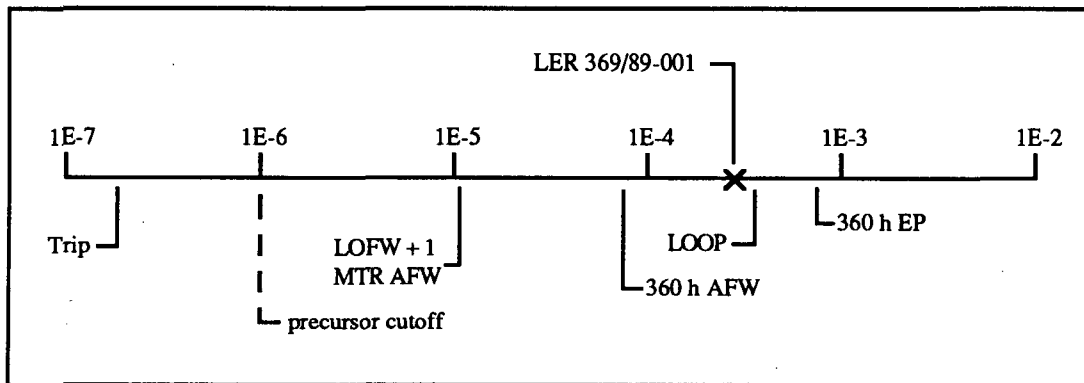


ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 369/91-001
 Event Description: Switchyard breaker test results in loss of offsite power
 Date of Event: February 11, 1991
 Plant: McGuire 1

Summary

Errors and equipment failures during installation of new switchyard relay protection resulted in the opening of all switchyard breakers connecting Unit 1 to the grid. Reactor and turbine trips followed, and both diesel generators (DGs) started and loaded. An excessive cooldown rate resulted in safety injection (SI) actuation and main steam isolation valve (MSIV) closure. Subsequently, reactor coolant pressure increased, and two pressurizer power-operated relief valves (PORVs) actuated. Containment pressure increased to 0.76 psig. Offsite power was restored, and operators began unloading the DGs after about 1.25 h. The conditional core damage probability estimated for the event is 2.6×10^{-4} . The relative significance of this event compared to other postulated events at McGuire 1 is shown below.



Event Description

Prior to the event, Unit 1 was operating at 100% power while relay protection modifications for the switchyard autotransformer were in progress. At McGuire, the autotransformer serves to cross-tie the Unit 1 230-kV switchyard to the Unit 2 525-kV switchyard. A sudden pressure fault detection relay had been added to the autotransformer, and testing was in progress to verify that operation of the relay would properly isolate the autotransformer. The autotransformer feeder breakers' trip coil circuits were blocked to prevent their actuation, and a simulated fault pressure signal was introduced. Additional protective relaying that had not been blocked detected the

simulated sudden pressure relay operation and the failure of the autotransformer breakers to open. This actuated a breaker failure scheme that cleared both main buses in the 525-kV and 230-kV switchyards. Each McGuire unit remained connected to the grid through two transmission lines, which connect directly to the main transformer outputs, bypassing the switchyard buses.

The output from the Unit 1 generator was directed to the Craighead and Mecklenburg transmission lines. The increased current in the Craighead line was detected by relay protection as an overcurrent condition. This, in conjunction with a failed distance relay for the Craighead line, resulted in opening of the Craighead line feeder breaker. The entire output of the unit was then directed to the Mecklenburg line, which was sized for only one-half of the unit's output. The feeder breaker for this line tripped on overcurrent, and all offsite power was lost to Unit 1.

When all connections to the grid were lost, the generator output frequency rose, increasing reactor coolant pump (RCP) speed and flow. The resulting increase in reactor power initiated a high flux rate reactor trip, which was followed by a turbine trip. DGs 1A and 1B started and automatically picked up their emergency loads.

The loss of power to nonsafety-related valves prevented operators from isolating certain main steam loads, and excessive cooling of the reactor coolant system (RCS) resulted. Low steamline pressure initiated a SI and automatic isolation of the MSIVs. RCS temperature and pressure then began rising until limited by operation of two PORVs (a third valve was unavailable because of maintenance). Containment pressure began rising, ultimately reaching 0.76 psig.

The SI signal was reset, and power was restored to the switchyard. About 75 min into the event, operators began removing loads from the DGs and restoring the plant to a normal alignment.

Additional Event-Related Information

The utility reported that 4 min into the event, the condenser "was in full load rejection mode." It was also reported that an inability to isolate steamline drains and other main steam valves contributed to excessive steam demand and cooldown.

