U.S. NUCLEAR REGULATORY COMMISSION

REGION V

AUGMENTED INSPECTION TEAM (AIT) REPORT

Report No 50-275/91-09
License No. DPR-80
Docket No. 50-275

Licensee: Pacific Gas and Electric Company
77 Beale Street
San Francisco, California 94106

Facility Name: Diablo Canyon Nuclear Power Plant, Unit No. 1

Inspection at: Diablo Canyon Site
San Luis Obispo County, California

Inspection Conducted: March 8-13, 1991

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Inspection Summary:

Inspection on March 8 - 13, 1991 (Report No. 50-275/91-09)

Areas Inspected: Augmented Inspection Team (AIT) examination of the circumstances associated with a complete loss of off-site power to Diablo Canyon Unit 1 during core reload at the end of a refueling outage.

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INSPECTION DETAILS

I. INTRODUCTION - MANAGEMENT SUMMARY AND EVENT OVERVIEW

A. Purpose and Scope of the AIT Inspection

This report presents the findings of an NRC Augmented Inspection Team (AIT) examination and evaluation of a loss of off-site power (LOP) event which occurred on March 7, 1991 at the Diablo Canyon Unit 1 reactor facility.

The decision to dispatch an AIT was made by NRC management based on the similarities to the Vogtle event (in March 1990), which resulted in a loss of power and a complete loss of core cooling for one and one-half hours at the Vogtle site. Other issues which supported the formation of an AIT included; (1) concern over management controls of Diablo Canyon outage activities, (2) questions regarding the effectiveness of licensee actions following the Vogtle event, and (3) possible generic implications for the conduct of outage activities.

The AIT consisted of three Region V staff personnel augmented by three Headquarters technical experts. The AIT Charter, which is included in Appendix A, directed that the team verify the circumstances and evaluate the significance of the LOP event. The inspection was conducted during the period March 8 through March 13, 1991. An entrance meeting was held with licensee management on March 9, 1991 at the plant site. The exit meeting was held on March 13, 1991 at the plant site. Appendix B provides a list of the attendees at these meetings.

B. Inspection Methodology

The inspection was conducted by reviewing licensee records, interviewing licensee personnel, and inspecting selected portions of the plant. Charts, logs, written statements, procedures, memos, action requests, quality evaluations, and non-conformance reports were reviewed. Appendix D contains a list of documents examined or referenced by the team. Appendix E summarizes the AIT's review of the Licensee's Policies and Procedures related to control of outage activities.

Following the initial review, involved licensee personnel were interviewed including: the licensed operators on shift, the personnel using a crane near the 500 kV line that shorted, licensee managers, and outage planning personnel. Fact finding was emphasized. Additional interviews and follow-up were conducted as appropriate. Region V management was briefed on a daily basis concerning the progress of the inspection and any potentially generic issues.

C. Loss of Power Event Outline

Diablo Canyon Unit 1 had been in its fourth refueling outage, beginning February 1, 1991, and had entered mode 6 on February 5, 1991. Early in the outage the core was off-loaded to the spent fuel pool. Reloading of the core was commenced on March 3, 1991.

On March 7, 1991, at 8:07 a.m., Diablo Canyon Unit 1 experienced a total loss of off-site power. This event was due to a mobile crane, with the boom about three feet from a 500 kV line, inadvertently causing an air arc of the Unit 1 phase 'A' 500 kV supply to ground. The Unit 1 standby startup transformer had been deenergized for outage maintenance, and the main transformer was supplying plant power by back-feeding off-site power from the 500 kV switchyard.

At the time of the event, refueling was nearly complete with the reactor cavity filled with borated water and 188 of the 193 fuel bundles placed into the core. The emergency diesel generators started and provided power to the Unit 1 safety related busses. Operation of the residual heat removal (RHR) system to cool the core was interrupted for about one minute. No core heat up or radiological release was observed. Unit 2 was generally unaffected and continued to operate at 100% power.

The licensee declared an Unusual Event (UE) and made notifications to off-site agencies and the NRC. The licensee elected not to staff the Technical Support Center (TSC) and to use normal plant procedures to restore power. The workers in the vicinity of the arc were unhurt. While being monitored by the NRC resident inspectors, the licensee completed clearances and inspections to restore an off-site power supply. Subsequently, off-site power was restored at approximately 1:00 p.m., and the UE was terminated at 1:25 p.m.

The AIT was formed on March 7 and was dispatched to the site on March 8. Badging and training of NRC personnel were completed the evening of March 8 at the Diablo Canyon site. The entrance meeting was held with licensee management at 8:00 a.m. on March 9, 1991.

D. Major AIT Conclusions

The licensee missed an opportunity to avoid the event by not implementing a lesson learned from the Vogtle event in that vehicle traffic around plant off-site power supplies was not controlled.

The licensee's policy to avoid mid-loop operation appears to have had a positive safety effect and to have actually simplified the outage activities. The licensee's schedule has been constructed so that mid-loop operations would only be used if needed at the end of an outage when decay heat is low. The loss of off-site power or loss of RHR is much less significant with this strategy.

The emergency operating procedures (EOPs) and abnormal operating procedures (AOPs) were generally prepared for the plant operating at

power. It appears that there was some difficulty in implementing the appropriate EOPs and AOPs, since much in these procedures was not applicable during refueling. Additional procedures or revisions to existing documents may be necessary. This appears to be a generic issue.

In addition, little attention had been given to the potential for a loss of cooling of the spent fuel pool, which may have a very high heat load shortly after defueling of the reactor core. It appears that new procedures or written strategies for maintaining adequate spent fuel pool cooling are in order. This appears to be a generic issue.

Outage management was generally effective, but policies and guidance have not been centralized or formalized in one document. The licensee did have draft outage policies and procedures which had not been implemented. These documents appeared to be a step in the right direction, although the team felt they were not comprehensive and needed a higher level of management approval.

II. EVENT DESCRIPTION

A. Background

Diablo Canyon is generally a second generation standard Westinghouse 1200 MWe nuclear plant. Figures C-2 and C-3 of Appendix C of this report, depict the plan view of the facility.

On February 1, 1991 after a unit trip, Unit 1 entered refueling outage 1R4 (Unit 1, fourth refueling). The unit entered mode 6 operation on February 5, 1991.

(1) Electrical Systems

Diablo Canyon is a two unit plant. Figures C-4 and C-5 of Appendix C depict the plant electrical single line diagram. Each unit has one 25 kV main generator feeding three single phase 500 kV/25 kV transformers (A, B, & C) which together comprise the main transformer. Each main generator also feeds two auxiliary transformers; one for reactor coolant pumps and large loads (12 kV) and the other (4 kV) for all other plant loads. There is a motor-operated disconnect switch between the generator and the main transformer to allow disconnecting the generator from the 25 kV bus. This allows backfeeding of power from the 500 kV system through the main and auxiliary transformers. There are also two 230 kV/12 kV three phase standby startup transformers, Nos. 1-1 and 2-1 feeding, respectively, one 12 kV standby startup bus for each unit. The Unit 1 and Unit 2 standby startup busses can be cross connected through a 12 kV tie breaker. Each unit's 12 kV standby startup bus feeds the unit's 4 kV engineered safety busses (F,G, and H) and 4 kV auxiliary buses (D and E) through a 12 kV/4 kV three phase standby startup transformer (No. 1-2 for Unit 1 and No. 2-2 for Unit 2). Each unit is provided with two emergency 4 kV diesel generators. A fifth

diesel generator, No. 1-3, is a swing generator between the two units to provide emergency power to bus 1F or 2F. In the event of a loss of any diesel generator, cross tie breakers could allow its associated bus to be powered from another diesel generator in the same unit.

(2) Cooling Systems

The ultimate heat sink is salt water from the Pacific Ocean, which is supplied by four auxiliary salt water (ASW) pumps (numbered 1-1, 1-2, 2-1, & 2-2) in the intake structure. The discharge of each unit's two dedicated ASW pumps is normally cross connected so that one normally running pump will keep the unit's ASW piping full of water. The Unit 1 and Unit 2 ASW systems can be cross connected either from the control room or manually.

In each unit ASW provides cooling to the component cooling water (CCW) system, which has two heat exchangers and three pumps. For plant safety purposes, the CCW System is separated into two safety related trains and a non-safety related train. The safety related portions of the CCW System provide cooling to the two residual heat removal (RHR) heat exchangers and to the two spent fuel pool cooling (SFPC) heat exchangers. There are two RHR and two SFPC pumps for each unit. The CCW, RHR, and SFPC systems are not cross connected between units. During outages the RHR system is operated to remove decay heat from the core while it is in the reactor vessel. The SFPC system is operated to remove decay heat from the spent fuel pool and to maintain the fuel pool water chemistry. Table C-1 of Appendix C lists the major relevant safety related components and their power supplies.

(3) Inoperable Equipment and Abnormal System Alignments

Maintenance was in progress on a variety of systems and equipment in Unit 1 such that some equipment was out of service and several systems were in abnormal configurations. However, most outage work on safety related components had been completed.

Following the plant scheduled outage plan, the 500 kV/25 kV main transformer for Unit 1 was taken out of service for maintenance on February 3, 1991. During this main transformer maintenance, the off-site power was fed to the Unit 1 12 kV standby startup bus through the 230 kV/12 kV standby startup transformer No. 1-1 and from the 12 kV standby startup bus to 4 kV busses D, E, F, G, and H through the 12 kV/4 kV standby startup transformer 1-2.

On completion of maintenance work on the Unit 1 main transformer, the transformer was put back in service on March 5 to feed the 12 kV auxiliary buses D and E and 4 kV auxiliary buses D and E through unit auxiliary transformers, Nos. 1-1 and 1-2. To enable this backfeed, the main generator was disconnected from the system by opening the motor-operated disconnect switch.

On March 6, the 230 kV/12 kV standby startup transformer No. 1-1 and the 12 kV/4 kV standby startup transformer No. 1-2 were taken out of service for maintenance. Also, 12 kV breakers and 4 kV breakers used to supply startup power to vital busses were taken out of service for maintenance. With this configuration, only one off-site power source was available to Unit 1; the main transformer backfeeding through the unit auxiliary transformers.

All three emergency diesel generators (which included the swing diesel generator, 1-3) were operable and in standby. Both RHR pumps were operable with RHR pump 1-2 in operation providing reactor core cooling. All three component cooling water (CCW) pumps were operable with two pumps operating to supply RHR heat exchanger cooling as well as other safety related loads. Only one auxiliary saltwater pump was operable, supplying cooling to the 1-2 CCW heat exchanger. Maintenance activities on ASW pump 1-1 were in progress.

The licensee was in the process of refueling the reactor core. At the time of the event, all but five fuel assemblies had been loaded into the core. One new fuel assembly was in the manipulator crane mast and was being positioned over the core for loading. A second fuel assembly was in containment and was horizontal in the transfer cart. Containment was closed in accordance with Technical Specification requirements for refueling activities.

(4) Incident Initiator

Between February 3 and March 5, with the 500 kV lines deenergized, a telescopic boom crane was used to lower a main steam safety valve, RV-5, from a pipe rack at elevation 118'. No specific instructions had been provided for the movement of the valve to and from the pipe rack. The preferred method of moving the valve, which had been used in the past, was by using the crane. On March 7, 1991, at a 6:30 a.m. morning schedule meeting, the valve maintenance foreman responsible for the installation of RV-5 confirmed that the utility foreman responsible for mobile cranes had a telescopic boom crane available. At about 7:00 a.m., the utility foreman scheduled a crew of two to lift valve RV-5. The first person of this crew was a tool clerk upgraded to a mechanic for the outage period. This person had about 1½ years experience on crane operation. He had attended a three day training course on crane operation and was a certified crane operator. He was knowledgeable of the licensee's physical clearance requirements for working cranes around electrical areas. The second person, a tool clerk upgraded to a rigger, was assigned to help in rigging and assisting the crane operator. The individual had no training for working in electrical areas and was not aware of the dangers involved. A third person, who was a pipe fitter, was assigned by the valve maintenance foreman to install valve RV-5. The pipefitter had no training for working in electrical areas and was not aware of the dangers involved. The two foremen had no special training for working with cranes or working in electrical areas although they were aware of the electrical clearance specified in PG&E Accident Prevention Rules. PG&E Accident Prevention Rule 39

requires a minimum crane clearance of 27 feet from energized 500 kV lines when hoisting a load.

On the day of the event, the space used by the cranes on previous occasions was occupied by compressors to be used for the containment integrated leak rate test. The crane operator placed his crane in the location shown on Figure C-1 of Appendix C.

