

PRECURSOR DESCRIPTION SHEET

LER No.: 346/87-011
Event Description: Trip with 13.8-kV power failure, service water pump inoperability, and decay heat train failure
Date of Event: 9/6/87
Plant: Davis-Besse 1

EVENT DESCRIPTION

Sequence

While at 100% power at 1139, on September 6, 1987, a main feedwater flow transmitter failed causing a low flow indication in Loop 2. As a result, the ICS increased feedwater flow, which resulted in a power increase to 103%. The situation was aggravated when an operator adjusted the axial power shaping rods in lieu of the normally controlling Group 7 rods. At 1140, the reactor tripped on high flux and the main steam safety valves lifted. All valves except one reseated. At 1142 power to 13.8-kV Bus A was lost when breaker HX01A failed to auto-transfer on demand. The power failure caused the loss of two reactor coolant pumps, two circulating water pumps, and a failure to automatically isolate steam flow to the moisture separator reheater No. 1 second-stage reheat.

Emergency diesel generator 1 started as required on loss of bus C1; however, service water pump 1 did not auto restart when power was restored. During this time the pressurizer level reached a low level of 15.47 in. At 1147 service water pump 1 was manually started. At 1321, an operator inadvertently tripped RCP 2-1. Within 1 min, this pump was restarted. After power was restored on Bus A (1343 h), operators continued recovery by restarting the motor-driven feed pump and the two failed reactor coolant pumps. Normal recovery continued until 1510 when a turbine bypass valve failed to open due to an improper valve travel stop adjustment. This caused a steam and feedwater rupture control system (SFRCS) actuation, which started both auxiliary feed pumps. The steam generators were allowed to reach a level of 60 in. each before the auxiliary feed pumps were secured. During continued cool down the next morning (0500 h), operators failed in two successive attempts to put decay heat loop 2 in service, resulting in pressurizer level drops. Failure of the decay heat removal system was later attributed to 50 ft³ nitrogen void in the low-pressure injection system discharge piping inside containment.

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Corrective Action

Failed components in the service water pump, valve SP13A3, the feedwater flow transmitter, and the 345-kV switchyard main disconnect transfer breaker were repaired/replaced. A vent valve was installed to provide a constant bleed-off of system water and nitrogen to prevent a recurrence of the void in the DHR/LPI piping.

Plant/Event Data Systems Involved:

13.8-kV AC power
Service water
Main feedwater
Low-pressure injection

Components and Failure Modes Involved:

Breaker HX11A - failed to auto-transfer on demand
Service water pump 1 - failed to auto-restart on demand
Turbine bypass valve SP13A3 - fails open
Low pressure injection - train unavailable due to nitrogen void

Component Unavailability Duration: N/A

Plant Operating Mode: 1 (100% power)

Discovery Method: Operational event

Reactor Age: 10.1 y

Plant Type: PWR

Comments

To address the potential for recovery of the faulted DG, the calculation was performed in two steps:

1. core damage likelihood was calculated given the diesel was failed, and
2. core damage likelihood was calculated given the diesel was recovered.

These two estimates were combined considering the likelihood of failing to recover the diesel: $p(\text{core damage}) = p(\text{core damage DG faulted}) * p(\text{DG remained faulted}) + p(\text{core damage DG recovered}) * p(\text{DG recovered})$.

For the first calculation, feed and bleed, LPI, HPR, and LPR were assumed faulted and not recoverable. One train of HPI was assumed unavailable, and secondary-side release was assumed not terminated (because of the stuck-open relief valve and TBV). Feed and bleed was assumed unavailable because both makeup pumps must operate for successful feed and bleed on Davis-Besse (along with opening of the PORV). LPI, LPR and HPR were assumed failed because of the nitrogen in DHR loop 2 plus the assumed faulted DG. For the second calculation, secondary-side release was assumed failed and LPI and LPR were assumed degraded (because of the nitrogen bubble).

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Using a nonrecovery likelihood of 0.12 for failing to recover the DG results in an overall estimate for the event of: $p(\text{core damage}) = 4.3 \times 10^{-5} * 0.12 + 7.6 \times 10^{-7} * (1-0.12) = 5.8 \times 10^{-6}$.

MODELING CONSIDERATIONS AND DECISIONS

Initiators Modeled and Initiator Nonrecovery Estimate

Transient	1.0	No recovery assumed possible
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Branches Impacted and Branch Nonrecovery Estimate

See comments

Plant Models Utilized

PWR plant Class B

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 346/87-011
 Event Description: Trip with Unavailable Essential Bus (Bus Faulted)
 Event Date: 09/06/87
 Plant: Davis-Besse

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS 1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	4.3E-05
Total	4.3E-05
CV	
TRANS	2.9E-03
Total	2.9E-03
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
126 trans -rt afw mfw HPI(F/B) -ss.depress cond/mfw	CD	3.1E-05	3.1E-02
103 trans -rt -afw porv.or.srv.chall porv.or.srv.reseat -HPI HPR/ -HPI -ss.depress LPR/-HPI.HPR	CD	8.4E-06	1.1E-02
127 trans -rt afw mfw HPI(F/B) ss.depress	CD	3.4E-06	9.2E-02
109 trans -rt -afw -porv.or.srv.chall SS.RELEAS.TERM HPI	CV	2.6E-03	2.9E-01
101 trans -rt -afw porv.or.srv.chall -porv.or.srv.reseat SS.RELEAS .TERM HPI	CV	2.3E-04	2.9E-01
128 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**
101 trans -rt -afw porv.or.srv.chall -porv.or.srv.reseat SS.RELEAS .TERM HPI	CV	2.3E-04	2.9E-01
103 trans -rt -afw porv.or.srv.chall porv.or.srv.reseat -HPI HPR/ -HPI -ss.depress LPR/-HPI.HPR	CD	8.4E-06	1.1E-02
109 trans -rt -afw -porv.or.srv.chall SS.RELEAS.TERM HPI	CV	2.6E-03	2.9E-01
126 trans -rt afw mfw HPI(F/B) -ss.depress cond/mfw	CD	3.1E-05	3.1E-02
127 trans -rt afw mfw HPI(F/B) ss.depress	CD	3.4E-06	9.2E-02
128 trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\newmodel\pwr_bnew.cmp
 BRANCH MODEL: c:\asp\newmodel\davis.new
 PROBABILITY FILE: c:\asp\newmodel\pwr_bnew.pro

