional probability of core damage estimated for this event is  $6.1 \times 10^{-4}$ . The dominant core damage sequence, highlighted on the following event tree, involves a station blackout. In the event that RCS and SG parameters can be successfully monitored without 120-VAC power to allow decay heat removal, the conditional core damage probability estimated for the event is  $4.3 \times 10^{-4}$ .

Dominant core damage sequence for LER 029/91-002

# B-11

## CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 029/91-002  
 Event Description: LOOP and degraded instrument power caused by lightning  
 Event Date: 06/15/91  
 Plant: 029/91-002

### INITIATING EVENT

#### NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 5.0E-01

#### SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	6.1E-04
Total	6.1E-04
ATWS	
LOOP	0.0E+00
Total	0.0E+00

#### SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
46 LOOP -rt/loop emerg.power	CD	2.2E-04	4.0E-01
45 LOOP -rt/loop -emerg.power afw/emerg.power hpl(f/b)	CD	2.0E-04	1.4E-01
43 LOOP -rt/loop -emerg.power afw/emerg.power -hpl(f/b) -hpr/-hpi porv.open	CD	1.7E-04	1.7E-01
44 LOOP -rt/loop -emerg.power afw/emerg.power -hpl(f/b) hpr/-hpi	CD	1.7E-05	1.7E-01

\*\* non-recovery credit for edited case

#### SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
43 LOOP -rt/loop -emerg.power afw/emerg.power -hpl(f/b) -hpr/-hpi porv.open	CD	1.7E-04	1.7E-01
44 LOOP -rt/loop -emerg.power afw/emerg.power -hpl(f/b) hpr/-hpi	CD	1.7E-05	1.7E-01
45 LOOP -rt/loop -emerg.power afw/emerg.power hpl(f/b)	CD	2.0E-04	1.4E-01
46 LOOP -rt/loop emerg.power	CD	2.2E-04	4.0E-01

\*\* non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\02991002.cmp  
 BRANCH MODEL: c:\asp\1989\yrowe.sll  
 PROBABILITY FILE: c:\asp\1989\pwr\_bsll.pro

No Recovery Limit

#### BRANCH FREQUENCIES/PROBABILITIES

Event Identifier: 029/91-002

# B-12

Branch	System	Non-Recov	Opr Fail
trans	2.5E-04	1.0E+00	
LOOP	1.6E-05 > 1.6E-05	5.3E-01 > 5.0E-01	
Branch Model: INITOR			
Initiator Freq:	1.6E-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	5.4E-04	8.0E-01	
afw	1.3E-03	2.6E-01	
afw/emerg.power	1.0E-01	3.4E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	4.0E-02	1.0E+00	
porv.or.srv.reseat	2.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	2.0E-02	1.0E+00	
seal.loca	0.0E+00	1.0E+00	
ep.rec(sl)	0.0E+00	1.0E+00	
EP.REC	1.7E-01 > 1.1E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.7E-01 > 1.1E-01		
hpi	3.0E-04	8.4E-01	
hpi (f/b)	2.4E-03	8.4E-01	1.0E-02
hpr/-hpi	1.5E-05	1.0E+00	1.0E-03
porv.open	1.0E-02	1.0E+00	4.0E-04
* branch model file			
** forced			

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Event Identifier: 029/91-002