Around 7:50 a.m., the crane operator proceeded to hoist valve RV-5. The utility foreman was present for the initial hoist. During this operation, the crane boom might have been as close as 3 feet from phase A of the 500 kV lines. The pipe fitter on the pipe rack handled the valve for about 10 minutes and then signalled the crane operator to lower the valve for more height adjustment. At this point, feeling uneasy about the proximity of the boom to the overhead lines, the utility foreman went to the nearest telephone to check the status of the lines with the control room. However, prior to the call, at 8:07 a.m., phase A of the 500 kV line flashed over with a loud bang. The crane ground cable, normally used for working in non-electrical areas, was inadequate for this type of event and was severely damaged.

The flashover of the 500 kV line initiated an immediate trip of the main transformer lockout relays, which tripped the 500 kV circuit breakers feeding power to the main transformers. In that the standby startup transformer for Unit 1 was deenergized for maintenance, these trips resulted in a total loss of off-site power to Unit 1. No individual was electrocuted or suffered physical harm.

During subsequent interviews, both the crane operator and utility foreman indicated that prior to the lift, the utility foreman had asked the crane operator if the lines were deenergized. The crane operator said that he thought the lines were deenergized. The utility foreman cautioned the crane operator to stay clear of the lines. Both individuals later indicated that they had assumed that these were the plant output lines, and since the plant was shut down, the lines would be deenergized.

B. Loss of Electrical Power and Recovery

(1) Loss of Electrical Power

At 8:07 a.m., the main output breakers opened, sensing a phase to ground fault. The following sequence occurred without operator action:

- o An auto transfer was initiated for the three vital busses. Transfer logic sensed the unavailability of the standby startup power source and initiated diesel generator start signals.

- o Non-vital power was lost. Unit 1 plant lighting was reduced to emergency AC and DC lights. The Unit 1 public address (PA)

system, as well as the refueling cranes in containment and at the spent fuel pool, lost power.

- Emergency loads sequenced onto the three vital busses as designed, except for auxiliary building ventilation. Diesel generator 1-1 energized its vital bus 20 seconds after the loss of off-site power, approximately 10 seconds slower than was required by design.

- Normal control room lighting, powered from non-vital power, was lost. Emergency control room AC lighting was lost due to a previously existing undetected switching error. Emergency DC lights and light from the adjacent Unit 2 control room illuminated the Unit 1 control room.

- The continuous intercom link with the refueling senior reactor operator (SRO), powered by the control room AC lighting power supply, was lost.

(2) Recovery

The control room staff assessed that the diesel generators had started and loaded. Since RHR pumps do not automatically load on a bus transfer, the control operator restarted RHR pump 1-2.

The control room staff's next actions were to assess the severity of the situation. The following concerns were addressed:

- The Operators became aware of the incident with the crane when the utility crew foreman phoned in on the emergency number. Safety and operations personnel were dispatched to assess possible injuries and the extent of damage to the main transformers and their output lines.

- Communications were established with the refueling SRO. When it became apparent that non-vital power would not be restored in short order, the decision was made to manually move the manipulator crane from its location over the reactor vessel.

- Recognizing that the auxiliary building ventilation system had not restarted after the bus transfer, operators attempted to restart it with no success. The decision was made to allow the fan motors to cool for ten minutes in case thermal overload protection devices were tripping the fan motor breakers. However, when attempts were made to start the system after the cool off period, the system again failed to start. The Shift Foreman requested that an auxiliary operator monitor the operating RHR pump room temperatures (of the operating auxiliary building pumps, the RHR pumps were in smallest rooms). The room temperature of the operating RHR pump stabilized approximately 15 to 20 degrees F higher than the room temperature of the RHR pump in standby.

- A review of emergency classifications was initiated approximately 10 to 15 minutes following the loss of off-site power. An off watch SRO, responding to the control room after the PA announcements, had been asked by operations management to review the event for reportability.

After the declaration of an Unusual Event, operations personnel initiated action to have phase A of the main tranformer inspected and initiated action to have maintenance crews restore the standby startup system to an operable status.

To allow the inspection of the main transformer, operations personnel initiated a clearance request, involving two breakers in the 500 kV switchyard and several breakers onsite, to prevent inadvertantly backfeeding the transformer. Once the clearance was established, the plan was to move the mobile crane, inspect the phase A transformer, and finally remove the clearance and energize the transformer.

A parallel path was initiated to reestablish standby startup power from the Unit 2 crosstie breaker. Ultimately, this was the successful path. Within an hour of the loss of off-site power, maintenance crews were asked to return equipment to the as-found condition. Three relays and several breakers, which had been removed for maintenance, were reinstalled. One breaker, needed to reestablish off-site power to non-vital 4 kV busses, was being disassembed, and a spare breaker had to be installed.

Operations initiated formal documentation to restore breakers to their position, providing a switching log for each breaker, and drafted a "formal commumunication" to provide switch sequencing. In subsequent interviews, operations personnel indicated that they felt that with the three operable diesel generators, the plant status was stable, allowing them to establish a documented methodical recovery plan.

By 10:20 a.m., maintenance had restored necessary equipment, and operations began restoring necessary clearance points. At 12:11 p.m., operations initiated switching to reestablish off-site power. By 12:39 p.m., power had been restored to non-vital equipment and by 1:00 p.m., off-site power was restored to vital busses. The diesel generators were then shutdown and placed in automatic.

(3) Short Term Licensee Actions

The Vice President of Diablo Canyon Operations and Plant Manager sent a letter to the Regional Administrator of NRC Region V (Reference 16) describing some of the short term corrective actions being taken by the licensee.

The licensee instituted a 24-hour outage suspension. The purpose of the suspension was to allow plant employees to reflect on and evaluate all work activities to ensure that the performance of those

activities would be done in a safe manner. The outage suspension was also put in place to permit plant employees to evaluate personnel safety practices and the potential effect that individual work practices might have on plant safety. First line supervisors were asked to communicate to their employees the importance of safe work practices at Diablo Canyon.

The licensee also prepared an Event Response Plan and formed an Event Investigation Team (EIT) following the loss of off-site power (Reference 31).

The Vice President of Diablo Canyon Operations and Plant Manager issued a policy statement to Outage Managers on removing from service one of two off-site power sources during the remainder of the Unit 1 refueling outage (Reference 35). This policy outlined Outage Manager, Shift Foreman, Balance of Plant Coordinator, and Electrical Maintenance General Foreman involvement with any work which could, either directly or indirectly, affect a single operable off-site power source. The policy addressed work activities related to the single operable power sources and included all major electrical components and both the 230 kV and 500 kV switchyards. It required strict adherence to PG&E's Accident Prevention Rules and imposed additional restrictions on the use of telescopic boom cranes.

Operating Shift Orders were issued regarding the availability of equipment and power sources for the upcoming refueling cavity draindown (Reference 12). This specified in part that:

- Where two operable RHR trains are required, the operating philosophy shall be to maintain sufficient equipment in service to ensure an adequate heat removal capability for the reactor and the spent fuel pool, assuming a loss of the normal off-site power source in addition to a failure of one of the operable diesel generators.

- For each component in the heat removal train (ASW, CCW, RHR, and SFPC pumps), two power sources will be required to be available to each of the redundant components. If one of the redundant pumps other than RHR is out of service, it will be acceptable to drain down provided that an off-site and two onsite power sources are available for the operable pump. Two onsite power sources means the associated diesel and the capability to crosstie the associated vital bus to another diesel.

C. Equipment Problems

Several plant equipment problems resulted from the loss of off-site power. Although the problems did not significantly affect the licensee's response to the March 7 event, given other circumstances some of the problems could have had a significant effect. With the exception of the diesel generator slow start, all the problems were

identified by the licensee. The equipment problems were also addressed by the licensee EIT. At the conclusion of the AIT, several of the problems had not been resolved. Followup of the licensee's corrective actions will be accomplished through the routine NRC inspection program.

(1) Loss of Control Room Lighting

Control room emergency AC lighting, which has an uninterruptible vital power supply, did not not operate following the loss of off-site power. Additionally, the intercom link with containment refueling operations, which was powered by control room lighting, was interrupted. Control room lighting was restored by approximately 8:30 a.m. when operations personnel switched normal control room lighting power to its alternate Unit 2 power supply.

It was subsequently discovered that a switching error had aligned control room emergency AC lighting with non-vital 480V power. During the vital bus H outage, which is the preferred power source for emergency control room lighting, the decision was made to switch to the non-vital secondary power supply. This prevented the uninterruptible power supply battery from draining down while vital bus H was deenergized. Apparently, this action was not tracked by a licensee procedure or the clearance request, and as a result the power supply was not switched back to the uninterruptible source when vital bus H was returned to service on February 21, 1991.

The licensee was addressing the switching error in their EIT followup (licensee Quality Evaluation Q0008663). This error will be followed up in a routine inspection (Open Item 50-275/91-09-01).

(2) Loss of Auxiliary Building Ventilation

The auxiliary building ventilation system (ABVS) fans did not automatically restart after the vital busses were reenergized by the diesel generators. The fans could not subsequently be restarted by operators. As discussed in Section II.B.(2), operators monitored operating pump room temperatures to ensure room temperature limits were not exceeded. In subsequent interviews and statements, operations personnel indicated that it became clear that room temperatures were not an immediate concern, providing time for a more thorough evaluation.

At approximately 1 p.m., the Shift Foreman authorized operations personnel to fail open two suction dampers for the E-1 exhaust fan and then turn the exhaust fan on, essentially overriding the control logic. This provided an exhaust path which reduced concerns of a potential increase in airborne radiation contamination. The Shift Foreman elected not to attempt the same type of action on a supply fan since that would entail changing the state of a number of dampers and would put the ventilation system into a unreviewed configuration. The Shift Foreman stated later that had room

temperatures become a concern, the realignment of the ABVS supply train could have been attempted.

At 3:15 p.m., I&C technicians deenergized and then reenergized the ABVS control logic panel. The system was subsequently started and it functioned as designed.

I&C preliminarily determined that the most likely cause of the failure of the ABVS to restart was that one of four power supply regulators for the ABVS control logic had not reset after the reenergization of its power input. I&C's conclusion was supported with manufacturer's data which indicated that this could happen under certain conditions, including a restart after a loss of control logic power. Subsequent to the event, licensee personnel replaced several capacitors in the ABVS control system power supply and tested the ABVS control system to ensure it was operating correctly.

The ABVS control logic is normally powered by a vital instrument AC inverter which is supplied by a battery. However, the inverter was out of service for outage maintenance, and the backup vital power supply (which did not have battery backup) was supplying the distribution panel. Therefore, while the ABVS control logic does not normally experience a loss of voltage during a bus transfer, it did during this event.

The Auxiliary Building ventilation system's failure to start could have been a much larger problem early in the outage. If the reactor coolant system had been higher in temperature when the ventilation system failed to restart, it appears that there could have been a substantial heat load in some plant locations. Consequently, the operators would have needed to restart the ventilation system manually. The failure of the ventilation system while the plant was relatively cold was fortunate in disclosing a problem which could have been much more significant. ABVS control system failure will be followed up in a routine inspection. (Open Item 50-275/91-09-02)

(3) Emergency Lighting and Communication

The loss of off-site power resulted in the loss of normal plant lighting, which is powered from non-vital busses. Additionally, the PA system was rendered inoperable for Unit 1. Although the loss of normal lighting and the loss of the PA system did not adversely affect the response to the event, the licensee was concerned that response could have been impaired had a loss of power occurred under less favorable conditions (i.e. while the unit was at power or at night).

Operations took advantage of the loss of power condition and performed a walkdown of plant areas to identify plant lighting weaknesses. The EIT action plan included action to investigate plant lighting problems and to address the power supply to the Unit 1 PA system. The results of the EIT action plan for these two items

will be followed up in a routine inspection (Open Item 50-275/91-09-03).

(4) Diesel Generator 1-1 Slow To Load

Diesel Generator 1-1 energized its vital bus 20 seconds after it received a start signal, 10 seconds slower than design. The slow start was identified by the AIT during a review of the sequence of events. The licensee declared the diesel generator inoperable on March 11, 1991, after the slow start was brought to their attention.

During subsequent testing of diesel generator 1-1, the licensee was unable to duplicate the slow start. A nonconformance report was initiated to address the failure of the licensee's review process to identify the slow diesel generator start and its cause (NCR DC1-91-TN-N032). This failure will be followed up in a routine NRC inspection. (Open Item, 50-275/91-09-04)

(5) Equipment Problems at Unit 2

A number of minor equipment problems occurred at Unit 2 as a result of the loss of Unit 1 off-site power.

