B.5 LER No. 254/82-012, -013, and -018

Event Description:	Postulated LOOP with 2 EDGs Inoperable (Unit 1) and Plant-centered LOOP with one EDG Inoperable (Unit 2)
Date of Event:	June 22, 1982
Plant:	Quad Cities 1 and 2

B.5.1 Summary

During normal operation on June 22, 1982, Unit 2 reactor experienced a loss of offsite power (LOOP) and a trip while the reserve auxiliary transformer 22 was being removed from service for maintenance. Both the Unit 2 and swing emergency diesel generators (EDGs) loaded to their respective emergency buses. The swing diesel generator tripped when the A residual heat removal service water (RHRSW) pump was started. One day prior to the Unit 2 loss of offsite power, the Unit 1 EDG was removed from service due to the failure of the diesel generator cooling water pump to provide flow to the EDG during a high-pressure coolant injection (HPCI) flow rate surveillance test. Thus, when the Unit 2 LOOP occurred, Unit 1 began operating without any EDGs available. The estimated increase in core damage probability, or importance, over the duration of the postulated LOOP at Unit 1 with both EDGs inoperable is 1.4×10^{-4}. The base-case core damage probability (CDP) over the duration of the event is 2.2×10^{-6}, resulting in an estimated conditional core damage probability (CCDP) of 1.4×10^{-4}. The conditional core damage probability estimate for the plant-centered LOOP with one EDG inoperable at Unit 2 is 1.1×10^{-4}.

B.5.2 Event Description

During normal operation on June 22, 1982, at 0526 hours, Unit 2 reactor experienced a trip due to a reactor feedwater pump trip and subsequent low water level due to a loss of bus 22 while the reserve auxiliary transformer 22 was being removed from service for maintenance. An equipment operator mistakenly pulled out the fuses for a 4-kV bus instead of pulling the transformer fuses. The error disconnected power to the 2B reactor feedwater pump, which caused a low water level and initiated a trip. The Unit 2 main generator subsequently tripped and all normal ac power to Unit 2 was lost. Following the LOOP, both the Unit 2 and swing emergency diesel generators (EDGs) loaded to their respective emergency buses. Approximately 22 minutes later, the swing diesel generator tripped when the A residual heat removal service water (RHRSW) pump was started. Because of an error in the design of the EDG protective relaying, the EDG underexcitation relay was unblocked and thus tripped when the RHRSW pump was initiated. Actuation of the underexcitation relay tripped the EDG lock-out relay as well. To restart the EDG, the relay had to be manually reset by the equipment operator. The resetting of the lock-out relay was delayed since the equipment operator had been sent to the switchyard to expedite the restoration of offsite power. Subsequent to the event, the under-excitation relays were temporarily removed on all three diesel generators until a permanent design change could be completed.

One day prior to the Unit 2 LOOP, the Unit 1 EDG was removed from service due to the failure of the diesel generator cooling water pump to provide flow to the EDG during a HPCI flow rate surveillance test.

Investigation revealed that the pump was air bound due to air which entered the suction line while RHRSW A was being drained to install system modifications. The rotating element of the pump was replaced and the pump was returned to service in the late afternoon of June 22nd. When the Unit 2 LOOP occurred, Unit 1 began operating without any EDGs available.

LER 254/82-018 indicates that on June 26th, the Unit 1 EDG cooling water pump was again removed from service to reduce the vibration of the pump due to misalignment of the motor and pump. The motor and pump were re-aligned, and the pump was returned to service. This event occurred after the LOOP and was not modeled.

B.5.3 Additional Event-Related Information

Quad Cities Units 1 and 2 each have one EDG (EDG 1 and EDG 2) dedicated to that unit. They share a common swing EDG (EDG 1/2). EDGs 1 and 2 supply emergency power buses 14-1 and 24-1, respectively, which power core spray pumps 1B and 2B, RHR pumps 1C, 1D, 2C, and 2D, and RHRSW pumps 1C, 1D, 2C, and 2D. The swing EDG can be aligned to power either bus 13-1 or 23-1. Bus 13-1 supplies core spray pump 1A, RHR pumps 1A and 1B, and RHRSW pumps 1A and 1B. Bus 23-1 supplies core spray pump 2A, RHR pumps 2A and 2B, and RHRSW pumps 2A and 2B. The emergency power buses are automatically fed from the EDGs on a loss of offsite power. Unit 1 bus 14-1 and Unit 2 bus 24-1 can be cross-tied by closing two normally open breakers. This provides recovery if normal power is available on the other unit (plant-centered LOOP).

