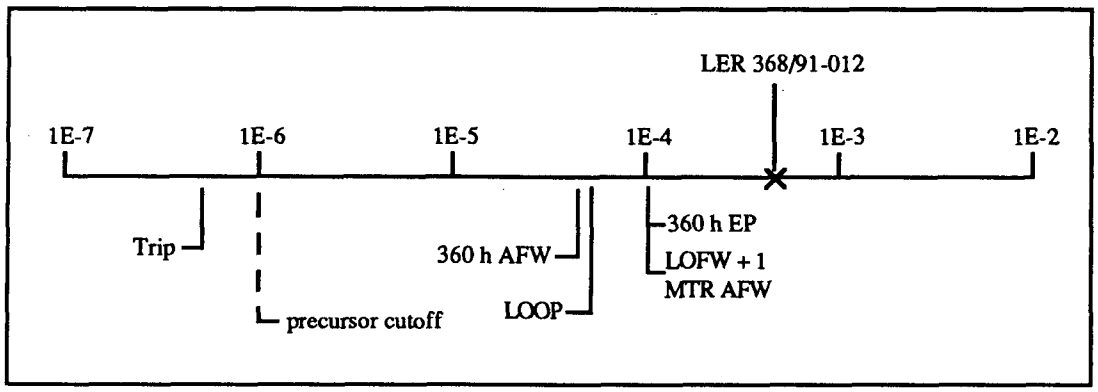
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 368/91-012
Event Description: Both normal service water trains fouled by debris
Date of Event: April 16, 1991
Plant: Arkansas Nuclear One, Unit 2

Summary

Maintenance and operational errors at Arkansas Nuclear One, Unit 2 (ANO 2) resulted in rotation of debris-laden raw water traveling screens while the screen wash system was not operating. This permitted significant quantities of debris to carry over into the common service water (SW) pump suction pit and into the SW system. Pump discharge strainers on both operating SW trains quickly became fouled, and both trains were declared inoperable. A third (standby) pump was aligned to an alternate suction source and placed in service to supply loop I SW loads. The loop I normal supply pump SW strainer was cleaned, and the loop was restored to normal alignment. The standby pump was then aligned to supply loop II, restoring the Tech Spec-required SW configuration approximately 2 h after the fouling occurred. The conditional core damage probability estimated for this event is 4.8×10^{-4}. The relative significance of this event compared to other postulated events at ANO 2 is shown below.



Event Description

While performing preventive maintenance on the SW traveling screens with the plant in startup, plant maintenance personnel rotated the screens without operating the screen wash system. The traveling screens serve to prevent debris from entering the SW pump suction pit, and this debris builds up on the screens over time. When the screens are rotated, screen wash sprays are normally operated to remove the debris. When the screens were rotated without operation of the screen wash system, the debris was carried

over into the SW pump suction pit and was entrained in the SW pump suction supply. Pump discharge strainers in each of the two service water loops quickly became obstructed, rendering the trains inoperable.

Operators then started the standby SW pump to supply loop I, aligning its suction to the emergency cooling pond to prevent it from being fouled by the debris in the common SW pump bay. The normal loop I supply pump discharge strainer was cleaned, and the pump was returned to service. The standby pump was then aligned to supply loop II, restoring the plant to a normal configuration. The time required to clean the pump strainer and return loop I to service using that pump was ~90 min.

Additional Event-Related Information

The SW system at ANO 2 normally takes suction from the Dardenelle Reservoir, and an alternate supply is available from an emergency cooling pond (ECP). Two independent SW loops supply cooling water to engineered safety feature equipment, to component cooling heat exchangers, and to the nonsafety-related auxiliary cooling water system.

The service water system supplies the following major loads (partial listing):

emergency diesel generator (EDG) heat exchangers
component cooling water (CCW) heat exchangers,
shutdown cooling heat exchangers,
high-pressure safety injection (HPSI) pump coolers,
low-pressure safety injection (LPSI) pump coolers,
containment spray (CS) pump coolers,
charging pump room coolers,
containment cooling units, and
various safety-related room coolers.

