PRECURSOR DESCRIPTION SHEET

LER No.: 331/84-001
Event Description: LOFW and SRV Opens Briefly
Date of Event: June 7, 1984
Plant: Duane Arnold

EVENT DESCRIPTION

Sequence

At 08:08:26 (T = 0), while the reactor was at 99.8% power, feedwater recirculation valve B (SJ-FCV-1611) failed open because of a broken air supply line fitting. As a result, a portion of "B" reactor feedwater flow was returned to the condenser, and the vessel level immediately began to drop. While operators were diagnosing and compensating for the decrease in vessel level, a technician's error caused the "B" feedwater pump to trip on low suction pressure and one of two SRVs (SB-RV-4401) utilizing low-low set logic to cycle open at T + 43 s. After the RV opened, a momentary upswing in vessel level was experienced, followed by a rapid decrease in level to the low-level trip set point (170 in.) and an automatic scram initiation at T + 44 s. At T + 57 s, the "B" feedwater pump breaker was reset. At T + 66 s, both feedwater pumps tripped on low suction pressure (due to condensate pumps being unable to match RFP flow with the high vessel demand and return flow to the condenser). During this time, the vessel level was continuing to fall until the low-low level HPCI/RCIC initiation set point of 119.5 in. was reached at T + 73 s. At this point, HPCI and RCIC initiated per design, and the level began to rise. As the vessel level momentarily fell to the low-low level set point, HPCI initiated but did not inject at any time in the event. HPCI control logic requires low-low level signal to remain present for the duration of the IV initiating time (~15 s) to have HPCI actually inject. At T + 112 s, the "B" reactor feedwater pump breaker was again closed to provide additional makeup, and it remained closed with no further trips. After operator action, the open SRV was reseated at T + 118 s and remained closed. As RCIC was injecting and the "B" feedwater pump was functioning, the level quickly recovered to normal operating level (maximum level reached was 204.4 in. at T + 4 min and 30 s). After the level had recovered, RCIC secured at T + 3 min 50 s, and HPCI was secured at T + 4 min and 30 s. At this point, the vessel level and pressure were stable at 194 in. and 810 psig, respectively. All systems necessary for remaining in a safe shutdown condition were operable, and no further system perturbations were experienced.

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Main steam SRV valve (SB-RV-4401) is one of two non-ADS SRVs that are utilized in the low-low set logic. Following an event that has opened one of the six SRVs, the low-low set logic established a lower opening pressure (lifting pressure: 1020 to 1025 psig, reseating pressure: 900 to 905 psig, respectively). Investigation revealed that the lifting of the SRV was totally unrelated to the failure of the feedwater recirculation valve. Prior to the recirculation valve failure, a low-low set instrument functional test had commenced. While performing the routine surveillance procedure, the instrument technician erroneously placed an ohmmeter across the high-pressure switch contacts too early in the procedure. As a result, the SRV actuation solenoid relay was falsely energized with a high-pressure test signal that, in conjunction with the procedure step to push the test button, caused the valve to cycle open (~40 s after the recirculation valve failure). Approximately 75 s after the SRV had opened, the operators reset the low-low SRV logic, thereby disarming the solenoid and cycling the valve closed. It was later theorized that the relatively low internal impedance of the ohmmeter caused the meter to act as a jumper and to bypass the contacts. It is noteworthy that prompt identification of the cause of the SRV actuation was greatly aided by the technician volunteering that he had indeed committed an error. This theory was confirmed prior to startup after a special test procedure was run. This procedure recreated the applicable sequence of test steps leading up to the opening of the SRV and revealed that the connection of an ohmmeter across the contacts, in conjunction with pressing the test button, does in fact energize the SRV solenoid.

Corrective Action

The following causes and determinations can be made as to the exact component failures and related events leading up to, and after, the scram.

The feedwater recirculation valve (SJ-FCV-1611) is an air-actuated, fail-open control valve, Control Components model No. PDA964-96BW. Investigation revealed that a flexible air-supply line fitting broke due to fatigue. When the air supply was lost, the valve cycled open. Prior to startup, the broken air line on the "B" recirculation valve was repaired. As an additional precaution, the identical airline on the "A" recirculation valve (SJ-FCV-1569) was inspected and found satisfactory. As a long-term corrective action, a maintenance action request has been generated to replace the fittings subject to fatigue with higher strength fittings.

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To preclude recurrence of similar SRV opening situations, all instrument technicians were assembled and shown the exact cause of the event during a step-by-step reconstruction. The importance of procedural compliance without deviating from the prescribed testing sequence was impressed upon them. To reduce the margin for personnel error, the surveillance test procedure has been revised to utilize a volt meter in lieu of an ohmmeter. This revision will eliminate the possibility of the meter acting as a jumper in a circuit under test, regardless of when it is inserted. As a long-term corrective action, selected surveillance test procedures are continuing to be revised to simplify and clarify the testing sequence, thereby reducing the possibility of personnel error. In addition to this, a joint management and union task force is being formed to determine and implement methods of maintaining a heightened awareness of the importance of minimizing personnel errors.

Prior to startup, all systems initiated during the scram and subsequent evolutions were reviewed to determine whether they had functioned per design and Technical Specifications. At the 170-in. reactor water level, the reactor scrammed; valve groups 2, 3, 4, and 5 isolated; and both trains of the standby gas treatment system initiated per design. At the 119.5 in. reactor water level valve group 8 isolated, LPCI logic tripped both recirculation pumps, loop-select logic initiated and performed its function, and HPCI/RCIC initiated per design. During and after the transient, the operators observed a normal SRV tail-pipe temperature response. As an additional precaution, a walkdown was performed on the tailpipe of the opened SRV. The piping and restraints were inspected and found satisfactory.

