PRECURSOR DESCRIPTION AND ANALYSIS

LER No.: 206/85-017
Event Description: Effective LOOP and AFW System Unavailability
Date of Event: November 21, 1985
Plant: San Onofre 1

EVENT DESCRIPTION

Sequence

While operators were searching for a ground on 4160-V safety bus 1C, a differential relay actuated because of a ground fault and opened breakers that isolated auxiliary transformer C from the switchyard. This resulted in loss of power to bus 2C, the other safety bus, and trip of the main feed pump supplied by that bus. The 1C bus, which is normally fed from auxiliary transformer C, was powered by bus 1A from auxiliary transformer A, which was tied to the main generator output. The operators believed that a loss of offsite power had occurred and manually scrammed the reactor and tripped the turbine. Because safety bus 1C was supplied from auxiliary transformer A (tied to the main generator), power was lost to all 4160-V buses.

Both diesel generators started but were not loaded as required (manual action required). Instead, operators began to restore power by backfeeding through the main transformer, which is allowed by plant operating procedures.

Shortly after the loss of power to safety bus 2C, a loud bang was heard. The east Nos. 4-5 feedwater heater tubes and shell (a 15- by 2-ft break) had ruptured because of overpressurization from the west main feed pump and failure of the east MFW pump discharge check valve to seat correctly. The continued operation of the west main feed pump was due to the unusual electrical alignment (power to the west feed pump was lost subsequent to trip of the plant).

Feed flow to all steam generators was terminated when the unit tripped. However, the A, B, and C feedwater regulating valve discharge check valves failed to seat. All three steam generators began blowing down through the stuck-open check valves.

The turbine-driven auxiliary feed pump started as required but was initially prevented from delivering flow because of a pump warm-up period. After 3.5 min the pump began to supply relatively cold AFW to the three MFW lines. Because of the failed check valves, AFW in the feedwater lines flowed toward the feed pumps. After 8.5 min the operators closed the feedwater regulating valves. Continued AFW subsequently encountered steam in a horizontal pipe run, rapid

condensation occurred, and a water slug in the line was accelerated in the direction of the main feed pumps. This resulted in damage to the B feedwater line and supports, damage to the B feedwater regulating valve bypass line check valve top-hat bolts, and extrusion of the check valve gasket, which resulted in a nonisolable leak.

Power was restored to the 4160-V buses ~4 min into the transient, at which time the motor-driven AFW pump started. AFW flow was set at 25 gal/min to each steam generator to limit RCS cooldown.

Subsequently, wide-range level was observed off scale (low) in all three steam generators, and AFW flow was increased and blowdown secured. Steam generator B is believed to have gone dry at this time, although some water remained in the other two steam generators. At this point, also, the feedwater regulating valves were closed by the operators, restoring AFW flow to the steam generators.

Corrective Action

Investigation into the cause and determination of corrective action were initiated in cooperation with the NRC Incident Investigation Team (see NUREG-1190).

Plant/Event Data

Systems Involved:
Electrical, MFW and condensate, and AFW

Components and Failure Modes Involved:
Check valves, transformer, pipes, supports, AFW — fail in operation and on demand

Component Unavailability Duration: NA
Plant Operating Mode: 1 (60% power)
Discovery Method: Operational event
Reactor Age: 18.4 years
Plant Type: PWR

Comments

None

Event Identifier: 206/85-017

MODELING CONSIDERATIONS AND DECISIONS

Initiators Modeled and Initiator Nonrecovery Estimate

Unique transient (includes LOOP)	1.0	

Branches Impacted and Branch Nonrecovery Estimate

AFW	0.04	Recoverable from the control room
AFW given emergency power failure	0.12	Lack of information available and tension during event
MFW	Base case	Loss of flow through the damaged check valve not believed large enough to prevent sufficient feedwater flow had it been demanded

Plant Models Utilized

Unique to this event

Event Identifier: 206/85-017

CONDITIONAL CORE DAMAGE CALCULATIONS

LER Number: 206/85-017
Event Description: Effective LOOP and AFW Unavailability
Event Date: 11/21/85
Plant:

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.000E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	9.346E-04
Total	9.346E-04
CV	
TRANS	1.068E-03
Total	1.068E-03
ATWS	
TRANS	3.600E-05
Total	3.600E-05

