PRECURSOR DESCRIPTION SHEET

LER No.: 388/84-013
Event Description: LOOP Test with Failure of EPS to Start
Date of Event: July 26, 1984
Plant: Susquehanna 2

EVENT DESCRIPTION

Sequence

On July 26, 1984, Operations personnel were performing plant alignment in accordance with loss of TG and LOOP startup test. Included in the lineup was racking out the four feeder breakers that supply power to the Unit 2 4.16-kV buses from the Unit 1 T10 ESS transformer.

The normal operating practice for racking out a 4-kV breaker is to ensure that the breaker is open, open the dc knife switch to the dc control power for the breaker, and then to rack out the breaker. The T10 ESS transformer feeder breakers 2A20101, 2A20201, and 2A20401 are all in the 01 cubicles of the 4-kV ESS buses. The 01 cubicle has two dc knife switches, whereas all other breakers in the switchgear bus have only one dc knife switch that provides dc control power to the breaker. The additional dc knife switch in the 01 cubicle provides dc power to the logic circuitry for the bus and DG autostart. Prior to physically racking out the breaker, the operator opened the dc knife switch to the bus logic rather than the dc knife switch to the 01 breaker control circuit. The two dc knife switches in the Unit 2 4-kV ESS bus 01 cubicle were labeled as follows:

BREAKER AND CONTROL SWITCH AND TRIP CIRCUIT FUSES

D.C. CONTROL

The dc knife switch on the left supplies dc power to the 01 breaker. The dc knife switch on the right (the one operator opened) supplies dc control power to the bus logic. When the operator opened the first 01 cubicle door, he called the control room personnel, informed them that he was at the breaker, and requested confirmation that the breaker be racked out and the dc opened. The operator subsequently opened the dc control knife switch and racked out the breaker. This action was repeated at each 4-kV 01 breaker.

At 0137 h on July 26, 1984, with Unit 2 operating at 30% power, a loss of TG and LOOP startup test was initiated from the control room by opening the Unit 2 main generator 500-kV output breakers 2T and 4T and the startup transformer T20 to bus 20 breaker 0A10401. This resulted in a reactor scram due to turbine control valve fast closure; the deenergization of the 13.8-kV buses 20, 12A, and 12B; and the deenergization of 4.16-kV buses 2A, 2B, 2C, and 2D. These were expected actions and were indicated in Technical Specification 31.1.

Following the initiation of the test, the operator located at electrical panel 0C653 noted that the four EDGs did not start. When the 4.16-kV buses were deenergized, he noted that the feeder breakers from the bus 20 ESS transformers 201 and 211 to the 4.16-kV ESS buses were closed. Because the 4.16-kV bus was deenergized, these four feeder breakers should have opened.

The failure of the DGs to start initially was due to the T20 ESS transformer feeder breakers being closed in on the dead ESS bus. The T20 ESS transformer feeder breakers did not open because the open dc knife switch to the bus control logic prevented the bus undervoltage relay from energizing and giving a trip signal to the feeder breakers. When the operator manually opened the T20 ESS transformer feeder breakers, the DGs again did not start because the open dc knife switch removed power to the bus 62A timers, which must energize for the DGs to start.

The operator knew that the feeder breakers had to be open for the DGs to automatically start. He manually opened the feeder breakers, and the DGs still did not start. He then manually started the four DGs. The "D" DG tripped on overvoltage; the "B" DG tripped on overvoltage and underfrequency. The "A" and "C" DGs idled but did not close into their associated 4.16-kV Bus. The "A" DG exhibited frequency oscillations and was manually tripped by the operator. The operator then tried to manually close the "C" DG onto the 4.16-kV, bus but the breaker would not close. The operator then reenergized bus 20 by closing 0A10401 and reenergized ESS transformers 201 and 211 by closing 0A10406 and 0A10412. He then attempted to close the feeder breakers from the ESS transformer to the 4.16-kV buses. The feeder breakers would not close. The 4.16-kV buses were still deenergized. The unit supervisor then instructed the reactor building plant operator to rack in the feeder breakers and close the dc knife switch. As the feeder breakers from the T10 ESS transformer were racked in and the dc knife switches closed, the preferred feeder breaker to the ESS bus closed, reenergizing the bus. Power was restored to the first bus 11 min into the transient and to the last bus 17 min into the transient. When power was restored to all four ESS buses, the operator noted that "A," "B," and "D" DGs had high-priority alarms, so he manually shut them down. The operator in the DG building reset the high-priority alarm on the "A" DG but could not reset the high-priority alarm on the "B" and "D" DGs.

Event Identifier 388/84-013

When the DGs failed to start and initial attempts at reenergizing the 4-kV ESS buses did not succeed, the shift supervisor entered the emergency plan and declared an unusual event at 0150 h. Once power was fully restored, the unusual event was terminated at 0230 h.