Two 250-V dc and two 125-V dc batteries are shared between both units. Each battery is sized to power its respective loads for 4 hours. Unit 1 batteries are charged from bus 14-1 through bus 19, and Unit 2 batteries are charged from bus 24-1 through bus 29. An alternative charger can be powered from bus 13-1 and 23-1, and can charge either unit's battery. The 480-V ac buses power the battery chargers on each unit, and can also be cross-tied.

B.5.4 Modeling Assumptions

This event was modeled as two separate events. The first analysis considers a postulated LOOP with two EDGs inoperable for Unit 1 and assumes that both of the EDGs were inoperable for up to half the surveillance period on the EDGs, 15 days. One train of emergency power (EP) was set to failed to reflect the failure of EDG 1/2, and the other train was set to unavailable to reflect EDG 1's unavailability due to maintenance. Since power can be recovered from Unit 2 following a plant-centered LOOP at Unit 1 (only Unit 2 would be without offsite power in this case), only dual-unit LOOPs (grid-and weather-related) were considered in this analysis. The frequency of LOOP and the probability of not recovering offsite power was revised to reflect this.

The second analysis considers the plant-centered LOOP which occurred at Unit 2 and the inoperability of the swing EDG. The LOOP frequency and the probabilities of failing to recover offsite power in the short term and before battery depletion were modified for a plant-centered LOOP using the models described in *Revised LOOP Frequency and PWR Seal LOCA Models,* ORNL/NRC/LTR-89/11, August 1989. One train of emergency power was set to failed to reflect the failure of EDG 1/2, and all associated equipment powered by the swing EDG was set to unavailable. The probability of failing to recover offsite power prior to battery depletion was revised to reflect the potential for recovery from Unit 1. The probability of failing to recover power from Unit 1 was assumed to be 0.1 (see Appendix A).

In this event, Unit 1 remained operating during the Unit 2 LOOP. Had Unit 1 tripped and experienced a LOOP during the Unit 2 LOOP, Unit 1 would have experienced a station blackout.

B.5.5 Analysis Results

The estimated increase in core damage probability over the duration of the postulated LOOP at Unit 1 is 1.4×10^{-4}. The base-case CDP (not shown in calculation) is 2.2×10^{-6}, resulting in an estimated CCDP of 1.4×10^{-4}. The dominant sequence, highlighted on the event tree in Figure B.5.1, involved a successful reactor shutdown, failure of emergency power, and failure to recover offsite power prior to battery depletion. The estimated conditional core damage probability for the Unit 2 plant-centered LOOP with one EDG inoperable is 1.1×10^{-4}. The dominant sequence involves a successful reactor shutdown, successful emergency power, successful HPCI, and failure of RHR.

