# ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No: 327/89-033
Event Description: RWST level and other instrument transmitters inoperable
Date: December 16, 1989
Plant: Sequoyah 1 and 2

Summary

During a cold snap, all four level transmitters that indicate refueling water storage tank (RSWT) level on Unit 1 froze and failed to indicate correctly. This would have prevented automatic switchover from the RWST to the containment sump in the event of a LOCA or feed and bleed. Main steam pressure and feedwater flow indicators also froze and failed. Similar difficulties were experienced on Unit 2. The conditional probability of core damage estimated for this event is 4.8×10^{-6} on Unit 1 and 3.6×10^{-6} for Unit 2. The relative significance of this event compared with other postulated events at Sequoyah is shown below.
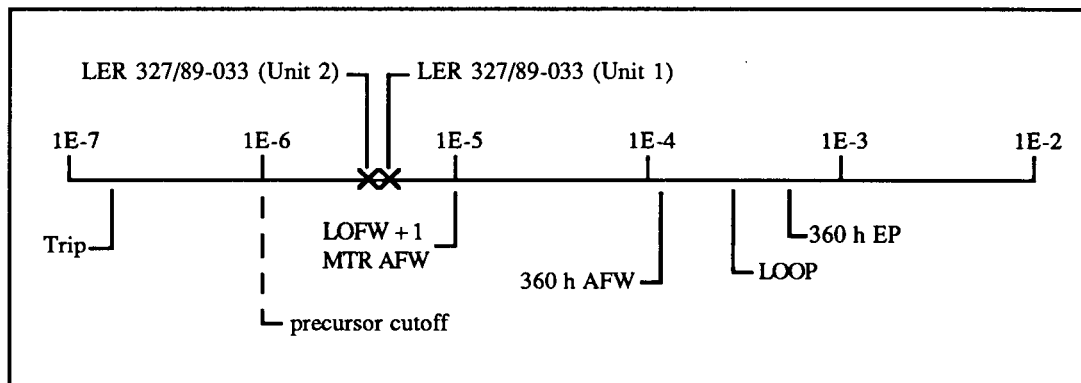
Event Description

On December 16, 1989, Sequoyah 1 was at 100% power when, one after the other, all four refueling water storage tank level transmitters (LT 63-50, -51, -52, -53) froze and failed high. These failures were attributed to the unusually low temperature experienced (8°F), as well as to other causes, including the deenergization of heat tracing on the instruments. This condition existed for approximately 39 h on Unit 1. A similar condition (three of four transmitters inoperable) existed on Unit 2 for approximately 25 h.

The RWST level transmitter heat tracing was de-energized around September 1989, in response to concerns that the heat trace thermostats were not known to be class 1E rated but were capable of impairing the performance of class 1E equipment. Calculations performed at the time indicated that the level transmitters would function acceptably at low temperatures. The heat tracing was originally installed in response to 1980-81 incidents in which the RWST sensing lines also froze.

Main steam pressure transmitter PT-1-9A froze and failed high on Unit 1. This pressure transmitter indicates when main steam pressure is low, providing input to flow transmitter FT-1-10A. Low main steam pressure, coincident with high steam line flow, initiates steam line isolation and safety injection. The instrumentation remained inoperable for about 37 h.

Feedwater flow transmitter FT-3-90A froze and failed high on Unit 2. This transmitter provides indication to the steam flow/feed flow mismatch reactor trip circuitry. Steam flow/feed flow mismatch coincident with low steam generator level will initiate a reactor trip. At the time it failed, the flow transmitter's signal was also being used for steam generator level control. When it failed high, flow to the loop 3 steam generator was reduced, requiring prompt operator intervention to prevent a steam generator low level reactor trip. The transmitter was apparently inoperable for about 33 h. The instrumentation failures were attributed to the temperature, to improper insulation, and to greater than expected cooling by ventilation air flow.

Additional Event-Related Information

During a LOCA, the residual heat removal (RHR) system automatically switches from borated water injection to recirculation when the RWST level transmitters indicate a low level (coincident with high level in the containment sump). The RWST level transmitters failed "high," indicating the presence of a high level in the tank. Had a LOCA occurred during the time that the transmitters were inoperable, or if bleed and feed had been required for trip mitigation, the automatic switchover of suction supply to the RHR pumps from RWST to sump would not have occurred. The switchover could have been accomplished manually, however, if done before the RHR and HPI pumps were damaged.