At the time of the event, the reactor was in the startup mode at low power. Had the SW failure occurred during full-power operations, the consequences could have been more severe. This event could also have been more serious had the plant operators failed to recognize the need to align the remaining SW pump to its emergency suction supply before starting it.

ASP Modeling Assumptions and Approach

This event was modeled as a postulated loss of SW while at power. Given the loss of SW, successful operator action to align the standby pump to the ECP and start the pump (which requires an understanding of the cause of the loss of SW before pump start) will provide SW to one of the two SW loops. Loss of SW will result in the loss of the CCW heat sink. Loss of CCW cooling to the main feed pump lube oil coolers, instrument and

service air compressors, and the reactor coolant pump (RCP) motors is assumed to result in an automatic or manual scram and loss of feedwater (LOFW).

Both auxiliary feedwater (AFW) pumps on ANO 2 are self-cooled and were considered available without SW. SW cooling is provided to the charging pump room coolers and the high-pressure injection (HPI) pumps and room, but SW for this purpose was assumed to be required only in the recirculation phase following a loss-of-coolant accident (LOCA). Unlike many other RCP seals, which use both seal injection and thermal barrier cooling, the RCP seals at ANO-2 use only CCW for thermal barrier cooling. Unavailability of CCW for an extended period of time (as could be the case following a loss of SW) may result in a small-break LOCA.

The resulting core damage model used to analyze this event considered the potential failure of the operator to align the standby pump to the ECP, and the potential failure to clean the two service water strainers and return the two service water loops to service. The event was modeled assuming the plant was at power and that, had alignment of the standby pump to the ECP not been successful, a trip and loss of feedwater would have resulted from the loss of cooling to the RCP motors (which would require RCP trip for motor protection), main feed pump lube oil coolers, and air compressors.

If SW were not recovered within ~1 h, then the potential for an RCP seal LOCA was considered. In the event of a small-break LOCA from either a stuck-open relief valve (transient-induced LOCA) or an RCP seal failure, sump switchover was assumed to occur ~6 h after the LOCA. Unavailability of SW at this time was assumed to result in unavailability of containment spray recirculation (CSR) and high-pressure recirculation (HPR).

A conditioning event tree was used to characterize the plant status associated with success or failure in recovering SW. This event tree is shown in Fig. 1. Successful alignment of the standby pump to the ECP was assumed to not result in a reactor trip (although plant shutdown may still be required). If the operator fails to align the standby pump to the ECP, then recovery of SW requires cleaning of the discharge strainers. Because of the length of time required for this, a small-break LOCA may result from the unavailability of RCP seal cooling. This is represented by the next branch on the event tree (occurrence of an RCP seal LOCA is associated with the "up" branch). The next two branches represent successful recovery of the first and second clogged strainer prior to switchover to sump recirculation, when SW is assumed to be required. For situations in which an RCP seal LOCA does not occur (RCP seal LOCA "down" branch), SW is assumed only to be necessary to mitigate a LOCA resulting from a stuck-open relief valve.

The transients associated with the six sequences involving failure to align the standby pump to the ECP are listed in Fig. 1, along with the probability of the conditioning sequence, the conditional probability of core damage given the conditioning sequence,

and the core damage probability for the sequence. The follow assumptions were made to estimate the conditioning sequence probabilities:

a. The probability of the operator failing to correctly align the standby pump to the ECP was assumed to be 0.12.

b. The time required during the event to clean the first strainer (90 min) was assumed to consist of a 30-min preparation period and a 60-min time-to-repair after work orders were prepared, tools were drawn, and the repair crew reached the strainer. Assuming an exponential repair model with 1 h as the median repair time, the probability of not recovering one strainer at time t is $p_{1STR}(t)=e^{-.693(t-.5)}$, $t > 0.5$ h, and the probability of not recovering both strainers at time t is $p_{2STR}(t)=e^{-.693\,(t/2-.5)}$, $t > 1.0$ h.