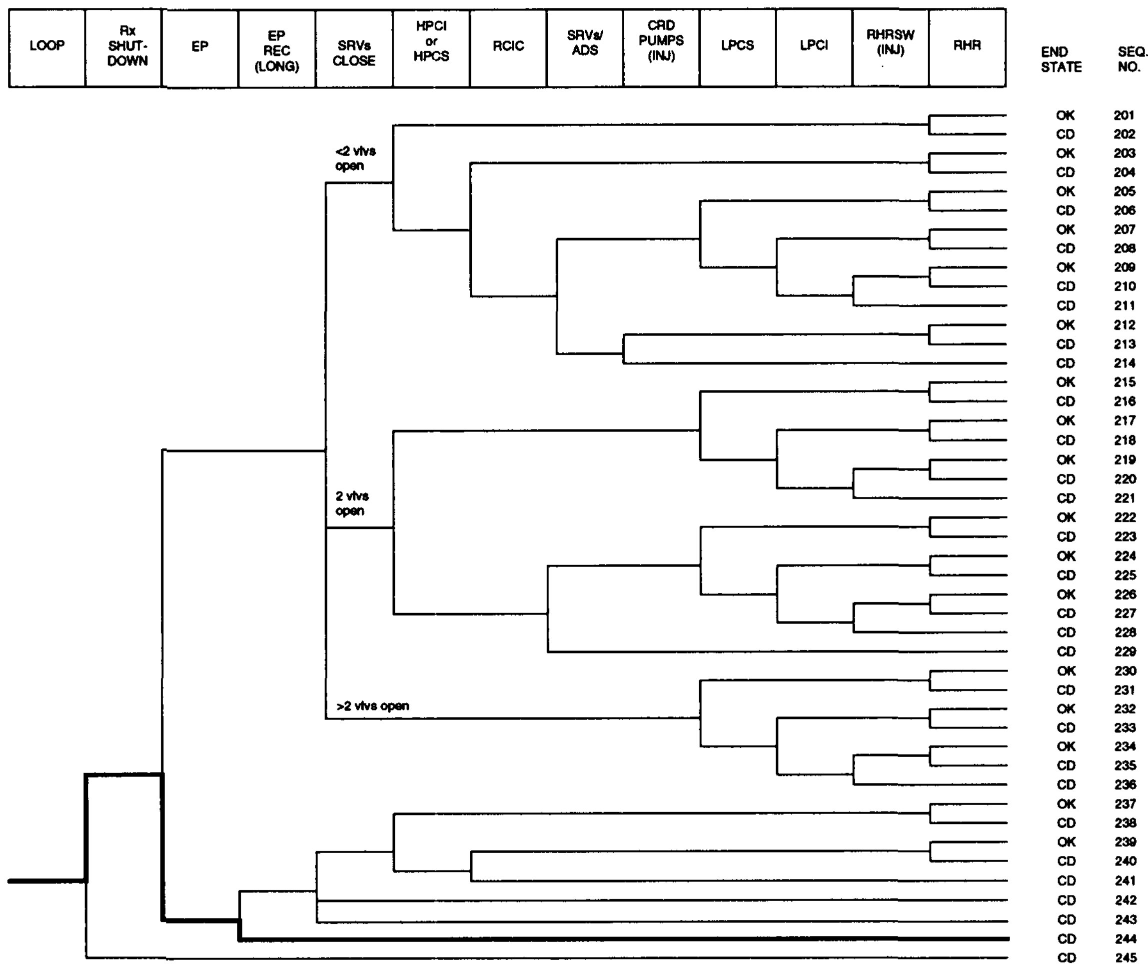

Figure B.5.1 Dominant core damage sequence for LER 254/82-012, -013, and -018

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 254/82-012, -013 and -018
Event Description: Postulated LOOP with two EDGs inoperable (Unit 1)
Event Date: June 22, 1982
Plant: Quad Cities 1

UNAVAILABILITY, DURATION= 360

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP	6.7E-04

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	1.4E-04
Total	1.4E-04

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
244	LOOP -rx.shutdown EP EP.REC	CD	1.4E-04	6.6E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
244	LOOP -rx.shutdown EP EP.REC	CD	1.4E-04	6.6E-01

** non-recovery credit for edited case

Note: For unavailabilities, conditional probability values are differential values which reflect the added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

SEQUENCE MODEL: c:\asp\1982-83\bwrc8283.cmp
BRANCH MODEL: c:\asp\1982-83\quadcit1.82
PROBABILITY FILE: c:\asp\1982-83\bwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.5E-03	1.0E+00	
LOOP	1.6E-05 > 2.8E-06	5.3E-01 > 6.6E-01	
Branch Model: INITOR			

Initiator Freq:	1.6E-05 > 2.8E-06		
loca	3.3E-06	6.7E-01	
rx.shutdown	3.5E-04	1.0E-01	
pcs	1.7E-01	1.0E+00	
srv.ftc.<2	1.0E+00	1.0E+00	
srv.ftc.2	1.3E-03	1.0E+00	
srv.ftc.>2	2.2E-04	1.0E+00	
mfw	2.9E-01	3.4E-01	
hpci	2.9E-02	7.0E-01	
rcic	6.0E-02	7.0E-01	
srv.ads	3.7E-03	7.0E-01	1.0E-02
crd(inj)	1.0E-02	1.0E+00	1.0E-02
cond	1.0E+00	3.4E-01	1.0E-03
lpcs	2.0E-03	1.0E+00	
lpci	1.1E-03	1.0E+00	
rhrsw(inj)	2.0E-02	1.0E+00	1.0E-02
rhr	1.5E-04	1.6E-02	1.0E-05
rhr.and.pcs.nrec	1.5E-04	8.3E-03	1.0E-05
rhr/-lpci	0.0E+00	1.0E+00	1.0E-05
rhr/lpci	1.0E+00	1.0E+00	1.0E-05
rhr(spcool)	2.1E-03	1.0E+00	1.0E-03
rhr(spcool)/-lpci	2.0E-03	1.0E+00	1.0E-03
EP	2.9E-03 > 1.0E+00	8.7E-01 > 1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	5.0E-02 > Failed		
Train 2 Cond Prob:	5.7E-02 > Unavailable		
EP.REC	4.9E-02 > 2.1E-01	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.9E-02 > 2.1E-01		
rpt	1.9E-02	1.0E+00	
slcs	2.0E-03	1.0E+00	1.0E-02
ads.inhibit	0.0E+00	1.0E+00	1.0E-02
man.depress	3.7E-03	1.0E+00	1.0E-02

