

A.14 LER Nos. 498/93-005 and -007

Event Description: Unavailability of One Emergency Diesel Generator and the Turbine-Driven Auxiliary Feedwater Pump

Date of Event: December 29, 1992, through January 22, 1993

Plant: South Texas Project, Unit 1

A.14.1 Summary

For a period of ~ 25 d, South Texas Project (STP) Unit 1 operated with one emergency diesel generator (EDG) and the turbine-driven auxiliary feedwater (TDAFW) pump inoperable. The EDG was rendered inoperable because of binding of the fuel metering rods. The TDAFW pump was inoperable because of water intrusion into the turbine, which would have prevented the automatic start of the TDAFW pump. During this same period, a second EDG was removed from service for maintenance for a period of 61 h. The conditional core damage probability for this event is 1.2×10^{-5} . The relative significance of this event compared to other postulated events at STP Unit 1 is shown in Fig. A.14.1.

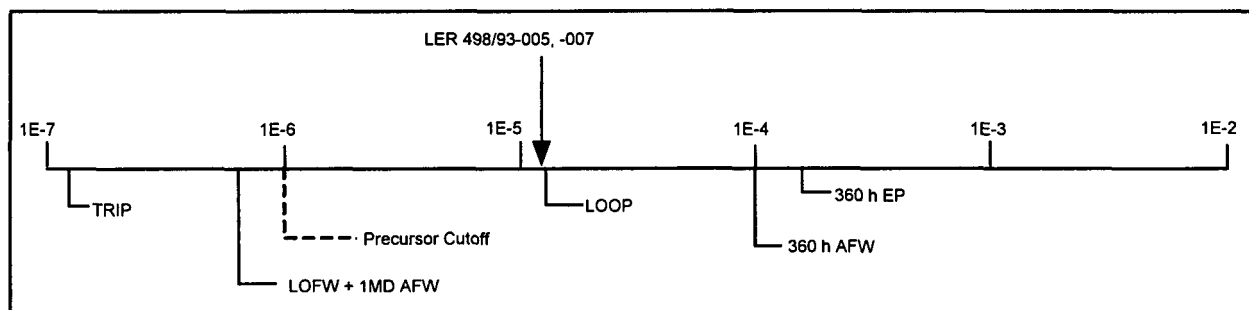


Fig. A.14.1 Relative event significance of LER Nos. 498/93-005 and -007 compared with other potential events at South Texas Project 1

A.14.2 Event Description

STP Unit 1 was operating at 95% power on January 20, 1993, when EDG 13 failed to start during a monthly surveillance test. The EDG had been painted during a 3-d period beginning December 29, 1992. Paint applied to the fuel injection pumps ran into the fuel metering ports, which caused the binding of the fuel metering rods. An operability test of the EDG was not performed after the completion of the painting. Following repair of the EDG, it was returned to service on January 22, 1993, ~ 25 d after it initially had been rendered inoperable. During the time period that EDG 13 was inoperable, EDG 12 had also been removed from service for 61 h.

The TDAFW pump was also inoperable for the 25-d period that EDG 13 was inoperable. During the fourth refueling outage, the TDAFW turbine trip/throttle valve, which had been leaking before the outage, was disassembled for repair. Although the disc and stem had steam cuts, no replacement parts could be located, so the valve was reassembled and returned to service. On December 27, 1992, the day after the end of the fourth refueling outage, the pump was tested as part of a post-maintenance test. The turbine oversped and tripped. The pump was then successfully slow started and was declared operable. Two other slow starts were successfully performed on December 31, 1992, using the anticipated transient-without-scrum (ATWS) mitigation system actuation circuitry (AMSAC). The next test of the TDAFW pump was on January 28,

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1993. Following maintenance, the turbine tripped during a fast start. The next day the turbine tripped during a slow start. Following repairs to the governor and a number of successful starts, the pump was returned to service on January 30, 1993. On February 1, 1993, the TDAFW pump again failed its surveillance test. Two days later the TDAFW turbine for Unit 2 oversped and tripped following a Unit 2 plant trip. A review of the maintenance history on the Unit 2 TDAFW pump also revealed problems with the overspeed trip device that rendered the pump inoperable for 4 d. This led to the decision to shut down Unit 1. The cause of the TDAFW pump overspeed events at both units was water intrusion into the turbine.