- Failure alarms were received on the Unit 2 containment hydrogen monitors and the control room pressurization system chlorine detectors. The failure alarms were reset and the monitors subsequently operated as designed.

- Alarms were initiated on several channels of both the Unit 1 and Unit 2 vibration and loose parts monitors.

- The intake traveling screen wash control for both Unit 1 and Unit 2 were powered by Unit 1 non-vital power. As a result, Unit 2 screen wash control was temporarily lost during the event. This problem had been recognized the week prior to the event when screen wash control for Unit 2 was lost when a Unit 1 bus was deenergized for maintenance. A temporary modification, used during the bus maintenance, was reused to reenergize Unit 2 screen wash control.

- Although power to the instrument air compressors was split between Unit 1 and 2 non-vital power, the air dryers for both units were powered by Unit 1 non-vital power. During the event, the dew point was monitored, and the air header was blown down for water. This problem had been previously identified by the licensee, and a design change had been written.

These problems were being addressed by the licensee's EIT.

D. <u>Administrative Control Problems</u>

(1) Determination of an Unusual Event

Licensee emergency procedure EP G-1 requires that a loss of off-site power be declared an Unusual Event. The loss of off-site power occurred at 8:07 a.m., and the declaration of Unusual Event was made 23 minutes later at 8:30 a.m. The NRC and the licensee's EIT questioned the timeliness of the declaration of Unusual Event.

The licensee's EIT concluded that;

"The classification of the event was done accurately and in a timely manner considering the amount of data that had to be assimilated and confirmed to assure this event did not require an elevated classification."

The concerns of the control room staff included;

- o The status of RHR cooling.
- o The medical response and notifications.
- o Securing and evaluating refueling operations.
- o The availability of off-site power (i.e. could off-site power be restored with limited action or, as was the case, were time consuming efforts required).

The licensee contacted the County of San Luis Obispo, who concurred that the incident was handled appropriately. The county was concerned with followup information, such as the announcement of the NRC AIT which was received through another source. The county's concern was being addressed by the licensee's EIT.

(2) Two New Fuel Elements in Transit Inside Containment

The loss of off-site power occurred with two new fuel elements in transit inside containment; one in the manipulator crane mast positioned over the core, and one horizontal in the fuel transfer cart. The licensee questioned the practice of having two fuel assemblies in transit inside containment. If the refueling cavity lost inventory, such as through a failed refueling cavity seal or failed steam generator nozzle dam, the configuration of fuel assemblies in transit would require that the assembly in the manipulator be either set in the core or placed in the fuel transfer cart. To place the assembly in the cart would have required that the fuel assembly already in the cart be transferred to the spent fuel pool.

The licensee reviewed operating procedures and previous commitments made as a result of industry experience with loss of refueling cavity inventory events (NRC IEB 84-03 and INPO SOER 85-01). The licensee concluded that refueling practices were consistent with procedures and that practices for control of fuel assemblies in transit were consistent with those used during the first refueling outage. Additionally, the licensee found that refueling practices

were consistent with the industry and that refueling with the fuel transfer cart empty while moving an element to the core did not significantly enhance safe refueling. However, the licensee was considering a change to fuel loading procedures to "slow down" fuel movement by keeping the fuel transfer cart empty while moving fuel to the core.

Additionally, plant reactor engineering determined that a commitment made based on INPO SOER 85-01, had not been implemented. The INPO SOER recommended that plants in areas with high seismic potential consider providing an alternate power source for the refueling cranes. The licensee stated in an 1986 internal memorandum that an emergency procedure would be written which would address placing fuel assemblies in a safe location during a loss of refueling cavity inventory concurrent with a loss of power. The loss of power aspect was never implemented in procedures.

The licensee has committed to address outage procedure guidance by their EIT, including actions to be taken in the event of a loss of off-site power while moving fuel. The licensee's actions to change refueling procedures will be examined in a routine inspection. (50-275/91-09-05)

E. Radiological Effects

The event had no significant radiological effect and no release occurred as a result of the event. The 85' Access Control for the radiological controlled area (RCA) lost power to normal lighting and radiation monitors (PCMs). Emergency lighting was energized within approximately one minute and workers exiting the RCA were sent to the 140' Access Control to frisk out. Radiation Protection personnel evacuated nonessential personnel from the containment and the RCA. The failure of the auxiliary building ventilation system to restart may have allowed some increase in local airborne concentrations, however no regulatory or administrative limit was reached.

F. Safeguards Effects

There were no untoward safeguards effects as a consequence of this event. The security standby diesel generator started properly. Card readers and intrusion alarms functioned properly.

III. TIME LINE OF THE EVENT

The following time line was developed from a variety of sources including; plant logs, written statements by licensee personnel (References 25, 26, 27, and 28), the licensee's EIT work, and interviews with personnel.

DATE/TIME	DESCRIPTION
February 1, 1991, 9:09 a.m.	Outage 1R4 begins

February 2, 1991, 2:00 p.m.	Enter mode 5
February 3, 1991, 1:00 a.m.	Main transformer deenergized
February 5, 1991, 2:32 p.m.	Enter mode 6
February 10, 1991, 10:00 p.m.	Core off-load completed
March 3, 1991, 11:59 p.m.	Core reload started
March 5, 1991, 11:27 p.m.	Main transformer energized
March 6, 1991, 1:00 a.m.	Start-up transformers deenergized
March 7, 1991, 6:00 a.m.	At General Maintenance Foreman's morning meeting decision reached to go ahead with valve (RV-5) installation work
March 7, 1991, 7:00 a.m.	Valve installation crew started work
March 7, 1991, 7:50 (approx.) a.m.	Utility Crew Foreman at work site, valve picked up.
March 7, 1991, 8:07 a.m.	500 kV line flashed over
March 7, 1991, 8:07:05 a.m.	Main transformer tripped
March 7, 1991, 8:07:06 a.m.	Generator breaker tripped
March 7, 1991, 8:07:06 a.m.	Diesels 1-1, 1-2, and 1-3 cranked
March 7, 1991, 8:07:14 a.m.	Diesels 1-2 and 1-3 fed 4 kV buses G and F
March 7, 1991, 8:07:25 a.m.	Diesel 1-1 fed 4 kV bus H
March 7, 1991, 8:30 a.m.	Unusual Event announced
March 7, 1991, 12:35 p.m.	4 kV buses 11D, 12D and 13D energized from off-site power source
March 7, 1991, 1:00 p.m.	4 kV buses F, G and H energized from off-site power and diesels 1-1, 1-2, and 1-3 deenergized
March 7, 1991, 1:25 p.m.	Unusual Event terminated
March 7, 1991, 6:14 p.m.	Refueling completed

TIME/DESCRIPTION

March 7, 1991, 7:00 a.m. (approx)

A mobile boom crane traveled under the Unit 1 main generator transformer output lines to get into a position to lift a main steam safety valve to the Unit 1 pipe rack. After rigging the valve, the crane was positioned under the main transformer phase A 500 kV lines.

7:50 a.m. (approx)

The crane operator lifted the safety valve to the pipe rack where a pipe fitter was waiting to install the valve. The crane operator positioned the boom such that the boom arm was within 3 to 5 feet of the 500 kV lines. From this point forward, the proximity of the boom arm to the output lines did not change.

8:06 a.m. (approx)

The pipe fitter, after handling the safety valve, observed that it could not be landed on the pipe rack as rigged and signaled to the crane operator to retract the boom arm.

8:07 a.m.

As the safety valve cleared the pipe rack, the 500 kV phase A output line arced to ground. The ground path was from the output line to the boom, through the mobile crane, and through a grounding strap.

The main generator output breakers opened, sensing the momentary ground.

The three vital busses initiated an auto transfer. The diesel generators received a start signal.

Emergency control room AC lighting was lost due to a previously existing undetected switching error. Emergency DC lights and light from the adjacent Unit 2 control room illuminated the Unit 1 control room.

The intercom link with the refueling SRO was lost since it was powered by the control room AC lighting power supply.

8:08 a.m. (approx)

The Unit 1 control operator (CO) manually started RHR pump 1-2 which by design does not automatically reload on a bus transfer.

The Unit 1 Senior Control Operator (SCO) made a PA announcement to suspend fuel movement. However, since the Unit 1 portion of the PA system is powered by non-vital Unit 1 power, the announcement was

never heard in Containment. Regardless, refueling operations had ceased when power was lost to the refueling manipulator crane.

8:09 a.m. (approx)

The CO verified that all equipment which is designed to start automatically was running.

8:10 a.m. (approx)

The utility crew foreman, responsible for the crew using the crane, activated the fire alarm by phoning the emergency number. He reported the incident and informed the control room that the crane operator did not appear to be injured.

8:12 a.m. (approx)

The SCO made a PA announcement regarding the crane accident and informed personnel to stay clear of the area. The announcement was not heard in Unit 1 due to loss of normal plant lighting, which powers the PA system in each unit. Fuel handling in Unit 1 stopped due to loss of normal lighting.

8:14 a.m. (approx)

Plant operations management and the NRC resident inspector arrived at the control room.

8:15 a.m. (approx)

The CO reset the auto transfer relays for the vital busses and stopped the operating high head injection pump, and four of five containment fan cooler units.

The SCO made a plant announcement that non-vital power for Unit 1 was not available and informed personnel to place workstations in a safe condition.

8:20 a.m. (approx)

After telephone conversations with the control room, the refueling SRO determined that power would not be restored for an extended period and took action to manually move the manipulator crane clear of the core.

A SRO, responding to the control room, was directed by the Operations Manager to review reportability requirements.

8:25 a.m. (approx)

The SRO reviewing reportability requirements found that a loss of off-site power should be classified as an Unusual Event. This was

reported to the Shift Supervisor (SS), the Operations Manager, and the Assistant Plant Manager, Operations.

8:30 a.m.

Operations management, after discussing the applicability of the reporting requirements in the refueling mode and after determining that off-site power could not be easily restored, declared an Unusual Event.

The auxiliary building auxiliary operator (AO) restarted spent fuel pool pump 1-2.

8:37 a.m.

The licensee informed the San Luis Obispo County Sheriff's office of the declaration of Unusual Event.

8:50 a.m.

Workers began to restore the Unit 1 standby startup bus to operable status.

8:55 a.m. (approx)

The mobile crane operator exited the crane cab via a fiberglass ladder after a new ground strap was installed to ground the crane.

9:00 a.m.

The licensee notified the NRC Operations Center of the declaration of an Unusual Event.

Plant management met to assess the loss of off-site power situation and the most expeditious means of reestablishing off-site power. Simultaneous paths were initiated to restore the standby startup busses and inspect the main transformer and lines.

9:30 a.m. (approx)

The Plant Manager informed the resident inspector that the Technical Support Center would not be staffed and that the Plant Manager would act as the recovery manager.

10:20 a.m.

Electrical maintenance signed off the standby startup bus clearance indicating that equipment removed for maintenance had been returned to a functional condition. Operations proceeded to realign breakers to establish standby startup power to 4 kV vital and non-vital loads.

12:00 p.m.

The Plant Manager issued a 24 hour suspension on all work except that required to return plant equipment to a safe condition.

12:30 p.m.

4 kV non-vital busses were energized from the standby startup busses.

12:39 p.m.

Power was restored to 480V non-vital busses.

1:00 p.m.

Offsite power was restored to all 4 kV vital busses. All three diesel generators were secured and returned to automatic.

1:25 p.m.

Following a walkdown of electrical distribution centers, the SS terminated the Unusual Event.

1:30 p.m.

In a conference call between the Region V Director of the Division of Reactor Safety and Projects and the Plant Manager, an NRC Augmented Inspection Team was announced.

3:15 p.m.

The auxiliary building ventilation system was restored to normal after I&C technicians depowered and repowered the logic control center.

3:53 p.m.

The Plant Manager authorized the resumption of core loading

4:00 p.m.

The Plant Manager conducted a meeting with plant supervision to discuss the event, the near fatalities, and the 24 hour stop work order.

4:45 p.m.

The control room was informed by switchyard personnel that an inspection of the main generator A phase transformer and its associated output lines had been completed, and the components were acceptable to return to service.

6:14

The last fuel assembly was unlatched in the core.

