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SUBJECT: LER 91-004-01:on 910307,loss of offsite power occurred when mobile crane boom came too close to 500 kV power lines. Caused by crane operator & foreman error.Personnel trained on electrical safety issues.W/920424 ltr.

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Gregory M. Rueger
Senior Vice President and
General Manager
Nuclear Power Generation

April 24, 1992

PG&E Letter No. DCL-92-101

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
Licensee Event Report 1-91-004-01
Loss of Offsite Power During Refueling Caused by a Crane Due to Personnel Error

Gentlemen:

Pursuant to 10 CFR 50.73(a)(2)(iv) and 10 CFR 50.73(a)(2)(v), PG&E is submitting the enclosed revision of a Licensee Event Report (LER) concerning the loss of offsite power to Unit 1 due to personnel error. The revision is being submitted to finalize and update the status of the corrective actions and clarify a contributory cause.

The Augmented Inspection Team report (NRC Inspection Report No. 50-275/91-09, dated July 8, 1991) noted the development of baseline coping strategies for restoration of power and cooling in the event of a loss of offsite power. The coping strategies were completed prior to the Unit 2 fourth refueling outage, which began on August 31, 1991. These and other actions taken in response to this event are discussed in Sections II.D, "Other Systems or Safety Functions Affected," and V, "Corrective Actions," of the LER.

This event has in no way affected the health and safety of the public.

Sincerely,

Greg Rueger

Gregory M. Rueger

DC1-91-MM-N028
DC1-91-TN-N032

cc: Ann P. Hodgdon
John B. Martin
Philip J. Morrill
Harry Rood
CPUC
Diablo Distribution
INPO

Enclosure

5744S/85K/ALN/2246

JE22

LICENSEE EVENT REPORT (LER)

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TITLE (4) LOSS OF OFFSITE POWER DURING REFUELING CAUSED BY A CRANE DUE TO PERSONNEL ERROR

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MON	DAY	YR	YR	SEQUENTIAL NUMBER	REVISION NUMBER	MON	DAY	YR	FACILITY NAMES	DOCKET NUMBER (S)
										0 5 0 0 0
03	07	91	91	- 0 0 4 -	0 1	04	24	92		0 5 0 0 0

OPERATING MODE (9)	6
POWER LEVEL (10)	0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (11)

X 10 CFR 50.73(a)(2)(iv) and 50.73(a)(2)(v)

OTHER -

(Specify in Abstract below and in text, NRC Form 366A)

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER	
	AREA CODE	
MARTIN T. HUG, SENIOR REGULATORY COMPLIANCE ENGINEER	805	545-4005

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
[ ] YES (if yes, complete EXPECTED SUBMISSION DATE)	[X] NO				

ABSTRACT (16)

On March 7, 1991, at 0807 PST, with Unit 1 in Mode 6 (Refueling), a loss of offsite power (LOOP) to Unit 1 occurred when a mobile crane boom came too close to the 500 kV power lines. The 500 kV line arced to ground through the crane boom, and caused the LOOP. The emergency diesel generators (DGs) started and loaded to the vital busses. An Unusual Event was declared at 0830 PST, March 7, 1991. A one-hour emergency report was made in accordance with 10 CFR 50.72(a)(3) at 0900 PST. A four-hour non-emergency report was made in accordance with 10 CFR 50.72(b)(2)(ii) and (b)(2)(iii) on March 7, 1991, at 1011 PST, due to the actuation of engineered safety features and momentary loss of residual heat removal, respectively. Special Report 91-02 was submitted as the result of a DG 1-1 non-valid failure that occurred during the event.

The root cause was determined to be personnel error by the crane operator and the foreman in implementation of PG&E's accident prevention rules.

Corrective actions to prevent recurrence include training applicable personnel on electrical safety issues, posting warning signs and barriers around high voltage lines and transformers within the plant protected area, issuing a memorandum stressing the importance of tailboards, and revising the operating experience assessment process to assure more timely and thorough response.

