C.6 LER No. 266/94-002

Event Description: Both Diesel Generators Inoperable

Date of Event: February 8, 1994

Plant: Point Beach 1 and 2

C.6.1 Summary

Point Beach Units 1 and 2 were operating at 100% power when emergency diesel generator (EDG) G02 was taken out of service for maintenance. Plant technical specifications require that, if one EDG is removed from service, the other must be tested daily to verify its operability. When the EDG remaining in service was tested, electric fuel pump and exciter failures were experienced, and the EDG was declared inoperable. Both EDGs were, therefore, simultaneously unavailable. These unavailabilities would have impacted the Point Beach plant response to a loss-of-offsite power (LOOP) had it occurred during the unavailability period. The conditional core damage probability estimated for this event, 1.2×10^{-5}, is applicable to both units.

C.6.2 Event Description

EDG G02, the B train emergency power source for both units at Point Beach, was removed from service for maintenance at 0339 hours on February 7, 1994. At 0753 hours on February 8, 1994, an operability test of the A train emergency power source, EDG G01, was begun. At 0951 hours trouble annunciations were received for that EDG.

Investigation determined that the electric fuel pump for EDG G01 had failed. The EDG continued to run, however, with fuel supplied by a shaft-driven mechanical pump. The diesel was allowed to continue to run unloaded while repairs were made to the electric fuel pump. At 1940 hours repairs were complete, and the EDG was shut down.

At 2046 hours EDG G01 was started and loaded for a hard run to clean its exhaust system of deposits accumulated during the prior prolonged no-load run. At 2100 hours power swings were noted on the EDG varmeter. These swings increased in intensity, and at 2204 hours EDG G01 was declared inoperable.

A stationary brush jumper cable in the EDG's exciter was found to be contacting a rotating bus bar, shorting out the dc excitation voltage. This condition was repaired, and the EDG was declared operable at 0244 hours on February 9, 1994.

C.6.3 Additional Event-Related Information

The Licensee Event Report (LER) for this event indicates that the brush jumper cable was installed incorrectly during an annual maintenance outage on February 3, 1994. The report further indicates that EDG G01 was run for 3 h on February 4, 1.9 h on February 7, and 10.3 h on February 8 (while the electric fuel pump was repaired). The LER also indicates that a gas turbine generator was available as a backup source of emergency ac power.

C.6.4 Modeling Assumptions

This event was modeled as a 47-h simultaneous unavailability of both EDGs. As it was out of service for maintenance, EDG G02 was assumed to be unavailable after 0339 hours on February 7, 1994. EDG G01 experienced fuel pump and exciter failures that resulted in its being declared inoperable on February 8, 1994. After investigation, the exciter failure was attributed to maintenance errors that occurred on February 3, 1994. EDG G01 was operated on occasion between February 3 and February 8; however, the EDG ran unloaded for most of this time. After it was restarted to run under

load on February 8, the EDG only operated for about 15 min before erratic exciter performance was observed. While it is possible that the EDG could have successfully run for an extended time in a loaded condition, this analysis assumes EDG G01 was unavailable to perform its safety function of supplying long-term emergency power until the exciter repair was completed on February 9, 1994. Due to the nature of the EDG unavailabilities, no EDG recovery was assumed to be possible. Because of the unavailability of both EDGs, the core damage sequences of primary concern in this analysis are those associated with a postulated LOOP and subsequent station blackout.

The probability of a LOOP in the 47-h period, the probability of its short-term and long-term recovery, and the probability of a reactor coolant pump (RCP) seal loss-of-coolant accident (LOCA) following a postulated station blackout were developed based on data contained in NUREG-1032, *Evaluation of Station Blackout Accidents at Nuclear Power Plants*, and RCP seal loss-of-coolant (LOCA) models developed as part of the NUREG-1150 probabilistic risk assessment (PRA) efforts, as described in *Revised LOOP Recovery and PWR Seal LOCA Models*, ORNL/NRC/LTR-89/11, August 1989.

The Final Safety Analysis Report (FSAR) indicates that a gas turbine generator is available at the Point Beach site that can be started and loaded within 10 min. This gas turbine generator is credited as a source of emergency ac power in the Point Beach Individual Plant Examination (IPE), and failure to recover ac power using the gas turbine is assigned a probability of 0.13 in the IPE. That value is employed in this analysis for the probability of failure to recover emergency ac power.

The IRRAS-based ASP model for Point Beach was modified to reflect the conditions observed during the event by setting the independent failure basic events associated with each EDG (EPS-DGN-FC-1A, B) to true, the EDG common-cause failure basic event (EPS-DGN-CF-ALL) to false, and the emergency power nonrecovery probability (EPS-XHE-NOREC) to 0.13. Basic events and their probabilities are shown in Table C.6.1. The incremental core damage probability over 47 h was then calculated by re-solving the accident sequence model.

The current ASP LOOP model for Point Beach assumes that the PORVs will be challenged, and that they will fail to reclose with a probability of 3×10^{-3} (IRRAS model default value) each. This assumption may be conservative, but it did not affect the dominant sequence for the event.