* branch model file
** forced

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 254/82-012. -013 and -018
Event Description: Plant-centered LOOP with one EDG inoperable (Unit 2)
Event Date: June 22. 1982
Plant: Quad Cities 2

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP	5.0E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP	1.1E-04
Total	1.1E-04

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
242	LOOP -rx.shutdown EP -EP.REC srv.ftc.2	CD	3.2E-05	4.3E-01
241	LOOP -rx.shutdown EP -EP.REC srv.ftc.<2 hpci rcic	CD	2.1E-05	2.1E-01
245	LOOP rx.shutdown	CD	1.8E-05	5.0E-02
244	LOOP -rx.shutdown EP EP.REC	CD	1.6E-05	4.3E-02
202	LOOP -rx.shutdown -EP srv.ftc.<2 -hpci RHR	CD	1.2E-05	7.9E-03
243	LOOP -rx.shutdown EP -EP.REC srv.ftc.>2	CD	5.5E-06	4.3E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
202	LOOP -rx.shutdown -EP srv.ftc.<2 -hpci RHR	CD	1.2E-05	7.9E-03
241	LOOP -rx.shutdown EP -EP.REC srv.ftc.<2 hpci rcic	CD	2.1E-05	2.1E-01
242	LOOP -rx.shutdown EP -EP.REC srv.ftc.2	CD	3.2E-05	4.3E-01
243	LOOP -rx.shutdown EP -EP.REC srv.ftc.>2	CD	5.5E-06	4.3E-01
244	LOOP -rx.shutdown EP EP.REC	CD	1.6E-05	4.3E-02
245	LOOP rx.shutdown	CD	1.8E-05	5.0E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1982-83\bwrc8283.cmp
BRANCH MODEL: c:\asp\1982-83\quadcit2.82
PROBABILITY FILE: c:\asp\1982-83\bwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	6.9E-04	1.0E+00	
LOOP	1.6E-05 > 1.4E-05	5.3E-01 > 5.0E-01	
Branch Model: INITOR			
Initiator Freq:	1.6E-05 > 1.4E-05		
loca	3.3E-06	6.7E-01	
rx.shutdown	3.5E-04	1.0E-01	
pcs	1.7E-01	1.0E+00	
srv.ftc.<2	1.0E+00	1.0E+00	
srv.ftc.2	1.3E-03	1.0E+00	
srv.ftc.>2	2.2E-04	1.0E+00	
mfw	2.9E-01	3.4E-01	
hpci	2.9E-02	7.0E-01	
rcic	6.0E-02	7.0E-01	
srv.ads	3.7E-03	7.0E-01	1.0E-02
crd(inj)	1.0E-02	1.0E+00	1.0E-02
cond	1.0E+00	3.4E-01	1.0E-03
LPCS	2.0E-03 > 2.0E-02	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	2.0E-02		
Train 2 Cond Prob:	1.0E-01 > Unavailable		
LPCI	1.1E-03 > 2.0E-03	1.0E+00	
Branch Model: 1.OF.4+ser			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Unavailable		
Train 4 Cond Prob:	5.0E-01 > Unavailable		
Serial Component Prob:	1.0E-03		
rhrsw(inj)	2.0E-02	1.0E+00	1.0E-02
RHR	1.5E-04 > 1.0E-03	1.6E-02	1.0E-05
Branch Model: 1.OF.4+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Unavailable		
Train 4 Cond Prob:	5.0E-01 > Unavailable		
RHR.AND.PCS.NREC	1.5E-04 > 1.0E-03	8.3E-03	1.0E-05
Branch Model: 1.OF.4+opr			
Train 1 Cond Prob:	1.0E-02		
Train 2 Cond Prob:	1.0E-01		
Train 3 Cond Prob:	3.0E-01 > Unavailable		
Train 4 Cond Prob:	5.0E-01 > Unavailable		
rhr/-lpci	0.0E+00	1.0E+00	1.0E-05
rhr/lpci	1.0E+00	1.0E+00	1.0E-05
rhr(spcool)	2.1E-03	1.0E+00	1.0E-03
rhr(spcool)/-lpci	2.0E-03	1.0E+00	1.0E-03
EP	2.9E-03 > 5.7E-02	8.7E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	5.0E-02 > Failed		
Train 2 Cond Prob:	5.7E-02		
EP.REC	4.9E-02 > 6.4E-03	1.0E+00 > 1.0E-01	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	4.9E-02 > 6.4E-03		
rpt	1.9E-02	1.0E+00	
slcs	2.0E-03	1.0E+00	1.0E-02

ads.inhibit	0.0E+00	1.0E+00	1.0E-02
man.depress	3.7E-03	1.0E+00	1.0E-02

* branch model file
** forced