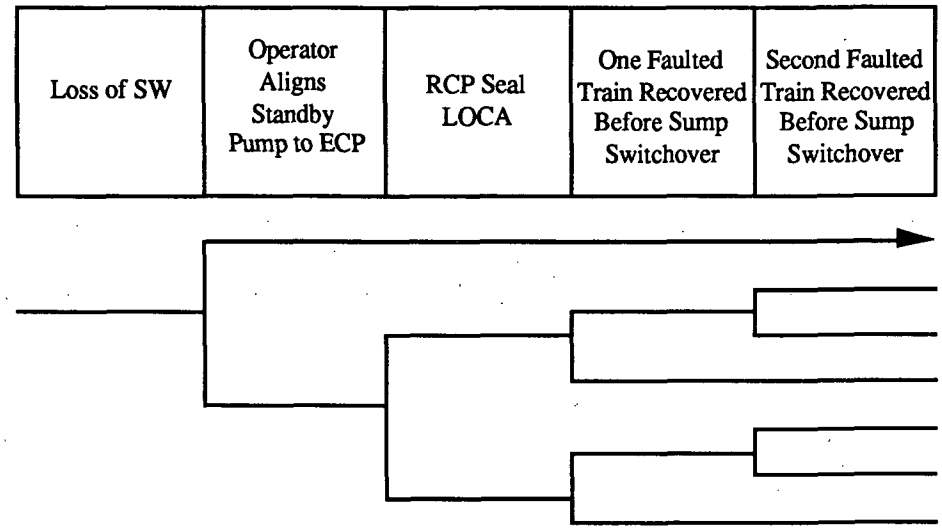
c. The ANO 2 safety analysis report (SAR) notes that experience with loss of cooling to RCP seals of the same design as used on ANO-2 indicates that the seals will continue to function for time periods up to 40 min. No data were provided for losses of cooling greater than 40 min. In this analysis, the probability of an RCP seal LOCA was assumed to be zero up to 1 h after seal cooling was lost. Beginning at 1 h, the probability of an RCP seal LOCA was assumed to increase linearly to 0.34 at 1.5 h, after which no additional seal failures were assumed to occur ($p_{SL} = 0$, $t < 1$ h; $p_{SL} = 0.68(t-1)$, $1 \le t < 1.5$ h; $p_{SL} = 0.34$, $t \ge 1.5$ h). This type of seal failure model is similar to that used in the Accident Sequence Precursor (ASP) Program for modeling station blackout sequences (see ORNL/NRC/LTR-89/11, *Revised LOOP Recovery and PWR Seal LOCA Models*, August 1989). Using a convolution approach similar to that in ORNL/NRC/LTR-89/11 to combine the probability of failing to recover SW with the probability of an RCP seal LOCA allows the probability of the remaining portions of each sequence to be estimated. For example, the probability of the third sequence, which involves failure of the operator to align the standby pump to the ECP, an RCP seal LOCA due to unavailability of seal cooling, and failure to recover SW before sump switchover (assumed to occur 6 h after the RCP seal LOCA), is calculated as follows:

$$p(\text{seq.3}) = p(\text{opr fails to align standby pump to ECP}) \times \int p_{1STR}(t) \times f_{SL}(t) \times p_{1STR}(t+6 \mid t)\, dt$$

where $f_{SL}(t)$ is the probability density function for RCP seal LOCA and $p_{1STR}(t + 6 \mid t)$ is the probability of not recovering one train of SW at $t + 6$, given it was not recovered at t. Since $f_{SL}(t)$ is non-zero only between 1 and 1.5 h, and $p_{1STR}(t + 6 \mid t) = e^{-.693\,(t+6-.5)} / e^{-.693(t-.5)}$, the probability for this sequence is $0.12 \times \int_1^{1.5} 0.68 \times e^{-.693(t+5.5)} dt = 3.8 \times 10^{-4}$.