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I. Plant Conditions

Unit 1 was in Mode 6 (Refueling) at 0 percent power for the Unit 1 fourth refueling outage. Offsite electrical power was being supplied to the unit from the 500 kV system (FK). The Unit 1 230 kV startup power system (FK) was cleared for maintenance, and all three emergency diesel generators (DGs) (EK)(DG) were available. This electrical configuration was planned as part of the AC power source management during plant outage conditions in response to NUREG-1410, "Loss of Vital AC Power and the Residual Heat Removal System During Mid-Loop Operations at Vogtle Unit 1 on March 20, 1990."

II. Description of Event

A. Event:

On March 7, 1991, a mobile crane was being used to lift a relief valve (SB)(RV) into position for installation onto a main steam (SB) line outside of containment (NH). The crane was grounded to the main transformer (FK)(XFMR) grounding pad.

At 0807 PST, the boom of the mobile crane came too close to one phase of the 500 kV system and caused a flashover from the conductor. This caused the 500 kV system power circuit breaker (PCB) PCB-532 (FK)(52) to open and isolate offsite power from Unit 1. The 230 kV startup power system had been cleared for maintenance and was not available. The crane operator and other work crew personnel were not injured during the event.

At the time of the event, refueling was in progress with five fuel assemblies (AC) remaining to be reloaded to complete the reload sequence. One new fuel assembly was located in the manipulator crane mast (DF)(CRN) in the full-up position. The manipulator crane was positioned over the core (AC). Another new fuel assembly was located in the upender (DF) inside containment in the horizontal position. The other three assemblies were in the spent fuel pool.

At 0807 PST, all three DGs automatically started, supplying power to their respective 4 kV vital busses (EB). The senior control operator verified that an auxiliary salt water (ASW) pump (BS)(P), two component cooling water (CCW) pumps (BI)(P), all containment fan cooling units (CFCUs) (BK)(FCU), and one centrifugal charging pump (CCP) (BQ)(P) were running. At 0808 PST, a Unit 1 control operator manually started Residual Heat Removal (RHR) Pump (BP)(P) 1-2. An announcement was made over the public address system (PA) to suspend fuel movement due to the loss of offsite power; however, fuel movement had already been suspended due to loss of normal lighting (FF) in the Unit 1 fuel handling building (FHB)(ND) and containment building.

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At 0820 PST, the senior reactor operator in charge of refueling determined, after conversations with control room personnel, that the loss of power would continue for some time. He directed that the manipulator crane be manually moved away from the core region.

In accordance with plant procedures, the Shift Supervisor declared an Unusual Event at 0830 PST due to the loss of offsite power. Unit 2 was not affected by the event, and all safety systems for Unit 2 remained operable.

The San Luis Obispo County Sheriff's office Watch Commander was notified at 0837 PST, March 7, 1991. The one-hour emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(3) at 0900 PST. At 1011 PST, a four-hour non-emergency report was made in accordance with 10 CFR 50.72(b)(2)(ii) and 50.72(b)(2)(iii). The four-hour report was made due to the temporary loss of RHR, the starting of the DGs, and the transfer of the control room ventilation system (VI) to Mode 4 (pressurization). The FHB ventilation system (VG) transferred to the iodine removal mode of operation; however, this information was not included in the report.

By 0930 PST, an action plan was developed to restore offsite power to Unit 1. During the development of the action plan, management considered restoration of offsite power from both the 500 and 230 kV systems. Further review determined that the 230 kV startup power system could be more quickly restored by reenergizing the 230 kV switchgear (FK)(SWGR). The switchgear had been cleared the previous day for maintenance and was within a few hours of being returned to service. The decision was made to restore offsite power via the 230 kV startup power system because the condition of the 500 kV line and transformer was unknown, and it was unknown if the crane could be easily moved. If all AC power had been lost, power could have been restored in approximately 4 hours using emergency maintenance techniques.

At 1228 PST, offsite power was restored to the Unit 1 Startup Transformer 1-2 (FK)(XFMR).