Calculations were performed for Point Beach Unit 1, the unit reported in the LER. Since EDG G01 and G02 also provide emergency power for Unit 2, the calculations are equally applicable to that unit.

The FSAR for Point Beach also indicates that the station batteries are designed to carry shutdown loads following a plant trip and loss of all ac power for a period of 1 h. Information provided by Point Beach indicates that the expected battery lifetime is 2 h. This analysis was performed based on the expected 2 h battery lifetime.

C.6.5 Analysis Results

The estimated conditional core damage probability associated with this event at each unit is 1.2×10^{-5}. The dominant core-damage sequence, highlighted on the event tree in Figure C.6.1, involves a postulated loss-of-offsite power, unavailability of emergency power because of the unavailability of both EDGs, failure to recover emergency power through use of the gas turbine generator, RCP seal LOCA, and failure to recover ac power prior to core uncovery.

Definitions and probabilities for selected basic events are shown in Table C.6.1. The conditional probabilities associated with the highest probability sequences are shown in Table C.6.2. Table C.6.3 lists the sequence logic associated with the sequences listed in Table C.6.2. Table C.6.4 describes the system names associated with the dominant sequences. Cutsets associated with each sequence are shown in Table C.6.5.

C.6.6 Reference

1. LER 266/94-002, "Inoperability of Both Emergency Diesel Generators," March 9, 1994.

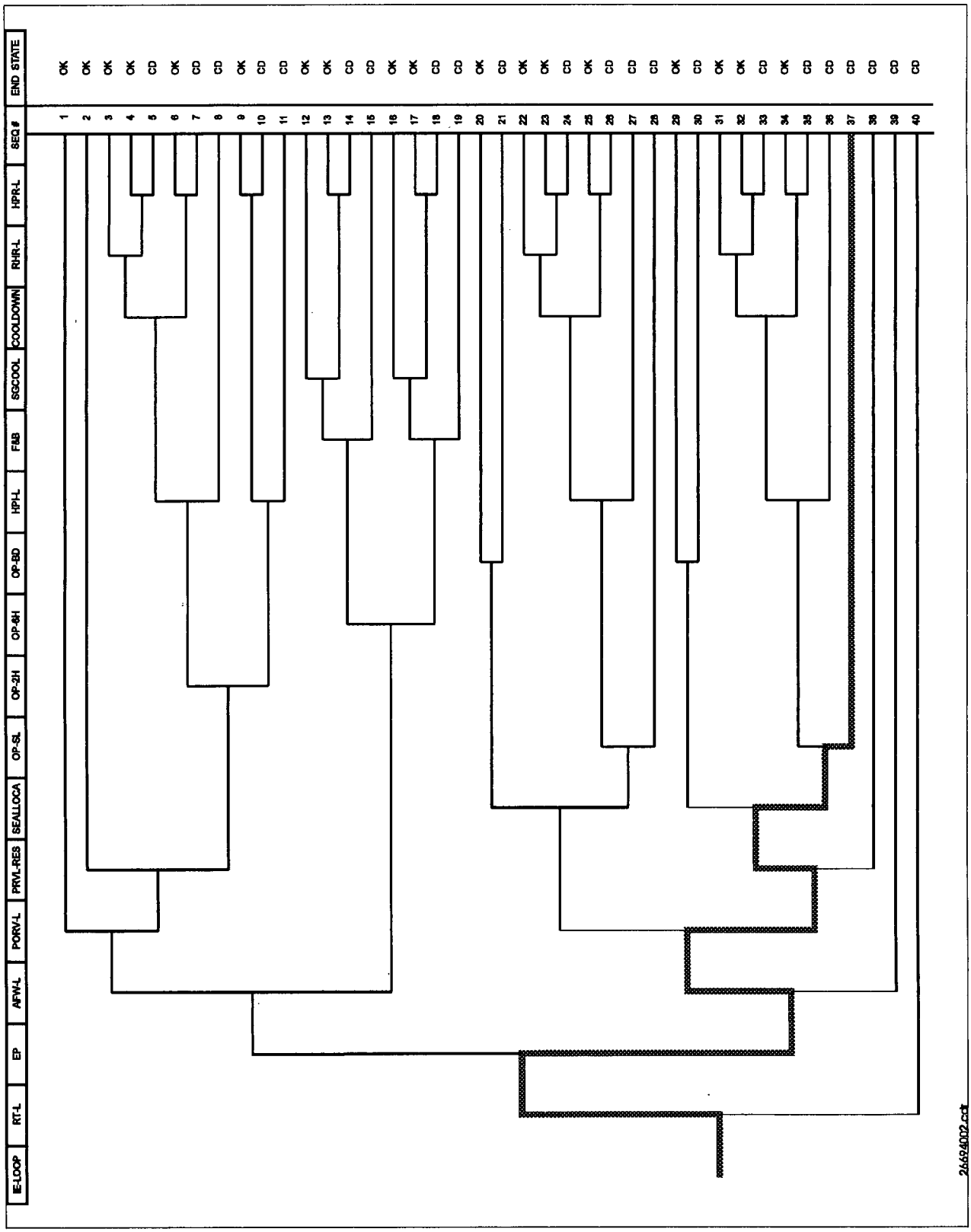

Figure C.6.1. Dominant core damage sequence for LER 266/94-002.