Analysis Results

The conditional core damage probability for this event is estimated to be 4.8×10^{-4}. This value is strongly influenced by assumptions made concerning recovery of the faulted SW trains and the probability of an RCP seal failure. The dominant sequence, highlighted on the following event tree, involves an RCP seal LOCA and failure of HPR and CSR due to unavailability of SW.



Sequence	Conditioning Sequence Probability	Resulting Transient and Transient Conditional Probability	Sequence Conditional Probability
no trip			
1	3.6×10^{-2}	Note 1	5.0×10^{-5}
2	4.7×10^{-3}	Note 2	5.2×10^{-5}
3	3.8×10^{-4}	Note 3	3.8×10^{-4}
4	7.8×10^{-2}	Note 4	6.1×10^{-7}
5	1.7×10^{-2}	Note 5	2.2×10^{-7}
6	2.2×10^{-3}	Note 6	7.3×10^{-7}
			4.8×10^{-4}

Note 1. Small-break LOCA with both SI trains available following sump switchover [p(cd | small-break LOCA and both SW trains available for recirculation) = 1.4×10^{-3}]

Note 2. Small-break LOCA with one SI train available following sump switchover [p(cd | small-break LOCA and one SW train available for recirculation) = 1.1×10^{-2}]

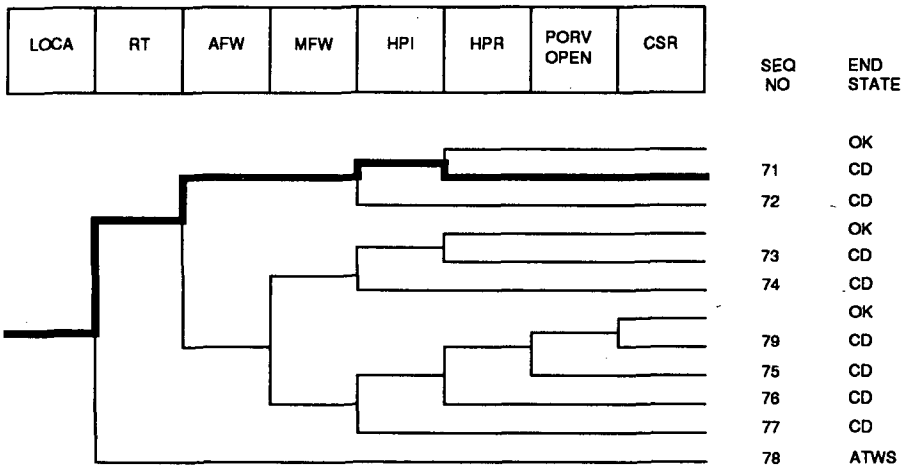
Note 3. Small-break LOCA with no SI train available following sump switchover [p(cd | small-break LOCA and no SW train available for recirculation) = 1.0]

Note 4. LOFW with both SI trains available following sump switchover in the event of a stuck-open primary relief valve [p(cd | trip with MFW unavailable and both SW trains available for recirculation) = 7.8×10^{-6}]

Note 5. LOFW with one SI train available following sump switchover in the event of a stuck-open primary relief valve [p(cd | trip with MFW unavailable and one SW train available for recirculation) = 1.3×10^{-5}]

Note 6. LOFW with no SI train available following sump switchover in the event of a stuck-open primary relief valve [p(cd | trip with MFW and both SW trains unavailable) = 3.3×10^{-4}]

Fig. 1. Conditioning event tree for LER 368/91-012



Dominant core damage sequence for LER 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 1)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOCA	1.4E-03
Total	1.4E-03
ATWS	
LOCA	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	LOCA -rt -afw -hpi hpr/-hpi	CD	1.1E-03	1.0E+00
72	LOCA -rt -afw hpi	CD	2.5E-04	8.4E-01
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** 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	1.1E-03	1.0E+00
72	LOCA -rt -afw hpi	CD	2.5E-04	8.4E-01
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrgseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	