IV. LICENSEE MANAGEMENT OF OUTAGE ACTIVITIES

A. Electrical Power Sources

During the outage the licensee had implemented a policy of requiring three diverse electrical power supplies whenever two RHR trains were required by Technical Specifications. This policy was documented in a memorandum dated October 17, 1990 (Reference 10) to the 1R4 Outage Manager from the Operations Manager. In response to the Operations Manager's memo, the 1R4 Outage Coordinator outlined specific equipment schedule requirements for the outage to the Outage Manager in a memo dated October 24, 1990 (Reference 20). These memos were written in response to the licensee's review of the Vogtle event. The licensee had also prepared a draft procedure OMP-8 (Reference 36), "Control of Off-Site Power Supplies to Vital Buses." This procedure had not been issued for use, but it formed the basis for the power supply removal policy issued after the event (Reference 35).

Technical Specifications required two RHR trains in mode 6 whenever; (1) reactor coolant loops were not filled (ie: mid-loop), or (2) after the reactor vessel head was removed and before the reactor cavity was flooded to 23 feet above the reactor vessel flange. The electrical power sources were considered to be startup power, auxiliary power, emergency diesel generators (EDGs), and cross ties to Unit 2.

The Operations Manager's memo did not address all of the plant conditions that would occur during the refueling outage. However, the Outage Coordinator did schedule two EDGs and one off-site power supply to be available during core off-load. At other times during the outage at least one EDG and one off-site power supply was scheduled to be available.

Based on the AIT's review of the outage and interviews with licensee personnel, it appears that the outage planning also considered the removal of electrical power supplies in that only one off-site power supply was taken out of service at a time, and removing EDGs from service was controlled to comply with the Outage Manager's memo (Table C-2 of Appendix C).

Although the management of AC power sources and resultant outage schedule appeared to have been implemented as originally intended, there were several issues which were not addressed. The electrical issues not addressed included; (1) requirements for power when one RHR train was required, (2) requirements for power when no RHR was required, (3) protecting off-site power supplies from vehicles or outage activities, and (4) plans for actions to be taken if power to one or more sources was lost.

B. Core and Spent Fuel Cooling

Following the LOP event on March 7, 1991, the AIT met with licensee personnel and examined licensee records to review equipment and power supply status during the outage to identify any situations which could have been a major safety problem, should the LOP have occurred earlier. Licensee personnel prepared a matrix tabulating equipment and electrical power availability (Table C-2 of Appendix C). NRC inspectors reviewed this chart and after discussions with the licensee reached the following conclusions.

Only one RHR train was required early in the outage after the reactor head had been removed, and the reactor cavity had been flooded to more than 23 feet. If the operating RHR train had been lost while the upper internals were in place, within a relatively short time a steam bubble could form in the reactor core region. With high decay heat shortly after shutdown, steam could form fast enough to prevent the refueling cavity water from flowing down through the upper internals. It appears that Unit 1 was flooded to 23 feet with the upper internals installed for approximately 12 hours on February 8, 1991. However, at Diablo Canyon both RHR trains and three power supplies were available at that time. This is a potentially generic problem.

The core off-load was completed on February 10, 1991. Subsequently, on February 14, 1991, the licensee took SFPC pump 1-2 out of service for maintenance for approximately seven days. One off-site (startup power) and one onsite (EDG 1-2) power supply were initially available. After February 15, the available onsite power supply was EDG 1-3. During this period, the Region V staff questioned the licensee as to how long it would take for the fuel pool to heat to boiling and what contingency actions had been considered. Licensee personnel responded that they estimated it would take the spent fuel pool 24 hours to boil and that make-up water was available from the fire protection system (Reference 33). During the AIT inspection the team learned that the 24 hours was based on the decay heat produced 30 days after shutdown. Five days after shutdown (right after core off-load), the licensee calculated that the pool could reach boiling in less than five hours. Licensee personnel agreed that the SFPC pump should not have been taken out of service at that time. Reportedly, one Assistant Plant Manager recognized this problem, had attempted to reschedule this maintenance, but the work on the pump had already been started.

C. Mid-loop Operations

On April 10, 1987, Diablo Canyon Unit 2 experienced a loss of RHR for approximately one and one-half hours. The plant was at mid-loop at that time and reactor vessel water temperature increased from 87 degrees F to boiling, with the reactor coolant system pressurizing to approximately 10 psig. A NRC AIT was dispatched at that time and documented their inspection in NUREG-1269 (Reference 14). That AIT concluded that mid-loop operation presented a considerable challenge

to operators and that original plant design had not provided for mid-loop operations.

The licensee documented corrective actions in letter DCL-87-099, dated May 4, 1987. Since that event the licensee has nearly eliminated mid-loop operation by off-loading the core. This decision has been discussed with Region V during past management meetings.

The current AIT did not identify a specific policy document which stated that mid-loop operations would not be used or the circumstances and controls when mid-loop might be necessary. Conversely, the licensee had prepared a draft outage management policy which did address mid-loop operation, installation of nozzle dams, and control of AC power supplies (Reference 9). The policy was intended to ensure that non-operator personnel understood the issues associated with mid-loop operation. The focus on eliminating or minimizing mid-loop operation appeared to be a sound decision.

Licensee personnel stated that mid-loop might be necessary to install and remove nozzle dams if steam generator non-destructive examinations indicated additional examinations were necessary. They went on to explain that if mid-loop was used it would be at the end of the outage, when decay heat was low, and only after permission from senior PG&E management.

D. <u>Vehicle, Crane, and Material Controls</u>

Regarding vehicle control, aside from the PG&E Accident Prevention Rules, no specific controls were in place in the plant protected area. The inspectors observed that vehicles were also free to enter the 500 kV and 230 kV switchyards to the east of the plant.

The PG&E Accident Prevention Rules were dated 4-89 and were promulgated by the President of PG&E (Reference 19). On page 34 of the rules, the minimum clearance to a 500 kV line was specified as 27 feet. The use of the mobile crane so close to the 500 kV lines on March 7 was a clear violation of the Accident Prevention Rules. The Work Order, C0081217 (Reference 22), for removal, maintenance, and reinstallation of valve RV-5 did not address how the valve was to be removed or replaced.

Based on interviews with licensee personnel, it appeared that a similar boom crane had been used in the past to hoist material to and from the main steam line support structures. In those situations it was likely that the 500 kV lines were energized at least part of the time. Even if the compressors for the integrated leak rate test had not been next to Unit 1, the phase A 500 kV line was only 25 feet from the main steam support structure. Based on observing the location of permanent plant equipment (which is not all shown on the plant plan views, Figures C-1 and C-2 of Appendix C.), it appeared very difficult to get the crane into a position to make a hoist to the main steam support structure with more than 27

feet of clearance. Consequently, the 27 foot limit appears to have been repeatedly violated in the past without identification or correction.

V. LICENSEE USE OF PREVIOUS INDUSTRY EXPERIENCE

The licensee's Nuclear Operations Support (NOS) group evaluates previous industry events and prepares a Safety Event Review Follower (SERF) for those events that are considered to be significant. The licensee's QA/QC departments are not involved in the preparation of the SERFs; however, as non-voting members of the Plant Staff Review Committee, the departments have an opportunity to review the evaluations prior to approval. QA/QC, when requested, also monitors corrective actions taken in response to SERFs. QA/QC previously evaluated industry events, but this action was given to NOS in approximately 1987.

A. Response to Vogtle Event (NUREG 1410)

NOS completed a SERF on NUREG-1410, "Loss of Vital AC Power and the Residual Heat Removal System During Mid-Loop Operations at Vogtle Unit 1". The review, SERF-123, was dated February 6, 1991. The SERF addressed eleven issues developed by NOS after review of the NUREG. This document also addressed six observations made by the NRC in a letter to the licensee dated April 26, 1990 related to the licensee's response to Generic Letter 88-17, "Loss of Decay Heat Removal". The licensee concluded that four of the NRC's six observations were closely related to the issues developed in response to the Vogtle event.

Actions taken as a result of the Vogtle event included: (1) development of draft outage policies for reduced water inventory operations, (2) development and implementation of a policy to provide three sources of electrical power when two trains of RHR cooling are required, (3) review of procedures for loss of all AC power, malfunction of the RHR system, draining of the reactor coolant system to mid-loop, and mid-loop operations, and (4) incorporation of the Vogtle event into plant emergency response training.

One of the issues listed in SERF 90-123 indicated that careful planning of equipment outages should occur to ensure that a diesel generator, vital bus, and decay heat removal pump not be taken out of service on different trains simultaneously. In replying to the issue, the SERF stated that "The outage planners had already incorporated this philosophy into the outage schedule." The outage schedule was verified to represent this philosophy, but it was not apparent that the philosophy was consciously used when developing the outage schedule. Additionally, the draft outage management policies, reference 15, did not appear to incorporate this philosophy for future outages.

NUREG-1410 suggested that licensees develop procedures to interconnect vital and non-vital buses on the same unit and to interconnect

the Unit 1 distribution system with the Unit 2 distribution system in an effort to provide an extra means to power equipment on vital busses. The licensee's SERF stated that "procedure ECA 0.0 Appendix X already provides instructions for cross-tie of vital busses" and stated that "the consensus was that little value would be derived from additional procedures". This licensee response was made, at least in part, because Diablo Canyon Unit 1 had three vital 4 kV buses that could be cross-connected. The licensee indicated that additional flexibility was unnecessary.

Finally, the licensee's SERF gave little consideration to providing any corrective action for potential initiating events (e.g., loss of offsite power caused by vehicular traffic around transformers). The SERF disposition of this issue was that the initiating event was bounded with the policy to provide sufficient power sources.

B. Similarities and Differences to the Vogtle Event

The table below compares the March 20, 1990 loss of off-site power event at Vogtle Unit 1 with the March 7, 1991 loss of off-site power event at Diablo Canyon Unit 1.

INITIAL CONDITIONS

	Vogtle	Diablo Canyon
Containment	Open	Closed
RCS Inventory	Mid-loop	23' Above Flange
RCS Cooling	RHR Pumps Available	RHR Pumps Available (One Pump Operating)
Power	1 Off-site	1 Off-site (Main Transformer)
	1 Off-site OOS	1 Offsite OOS (S/U Transformer)
	1 EDG Available 1 EDG OOS	3 EDGs Available
Fuel Inventory	Core Fully Loaded	Core Almost Fully Loaded (188 Assemblies of 193 in Reactor, 2 Assemblies in Transit)

INITIATING EVENT

Vogtle	Diablo Canyon
Truck Backed Into 230KV Column	Crane Boom Approached and Shorted 500kV Line

IMPACT ON SECOND OPERATING UNIT

Vogtle	Diablo Canyon
Unit Tripped From 100% Power	Unit Remained At Full Power

PLANT RESPONSE

Vogtle	Diablo Canyon
Loss of Offsite Power For 2 Hours 10 Minutes	Loss of Offsite Power For 4 Hours 50 Minutes
1 DG Loaded After 36 Minutes	All 3 DGs Immediately Started And Assumed Load
Core Temperature Increased 46 Degrees To 136 Degrees	No Core Temperature Change
RHR Lost For 41 Minutes	RHR Interrupted For Less Than 1 Minute
Containment Closed 1 Hour and 22 Minutes Later	Containment Maintained Throughout
Reactor Inventory Unchanged	Reactor Inventory Unchanged
"Site Area Emergency" Declared	"Unusual Event" Declared

Since the three emergency diesel generators at Diablo Canyon started and powered their vital loads following the loss of off-site power event there was no damage or hazard to the health and safety of the public.

In contrast to Vogtle, PG&E did not rely solely on their technical specifications to specify core cooling and power source requirements during the outage. For example, there was an outage policy to have three power sources available when two RHR pumps were required. The licensee scheduled work which might require mid-loop operation or

steam generator nozzle dam installation for late in the outage when decay heat would be low.

C. Other Licensee or Industry Experience

Since 1988, nine Nonconformance Reports (NCRs) documented potential loss of off-site power, loss of power to vital busses, or personnel injury due to shock. Most of the NCRs were associated with diesel generator testing. The corrective actions taken in response to the NCRs appeared to be adequate. The NCRs did not reveal any particular susceptibility for loss of off-site power at Diablo Canyon.

NRC Information Notice 84-42, "Equipment Availability For Conditions During Outages Not Covered By Technical Specifications," illustrated the importance of controlling equipment availability. The licensee's actions as a result of the Notice included a review of procedures to verify there were controls on the availability of equipment. The licensee also concluded that the cause of the event that resulted in the Notice was not applicable to Diablo Canyon as a result of design differences.