At 1252 PST, operators began returning vital busses to startup power and shutting down the DGs. By 1300 PST, all Unit 1 busses were energized from offsite 230 kV startup power system and all DGs were shut down.

At 1325 PST, March 7, 1991, with offsite electrical power restored to all Unit 1 electrical systems via the 230 kV system and with the emergency DGs shutdown, the Unusual Event was terminated.

At 1600 PST, the Diablo Canyon Power Plant Vice President and Plant Manager conducted a meeting for all supervisory personnel, informing

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them that all non-critical work would be stopped for 24 hours to allow supervisors to review with their personnel any potential safety concerns with remaining outage work.

At 1638 PST, with specific permission from the Plant Manager, the core reload was resumed. The core reload was completed at 1814 PST, and the core mapping was completed at 1940 PST.

B. Inoperable Structures, Components, or Systems that Contributed to the Event:

The 230 kV startup power system was unavailable due to maintenance activities.

C. Dates and Approximate Times for Major Occurrences:

1. March 7, 1991 at 0807 PST: Event/Discovery date - While attempting to position a relief valve, a crane boom causes one phase of the 500 kV line to arc to ground. All offsite power was lost to Unit 1. All 3 DGs auto-started and supplied power to their respective vital busses.

2. March 7, 1991, at 0820 PST: A new fuel assembly suspended over the core in the manipulator crane mast was manually moved to clear the core region.

3. March 7, 1991, at 0830 PST: An Unusual Event was declared due to loss of offsite power.

4. March 7, 1991, at 0900 PST: A 1-hour emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(3).

5. March 7, 1991, at 0930 PST: An action plan for recovery of offsite power was developed.

6. March 7, 1991, at 1011 PST: A 4-hour non-emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(2)(ii) and 50.72(a)(2)(iii).

7. March 7, 1991, at 1325 PST: The Unusual Event was terminated with offsite power restored from the 230 kV startup power system.

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D. Other Systems or Secondary Functions Affected:

1. Auxiliary building (NS) fans (VF)(FAN) could not be restarted after the vital busses were reenergized by the DGs.

   An electrical power supply for the auxiliary building ventilation control system (VF) failed after the event. Investigation determined that the voltage regulator (VF)(90) for the power supply and several capacitors (VF)(CAP) had failed. The failed components were replaced, and the loss of power event was simulated. The power supply responded normally.

2. The control room ventilation system shifted to Mode 4 when offsite power was lost. This constituted an engineered safety feature (ESF) actuation.

   At the time of the event, the normal power supply for Radiation Monitor RM-26 (IL)(DET) was out of service for maintenance, and the monitor was being powered from its backup power supply. RM-26 monitors radiation levels at the control room ventilation system intake. When power was lost to Unit 1, RM-26 was deenergized until vital power was restored from the DGs. When power was lost to RM-26, it alarmed as designed and initiated the control room ventilation system shift to Mode 4. The equipment functioned as designed.

3. Following the loss of Unit 1 AC power, the Unit 1 control room emergency lighting (FH) failed to function. Lighting was restored when the normal control room lighting distribution panel was cross-connected to the Unit 2 supply. Subsequently, a walkdown of the emergency lighting supply found that the manual transfer switch (FH)(HS) to the emergency lighting dimmer panel was selected to the backup source and not to the emergency inverter (FH)(INVT). The backup source is supplied off of 480 volt bus 12D, which is not powered from the vital bus, and thus was not available during the loss of AC power. The inverter for the DC power supply had previously failed and did not provide power to the control room emergency lighting. Corrective actions include issuance of an Operations Incident Summary, relabelling of the switch, and revision of procedures.

4. The FHB ventilation system transferred from the normal mode of operation to the iodine removal mode. This constitutes an ESF actuation.