Event Identifier: 368/91-012

loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	
Branch Model: INITOR			
Initiator Freq:	2.4E-06		
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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
hpr/-hpi	1.5E-04	1.0E+00	
csr	2.0E-03	3.4E-01	

* branch model file
** forced

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08-11-1992
15:12:24

Event Identifier: 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 2)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOCA	1.1E-02
Total	1.1E-02
ATWS	
LOCA	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	LOCA -rt -afw -hpi HPR/-HPI	CD	1.1E-02	1.0E+00
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** *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	1.1E-02	1.0E+00
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrqseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sl1
PROBABILITY FILE: c:\asp\1989\pwr_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	

Event Identifier: 368/91-012

Branch Model: INITOR			
Initiator Freq:	2.4E-06		
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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
HPR/-HPI	1.5E-04 > 1.0E-02	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
CSR	2.0E-03 > 2.0E-02	3.4E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01 > Unavailable		

* branch model file
** forced

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08-11-1992
15:15:25

Event Identifier: 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 3)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOCA	1.0E+00
Total	1.0E+00
ATWS	
LOCA	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
71	LOCA -rt -afw -hpi HPR/-HPI	CD	1.0E+00	1.0E+00
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** 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	1.0E+00	1.0E+00
78	LOCA rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrgseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	

Event Identifier: 368/91-012

Branch Model: INITOR			
Initiator Freq:	2.4E-06		
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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
HPR/-HPI	1.5E-04 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
CSR	2.0E-03 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	2.0E-02 > Unavailable		
Train 2 Cond Prob:	1.0E-01 > Unavailable		

* branch model file
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08-11-1992
15:17:33

Event Identifier: 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 4)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	7.8E-06
Total	7.8E-06
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrqseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sl1
PROBABILITY FILE: c:\asp\1989\pwr_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	
Branch Model: INITOR			
Initiator Freq:	2.4E-06		

Event Identifier: 368/91-012

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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
hpr/~hpi	1.5E-04	1.0E+00	
csr	2.0E-03	3.4E-01	

* branch model file
** forced

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08-11-1992
15:18:46

Event Identifier: 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 5)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	1.3E-05
Total	1.3E-05
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrgseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	
Branch Model: INITOR			
Initiator Freq:	2.4E-06		

Event Identifier: 368/91-012

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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
HPR/-HPI	1.5E-04 > 1.0E-02	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
CSR	2.0E-03 > 2.0E-02	3.4E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01 > Unavailable		

* branch model file
** forced

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Event Identifier: 368/91-012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 368/91-012
Event Description: Both normal SW trains fouled (cond seq 6)
Event Date: 04/16/91
Plant: ANO - Unit 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	3.3E-04
Total	3.3E-04
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
18	trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrgseal.cmp
BRANCH MODEL: c:\asp\1989\ano2.sll
PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	2.2E-04	1.0E+00	
loop	1.6E-05	3.6E-01	
LOCA	2.4E-06 > 2.4E-06	4.3E-01 > 1.0E+00	
Branch Model: INITOR			
Initiator Freq:	2.4E-06		

Event Identifier: 368/91-012

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	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	2.0E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.0E-01 > Unavailable		
porv.or.srv.chall	2.0E-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	4.0E-02	1.0E+00	
ep.rec(sl)	5.9E-01	1.0E+00	
ep.rec	2.1E-02	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
porv.open	1.0E-02	1.0E+00	4.0E-04
HPR/-HPI	1.5E-04 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
CSR	2.0E-03 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	2.0E-02 > Unavailable		
Train 2 Cond Prob:	1.0E-01 > Unavailable		

* branch model file
** forced

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Event Identifier: 368/91-012