VI. RESULTS AND CONCLUSIONS

A. Outage Management Issues

Vehicles and heavy equipment were not controlled in the protected area or in the switchyards during the outage. The loss of all off-site power event occurred due to inattention to PG&E Safety Rules. It appears that the violation of safety rules involving minimum working distances to electrical power supplies had occurred before.

The licensee has stated that they intend to avoid mid-loop operations. This appears to be a sound decision and directed towards enhancing safe shutdown operation. One problem in this area is that the licensee has not yet provided written guidance and approval requirements if mid-loop operation should become necessary.

The licensee did have some guidance in place to maintain both off-site and onsite power supplies when two RHR pumps are required by Technical Specifications. This guidance was in the form of memorandums to outage personnel. The licensee also had policy documents for outage management in draft form, but these had not been implemented.

Although the licensee had established some requirements for AC power supplies during the outage they did not have specific guidance or strategies for restoration of AC power or spent fuel pool cooling should these be lost. Early in the outage, when the decay heat load is high, boiling could occur in the fuel pool in several hours. There was some misunderstanding in the licensee's organization as to how long it would take for boiling to occur in the fuel pool.

Early in the outage, the plant may be more vulnerable than expected when the reactor cavity is flooded and the upper internals are still in place. Decay heat generating steam may be sufficient to prevent water from the cavity from entering the core region. This is a potentially generic issue. (Unresolved Item 50-275/91-09-01)

The failure of some plant equipment to perform as expected was self-induced by the licensee. Better control of important equipment (ie: auxiliary building ventilation, control room lights, and the intercom circuit to the containment) could prevent adding additional challenges to the plant and the operators.

B. Control and Management of the Event

The licensee's initial response to the event appears satisfactory with one exception. The licensee's classification of the event as a UE appears to have taken longer (23 minutes) than expected (15 minutes). However, the licensee did inform off-site agencies in a timely manner (7 minutes) after the event was classified.

There appears to have been some problems associated with implementing the emergency and abnormal procedures. These documents were written based on the plant operating at power. Consequently, much of the material in the emergency and abnormal procedures is not applicable during an outage, but still must be checked. This appears to have lengthened the time it took to classify the event.

Licensee follow-up actions appear satisfactory. Suspending the outage for 24 hours appears to have been a sound decision. The EIT implemented by the licensee is an appropriate response to the event. Lastly, the memorandum sent out by the VP-Nuclear Operations addressing removal of off-site power sources was an appropriate action (Reference 35).

C. Licensee Actions from Previous Experience

The licensee's review of previous experience, especially the Vogtle event, generally covered the specific event or specific issues. There was one problem noted.

The licensee failed to take action to protect the off-site power supplies based on the Vogtle experience, by reasoning that they could not protect the 500 kV or 230 kV lines away from the plant. The fact was missed that the Vogtle event occurred in the licensee's switchyard and that the event was preventable.

D. Licensee Commitments

The licensee made the following commitments:

During the inspection, temporary barriers were established and memos were issued to the Outage Managers to control traffic around the plant off-site power supplies. Specific procedures for vehicle control and modifications to install physical barriers have been scheduled for completion in July 1991 and before the next outage (2R4 in September 1991) respectively. (Open Item 50-275/91-09-06)

The licensee will assess the event review process to strengthen and enhance that process. Feedback from the licensee's EIT will be used. This is scheduled for completion before the next refueling outage (2R4). (Open Item 50-275/91-09-07)

Completion of outage policy and program summary documents for safety assessment and control of activities will be rescheduled from September 1991 to July 1991. (Open Item 50-275/91-09-08)

Base line coping strategies for restoration of power and cooling or appropriate modifications to the EOPs and AOPs will be prepared before the next refueling outage. The focus of this effort is on modes 5 and 6 when the plant is shutdown and is in an outage. The licensee will consider spent fuel pool cooling, the LOP event of March 7, and other similar events as appropriate. (Open Item 50-275/91-09-09)

VII. EXIT INTERVIEW WITH LICENSEE MANAGEMENT

The findings and conclusions of the AIT's special inspection were discussed with licensee management and others as indicated in Appendix B at the conclusion of the inspection on March 13, 1991.

The principal commitments described in section VI.D of this report were made by licensee management at that time.

APPENDIX A

AUGMENTED INSPECTION TEAM CHARTER

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION V
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CALIFORNIA 94596

MAR 8 1991

Docket No. 50-275

MEMORANDUM FOR: P. J. Morrill, Leader
Diablo Canyon Augmented Inspection Team

FROM: J. B. Martin, Regional Administrator

SUBJECT: AUGMENTED INSPECTION TEAM CHARTER - LOSS OF ALL OFF-SITE POWER AT DIABLO CANYON UNIT 1

After being briefed on the March 7, 1991, loss of off-site power event at Diablo Canyon Unit 1, NRR, AEOD, and Region V senior management determined that an Augmented Inspection Team (AIT) inspection should be conducted at Diablo Canyon Unit 1 to verify the circumstances and evaluate the significance of the referenced event.

You have been designated as Team Leader. Enclosed is the charter for the Augmented Inspection Team delineating the scope of this inspection. The inspection is to be conducted in accordance with NRC MC 0513, NRC Inspection Manual 0535, Inspection Procedure 93800, and this memorandum.

for J. B. Martin
Regional Administrator

Enclosure:
(1) Augmented Inspection Team Charter
(2) Inspection Plan

cc: T. Murley, NRR
J. Partlow, NRR
M. Virgilio, NRR
B. Boger, NRR
C. Rossi, NRR
A. Chaffee, NRR
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J. Richardson, NRR
A. Thadani, NRR
B. Grimes, NRR
J. Roe, NRR
D. Ross, AEOD
J. Taylor, EDO
J. Sniezek, EDO
E. Jordan, AEOD
J. Caldwell, EDO
B. Faulkenberry, RV
R. Zimmerman, RV
R. Scarano, RV
S. Richards, RV
P. Narbut, SRI/Diablo
P. Morrill, RV
G. Cook, RV
D. Kunihiro, RV

Enclosure (1)

AUGMENTED INSPECTION TEAM CHARTER
DIABLO CANYON UNIT 1 TOTAL LOSS OF OFF-SITE POWER
ON MARCH 7, 1991

The Augmented Inspection Team (AIT) is to perform an inspection to accomplish the following:

1. Develop a complete description of the event, develop a detailed sequence of events that occurred during the loss of off-site power event, and identify all equipment failures and human errors that occurred during the event and during event recovery.

2. Determine the specific circumstances and events which led up to the shorting of the Unit 1 main transformer and attendant loss of all off-site power for Diablo Canyon Unit 1 on March 7, 1991. Interview licensee and contractor personnel as appropriate.

3. Verify and evaluate the licensee's immediate actions following this event, including ability to restore off-site power in a timely manner. Operations and management effectiveness are to be evaluated.

4. Evaluate the effectiveness of licensee management in corrective actions subsequent to the event.

5. Identify and evaluate the procedures used by the licensee which address outage type work, including vehicle access, near major external electrical supplies. Determine the effectiveness of, and adherence to, these procedures for the current event. Determine whether the procedures are "conditioned" to consider equipment out of service which amplifies the need to protect remaining equipment.

6. Determine the circumstances and events which allowed refueling to occur while the Unit 1 start-up bus was taken out of service for maintenance. Interview appropriate personnel and review work related documents as appropriate.

7. Determine the availability of major on-site and off-site power supplies, the status of the reactor core, and the availability of core cooling during the period January 31, 1991 through March 7, 1991. Correlate the availability of power supplies and core cooling with the condition of the core. Based on these determinations, identify any situations where equipment unavailability appeared excessive for plant conditions, had the loss of power occurred earlier in the outage.

8. Determine how the licensee made the various decisions to take major plant equipment out of service during the period January 31, 1991 through March 7, 1991. Determine whether the diesel generator configuration throughout the outage was appropriate to plant conditions and consciously made. Determine whether the licensee minimized mid-loop operation during this outage specifically because of the Vogtle event. Evaluate the safety consciousness exhibited by the licensee in these decisions and effectiveness of licensee procedures to maintain plant safety.

9. From a safety perspective, ascertain the similarities and differences of this event to the Vogtle event. Determine the licensee's actions and follow-up of similar industry events, and specifically the Vogtle event (IN 90-25/w Suppl. 1 and NUREG 1410-Section 10). Evaluate the effectiveness and comprehensiveness of these actions.

10. Evaluate other recent (last 3 years) instances of loss of off-site power (LOP) events to determine Diablo Canyon's susceptability to LOP events, and effectiveness of corrective actions previously taken.

11. Provide a Preliminary Notification upon initiation of the inspection and an update at the conclusion of the inspection.

12. Prepare a special inspection report documenting the results of the above activities within 30 days of the start of the inspection.

(Enclosure 2)

INSPECTION PLAN

Team Membership:

Phil Morrill, Section Chief, Reactor Projects Section 1 - Team Leader
Brad Olson, Project Inspector - Assistant Team Leader
Ken Johnston, Diablo Canyon Resident Inspector - Plant Expert
Subinoy Mazumdar, AEOD - Power Systems Expert
Warren Lyon, NRR, Reactor Systems - Vogtle Team Member
Dave Fischer, Events Assessment - Operating Events

Team Objectives:

1. Develop a detailed sequence of events leading up to the loss of power through termination of the Unusual Event.
2. Determine and evaluate licensee's relevant actions prior to the event.
3. Identify any weaknesses in the licensee's performance which could have prevented the event.
4. Evaluate the licensee's controls and considerations with respect to taking equipment out of service concurrent with significant outage activities.
5. Identify any missed management opportunities which could have prevented the event, (lessons learned from Vogtle event).
6. Identify and evaluate current licensee actions to learn from this event.

Tentative Schedule:

3/8/91	1400	Arrive at site, badging, obtain procedures, review licensee's activities & set up interviews
3/9/91	0800	Entrance meeting at site with licensee
	0900	Begin inspection
3/10/91	1400	Debrief with RV Management
3/11/91	1400	Debrief with RV Management
3/12/91	1400	Debrief with RV Management
3/13/91	1100	Complete inspection and debrief with RV
	1300	Exit meeting with licensee
3/26/91		Issue report

APPENDIX B

PRINCIPAL PERSONS CONTACTED

PRINCIPAL PERSONS CONTACTED

***	Name	Title or Department
1	G. Maneatis	President, PG&E
1	J. Shiffer	Sr. Vice President, Nuclear Power Generation
1,2	W. Fujimoto	Vice President, Nuclear Technical Services
1,2	J. Townsend	Vice President, Diablo Canyon Operations and Plant Manager
1,2	M. Angus	Assistant Plant Manager, Technical Services
1,2,3	D. Miklush	Assistant Plant Manager, Operations Services
1,2	B. Giffin	Assistant Plant Manager, Maintenance Services
1	D. Oatley	Assistant Plant Manager, Support Services
1,2,3	L. Womack	Manager, Nuclear Operations Support
1	W. Barkhuff	Manager, Quality Control
1,2,3	S. Fridley	Manager, Operations
1,2	T. Bennett	Manager, Mechanical Maintenance
1	B. Crockett	Manager, Instrumentation and Control
2	J. Bard	Manager, Work Planning
2,3	W. McLane	Manager, Outage Management
1	S. Banton	Manager, Plant Engineering
3	R. Kohout	Manager, Emergency / Safety Services
3	H. Phillips	Manager, Electrical Maintenance
1	T. Grebel	Supervisor, Regulatory Compliance
2	R. Flohaug	Sr. Supervisor, Quality Assurance
1,2,3	K. Bych	Sr. Engineer, Nuclear Operations Support
1,2	J. Griffin	Sr. Engineer, Regulatory Compliance
1,2	J. Hinds	Sr. Engineer, Regulatory Compliance
1	M. O'Connell	Engineer, Regulatory Compliance
3	A. Young	Sr. Engineer, Quality Assurance - Maintenance
1	A. Jorgensen	Quality Control Engineering
1,2	K. Oliver	HPES Coordinator, Reliability Engineering
2	J. Ekman	Training Department
2	D. Cosgrove	Specialist, Quality Control
2	D. Christensen	Nuclear General Engineer
2	J. Shoulders	Onsite Project Engineer, NECS
3	D. Armstrong	Outage Coordinator
3	K. Kaminski	Senior Instructor, Training Department
3	S. David	Operations Coordinator, Work Planning
3	M. Rhodes	Shift Foreman, Operations
3	G. Anderson	Shift Supervisor, Operations
3	W. Ryan	General Foreman, Mechanical Maintenance
3	W. Dolengewicz	Foreman, Mechanical Maintenance
3	J. Turlock	Foreman, Mechanical Maintenance
3	M. McDermott	Tool Clerk, Mechanical Maintenance
3	T. Buckley	Mechanic/Rigger, Mechanical Maintenance
3	D. Padlina	Pipefitter, Bechtel