A.14.3 Additional Event-Related Information

The STP units utilize a three-train safety system arrangement. Any train of equipment is sufficient to accomplish safe shutdown of a unit for most design basis accidents. For each unit, there are three EDGs, each supplying a separate and independent load group. The AFW scheme consists of four pumps. Three of the pumps are motor driven and are supplied by their associated safeguards bus and EDG. The fourth pump is a turbine-driven pump using steam from the steam generators to provide its motive force. All four of the AFW pumps are 100% capacity pumps.

A.14.4 Modeling Assumptions

This event is modeled as a potential loss-off-offsite power (LOOP) event from December 29, 1992, to January 22, 1993. EDG 13 was assumed to be inoperable from the time that painting was begun on December 29, 1992, until the EDG was returned to service on January 22, 1993 (a total of 597 h). EDG 12 was inoperable for 61 h during this period. When an EDG is inoperable, the equipment associated with that EDG is also inoperable during a potential LOOP event where offsite power is not recovered. The model was revised to reflect this by failing variously one or two trains of equipment dependent on emergency power. The EDG failure was modeled by assuming that the other EDGs were not susceptible to the same failure mode. In this event, the EDG failure from the painting process was discovered before the other EDGs were exposed to the same failure mechanism.

The licensee determined that the TDAFW pump was inoperable from the end of the fourth refueling outage (December 26, 1992) until the plant was shut down on February 3, 1993. This encompasses the time period when the EDGs were inoperable. The recovery value for the AFW system was not changed because the failures related to the TDAFW pump were, for the most part, recoverable by starting the pump after the overspeed was reset. In these cases, the initial start attempt cleared the condensate from the steam admission line and the turbine casing and prewarmed the turbine, increasing the likelihood of successful start on subsequent attempts.

Two cases were run for the Unit 1 unavailabilities. Case 1 was calculated as a LOOP with EDG 13 and the TDAFW pump inoperable (but recoverable) for 536 h (597 - 61 h). An hourly LOOP frequency of 2×10^{-5} was multiplied by 536 h and a short-term nonrecovery probability of 0.43 (see below) to obtain a LOOP frequency for the period of interest of 4.6×10^{-3} . A similar calculation was performed (Case 2) for the 61-h period during which EDGs 12 and 13 and the TDAFW pump were inoperable, and a LOOP frequency of 5.2×10^{-4} was estimated.

Nominal battery life at South Texas is 2 h. But, by shedding unnecessary loads, battery life may be extended to perhaps 8 h. To credit this strategy, each of the two cases was further decomposed to reflect the core damage probability with and without battery load shed. (Cases 1A and 2A use 2-h battery lifetimes, and Cases 1B and 2B use 8-h battery lifetimes.) As the actions involved in load shedding appeared to fall into ASP recovery class R3, a probability of failure to shed battery loads when required of 0.12 was assumed

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(a description of the ASP recovery classes may be found in Appendix A, NUREG/CR-4674, Vol 17) and a weighted core damage probability was calculated for each case:

$$0.12 \times p(\text{cd} | 2\text{-h battery life}) + (1 - 0.12) \times p(\text{cd} | 8\text{-h battery life}).$$

The LOOP frequency and electric power recovery probabilities for South Texas were calculated according to the methods detailed in ORNL/NRC/LTR-89/11R1, *Revised LOOP Recovery and Seal LOCA Models*, October 1993. For both the 2-h and 8-h battery lifetime cases, a short-term LOOP nonrecovery probability of 0.43 was calculated. The seal LOCA probability was estimated to be 0.31 and the probability of nonrecovery of ac power in the long term given a seal LOCA was estimated to be 0.7. The probability of ac power nonrecovery given that no seal LOCA occurred was estimated to be 0.11 for the 2-h battery lifetime case. For the 8-h battery lifetime case, a probability of nonrecovery of AC power prior to battery depletion of 0.012 was calculated.

