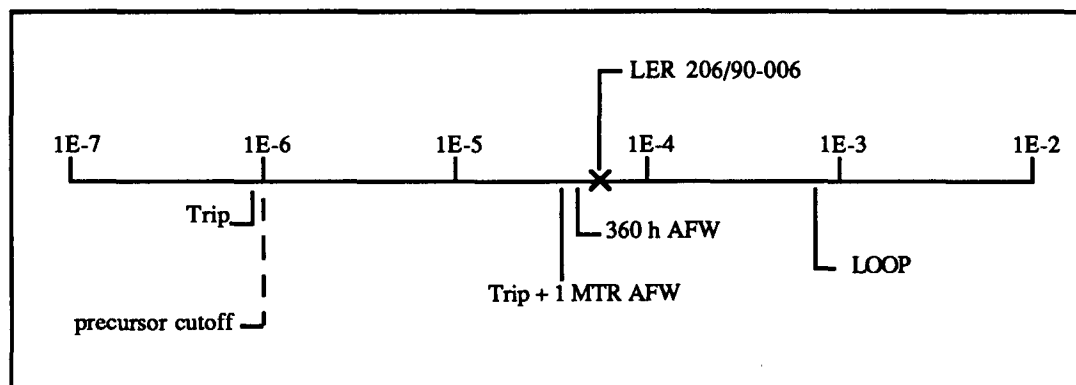


ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No.: 206/90-006
 Event Description: Wrong failure mode for a chemical and volume control valve
 Date of Event: February 20, 1990
 Plant: San Onofre 1

Summary

San Onofre 1 was operating at 90% of rated power when it was determined during surveillance testing that a chemical volume and control system (CVCS) pneumatic control valve had a non-conservative failure mode and potentially could cause failure of the charging pumps. The conditional core damage probability estimated for this event is 6.0×10^{-5} . The relative significance of this event compared to other postulated events at San Onofre 1 is shown below.



Event Description

While San Onofre 1 was performing fail-safe position testing of pneumatic control valves for the CVCS, it was discovered that the blended boric acid supply valve to the charging pump suction, CV-406B, had failed-open and not failed-closed upon a loss of the instrument air (IA) system as required by plant design. Failure of this valve to close when required during postulated accidents could result in inadvertent injection of the volume control tank (VCT) hydrogen gas into the suction of the charging pumps, potentially causing the pumps to gas bind and fail. Subsequent investigations revealed that the valve had been installed, since the plant's initial construction in 1967, as a fail-open valve.

Additional Event-Related Information

Loss of two support systems can fail CV-406B: (1) the IA system, which is a non-safety-related system, and (2) the valve control power supply (120 VAC).

The CVCS is designed to charge to and let down from the reactor coolant system (RCS) during normal operations, and assists in the recirculation of borated water to the RCS following a loss-of-coolant-accident (LOCA). The charging pumps usually take a suction from the VCT, which maintains a hydrogen overpressure during normal plant power operations to control oxygen levels in the RCS. During accident scenarios, the VCT is isolated from the charging pump suction by closing a motor-operated valve; however, if the IA system were to coincidentally fail also, there would exist a flow path available for the hydrogen gas in the VCT to become entrained in the charging pump suction.

The safety injection (SI) system at San Onofre 1 has two separate and independent trains that use the main feedwater pumps (MFWPs) for injecting borated water into the RCS at a rate of 10,500 GPM per train following a LOCA, which depressurizes the RCS. Each MFWP is supplied with borated water by one of two SI pumps. The two charging pumps are 12 stage centrifugal pumps with a design flow rate of 213 GPM. They are the primary means for injecting water into the core during the recirculation phase following a LOCA. It is estimated that the recirculation phase would be required about 5 h after the injection phase began.