***

1 Attended Entrance Meeting
2 Attended Exit Meeting
3 Interviewed by Team

APPENDIX C

REFERENCE FIGURES AND TABLES

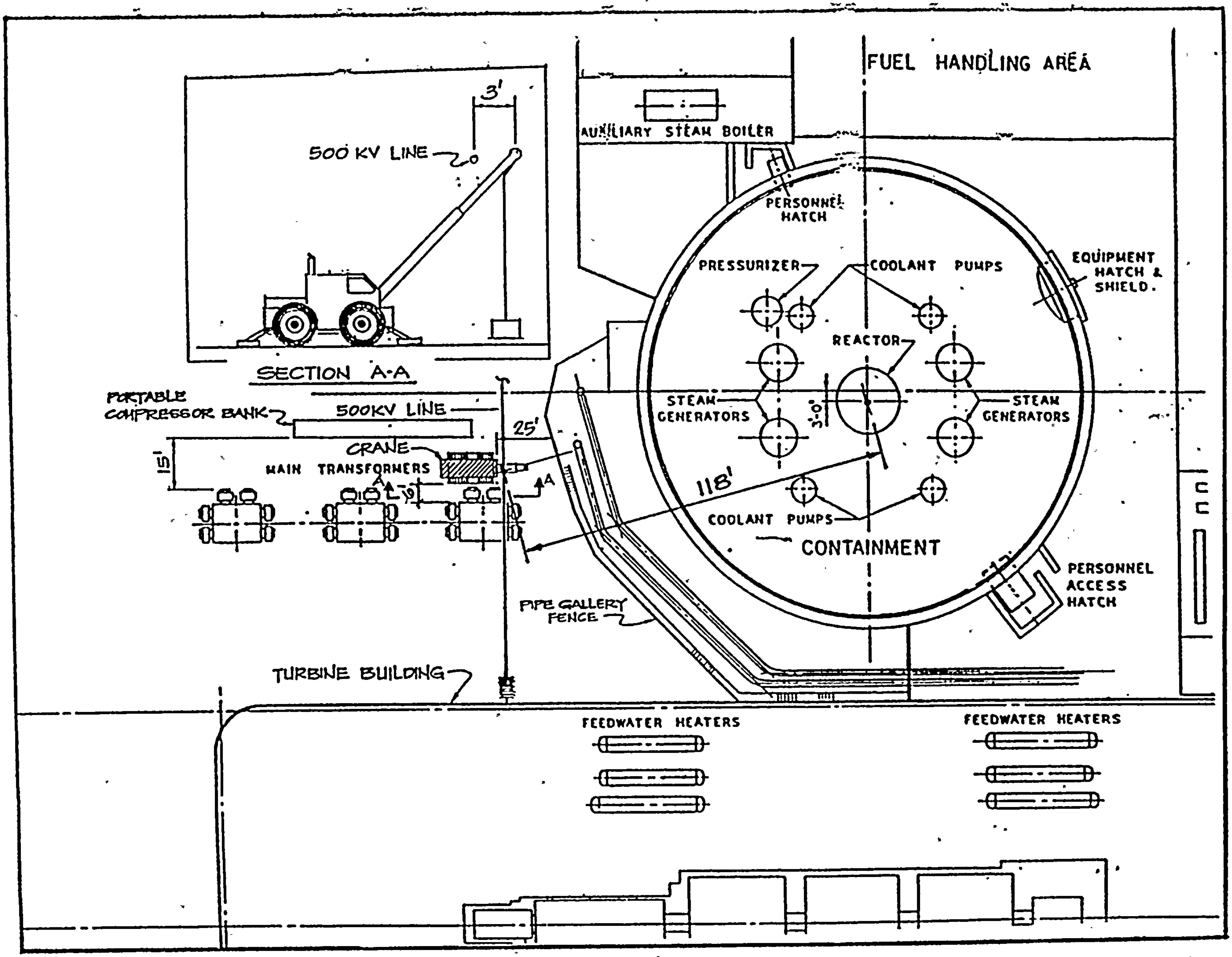


FIGURE C-1

LOSS OF OFF-SITE POWER EVENT

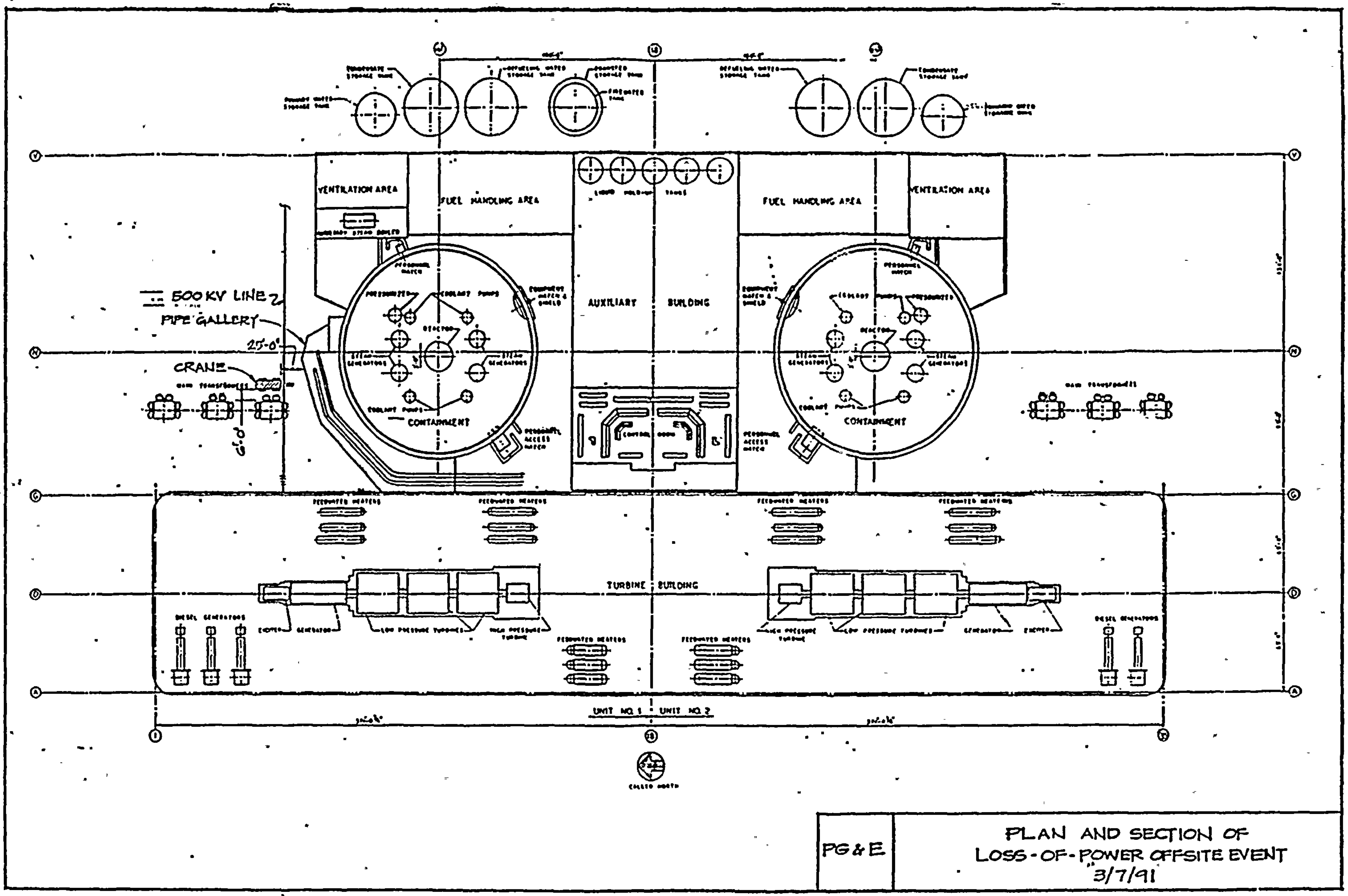


FIGURE C-2

PLAN VIEW, UNIT 1 AND 2

LOSS OF OFF-SITE POWER EVENT

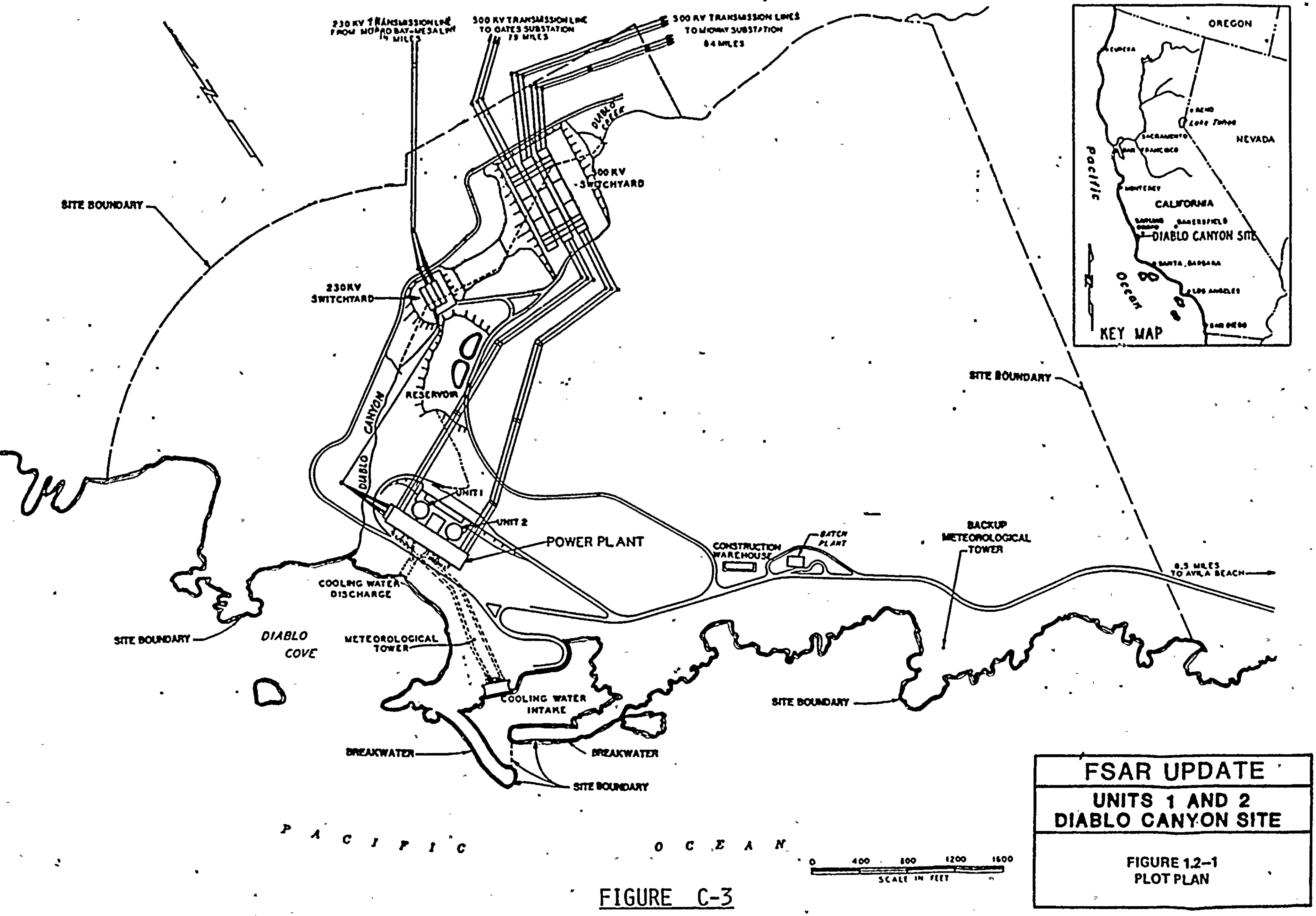
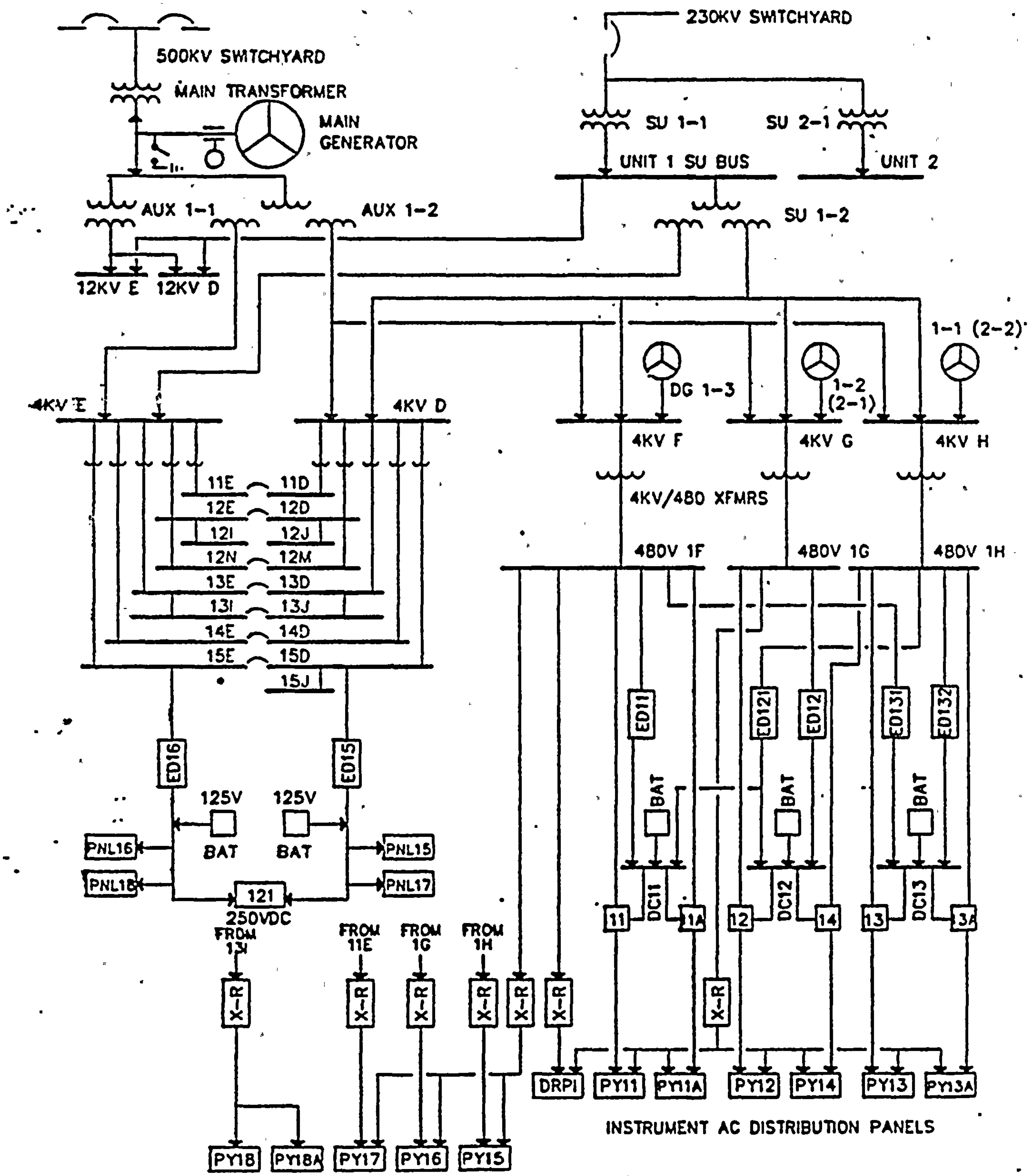