To credit the use of the positive displacement (PD) charging pump with power supplied by the Technical Support Center diesel, the base seal LOCA probability of 0.31 was multiplied by a nonrecovery value of 0.17 [0.12 (ASP operator nonrecovery class R3) + 0.05 (ASP probability that the EDG fails to start on demand, PD pump failure rate presumed to be small relative to EDG failure rate)] to obtain a reduced seal LOCA probability of 0.05.

The conditional core damage probability is calculated as follows:

$$0.12 \times p(\text{cd} | 2\text{-h battery life}) + (1-0.12) \times p(\text{cd} | 8\text{-h battery life})$$

Case 1

$$(0.12)(4.3 \times 10^{-6}) + (0.88)(3.8 \times 10^{-6}) = 3.9 \times 10^{-6}$$

Case 2

$$(0.12)(9.1 \times 10^{-6}) + (0.88)(7.9 \times 10^{-6}) = 8.0 \times 10^{-6}$$

Total

$$3.9 \times 10^{-6} + 8.0 \times 10^{-6} = 1.2 \times 10^{-5}$$

The Unit 2 plant trip with the subsequent overspeed trip of the TDAFW pump was also modeled. It was modeled as a transient with the TDAFW pump failed, but recoverable. The inoperability of the Unit 2 TDAFW pump was not modeled because it was treated as a loss of redundancy.

A.14.5 Analysis Results

The conditional core damage probability for the time period when just EDG 13 and the TDAFW pump were inoperable (Case 1), weighted to reflect the likelihood and effects of successful battery load shed, is calculated to be 3.9×10^{-6} . Similarly, the conditional core damage probability for the time period when EDGs 12 and 13 and the TDAFW pump were inoperable (Case 2) is 8.0×10^{-6} . Therefore, the total conditional core damage probability for the event is 1.2×10^{-5} . The dominant core damage sequence for

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both cases involves a postulated LOOP with failure of emergency power and AFW, and is highlighted on the event tree shown in Fig. A.14.2.

The modeling of the Unit 2 transient resulted in a value $< 1 \times 10^{-6}$. This is below the cutoff value for events in the ASP Program. Therefore this event is not a precursor. Additional information concerning this event is included in Augmented Inspection Team report 50-498/93-07; 50-499/93-07.

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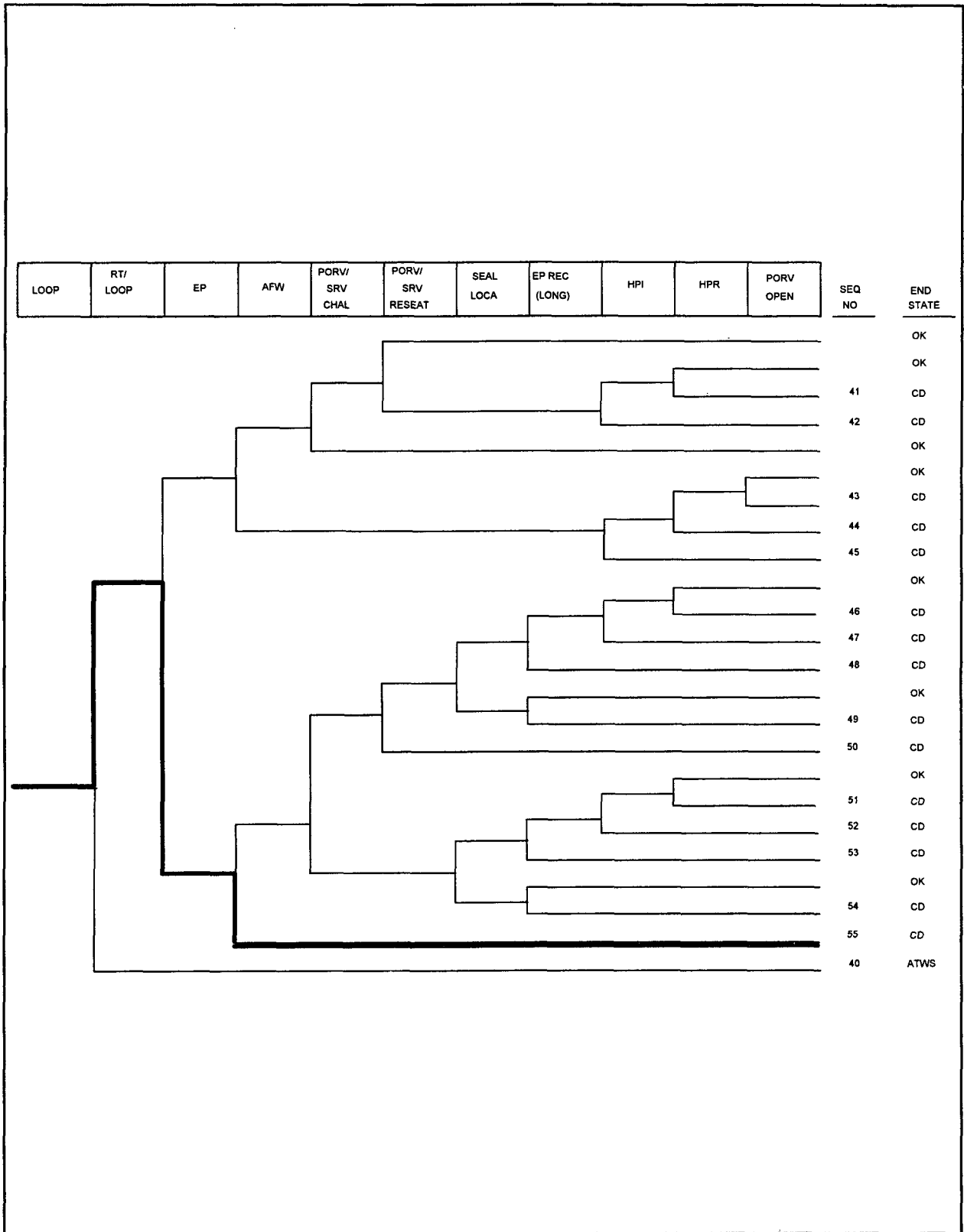