Plant/Event Data

Systems Involved:
Steam relief

Components and Failure Modes Involved:
MFW — failed in operation
Steam RVs — failed to close in operation

Component Unavailability Duration: NA
Plant Operating Mode: 1 (100% power)
Discovery Method: Operational event
Reactor Age: 9.8 years
Plant Type: BWR

Comments

None

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MODELING CONSIDERATIONS AND DECISIONS

Initiators Modeled and Initiator Nonrecovery Estimate

Small-break LOCA	0.34	Base case nonrecovery

Branches Impacted and Branch Nonrecovery Estimate

PCS	1.0	Unavailable
MFW	0.12	Failed but recoverable

Plant Models Utilized

BWR plant Class C

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

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INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOCA	3.4E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CV	
LOCA	8.6E-07
Total	8.6E-07
CD	
LOCA	1.2E-04
Total	1.2E-04
ATWS	
LOCA	6.9E-06
Total	6.9E-06

DOMINANT SEQUENCES

End State: CV Conditional Probability: 5.7E-07

314 LOCA SCRAM -SLC.OR.RODS PCS/LOCA FW/PCS.LOCA HPCI -SRV.ADS -COND/FW.PCS -RHR(SDC)

End State: CD Conditional Probability: 1.1E-04

310 LOCA -SCRAM PCS/LOCA FW/PCS.LOCA HPCI RCIC/LOCA SRV.ADS

End State: ATWS Conditional Probability: 6.9E-06

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332 LOCA SCRAM SLC.OR.RODS

SEQUENCE CONDITIONAL PROBABILITIES

	Sequence	End State	Prob	N Rec**
302	LOCA -SCRAM PCS/LOCA -FW/PCS.LOCA RHR(SDC) RHR(SPCOOL)/-LPCI.RHR(SDC) C.I.AND.V/RHR(SDC).RHR(SPCOOL)	CD	1.4E-05	3.5E-02
310	LOCA -SCRAM PCS/LOCA FW/PCS.LOCA HPCI RCIC/LOCA SRV.ADS	CD	1.1E-04 *	2.3E-02
314	LOCA SCRAM -SLC.OR.RODS PCS/LOCA FW/PCS.LOCA HPCI -SRV.ADS -COND/FW.PCS -RHR(SDC)	CV	5.7E-07 *	1.5E-02
318	LOCA SCRAM -SLC.OR.RODS PCS/LOCA FW/PCS.LOCA HPCI -SRV.ADS COND/FW.PCS -LPCS -RHR(SDC)	CV	2.9E-07	7.9E-03
332	LOCA SCRAM SLC.OR.RODS	ATWS	6.9E-06 *	3.4E-01

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

MODEL: b:\BWRCTREE.CMP
DATA: b:\ARNOLPRO.CMP

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.1E-03	1.0E+00	
LOOP	1.3E-05	3.4E-01	
LOCA	3.3E-06	3.4E-01	
SCRAM	4.1E-04	1.0E+00	
SLC.OR.RODS	1.0E-02	1.0E+00	4.0E-02
PCS/TRANS	1.7E-01 > 1.0E+00	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	1.7E-01 > Unavailable		
PCS/LOCA	1.0E+00	1.0E+00	
SRV.CHALL/TRANS.-SCRAM	1.0E+00	1.0E+00	
SRV.CHALL/TRANS.SCRAM	1.0E+00	1.0E+00	
SRV.CHALL/LOOP.-SCRAM	1.0E+00	1.0E+00	
SRV.CHALL/LOOP.SCRAM	1.0E+00	1.0E+00	
SRV.CLOSE	2.6E-02	1.0E+00	
EMERG.POWER	2.9E-03	5.1E-01	
FW/PCS.TRANS	2.9E-01 > 1.0E+00	3.4E-01 > 1.2E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.9E-01 > Unavailable		
FW/PCS.LOCA	4.0E-02 > 1.0E+00	3.4E-01 > 1.2E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.0E-02 > Failed		
HPCI	1.0E-01	5.7E-01	

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RCIC/TRANS.OR.LOOP	6.7E-02	5.7E-01	
RCIC/LOCA	1.0E+00	1.0E+00	
CRD	1.0E-02	1.0E+00	4.0E-02
SRV.ADS	6.7E-03	1.0E+00	4.0E-02
COND/FW.PCS	1.0E+00	3.4E-01	
LPCS	3.0E-03	3.4E-01	
LPCI(RHR)/LPCS	4.0E-04	3.4E-01	
RHRSW/LPCS.LPCI.TRANS	5.0E-01	1.0E+00	4.0E-02
RHRSW/LPCS.LPCI.LOOP	5.0E-01	1.0E+00	4.0E-02
RHRSW/LPCS.LPCI.LOCA	5.0E-01	1.0E+00	4.0E-02
RHR(SDC)	2.0E-02	3.4E-01	
RHR(SDC)/-LPCI	2.0E-02	3.4E-01	
RHR(SDC)/LPCI	1.0E+00	1.0E+00	
RHR(SPCOOL)/-LPCI.RHR(SDC)	2.0E-02	1.0E+00	
RHR(SPCOOL)/LPCI.RHR(SDC)	5.2E-01	1.0E+00	
C.I.AND.V/RHR(SDC).RHR(SPCOOL)	1.0E+00	3.4E-01	

*** forced

Minarick
04-12-1987
16:28:08

Event Identifier: 331/84-001