FIGURE C-3

DIABLO CANYON SITE AND SWITCHYARDS

ELECTRICAL DISTRIBUTION OVERVIEW



*NOTE: BUS 25I ON UNIT 2 IS SUPPLIED BY 25E
THERE IS NO 25J

FIGURE C-4

ELECTRICAL DISTRIBUTION OVERVIEW

DIABLO CANYON UNIT 1

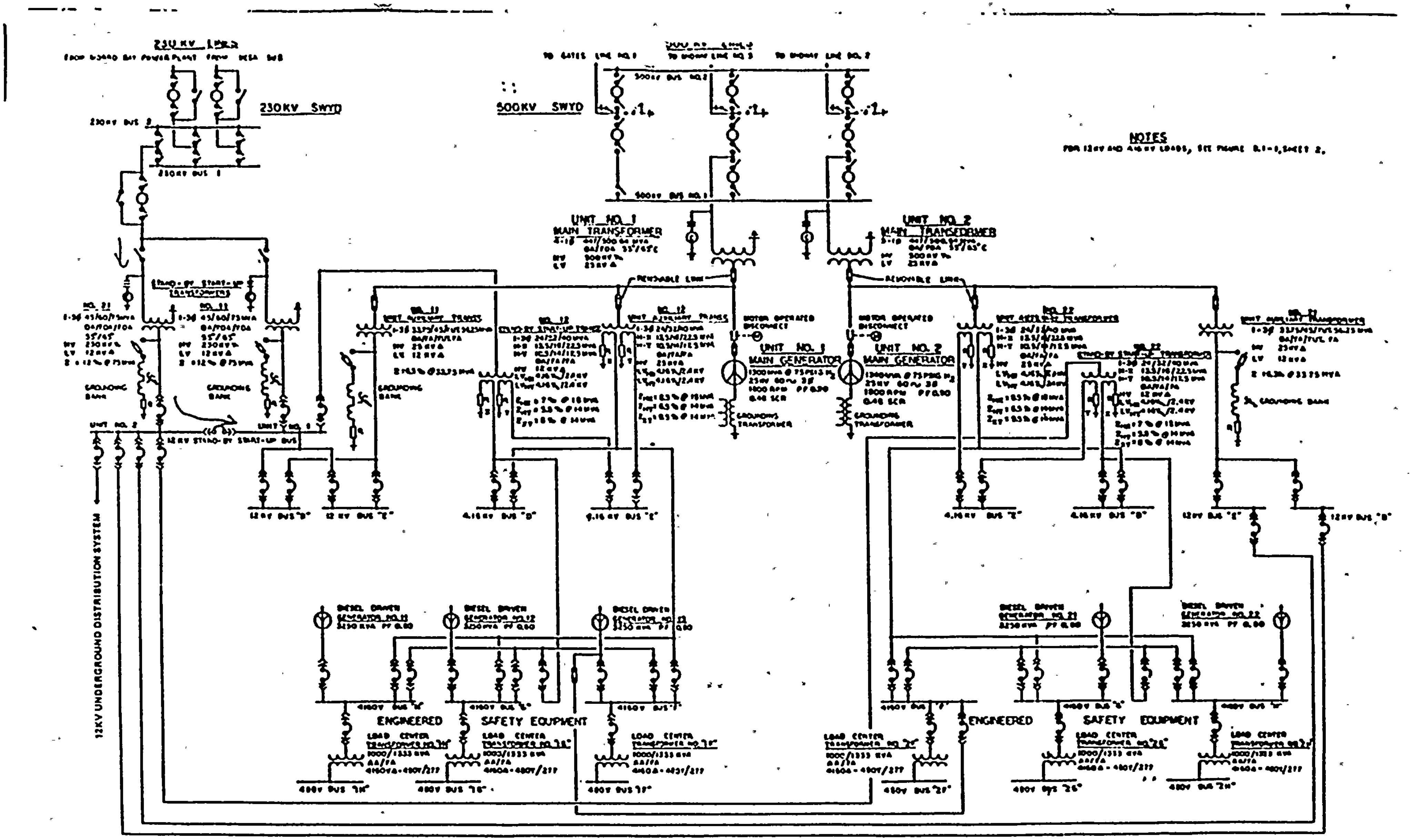


FIGURE C-5

DIABLO CANYON AC ELECTRICAL SYSTEM

FSAR UPDATE

UNITS 1 AND 2
DIABLO CANYON SITE

FIGURE 8.1-1 (Sheet 1 of 2)
PLANT SINGLE LINE DIAGRAM

TABLE C-1

DIABLO CANYON UNIT 1

MAJOR 4KV BUS LOADS

COMPONENT	BUS F	BUS G	BUS H
Diesel	1-3	1-2	1-1
480 MCC	F	G	H
Auxiliary Salt Water Pumps	1-1	1-2	
Centrifugal Charging Pump	1-1	1-2	
Reciprocating Charging Pumps		1-3	
Component Cooling Water Pumps	1-1	1-2	1-3
Safety Injection Pumps	1-1		1-2
Residual Heat Removal Pumps		1-1	1-2
Containment Spray Pumps		1-1	1-2
Auxiliary Feed Water Pumps	1-3		1-2
Containment Fan Coolers (Powered by 480V MCCs)	1-2 1-1	1-3 1-5	1-4
Spent Fuel Pool Cooling Pumps (Powered by 480V MCCs)		1-1	1-2

TABLE C-2, Sheet 1
DIABLO CANYON UNIT 1

OFFSITE POWER SOURCES		DIESEL GENERATOR AVAILABILITY			4 KV VITAL AVAILABILITY			RHR PUMP AVAILABILITY		ASW PUMP AVAILABILITY		CCW PUMP AVAILABILITY			SPENT FUEL PP AVAIL		
Aux	S/U	1-3	1-2	1-1	HF	HG	HH	1-1	1-2	1-1	1-2	1-1	1-2	1-3	1-1	1-2	
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Mode 4
																	Mode 5, 2/2/91:1400
2/3: 0100 Clr'd		2/3: 0305 Clr'd			2/4: 0308 Clr'd							2/4: 1736 Clr'd					
N	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	
																	Mode 6, 2/5/91:1432
					2/5: 1725 Rest.						2/5: 2237 Clr'd						
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	Rx Head Move 2/7/91:1042-1115
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	RCCA Unlatching 2/8/91:0248-1015
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	RX Internals Move 2/8/91:1115-1143
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	Fuel Movement Commences 2/9/91:0312
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	Core Unload Completed 2/10/91:2200
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	RX Internals Set 6" above Rx Head 2/10/91:2315-2351
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	Cavity Drain Down 2/11/91:0011-0203
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
																	RX Internals Set in Vessel 2/11/91:0330
N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	

TABLE C-2, Sheet 2
DIABLO CANYON UNIT 1

OFFSITE POWER SOURCES		DIESEL GENERATOR AVAILABILITY			4 KV VITAL AVAILABILITY			RHR PUMP AVAILABILITY		ASW PUMP AVAILABILITY		CCW PUMP AVAILABILITY			SPENT FUEL PP AVAIL		
Aux	S/U	1-3	1-2	1-1	HF	HG	HH	1-1	1-2	1-1	1-2	1-1	1-2	1-3	1-1	1-2	
									2/11: 0415 Clr'd								
N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	Y	RX Head Set 2/11/91:0600
		2/11: 1238 Rest.	2/12: 0725 Clr'd	2/11: 0815 Clr'd		2/22: 0430 Clr'd	2/15: 0512 Clr'd	2/13: 2136 Clr'd		2/27: 0823 Clr'd	2/26: 1300 Rest.	2/13: 1824 Rest.	2/23: 1506 Clr'd	2/15: 0522 Clr'd		2/14: 1010 Clr'd	
		2/13: 0217 Clr'd	2/13: 0214 Rest.	2/28: 0400 Rest.		2/23: 0520 Rest.	2/21: 0045 Rest.					2/28: 0838 Clr'd	2/28: 1024 Rest.	2/22: 0032 Rest.		2/22: 0256 Rest.	(RHR WINDOW MAINT)
		2/15: 1007 Rest.	2/15: 1027 Clr'd	3/1: 0214 Clr'd													
				3/1: 1600 Rest.													
N	Y	Y	N	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	Y	Y	RCS Fill Commences 3/1/91:1709
			3/1: 2300 Rest.									3/1: 1752 Rest.		3/2: 0325 Clr'd			
N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	RCS Fill Complete 3/2/91:0435
N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	Rx Internals Removed 3/2/91:0614
N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	

TABLE G-2, Sheet 3
DIABLO CANYON UNIT 1

OFFSITE POWER SOURCES		DIESEL GENERATOR AVAILABILITY			4 KV VITAL AVAILABILITY.			RHR PUMP AVAILABILITY		ASW PUMP AVAILABILITY		CCW PUMP AVAILABILITY			SPENT FUEL PP AVAIL		
Aux	S/U	1-3	1-2	1-1	HF	HG	HH	1-1	1-2	1-1	1-2	1-1	1-2	1-3	1-1	1-2	
			3/3: 0015 Clr'd 3/3: 1451 Rest.					3/3: 1451 Rest.									
N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	Y	Core Alts Begin 3/3/91:2359
N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	Y	Mode 6 Entered 3/4/91:0047
								3/5: 1000 Clr'd 3/5: 1420 Rest.	3/5: 1709 Rest.					3/5: 1606 Rest.			
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Aux. Power Restored 3/5/91:2327
Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Startup Cleared 3/6/91:0100
N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Aux. Power Relays Out, D/G's Start, RHR Pp 1-2 Restarted 3/7/91:0807
N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Startup Re-energized, D/G's Secured, 3/7/91:1230-1300
N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Core Alts Completed 3/7/91: 1638-1814

APPENDIX D

LIST OF REFERENCE MATERIAL

REFERENCES

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2. "Loss of Vital AC Power with Subsequent Reactor Coolant System Heat-up," NRC Information Notice No. 90-25, April 16, 1990.