Corrective Action

The labeling of the dc knife switches on the Units 1 and 2 4-kV ESS buses was found to be misleading. The labels were changed to be more clearly descriptive. The label on the dc control power for the 2A20101 breaker now reads in black letters on a white background:

BKR 2A20101
CONTROL AND TRIP
D.C. POWER

The label for the dc control power to the bus logic circuits reads in white letters on a red background:

BUS/DIESEL GEN A
AUX RELAY CONTROL
D.C. POWER

In addition, the handle for the dc knife switch for the bus logic circuits has been painted red, and a caution label has been added that reads in white letters on a red background:

CAUTION
OPENING THIS SWITCH
DISABLES O/G AND BUS
TRANSFER

With the "C" DG running and the 2C bus deenergized, the "C" DG breaker did not close in on the dead bus, nor could the operator manually close the breaker from the control room panel. That the breaker did not close automatically is explained by the open dc knife switch that removed power to the bus undervoltage relay, which must energize for the DG breaker to autoclose. For the operator to close the breaker manually, he must turn the keylocked synchronization switch to the "On" position and place the DG breaker control switch to the "Close" position. Additional permissives in the closing circuit are auxiliary relay V1, which deenergizes on loss of bus power (and should have been deenergized), and auxiliary relay V2, which energizes when DG voltage is present (and should have been energized). A retest has been performed to demonstrate that the DG breaker can be closed manually on to a dead bus from the control room.

Event Identifier: 388/84-013

Plant/Event Data

Systems Involved:
Emergency power and electrical

Components and Failure Modes Involved:
All DGs — failed to start on demand

Component Unavailability Duration: NA
Plant Operating Mode: 1 (30% power)
Discovery Method: During testing
Reactor Age: 0.2 year
Plant Type: BWR

Comments

A station blackout actually occurred for an hour. Reference: Abnormal Occurrence Reports to Congress, NUREG-0090, 1(3), 14.

MODELING CONSIDERATIONS AND DECISIONS

Initiators Modeled and Initiator Nonrecovery Estimate

LOOP	0.12	Assumed recoverable, although not procedurally based

Branches Impacted and Branch Nonrecovery Estimate

EPS	0.34	Assumed potentially recoverable in 20- to 30-min time period

Plant Models Utilized

BWR plant Class C

Event Identifier: 388/84-013

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

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Event Description: LOOP Test With Failure of EPS to Start
Event Date: 7/26/84
Plant: Susquehanna 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP	1.2E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CV	
LOOP	6.4E-08
Total	6.4E-08
CD	
LOOP	2.2E-04
Total	2.2E-04
ATWS	
LOOP	1.8E-05
Total	1.8E-05

DOMINANT SEQUENCES

End State: CV Conditional Probability: 6.4E-08

226 LOOP -EMERG.POWER SCRAM -SLC.OR.RODS HPCI RCIC/TRANS.OR.LOOP -SRV.ADS -LPCS -RHR(SDC)

End State: CD Conditional Probability: 1.2E-04

246 LOOP EMERG.POWER -SCRAM SRV.CHALL/LOOP.-SCRAM SRV.CLOSE HPCI RCIC/LOCA

End State: ATWS Conditional Probability: 1.7E-05

Event Identifier: 388/84-013

250 LOOP EMERG.POWER SCRAM

SEQUENCE CONDITIONAL PROBABILITIES

	Sequence	End State	Prob	N Rec**
215	LOOP -EMERG.POWER -SCRAM SRV.CHALL/LOOP.-SCRAM SRV.CLOSE HP CI RCIC/LOCA SRV.ADS	CD	1.1E-05	4.5E-02
226	LOOP -EMERG.POWER SCRAM -SLC.OR.RODS HPCI RCIC/TRANS.OR.LOOP -SRV.ADS -LPCS -RHR(SDC)	CV	6.4E-08 *	2.6E-02
240	LOOP -EMERG.POWER SCRAM SLC.OR.RODS	ATWS	1.6E-06	7.9E-02
243	LOOP EMERG.POWER -SCRAM SRV.CHALL/LOOP.-SCRAM -SRV.CLOSE HP CI RCIC/TRANS.OR.LOOP	CD	8.4E-05	1.3E-02
246	LOOP EMERG.POWER -SCRAM SRV.CHALL/LOOP.-SCRAM SRV.CLOSE HP CI RCIC/LOCA	CD	1.2E-04 *	2.3E-02
250	LOOP EMERG.POWER SCRAM	ATWS	1.7E-05 *	4.1E-02

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

MODEL: b:\bwrctree.cmp
DATA: b:\susqprob.cmp

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
TRANS	1.1E-03	1.0E+00	
LOOP	1.3E-05 > 1.3E-05	3.4E-01 > 1.2E-01	
Branch Model: INITOR			
Initiator Freq:	1.3E-05		
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	
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	5.3E-02	1.0E+00	
EMERG.POWER	5.4E-04 > 1.0E+00	5.1E-01 > 3.4E-01	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	5.0E-02 > Failed		
Train 2 Cond Prob:	5.7E-02 > Failed		
Train 3 Cond Prob:	1.9E-01 > Failed		
FW/PCS.TRANS	4.6E-01	3.4E-01	

Event Identifier: 388/84-013

FW/PCS.LOCA	1.0E+00	3.4E-01	
HPCI	1.0E-01	5.7E-01	
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
12:30:25

Event Identifier: 388/84-013