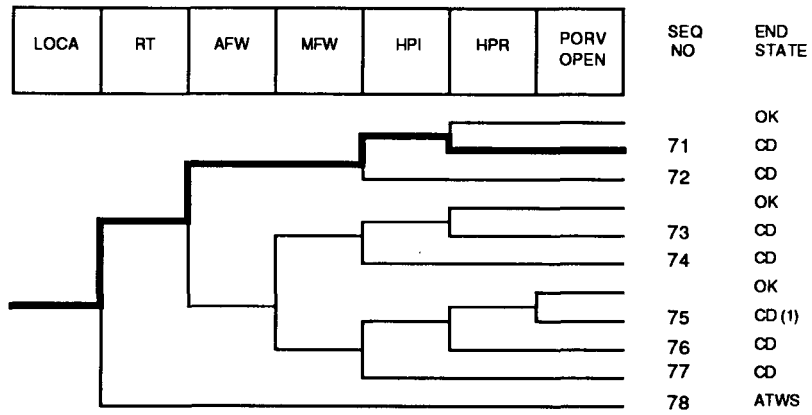## ASP Modeling Assumption and Approach

The event has been modeled as a 38.75-h unavailability of high-pressure recirculation on Unit 1. The likelihood of not recovering from the unavailability was assumed to be 0.12,

indicative of a nonroutine and nonproceduralized in-control room action.

For Unit 2, the high potential for reactor trip when FT-3-90A failed high was addressed by modifying the transient frequency used in the calculation such that the probability of trip over the 25-h unavailability of RWST indicaton was 0.3. Other assumptions for Unit 2 were the same as for Unit 1.

Analysis Results

The conditional core damage frequency estimated for the event on Unit 1 is 4.8×10^{-6}. For Unit 2, the estimated core damage probability is 3.6×10^{-6}. For both events, the dominant sequence involves a postulated LOCA with successful high-pressure injection and failure of high-pressure recirculation due to failure to correct switch from the RWST to the containment sump. This sequence is highlighted on the following event tree.

LOCA	RT	AFW	MFW	HPI	HPR	PORV OPEN

SEQ NO	END STATE
	OK
71	CD
72	CD
	OK
73	CD
74	CD
	OK
75	CD (1)
76	CD
77	CD
78	ATWS

(1) OK for Class D

Dominant core damage sequence for LER 327/89-033 (Sequoyah 1 calculation)

LOCA	RT	AFW	MFW	HPI	HPR	PORV OPEN

SEQ NO	END STATE
	OK
71	CD
72	CD
	OK
73	CD
74	CD
	OK
75	CD (1)
76	CD
77	CD
78	ATWS
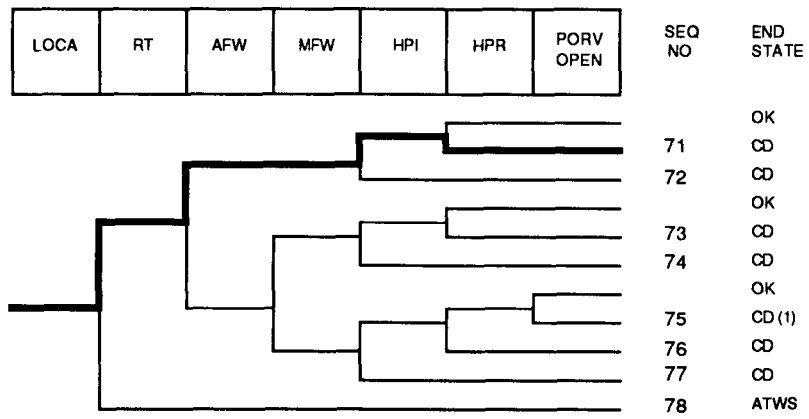
(1) OK for Class D

Dominant core damage sequence for LER 327/89-033 (Sequoyah 2 calculation)

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 327/89-033
Event Description: RWST level and other instrument transmitters inoperable
Event Date: 12/16/89
Plant: Sequoyah 1