Fig. A.14.2 Dominant core damage sequence for LER 498/93-005

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 498/93-005 and 498/93-007
 Event Description: EDG and AFW Pump Unavailability (Case 1A)
 Event Date: 12/29/92 - 1/22/93
 Case: EDG 13 and TDAFW Pump inoperable; 2 hr battery lifetime
 Plant: South Texas 1

UNAVAILABILITY, DURATION= 536

NONRECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 4.6E-03

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	4.3E-06
Total	4.3E-06

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	3.5E-06	1.2E-01
54 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall - seal.loca ep.rec	CD	5.0E-07	2.3E-01
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	1.7E-07	2.3E-01

** nonrecovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	1.7E-07	2.3E-01
54 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall - seal.loca ep.rec	CD	5.0E-07	2.3E-01
55 loop -rt/loop EMERG.POWER AFW/EMERG.POWER	CD	3.5E-06	1.2E-01

** nonrecovery 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: s:\asp\prog\models\pwralseal.cmp
 BRANCH MODEL: s:\asp\prog\models\southtex.sl1
 PROBABILITY FILE: s:\asp\prog\models\pwr_bsl1.pro
 No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Nonrecov	Opr Fail
trans	6.4E-04	1.0E+00	
loop	2.0E-05	4.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	

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EMERG.POWER	5.4E-04 > 2.9E-03	8.0E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	5.0E-02		
Train 2 Cond Prob:	5.7E-02		
Train 3 Cond Prob:	1.9E-01 > Failed		
AFW	3.1E-04 > 2.3E-03	2.6E-01	
Branch Model: 1.OF.4+ser			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Failed		
Train 4 Cond Prob:	5.0E-02 > Failed		
Serial Component Prob:	2.8E-04		
AFW/EMERG.POWER	5.0E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	5.0E-02 > Failed		
mfw	1.0E+00	7.0E-02	1.0E-03
porv.or.srv.chall	4.0E-02	1.0E+00	
porv.or.srv.reset	2.0E-02	1.1E-02	
porv.or.srv.reset/emerg.power	2.0E-02	1.0E+00	
seal.loc	3.1E-01 > 5.0E-02(1)	1.0E+00	
ep.rec(sl)	7.0E-01	1.0E+00	
ep.rec	1.1E-01	1.0E+00	
HPI	3.0E-04 > 1.0E-03	8.4E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPI(F/B)	3.0E-04 > 1.0E-03	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		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPR/-HPI	1.5E-05 > 1.5E-04	1.0E+00	1.0E-03
Branch Model: 1.OF.3+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02		
Train 3 Cond Prob:	1.0E-01 > Failed		
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
 ** forced