   Radiation Monitor RM-59 (IL)(DET) was powered from Instrument AC panel PY-13 (PAN), which was powered from its back-up transformer (IL)XFMR). When offsite power was lost, the back-up transformer, and subsequently RM-59, lost power. When power was

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lost to RM-59, it alarmed as designed. The alarm on RM-59 initiated a transfer of the FHB ventilation system to the iodine removal mode. All equipment functioned as designed.

5. DG 1-1 started and loaded to its vital bus. During an NRC inspector's review of the annunciator (IB) printout, the failure of DG 1-1 to load to its vital bus within ten seconds of the event, as required by TS 4.8.1.1.2, was noted. DG 1-1 took approximately 19 seconds to start and load to the bus. This constitutes a non-valid failure of DG 1-1. The non-valid failure was reported as Special Report 91-02 in PG&E Letter No. DCL-91-079, dated April 8, 1991.

An investigation was conducted to identify the cause of the delay in loading. The investigation did not identify any problems with the DG starting and loading circuitry. The following actions were performed to identify the cause:

a. Surveillance Test Procedure (STP) M-13H, "4kV Bus H Auto Transfer Timers Setting Verification," was performed in an attempt to recreate the event prior to any maintenance activities. The STP tests the portion of the circuitry responsible for starting and loading the DG. During this test, the auxiliary power feeder breaker is manually opened. During the event, the auxiliary power feeder breaker opened automatically due to the loss of power. The DG loaded to its vital bus within ten seconds. The STP did not identify any problems.

b. STP M-15, Part B, "Integrated Test of Engineered Safeguards and Diesel Generators," was performed three times. This STP tests the circuitry responsible for starting and loading the DG, and automatically opens the auxiliary power feeder breaker on a safety injection (SI) signal. All portions of the circuitry that actuated during the event, except for the auxiliary breaker opening automatically, were tested during this STP. The DG started and loaded onto its vital bus within ten seconds each time. The STP did not identify a problem with the circuitry. Visicorder traces of the relays in the circuitry were obtained. No anomalies were noted on the traces.

c. During the first performance of STP M-15, Part B, an inconsistency was noted in the annunciator printout for the sequence of events.

One inconsistency was the clearing of an undervoltage alarm on one DG prior to the alarm registering. The other inconsistency was that the sequence of events was not printed in chronological order.

The annunciator printout and system software were reviewed to determine if a problem existed. The review concluded that no problems existed with the annunciator.

d. The starting circuitry sequence was reviewed. During the event, it was determined that since the load shed relay (27XHHT) (EK)(RLY) was actuated, the first level undervoltage circuitry worked as designed. The problem occurred downstream of the load shed relay. The circuitry subsequently functioned satisfactorily four times, once during performance of STP M-13H and three times during performance of STP M-15, Part B.

   The relays and switches in the DG 1-1 feeder breaker closing circuit were reviewed to ascertain if there was proof that they functioned correctly, or if they could have delayed the closing of the DG onto the vital bus. All those relays which could have functioned incorrectly were tested by the STPs performed subsequent to the event and functioned correctly.

e. The loss of offsite power event was reviewed against STP M-15, Part B, to determine differences between the test and the event. The review identified several differences:

   1. A 300 MW ground fault occurred during the event. This condition cannot be safely recreated.

   2. The 230 kV startup power system was unavailable due to maintenance at the time of the event.

   3. The DG started due to a loss of power signal during the event. During STP M-15, Part B, the DGs started as the result of an SI signal. Both the loss of power signal and the SI signal test the same DG start circuitry.

   The change analysis did not identify any differences between the loss of offsite power and the performance of STP M-15, Part B, that could be recreated.

Investigation into the problem failed to identify any possible cause for the failure of DG 1-1 to load to its vital bus within ten seconds. The DG 1-1 problem could not be recreated.

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6. Two fuel elements (new) were being manipulated inside containment at the time of the loss of offsite power event (one assembly was in transit in the manipulator and one assembly was in the upender). Investigation determined that, although not optimal, the configuration was acceptable.