Table C.6.1. Definitions and probabilities for selected basic events for LER 266/94-002

Event name	Description	Base probability	Current probability	Type	Modified for this event
AFW-TDP-FC-1A	AFW Turbine Driven Pump Fails	3.3E-002	3.3E-002		N
AFW-XHE-NOREC-EP	Operator Fails to Recover AFW During Station Blackout	3.4E-001	3.4E-001		N
AFW-XHE-XA-PSWEP	Operator Fails to Align Backup Water Source During SBO	4.0E-002	4.0E-002		N
EPS-DGN-CF-ALL	Common Cause Failure of two diesel generators	1.1E-003	0.0E+000	FALSE	Y
EPS-DGN-FC-1A	Diesel Generator A Fails	4.2E-002	1.0E+000	TRUE	Y
EPS-DGN-FC-1B	Diesel Generator B Fails	4.2E-002	1.0E+000	TRUE	Y
EPS-XHE-NOREC	Operator Fails to Recover Emergency Power	8.0E-001	1.3E-001		Y
IE-LOOP	Loss-of-Offsite Power Initiating Event	5.8E-006	2.7E-004		Y
IE-SGTR	Steam Generator Tube Rupture Initiating Event	0.0E+000	0.0E+000		Y
IE-SLOCA	Small LOCA Initiating Event	0.0E+000	0.0E+000		Y
IE-TRANS	Transient Initiating Event	0.0E+000	0.0E+000		Y
OEP-XHE-NOREC-BD	Operator Fails to Recover Offsite Power Before Battery Depletion	8.3E-002	8.3E-002		N
OEP-XHE-NOREC-SL	Operator Fails to Recover Offsite Power (Seal LOCA)	6.5E-001	6.5E-001		N
PPR-SRV-OO-PRV1	PORV 1 Fails to Reclose After Opening	3.0E-002	3.0E-002		N
PPR-SRV-OO-PRV2	PORV 2 Fails to Reclose After Opening	3.0E-002	3.0E-002		N
RCS-MDP-LK-SEALS	RCP Seals Fail Without Cooling and Injection	2.6E-001	2.6E-001		N

Table C.6.2. Sequence conditional probabilities for LER 266/94-002

Event tree name	Sequence name	Conditional core damage probability (CCDP)	Core damage probability (CDP)	Importance (CCDP-CDP)	%Contribution
LOOP	37	5.9E-006	3.9E-007	5.5E-006	49.4
LOOP	30	2.9E-006	1.6E-008	2.9E-006	25.8
LOOP	38	2.1E-006	5.5E-008	2.0E-006	18.2
LOOP	39	8.7E-007	5.9E-008	8.1E-007	7.2
Total (all sequences)		1.2E-005			

Table C.6.3. Sequence logic for LER 266/94-002

Event tree name	Sequence name	Logic
LOOP	37	/RT-L, EP, /AFW-L-EP, PORV-L, /PORV-EP, SEALLOCA, OP-SL
LOOP	30	/RT-L, EP, /AFW-L-EP, PORV-L, /PORV-EP, /SEALLOCA, OP-BD
LOOP	38	/RT-L, EP, /AFW-L-EP, PORV-L, PORV-EP
LOOP	39	/RT-L, EP, AFW-L-EP

Table C.6.4. System names for LER 266/94-002

System name	Description
AFW-L-EP	No or Insufficient AFW Flow During Station Blackout
EP	Failure of Both Trains of Emergency Power
OP-BD	Operator Fails to Recover Offsite Power Before Battery Depletion
OP-SL	Operator Fails to Recover Offsite Power (Seal LOCA)
PORV-EP	PORVs Fail to Reclose (No Electric Power)
PORV-L	PORVs Open During LOOP
RT-L	Reactor Fails To Trip During LOOP
SEALLOCA	RCP Seals Fail During LOOP

Table C.6.5. Conditional cut sets for higher probability sequences for LER 266/94-002

Cut set No.	% Contribution	Conditional core damage probability (CCDP)	Cut sets
LOOP Seq: 37		5.9E-006	
1	100.0	5.9E-006	EPS-XHE-NOREC, OEP-XHE-NOREC-SL, RCS-MDP-LK-SEALS
LOOP Seq: 30		2.9E-006	
1	100.0	2.9E-006	EPS-XHE-NOREC, OEP-XHE-NOREC-BD
LOOP Seq: 38		2.1E-006	
1	50.1	1.0E-006	EPS-XHE-NOREC, PPR-SRV-OO-PRV1
2	50.1	1.0E-006	EPS-XHE-NOREC, PPR-SRV-OO-PRV2
LOOP Seq: 39		8.7E-007	
1	54.8	4.8E-007	AFW-XHE-NOREC-EP, EPS-XHE-NOREC, AFW-XHE-XA-PSWEP
2	45.2	3.9E-007	AFW-TDP-FC-1A, AFW-XHE-NOREC-EP, EPS-XHE-NOREC
Total (all sequences)		1.2E-005	