UNAVAILABILITY, DURATION= 38.75

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	3.0E-02
LOOP	3.3E-04
LOCA	4.0E-05

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	5.5E-08
LOOP	1.5E-08
LOCA	4.7E-06
Total	4.8E-06
ATWS	
TRANS	0.0E+00
LOOP	0.0E+00
LOCA	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	loca ¬rt ¬afw ¬hpi HPR/-HPI	CD	4.7E-06	5.2E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
71	loca ¬rt ¬afw ¬hpi HPR/-HPI	CD	4.7E-06	5.2E-02

** non-recovery credit for edited case

Note: For unavailabilities, conditional probability values are differential values which reflect the added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

SEQUENCE MODEL:	c:\asp\1989\pwrbseal.cmp
BRANCH MODEL:	c:\asp\1989\sequoyah.sll
PROBABILITY FILE:	c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	7.7E-04	1.0E+00	
loop	1.6E-05	5.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	

Event Identifier: 327/89-033

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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
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                          2.7E-01                    1.0E+00
ep.rec(sl)                         5.7E-01                    1.0E+00
ep.rec                             7.0E-02                    1.0E+00
hpi                                1.0E-03                    8.4E-01
hpi(f/b)                           1.0E-03                    8.4E-01          1.0E-02
HPR/-HPI                           1.5E-04 > 1.0E+00 **       1.0E+00 > 1.2E-01   1.0E-03 > 0.0E+00
   Branch Model:  1.OF.2+opr
   Train 1  Cond Prob:             1.0E-02
   Train 2  Cond Prob:             1.5E-02
porv.open                          1.0E-02                    1.0E+00          4.0E-04
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* branch model file
** forced

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CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 327/89-033
Event Description: Potential trip with unavailable RWST indication
Event Date: 12/16/89
Plant: Sequoyah 2

UNAVAILABILITY, DURATION= 25

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS   3.0E-01
LOOP   2.2E-04
LOCA   2.6E-05

SEQUENCE CONDITIONAL PROBABILITY SUMS

       End State/Initiator   Probability

CD

       TRANS   5.2E-07
       LOOP   9.4E-09
       LOCA   3.1E-06

       Total   3.6E-06

ATWS

       TRANS   8.1E-06
       LOOP   0.0E+00
       LOCA   0.0E+00

       Total   8.1E-06

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	loca -rt -afw -hpi HPR/-HPI	CD	3.1E-06	5.2E-02
11	TRANS -rt -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	2.7E-07	1.3E-03
16	TRANS -rt afw mfw -hpi(f/b) HPR/-HPI	CD	2.2E-07	2.2E-03
18	TRANS rt	ATWS	8.1E-06	1.2E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
11	TRANS -rt -afw porv.or.srv.chall porv.or.srv.reseat -hpi HPR/-HPI	CD	2.7E-07	1.3E-03
16	TRANS -rt afw mfw -hpi(f/b) HPR/-HPI	CD	2.2E-07	2.2E-03
18	TRANS rt	ATWS	8.1E-06	1.2E-01
71	loca -rt -afw -hpi HPR/-HPI	CD	3.1E-06	5.2E-02

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Note: For unavailabilities, conditional probability values are differential values which reflect the
added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk
compared to a similar period without the existing failures.

SEQUENCE MODEL: c:\asp\1989\pwrbseal.cmp
BRANCH MODEL: c:\asp\1989\sequoyah.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Event Identifier: 327/89-033

Branch	System	Non-Recov	Opr Fail
TRANS			
Branch Model: INITOR	7.7E-04 > 1.2E-02 **	1.0E+00	
Initiator Freq:	7.7E-04		
loop	1.6E-05	5.3E-01	
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	
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	2.7E-01	1.0E+00	
ep.rec(sl)	5.7E-01	1.0E+00	
ep.rec	7.0E-02	1.0E+00	
hpi	1.0E-03	8.4E-01	
hpi(f/b)	1.0E-03	8.4E-01	
HPR/-HPI	1.5E-04 > 1.0E+00 **	1.0E+00 > 1.2E-01	1.0E-02
Branch Model: 1.OF.2+opr			1.0E-03 > 0.0E+00
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02		
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
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