7. A number of minor equipment problems occurred in Unit 2 during the loss of offsite power event. The more significant include:

   a. Alarms activated for several channels of the Units 1 and 2 vibration and loose parts monitors (VLPM). Investigation determined that the alarms resulted from the VLPM being powered from Unit 1. The power loss to Unit 1 caused a momentary voltage transient in the VLPM, which caused the alarms to activate. The alarms were reset, and it was determined that the function of the VLPM was not impacted.

   b. The Units 1 and 2 intake traveling screen wash controls became inoperable during the loss of offsite power event.

      The controls for both units are powered by Unit 1 non-vital power. As a result, the power loss to Unit 1 caused the screen wash control for both units to be temporarily lost.

      Design changes are being developed to provide methods for powering the screen wash controls from their respective units.

   c. Units 1 and 2 lost power to the instrument air system air dryers during the loss of offsite power event.

      Design changes were implemented to provide cross connect capability between instrument air and service air dryers and to provide backup vital power to the instrument air dryers. A design change is being developed to replace the temporary service air compressors with permanent compressors.

8. At the time of the loss of offsite power event, coping strategies did not exist to provide guidance on the restoration of power or cooling during refueling operations.

   In response to the need for baseline coping strategies, abnormal operating procedures were developed to provide guidance to operators on restoration of power or cooling during Modes 5 (Cold Shutdown) and 6 (Refueling).

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E. Method of Discovery:

The loss of offsite power event was immediately apparent to plant operators due to alarms and indications received in the control room and the loss of lighting in Unit 1.

F. Operators Actions:

1. Operations personnel suspended fuel movement in the FHB and containment.
2. Equipment designed to auto-start was verified to be running.
3. RHR Pump 1-2 was manually restarted. The pump is not intended to automatically restart after vital bus transfer in Mode 6.
4. The manipulator crane was manually moved away from the core region.
5. Spent Fuel Pool Cooling Pump (DA)(P) 1-2 was restarted. The pump is not intended to automatically restart after vital bus transfers.
6. Plant busses were reconfigured to restore offsite power from the 230 kV startup power system.

G. Safety System Responses:

1. DGs 1-1, 1-2, and 1-3 started and loaded to supply power to vital busses.
2. ASW Pump 1-2 restarted on bus transfer. ASW Pump 1-1 was cleared for maintenance.
3. All CFCUs auto-started on bus transfer.
4. CCP 1-2 auto-started on bus transfer. CCP 1-1 was cleared for maintenance.
5. CCW Pumps 1-1, 1-2 and 1-3 auto-started on bus transfer.

All equipment functioned as designed.

III. <u>Cause of the Event</u>

A. Immediate Cause:

The immediate cause of the loss of offsite power was the grounding of the 500 kV line through the boom of the mobile crane.

B. Root Cause:

The root cause was determined to be personnel error (cognitive) in that the crane operator and the foreman did not follow the accident prevention rules and did not recognize the electrical safety issues during job planning and execution.

C. Contributory Cause:

The contributory causes were determined to be:

1. Work practices did not require a clearance for crane operation in the area of energized high voltage lines or transformers.

2. The evaluation by PG&E of NRC Information Notice 90-25, "Loss of Vital AC Power With Subsequent Reactor Coolant System Heat-up," and NUREG-1410 and the resulting corrective actions were ineffective in precluding this event. While PG&E had evaluated the events described in these reports, as a result of the method used to prioritize corrective actions identified through PG&E's operating experience assessment program the proposed actions had not yet been presented to management for approval.

3. Communication in the tailboard prior to beginning installation of the relief valve was not adequate to provide necessary job safety information to the foreman or crew.

4. Training was not adequate on electrical safety issues for non-electrical workers.

IV. <u>Analysis of the Event</u>

A. Safety Analysis:

During the event, RHR capability was lost for less than one minute, and the spent fuel pool pumps were inoperable for approximately 23 minutes. One pump was manually restarted. During the time the pumps were not running, the calculated maximum temperature rise was approximately 1.8 degrees Fahrenheit. There was no loss of inventory in the refueling cavity or the spent fuel pool.