NOTES

(1)Includes positive displacement pump

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 498/93-005 and 498/93-007
 Event Description: EDG and AFW pump unavailability (Case 1B)
 Event Date: 12/29/93 - 1/22/93
 Case: EDG 13 and TDAFW pump inoperable; 8 hr battery lifetime
 Plant: South Texas 1

UNAVAILABILITY, DURATION= 536

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 4.6E-03

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	3.8E-06
Total	3.8E-06
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	3.5E-06	1.2E-01
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	1.7E-07	2.3E-01

** nonrecovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	1.7E-07	2.3E-01
55 loop -rt/loop EMERG.POWER AFW/EMERG.POWER	CD	3.5E-06	1.2E-01

** nonrecovery 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: s:\asp\prog\models\pwr_bseal.cmp
 BRANCH MODEL: s:\asp\prog\models\southtex.sl1
 PROBABILITY FILE: s:\asp\prog\models\pwr_bsl1.pro
 No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Nonrecov	Opr Fail
trans	6.4E-04	1.0E+00	
loop	2.0E-05	4.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	

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EMERG.POWER	5.4E-04 > 2.9E-03	8.0E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	5.0E-02		
Train 2 Cond Prob:	5.7E-02		
Train 3 Cond Prob:	1.9E-01 > Failed		
AFW	3.1E-04 > 2.3E-03	2.6E-01	
Branch Model: 1.OF.4+ser			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Failed		
Train 4 Cond Prob:	5.0E-02 > Failed		
Serial Component Prob:	2.8E-04		
AFW/EMERG.POWER	5.0E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	5.0E-02 > Failed		
mfw	1.0E+00	7.0E-02	1.0E-03
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	3.1E-01 > 5.0E-02(1)	1.0E+00	
ep.rec(sl)	7.0E-01	1.0E+00	
ep.rec	1.1E-01 > 1.2E-02(2)	1.0E+00	
HPI	3.0E-04 > 1.0E-03	8.4E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPI(F/B)	3.0E-04 > 1.0E-03	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		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPR/-HPI	1.5E-05 > 1.5E-04	1.0E+00	1.0E-03
Branch Model: 1.OF.3+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02		
Train 3 Cond Prob:	1.0E-01 > Failed		
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
 ** forced

NOTES

- (1)Includes positive displacement pump
- (2)Reflects 8 hr battery lifetime

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 498/93-005 and 498/93-007
 Event Description: EDG and AFW Pump Unavailabilities (Case 2A)
 Event Date: 12/29/92 - 1/22/93
 Case: EDGs 12 and 13 and TDAFW Pump inoperable; 2 hr battery lifetime
 Plant: South Texas 1

UNAVAILABILITY, DURATION= 61

NONRECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 5.2E-04

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	9.1E-06
Total	9.1E-06

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	7.1E-06	1.2E-01
54 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall - seal.loca ep.rec	CD	1.4E-06	2.3E-01
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	4.6E-07	2.3E-01

** nonrecovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	4.6E-07	2.3E-01
54 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall - seal.loca ep.rec	CD	1.4E-06	2.3E-01
55 loop -rt/loop EMERG.POWER AFW/EMERG.POWER	CD	7.1E-06	1.2E-01

** nonrecovery 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: s:\asp\prog\models\pwrseal.cmp
 BRANCH MODEL: s:\asp\prog\models\southtex.sl1
 PROBABILITY FILE: s:\asp\prog\models\pwr_bsl1.pro
 No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	6.4E-04	1.0E+00	
loop	2.0E-05	4.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	