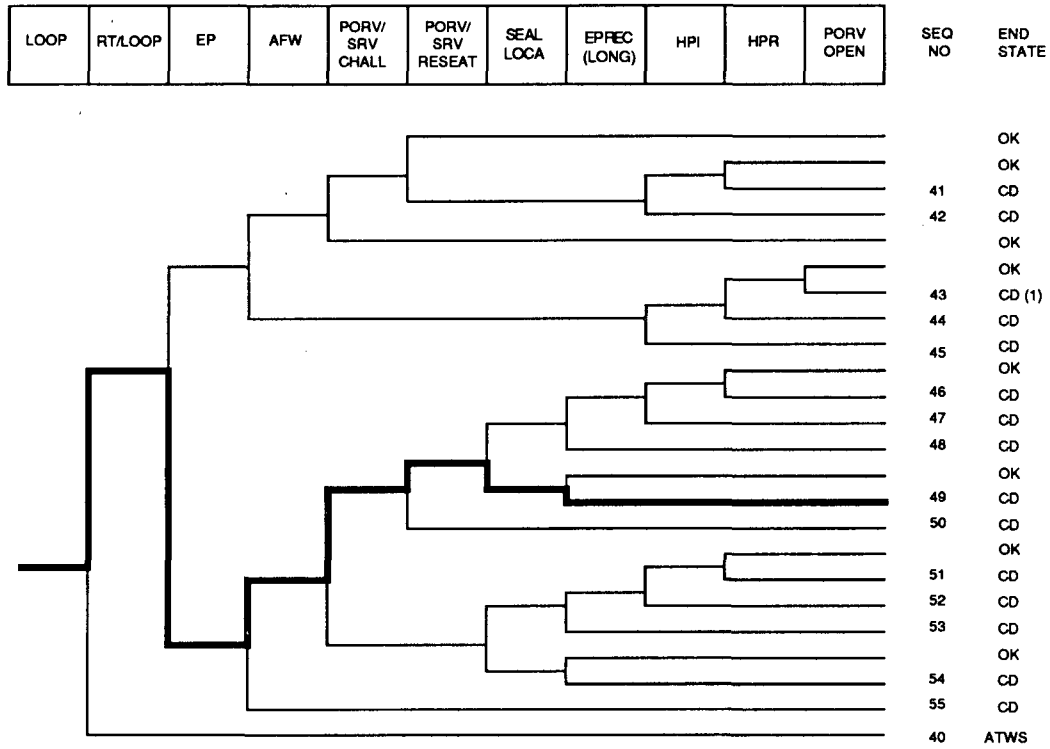
At McGuire, air is removed from the condenser by steam-jet air ejectors. This system might not be impacted by a loss-of-offsite power (LOOP). Condenser cooling is provided by the condenser circulating water system (CCW). The CCW system is crosstied between Units 1 and 2 via an 84-in. line. As power to Unit 2 was apparently maintained during the event, some CCW may have been available to the Unit 1 condenser. These features may have contributed to the excessive cooldown of the main steam system.

ASP Modeling Assumptions and Approach

This event was modeled as a plant-centered loss of offsite power with pressurizer PORVs demanded. Probabilities for LOOP non-recovery (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). The two operable PORVs were assumed to be adequate for feed and bleed.

Analysis Results

The estimated core damage probability associated with this event is 2.6×10^{-4} . The dominant core damage sequence, shown on the following event tree, involves a postulated loss of emergency power following the LOOP, and failure to recover AC power prior to battery depletion. If the unavailable PORV is assumed to fail feed and bleed, the resultant core damage probability is estimated to be 2.9×10^{-4} .



(1) OK for Class D

Dominant core damage sequence for LER 369/91-001

B-377

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 369/91-001
 Event Description: Switchyard breaker test results in a LOOP
 Event Date: 02/11/91
 Plant: McGuire 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 3.0E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	2.6E-04
Total	2.6E-04
ATWS	
LOOP	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
49 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power -seal.loca EP.REC	CD	2.3E-04	2.4E-01
50 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL porv.or.srv.reseat/emerg.power	CD	2.0E-05	2.4E-01
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	1.2E-05	8.2E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
49 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL - porv.or.srv.reseat/emerg.power -seal.loca EP.REC	CD	2.3E-04	2.4E-01
50 LOOP -rt/loop emerg.power -afw/emerg.power PORV.OR.SRV.CHALL porv.or.srv.reseat/emerg.power	CD	2.0E-05	2.4E-01
55 LOOP -rt/loop emerg.power afw/emerg.power	CD	1.2E-05	8.2E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrseal.cmp
 BRANCH MODEL: c:\asp\1989\mcguire.s11
 PROBABILITY FILE: c:\asp\1989\pwr_bs11.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Event Identifier: 369/91-001

B-378

Branch	System	Non-Recov	Opr Fail
trans	4.3E-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	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	3.8E-04	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	1.0E+00	7.0E-02	1.0E-03
PORV.OR.SRV.CHALL	4.0E-02 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
porv.or.srv.reseat	4.0E-02 > 1.0E+00		
porv.or.srv.reseat/emerg.power	3.0E-02	1.1E-02	
seal.loca	3.0E-02	1.0E+00	
ep.rec(s1)	0.0E+00	1.0E+00	
EP.REC	4.5E-01 > 3.5E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:			
hpi	4.5E-01 > 3.5E-01		
hpi(f/b)	1.0E-03	8.4E-01	
hpr/-hpi	2.2E-03	8.4E-01	1.0E-02
porv.open	1.5E-04	1.0E+00	1.0E-03
	1.0E-02	1.0E+00	4.0E-04
* branch model file			
** forced			

Minarick
03-11-1992
12:32:35

Event Identifier: 369/91-001