DOMINANT SEQUENCES

End State: CD Conditional Probability: 1.940E-04

40 TRANS -RT AB.BUS.PWR DG.PWR.C AFW/DG

End State: CV Conditional Probability: 3.358E-04

11 TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC B&F(CH.PUMPS) -SSR/COND

End State: ATWS Conditional Probability: 3.600E-05

41 TRANS RT

Event Identifier: 206/85-017

SEQUENCE CONDITIONAL PROBABILITIES

	Sequence	End State	Seq. Prob	Non-Recov**
7	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC -B&F(CH.PUMPS) -P ORV.OPEN RECIRC -SSR/COND	CV	3.187E-04	6.260E-04
8	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC -B&F(CH.PUMPS) -P ORV.OPEN RECIRC SSR/COND	CD	1.642E-04	3.225E-04
9	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC -B&F(CH.PUMPS) P ORV.OPEN -SSR/COND	CV	3.326E-04	6.521E-04
10	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC -B&F(CH.PUMPS) P ORV.OPEN SSR/COND	CD	1.713E-04	3.359E-04
11	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC B&F(CH.PUMPS) -S SR/COND	CV	3.358E-04 *	3.869E-04
12	TRANS -RT -AB.BUS.PWR -C.TO.AB AFW MFW.REC B&F(CH.PUMPS) S SR/COND	CD	1.730E-04	1.993E-04
19	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC -B&F(CH .PUMPS) -PORV.OPEN RECIRC -SSR/COND	CV	1.277E-05	2.641E-05
20	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC -B&F(CH .PUMPS) -PORV.OPEN RECIRC SSR/COND	CD	6.581E-06	1.361E-05
21	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC -B&F(CH .PUMPS) PORV.OPEN -SSR/COND	CV	1.333E-05	2.751E-05
22	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC -B&F(CH .PUMPS) PORV.OPEN SSR/COND	CD	6.869E-06	1.417E-05
23	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC B&F(CH .PUMPS) -SSR/COND	CV	1.346E-05	1.633E-05
24	TRANS -RT -AB.BUS.PWR C.TO.AB -DG.PWR.C AFW MFW.REC B&F(CH .PUMPS) SSR/COND	CD	6.934E-06	8.411E-06
26	TRANS -RT -AB.BUS.PWR C.TO.AB DG.PWR.C AFW/DG	CD	1.863E-04	2.093E-04
33	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC -B&F(CH.PUMPS) - PORV.OPEN RECIRC -SSR/COND	CV	1.331E-05	2.751E-05
34	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC -B&F(CH.PUMPS) - PORV.OPEN RECIRC SSR/COND	CD	6.856E-06	1.417E-05
35	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC -B&F(CH.PUMPS) PORV.OPEN -SSR/COND	CV	1.389E-05	2.866E-05
36	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC -B&F(CH.PUMPS) PORV.OPEN SSR/COND	CD	7.156E-06	1.476E-05
37	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC B&F(CH.PUMPS) - SSR/COND	CV	1.402E-05	1.701E-05
38	TRANS -RT AB.BUS.PWR -DG.PWR.C AFW MFW.REC B&F(CH.PUMPS) SSR/COND	CD	7.223E-06	8.761E-06
40	TRANS -RT AB.BUS.PWR DG.PWR.C AFW/DG	CD	1.940E-04 *	2.180E-04
41	TRANS RT	ATWS	3.600E-05 *	1.000E+00

* dominant sequence for end state
** non-recovery credit for edited case

Note:

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Conditional probability values are differential values which reflect the added risk due to observed failures.
Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

MODEL: A:sanonof.dat
DATA:

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.000E+00	1.000E+00	
RT	3.600E-05	1.000E+00	
AB.BUS.PWR	1.000E-04	1.000E+00	4.000E-02
C.TO.AB	1.000E-04	1.000E+00	4.000E-02
DG.PWR.C	8.000E-04	4.300E-01	4.000E-02
AFW	1.000E+00	4.000E-02	
AFW/DG	1.000E+00	1.200E-01	
MFW.REC	1.000E+00	3.400E-01	
RV.CHALL/-AFW	3.000E-01	1.000E+00	
RV.CHALL/MFW.REC	1.000E+00	1.000E+00	
RV.CLOSE	3.000E-04	1.000E+00	
CH.PUMPS	1.200E-03	5.200E-01	
B&F(CH.PUMPS)	1.200E-03	5.200E-01	4.000E-02
PORV.OPEN	2.000E-03	1.000E+00	4.000E-02
SI(MF.PUMPS)	5.000E-03	3.400E-01	
RECIRC	2.000E-03	1.000E+00	4.000E-02
SSR/COND	1.000E+00	3.400E-01	

forced

Austin
08-13-1986
00:46:07

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