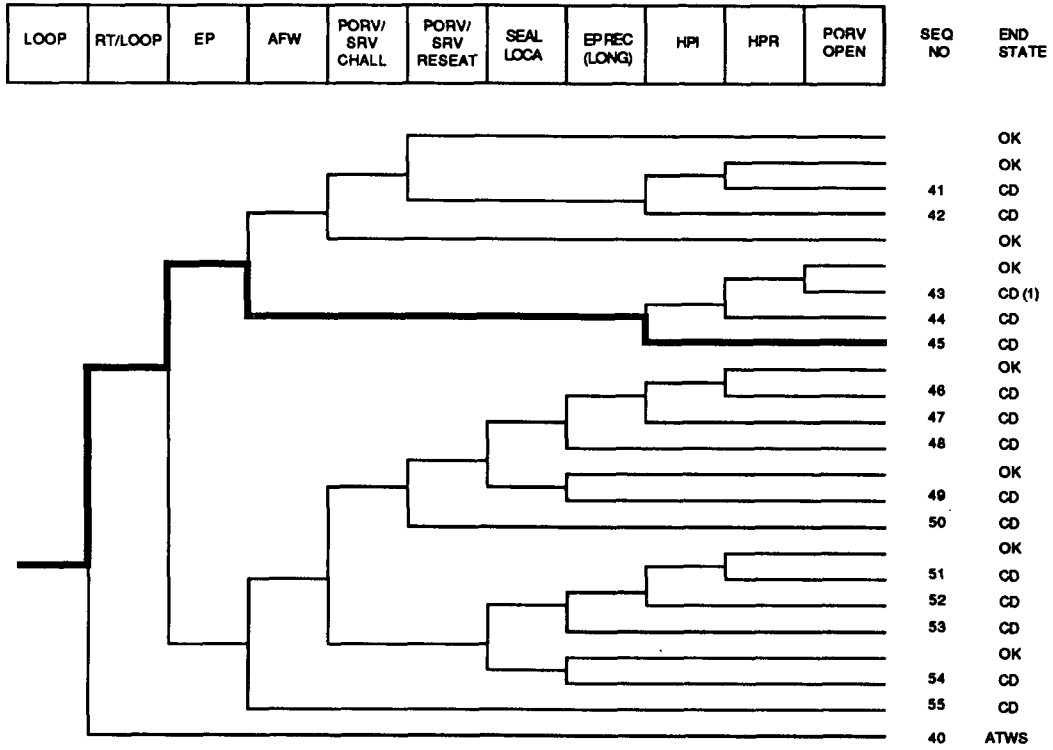
ASP Modeling Assumptions and Approach

This event has been modeled with the assumption that both charging pumps would fail upon loss of instrument air if the charging pumps were taking suction from the RWST. Charging pump operation is assumed required for small-break LOCA mitigation and for feed and bleed. Postulated scenarios that have been modeled are transient-induced LOCAs and loss of secondary-side cooling and feed and bleed following a postulated loss of offsite power (LOOP) or loss of instrument air. Loss of instrument air was also assumed to result in a loss of feedwater.

Analysis Results

The estimated conditional probability of severe core damage for this event over a 1-yr period is 6.0×10^{-5} . The dominant sequence involves loss of secondary-side cooling and failure of feed and bleed following a postulated LOOP. The dominant sequence to core damage is highlighted on the following event tree.

The conditional probability for the event was calculated by first estimating a conditional core damage probability for the IA and LOOP initiators over a 1-yr period assuming HPI and feed and bleed would be unavailable (first two calculations) and subtracting the conditional probability for the two initiators for 1-yr assuming HPI and feed and bleed were nominally available (reference calculations). This approach is consistent with the core damage probability algorithm used in the ASP Program and had to be used because loss of IA is not directly addressed in the models.



(1) OK for Class D

Dominant core damage sequence for LER 206/90-006

B-10

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 206/90-006
 Event Description: Wrong failure mode for CVCS valve (postulated loss of IA)
 Event Date: 02/20/90
 Plant: San Onofre 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E-02
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SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	6.0E-06
Total	6.0E-06

ATWS

TRANS	3.4E-07
Total	3.4E-07

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
17 TRANS -rt afw MFW HPI(F/B)	CD	5.9E-06	2.6E-03
18 TRANS rt	ATWS	3.4E-07	1.2E-03

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
17 TRANS -rt afw MFW HPI(F/B)	CD	5.9E-06	2.6E-03
18 TRANS rt	ATWS	3.4E-07	1.2E-03

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrseal.cmp
 BRANCH MODEL: c:\asp\1989\sanono1.sll
 PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.2E-04 > 1.2E-04	1.0E+00 > 1.0E-02	
Branch Model:	INITOR		
Initiator Freq:	1.2E-04		

Event Identifier: 206/90-006

B-11

loop	2.0E-05	5.8E-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	1.0E-03
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	1.9E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.9E-01 > Unavailable		
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	3.2E-01	1.0E+00	
ep.rec(sl)	7.6E-01	1.0E+00	
ep.rec	1.6E-01	1.0E+00	
HPI	1.0E-03 > 1.0E+00	8.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
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 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
hpr/-hpi	1.5E-04	1.0E+00	1.0E-03
porv.open	1.0E-02	1.0E+00	4.0E-04
* branch model file			
** forced			

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B-12

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 206/90-006
 Event Description: Wrong failure mode for CVSC valve (postulated LOOP)
 Event Date: 02/20/90
 Plant: San Onofre 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP	7.1E-02
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SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	1.4E-04
Total	1.4E-04
ATWS	
LOOP	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
53	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc a ep.rec(sl)	CD	5.3E-05	5.6E-02
45	LOOP -rt/loop -emerg.power afw HPI(F/B)	CD	4.2E-05	1.8E-02
54	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - seal.loc a ep.rec	CD	2.4E-05	5.6E-02
52	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc a -ep.rec(sl) HPI	CD	1.7E-05	5.6E-02
55	LOOP -rt/loop emerg.power afw/emerg.power	CD	4.0E-06	1.9E-02
48	LOOP -rt/loop emerg.power -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power seal.loc a ep.rec(sl)	CD	2.2E-06	5.6E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
45	LOOP -rt/loop -emerg.power afw HPI(F/B)	CD	4.2E-05	1.8E-02
48	LOOP -rt/loop emerg.power -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power seal.loc a ep.rec(sl)	CD	2.2E-06	5.6E-02
52	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc a -ep.rec(sl) HPI	CD	1.7E-05	5.6E-02
53	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.loc a ep.rec(sl)	CD	5.3E-05	5.6E-02
54	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - seal.loc a ep.rec	CD	2.4E-05	5.6E-02
55	LOOP -rt/loop emerg.power afw/emerg.power	CD	4.0E-06	1.9E-02