In Mode 6, the purpose of the RHR system is to remove decay heat from the fuel assemblies in the reactor vessel (AB)(RPV). The purpose of the spent fuel cooling pumps is to remove decay heat from spent fuel elements.

When the event occurred, all but five fuel assemblies had been loaded into the core. With the RHR and spent fuel cooling pumps inoperable, the water temperature in the refueling cavity would begin to increase

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approximately 4.6 degrees Fahrenheit per hour. It was determined that, if the water in the refueling cavity was at 90 degrees Fahrenheit initially and if the cycle 5 core had been completely reloaded at the time of the event, it would have taken approximately 26 hours for the water in the refueling cavity to begin to boil. This time conservatively assumes that no heat transfer to the concrete or to the atmosphere occurs.

If the event had occurred at the beginning of the outage, and the entire cycle 4 core had just been unloaded into the spent fuel pool, the heat input to the water in the pool would have been approximately 12 MW. Assuming the water was initially at 90 degrees Fahrenheit and the pool level was at the 137 foot elevation, it would take approximately 8 hours for the water in the spent fuel pool to begin to boil if all power was lost to the unit. This time conservatively assumes that no heat transfer occurs from the water to the pool liner or the atmosphere.

Had the DGs not started or had they been unavailable, power to the RHR pumps would have had to be supplied through the offsite power system. It took approximately 5 hours to restore offsite power from the 230 kV system. This would provide for restoration of the RHR pumps prior to boiling of the water in the refueling cavity with either the cycle 4 or cycle 5 core in the reactor vessel. If the event had occurred at a time when the 230 kV system could not have been quickly restored, conservative estimates concluded that offsite power from the 500 kV system could have been restored in approximately 4 hours using emergency maintenance procedures. This estimated time includes initial operator response to the event, removing the crane from the vicinity of the 500 kV lines even if the crane had been rendered inoperable by the event, removal of grounds from the line, and switching to restore power. The four hours estimated to restore offsite power, and subsequently RHR, from the 500 kV system is less than the time required to boil the water in the refueling cavity.

Since the water in the reactor cavity or spent fuel pool would not have boiled prior to cooling being restored, and therefore inventory would not have been depleted, the health and safety of the public were not significantly affected by the event.

V. Corrective Actions

A. Immediate Corrective Actions:

1. An Event Investigation Team was convened to investigate the problem.

2. Offsite power was restored via the 230 kV system.

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3. All outage work was suspended for a period of 24 hours.

4. A letter from the Senior Vice President and General Manager was issued to all plant personnel emphasizing safety on the job.

B. Corrective Actions to Prevent Recurrence:

1. All appropriate plant and construction personnel have been trained on the electrical safety portions of the PG&E accident prevention rules.

2. Administrative Procedure (AP) C-40S3, "Use of PIMS Corrective Maintenance Work Order Module," has been revised to provide guidance for preparing for work activities in the vicinity of power lines or transformers, including clearances required.

3. Areas in the vicinity of high voltage lines and transformers within the protected area have been posted and barriers provided to assure that vehicular and equipment access are appropriately controlled.

4. Precautions and actions involved for safe work activities around high voltage lines, transformers, and switchgear have been included in General Employee Training.

5. The maintenance training program has been revised to include electrical safety issues when working on or around transformers, high voltage lines, or switchgear.

6. The Maintenance Supervisory training course currently includes tailboard training. A memorandum has been issued by the Plant Manager to reemphasize the importance of conducting thorough tailboards.

7. AP C-14, "Dissemination of Operating Experience," which describes the operating experience assessment process, has been revised to include an initial team review of operating experience. The team review will prioritize and scope response to ensure timely and complete recommendations to management.

8. Procedures have been issued to control power sources and to identify limitations during refueling outages.

Further investigation identified no additional corrective actions.

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VI. Additional Information

A. Failed Components:

None.

B. Previous LERs:

None.