Event Identifier: 346/87-011

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	4.8E-04	1.0E+00	
loop	4.6E-06	3.9E-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	
ep.rec	1.0E+00	1.7E-01	
afw	5.0E-03	2.7E-01	
afw/emerg.power	5.0E-03	2.7E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-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	
SS.RELEAS.TERM	1.5E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.5E-02 > Failed		
HPI	1.0E-03 > 1.0E-02	8.4E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
HPI(F/B)	1.0E-03 > 1.0E+00	8.4E-01 > 1.0E+00	1.0E-02
Branch Model: 1.OF.2+opr			
Train 1 Cond Prob:	1.0E-02 > Unavailable		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
HPR/-HPI	1.5E-04 > 1.0E+00	1.0E+00	1.0E-03
Branch Model: 1.OF.2+opr			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
porv.open	1.0E-02	1.0E+00	4.0E-04
ss.depress	3.6E-02	1.0E+00	
cond/mfw	1.0E+00	3.4E-01	1.0E-02
LPI/HPI	1.5E-04 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.5E-02 > Unavailable		
LPR/-HPI.HPR	6.7E-01 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	6.7E-01 > Failed		
LPR/HPI	1.5E-04 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.5E-02 > Unavailable		

* branch model file
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CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 346/87-011
 Event Description: Trip with Unavailable Essential Bus (Bus Operable)
 Event Date: 09/06/87
 Plant: Davis-Besse

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS 1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	7.6E-07
Total	7.6E-07
CV	
TRANS	2.9E-04
Total	2.9E-04
ATWS	
TRANS	3.4E-05
Total	3.4E-05

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
126 trans -rt afw mfw hpi(f/b) -ss.depress cond/mfw	CD	3.3E-07	2.6E-02
120 trans -rt afw mfw -hpi(f/b) -hpr/-hpi porv.open -ss.depress cond/mfw	CD	3.1E-07	3.1E-02
127 trans -rt afw mfw hpi(f/b) ss.depress	CD	3.7E-08	7.7E-02
121 trans -rt afw mfw -hpi(f/b) -hpr/-hpi porv.open ss.depress	CD	3.5E-08	9.2E-02
123 trans -rt afw mfw -hpi(f/b) hpr/-hpi -ss.depress cond/mfw	CD	3.5E-08	3.1E-02
109 trans -rt -afw -porv.or.srv.chall SS.RELEAS.TERM hpi	CV	2.6E-04	2.9E-01
101 trans -rt -afw porv.or.srv.chall -porv.or.srv.reseat SS.RELEAS .TERM hpi	CV	2.3E-05	2.9E-01
128 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**
101 trans -rt -afw porv.or.srv.chall -porv.or.srv.reseat SS.RELEAS .TERM hpi	CV	2.3E-05	2.9E-01
109 trans -rt -afw -porv.or.srv.chall SS.RELEAS.TERM hpi	CV	2.6E-04	2.9E-01
120 trans -rt afw mfw -hpi(f/b) -hpr/-hpi porv.open -ss.depress cond/mfw	CD	3.1E-07	3.1E-02
121 trans -rt afw mfw -hpi(f/b) -hpr/-hpi porv.open ss.depress	CD	3.5E-08	9.2E-02
123 trans -rt afw mfw -hpi(f/b) hpr/-hpi -ss.depress cond/mfw	CD	3.5E-08	3.1E-02
126 trans -rt afw mfw hpi(f/b) -ss.depress cond/mfw	CD	3.3E-07	2.6E-02
127 trans -rt afw mfw hpi(f/b) ss.depress	CD	3.7E-08	7.7E-02
128 trans rt	ATWS	3.4E-05	1.2E-01

** non-recovery credit for edited case

Event Identifier: 346/87-011

SEQUENCE MODEL: c:\asp\newmodel\pwr_bnew.cmp
 BRANCH MODEL: c:\asp\newmodel\davis.new
 PROBABILITY FILE: c:\asp\newmodel\pwr_bnew.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	4.8E-04	1.0E+00	
loop	4.6E-06	3.9E-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	
ep.rec	1.0E+00	1.7E-01	
afw	5.0E-03	2.7E-01	
afw/emerg.power	5.0E-03	2.7E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-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	
SS.RELEAS.TERM	1.5E-02 > 1.0E+00	3.4E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob: 1.5E-02 > Failed			
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-03
porv.open	1.0E-02	1.0E+00	4.0E-04
ss.depress	3.6E-02	1.0E+00	
cond/mfw	1.0E+00	3.4E-01	1.0E-02
LPI/HPI	1.5E-04 > 1.5E-02	3.4E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob: 1.0E-02 > Failed			
Train 2 Cond Prob: 1.5E-02			
lpr/-hpi.hpr	6.7E-01	1.0E+00	
LPR/HPI	1.5E-04 > 1.5E-02	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob: 1.0E-02 > Failed			
Train 2 Cond Prob: 1.5E-02			

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