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EMERG.POWER	5.4E-04 > 5.0E-02	8.0E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	5.0E-02		
Train 2 Cond Prob:	5.7E-02 > Failed		
Train 3 Cond Prob:	1.9E-01 > Failed		
AFW	3.1E-04 > 2.0E-02	2.6E-01	
Branch Model: 1.OF.4+ser			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01 > Failed		
Train 3 Cond Prob:	3.0E-01 > Failed		
Train 4 Cond Prob:	5.0E-02 > Failed		
Serial Component Prob:	2.8E-04		
AFW/EMERG.POWER	5.0E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	5.0E-02 > Failed		
mfw	1.0E+00	7.0E-02	1.0E-03
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	3.1E-01 > 5.0E-02(1)	1.0E+00	
ep.rec(sl)	7.0E-01	1.0E+00	
ep.rec	1.1E-01	1.0E+00	
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 > Failed		
Train 3 Cond Prob:	3.0E-01 > Failed		
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 > Failed		
Train 3 Cond Prob:	3.0E-01 > Failed		
HPR/-HPI	1.5E-05 > 1.0E-02	1.0E+00	1.0E-03
Branch Model: 1.OF.3+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.5E-02 > Failed		
Train 3 Cond Prob:	1.0E-01 > Failed		
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
 ** forced

NOTES

(1)Includes positive displacement pump

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 498/93-005 and 498/93-007
 Event Description: EDG and AFW pump unavailabilities (Case 2B)
 Event Date: 12/29/93 - 1/22/93
 Case: EDGs 12 and 13 and TDAFW pump inoperable; 8 hr battery lifetime
 Plant: South Texas 1

UNAVAILABILITY, DURATION= 61

NONRECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 5.2E-04

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
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CD

LOOP	7.9E-06
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Total	7.9E-06
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ATWS

LOOP	0.0E+00
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Total	0.0E+00
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SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
55 loop -rt/loop EMERG.POWER AFW/EMERG.POWER	CD	7.1E-06	1.2E-01
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	4.6E-07	2.3E-01

** nonrecovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
53 loop -rt/loop EMERG.POWER -AFW/EMERG.POWER -porv.or.srv.chall seal.loca ep.rec(sl)	CD	4.6E-07	2.3E-01
55 loop -rt/loop EMERG.POWER AFW/EMERG.POWER	CD	7.1E-06	1.2E-01

** nonrecovery 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: s:\asp\prog\models\pwrseal.cmp
 BRANCH MODEL: s:\asp\prog\models\southtex.sl1
 PROBABILITY FILE: s:\asp\prog\models\pwr_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	6.4E-04	1.0E+00	
loop	2.0E-05	4.3E-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	5.4E-04 > 5.0E-02	8.0E-01	

Branch Model: 1.0F.3

Train 1 Cond Prob: 5.0E-02

A.14-13

	Train 2 Cond Prob:	5.7E-02 > Failed		
	Train 3 Cond Prob:	1.9E-01 > Failed		
AFW		3.1E-04 > 2.0E-02	2.6E-01	
	Branch Model: 1.OF.4+ser			
	Train 1 Cond Prob:	2.0E-02		
	Train 2 Cond Prob:	1.0E-01 > Failed		
	Train 3 Cond Prob:	3.0E-01 > Failed		
	Train 4 Cond Prob:	5.0E-02 > Failed		
	Serial Component Prob:	2.8E-04		
AFW/EMERG.POWER		5.0E-02 > 1.0E+00	3.4E-01	
	Branch Model: 1.OF.1			
	Train 1 Cond Prob:	5.0E-02 > Failed		
mfw		1.0E+00	7.0E-02	1.0E-03
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		3.1E-01 > 5.0E-02(1)	1.0E+00	
ep.rec(sl)		7.0E-01	1.0E+00	
ep.rec		1.1E-01 > 1.2E-02(2)	1.0E+00	
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 > Failed		
	Train 3 Cond Prob:	3.0E-01 > Failed		
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 > Failed		
	Train 3 Cond Prob:	3.0E-01 > Failed		
HPR/-HPI		1.5E-05 > 1.0E-02	1.0E+00	1.0E-03
	Branch Model: 1.OF.3+opr			
	Train 1 Cond Prob:	1.0E-02		
	Train 2 Cond Prob:	1.5E-02 > Failed		
	Train 3 Cond Prob:	1.0E-01 > Failed		
porv.open		1.0E-02	1.0E+00	4.0E-04

* branch model file
 ** forced

NOTES

(1)Includes positive displacement pump
 (2)Reflects 8 hr battery lifetime