Event Identifier: 206/90-006

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrbsseal.cmp
 BRANCH MODEL: c:\asp\1989\sanono1.s11
 PROBABILITY FILE: c:\asp\1989\pwr_bs11.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.2E-04 > 1.2E-04	1.0E+00 > 1.0E-02	
Branch Model: INITOR			
Initiator Freq:	1.2E-04		
LOOP	2.0E-05 > 2.0E-05	5.8E-01 > 7.1E-02	
Branch Model: INITOR			
Initiator Freq:	2.0E-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	1.0E-03
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	1.9E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.9E-01 > Unavailable		
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	3.2E-01	1.0E+00	
ep.rec(s1)	7.6E-01	1.0E+00	
ep.rec	1.6E-01	1.0E+00	
HPI	1.0E-03 > 1.0E+00	8.4E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.0E-02 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
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 > Failed		
Train 2 Cond Prob:	1.0E-01 > Failed		
hpr/-hpi	1.5E-04	1.0E+00	1.0E-03
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file
 ** forced

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Event Identifier: 206/90-006

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 206/90-006
 Event Description: Wrong failure mode for CVCS valve (reference loss of IA)
 Event Date: 02/20/90
 Plant: San Onofre 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E-02
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SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
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CD

TRANS	1.3E-07
Total	1.3E-07

ATWS

TRANS	3.4E-07
Total	3.4E-07

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

Sequence	End State	Prob	N Rec**
18 TRANS rt	ATWS	3.4E-07	1.2E-03

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

Sequence	End State	Prob	N Rec**
18 TRANS rt	ATWS	3.4E-07	1.2E-03

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\pwrseal.cmp
 BRANCH MODEL: c:\asp\1989\sanono1.sll
 PROBABILITY FILE: c:\asp\1989\pwr_bsll.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.2E-04 > 1.2E-04	1.0E+00 > 1.0E-02	
Branch Model: INITOR			
Initiator Freq:	1.2E-04		
LOOP	2.0E-05 > 2.0E-05	5.8E-01 > 7.1E-02	
Branch Model: INITOR			

Event Identifier: 206/90-006

B-15

Initiator Freq:	2.0E-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	1.0E-03
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	1.9E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.9E-01 > Unavailable		
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.loca	3.2E-01	1.0E+00	
ep.rec(sl)	7.6E-01	1.0E+00	
ep.rec	1.6E-01	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-03
porv.open	1.0E-02	1.0E+00	4.0E-04
* branch model file			
** forced			

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B-16

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 206/90-006
 Event Description: Wrong failure mode for CVCS valve (reference LOOP)
 Event Date: 02/20/90
 Plant: San Onofre 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP 7.1E-02

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	8.6E-05
Total	8.6E-05
ATWS	
LOOP	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
53	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.locs ep.rec(s1)	CD	5.3E-05	5.6E-02
54	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - seal.locs ep.rec	CD	2.4E-05	5.6E-02
55	LOOP -rt/loop emerg.power afw/emerg.power	CD	4.0E-06	1.9E-02
48	LOOP -rt/loop emerg.power -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power seal.locs ep.rec(s1)	CD	2.2E-06	5.6E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
48	LOOP -rt/loop emerg.power -afw/emerg.power porv.or.srv.chall - porv.or.srv.reseat/emerg.power seal.locs ep.rec(s1)	CD	2.2E-06	5.6E-02
53	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall seal.locs ep.rec(s1)	CD	5.3E-05	5.6E-02
54	LOOP -rt/loop emerg.power -afw/emerg.power -porv.or.srv.chall - seal.locs ep.rec	CD	2.4E-05	5.6E-02
55	LOOP -rt/loop emerg.power afw/emerg.power	CD	4.0E-06	1.9E-02

** non-recovery credit for edited case

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

Event Identifier: 206/90-006

B-17

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.2E-04 > 1.2E-04	1.0E+00 > 1.0E-02	
Branch Model: INITOR			
Initiator Freq:	1.2E-04		
LOOP	2.0E-05 > 2.0E-05	5.8E-01 > 7.1E-02	
Branch Model: INITOR			
Initiator Freq:	2.0E-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	1.0E-03
afw	2.3E-03	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
MFW	1.9E-01 > 1.0E+00	3.4E-01 > 1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.9E-01 > Unavailable		
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	3.2E-01	1.0E+00	
ep.rec(sl)	7.6E-01	1.0E+00	
ep.rec	1.6E-01	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-03
porv.open	1.0E-02	1.0E+00	4.0E-04

* branch model file

** forced

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