3. Bych, Ken, "NOS Response to the Vogtle Event," Pacific Gas and Electric Company, Nuclear Operations Support document No. 90-123, February 6, 1991.

4. "Spent Fuel Pool LVL/TEMP," Diablo Canyon Power Plant Annunciator Response, Window AR PK11-04, September 12, 1989.

5. "Reactor Vessel - Draining to Half Loop / Half Loop Operations with Fuel in Vessel," Diablo Canyon Power Plant Operating Procedure, OP A-2:III, May 7, 1990.

6. "Loss of Decay Heat Removal (Generic Letter No. 88-17), 10 CFR 50.54(f)," NRC letter to all holders of operating licenses or construction permits for pressurized water reactors, October 17, 1988.

7. "Malfunction of the RHR System,", Diablo Canyon Power Plant Operating Procedure, OP AP-16 Rev 7, March 19, 1990.

8. "Reactor Vessel - Draining the RCS to the Vessel Flange - with Fuel in Vessel," Diablo Canyon Power Plant Operating Procedure, OP A-2:II Rev 4, January 31, 1991.

9. "Outage Management Policy, Outage Planning & Management for Reactor Water Reduced Inventory Operations with Core Loaded During Outages," OMP-06, Draft, January 18, 1991.

10. S. R. Fridley, "Management of AC Power Sources During IR4," Diablo Canyon Memorandum to W. B. Mclane, October 17, 1990.

11. "Loss of All AC Power," Diablo Canyon Power Plant Emergency Procedure, EP ECS-0.0 Rev 3, January 15, 1991.

12. "Operations Shift Orders - AP C-151," Diablo Canyon Power Plant (Unsigned), March 8, 1991.

13. "Reactor Trip On Steam Generator Low Level With Steam Flow/Feedwater Flow Mismatch Due To Personnel Error," Diablo Canyon Unit 1 LER 91-002, Event date February 1, 1991, Report date March 1, 1991.

14. "Loss of Residual Heat Removal System, Diablo Canyon, Unit 2, April 10, 1987," NUREG-1269, June, 1987.

15. "Outage Management Organization," OMP-01 (draft), "Outage Philosophy," OMP-02 (draft), "Outage Planning and Implementation," OMP-03 (draft)

16. J. D. Townsend, "Loss of Offsite Power on Unit 1," Letter to John B. Martin (NRC) from Vice President, Diablo Canyon Operations and Plant Manager, PG&E Letter No. DCL-91-049, March 7, 1991.

17. A. C. Thadani, "'Loss of RHRS Cooling While the RCS is Partially Filled,' WCAP-11916, July 1988, and Other Related Westinghouse Owners Group Activities," Letter from NRC to Westinghouse Owners Group, December 11, 1989.

18. H. Rood, "NRC Staff Comments Regarding PG&E Response to Generic Letter 88-17 in the Area of Expeditious Actions for Loss of Decay Heat Removal (TAC Nos. 69740 and 69741)," Letter from NRC to J. D. Shiffer (Pacific Gas and Electric Company), April 26, 1989.

19. PG&E, Accident Prevention Rules, 01-6900 4-89.

20. D. A. Armstrong, "Response to S.R. Fridley letter dated 10/17/90, Management of AC Power Sources During 1R4," October 24, 1990.

21. DCPP, Radiation Protection Department memo to File, "Radiation Protection Activities During Unusual Event", March 7, 1991.

22. Work Order C0081217 (Electronic Copy), Numbers 1, 2, & 3; Remove RV-5, transport to shop and perform maintenance, and reinstall, January 28, 1991.

23. NRC Inspection Report 50-275/90-30, March 4, 1991.

24. K. Brown, Security Report 91-0323-08, March 8, 1991.

25. Supplemental Security Reports 91-0323-08, March 8, 1991; from D. Harnes, F. Fidel, G. Vickers, R. Arroyo, and J. Williams.

26. DCPP, Mechanical Maintenance Incident Reports dated March 7, 1991 by J. Trulock, D. Paolina, M. McDermott, and T. Buckley.

27. E-Mail message, R. Kohout to T. Bennett, "500 kV Phase incident", March 7, 1991.

28. Personnel Statements of C. Hiel, J. Beymer, G. Anderson, M. Rhodes, J. Helm, R. Aiellano, M. Kennedy, G. Deardorff, M. Griffin, and L. Sayer.

29. Action Request A0221824, "LOSS OF OFF-SITE POWER U-1, 3/7/91", March 7, 1991.

30. Non-Conformance Report Report DC1-91-MM-028/0 "Lost (sic.) of Off-Site Power U1", March 8, 1991.

31. L. Womack, "Loss of 500 kV Power, Event Response Plan" March 9, 1991, 1:30 p.m.

32. Action Requests: A0221783 "RO/ AUX BLDG VENT WILL NOT START AFTER 500 kV INCIDENT" March 7, 1991; A0222096 "INTERCOM LOST POWER", March 9, 1991; A0222126 "CONTROL ROOM LIGHTING IMPROPERLY ALIGNED", March 10, 1991.

33. Calculation, "SPENT FUEL POOL BOILING AFTER A LOSS OF COOLING U1/R4," Attachments 1 and 2, Document 164467.

34. T. Fetterman, "Vogtle's 3/20/90 Loss of Offsite Power" memos to M. Tresler dated April 3, 1990 and July 9, 1990.

35. "Policy for Removal From Service - One of Two Offsite Power Sources During 1R4", VP-Diablo Canyon Operations to Outage Managers, March 8, 1991.

36. "Control of Off-Site Power Supplies to Vital Buses", OMP-08, DRAFT, undated.

APPENDIX E

LICENSEE POLICIES AND PROCEDURES REGARDING OUTAGES

Licensee Policy and Procedures Regarding Outages

1. Licensee Policy

The licensee appears to be working to improve safe and prudent operation in the area of shutdown operations. Several examples of this approach were observed, including such activities as a general avoidance of mid-loop operation, a careful process to drain the steam generator (SG) tubes, examination of electrical power provisions, and the Plant Manager's decision to suspend operation for 24 hours following the event to evaluate all work activities that could influence safe operation (Reference 16). There also appears to be areas where improvements can be made to the licensee's conduct of shutdown and outage operations.

The team found examples of licensee guidance, such as the implemented policy of three sources of electrical power anytime two residual heat removal (RHR) systems are specified in Technical Specifications (TS), but did not find a cohesive, complete high level policy and guidance document. The licensee has draft outage procedures that could represent the beginning of such a document, but they do not appear to originate from an upper management charter that identifies the need and provides a clear policy.

There appears to be no policy regarding electrical power supplies when RHR is not required. This could become a problem shortly after fuel off-load due to high decay heat loads. The fuel pool could begin to boil in about four to five hours if all fuel pool cooling is lost.

The licensee depends upon an extensive outage plan and review process to control outages. There are several levels of review and applicable technical specialists appear to be involved, including considerable exposure via personnel with operating backgrounds. The entire process appears to be based upon individual judgements concerning such areas as critical path, near critical path, TS requirements, other regulatory requirements and commitments, licensee imposed operating restrictions, and perception of operating and safety needs.

2. The licensee outage planning and implementation process

Diablo Canyon has an outage organization tasked with development of outage plans. This work includes such activities as coordinating the many disciplines and areas involved in outage activities to arrive at a coordinated, workable plan, and includes following and updating the plan during its implementation. Multiple meetings are held daily during the outage and various schedule breakdowns are updated continuously to provide the many levels of detail needed for the management and conduct of outage work.

The following aspects and licensee approach were examined: (1) Technical Specification philosophy, (2) pre-outage activities, (3) mid-loop opera-

tion, (4) fuel off-load, (5) review of the plan and of its implementation, (6) post-outage review.

a. Philosophy with respect to TS

Licensee personnel were clear that they do not believe Technical Specifications alone are adequate to assure safety, and that they take additional steps to provide an adequate safety margin. They consider modes 5 and 6 as really four modes rather than two, due to the different plant conditions involved while refueling. Consequently modes 5 and 6 are considered as "blocks" that are generally representative of the plant condition, with specialized needs for each block.

b. Pre-outage activities

The licensee's maintenance management decided that outage-related work should not be performed before the outage unless it was on the daily schedule. This decision was implemented only within the outage scheduling group. In part as a result, personnel were building a scaffold within an activity not covered on the daily schedule. Their procedure did not provide adequate guidance. regarding sensitive equipment, and the activities led to a Unit 1 reactor trip on February 1, 1991 (Reference 13).

c. Mid-loop operation

Significant emphasis was placed upon avoiding mid-loop, which the licensee clearly perceives as an undesirable condition. Following the licensee's loss of the RHR system on April 10, 1987, the licensee apparently decided to eliminate mid-loop to improve the margin of safety. Several aspects of mid-loop operation are addressed in more detail later.

d. Fuel off-load

Licensee personnel provided additional insights into advantages of a complete fuel off-load that clearly influence the decision to follow the practice. These included:

- It is difficult to perform a fuel shuffle because fuel assemblies tend to warp during use, and it is difficult to move such assemblies into a "hole."

- There is less chance of damaging fuel due to attempting to load into "holes" since this operation is eliminated.

- Unnecessary fuel moves are eliminated. There are no temporary moves within the core.

- Once the reactor vessel is defueled, almost all equipment can be taken out of service for maintenance and testing. The only need is to assure spent fuel pool cooling. This is a significant advantage.

- The outage scope is reduced. For example, certain instrumentation is not needed.

- A complete fuel off-load takes 50 to 60 hrs. Reload takes the same time. Licensee personnel believe that, although "on paper" a core shuffle may look better, in practice the off-load will result in the best outage schedule.

e. Review of the Outage Plan

Reportedly licensee upper management (in the planning/outage implementation organization) watched certain areas carefully. The focus apparently was upon critical path and close to critical path items, plus several other areas. The critical paths were described as; (1) cooldown, refueling, heatup, and restart, (2) turbine/generator work, (3) new computer installation, (4) saltwater systems maintenance, and (5) containment integrated leak rate testing.

Additional areas considered that are of safety significance included; (1) emergency diesel power supply availability, (2) electrical bus outages, (3) RHR, whether on the critical path or not, and (4) major systems such as auxiliary salt water (ASW) and chemical and volume control.

Reviews of the outage plan and its implementation involve several levels of personnel. The licensee described the following as examples:

- Planning - Ex-operations personnel are involved and check such areas as the implications of taking equipment out of service.

- An outage control center is provided and manned with numerous disciplines. A control room (CR) representative is provided continuously.

- Clearance coordination - Ex-operations personnel are involved.

- Unit shift foreman - This is a senior reactor operator (SRO) who among other things performs an overview safety function. (Responsibility and accountability always remains in the CR.)

- Operators hanging tags also can identify problems (although these often are less experienced operators and there may be a large number of tags to be hung).

This process was described as tracking such areas as equipment needs and availability, low temperature overpressure protection (as a mini-strategy), and containment integrity.

f. Post-outage review

The licensee forms "high impact teams" for critical and near critical path tasks. These teams are composed of experienced

personnel that have performed the same function in past outages. Team members are issued shirts that identify them as members of the specific team. A goal for team composition is that 70% of the personnel have previously functioned in a similar task.

Each team conducts a highly critical self-critique following task completion. Licensee management has found these critiques to be highly demanding and valuable for future outages.

Availability of Electrical Power

The Diablo Canyon plant typically operates during an outage with only one source of off-site power for about five weeks. According to licensee personnel, their switchyard would have to be changed significantly in order to provide more than one source of off-site power during an outage and still be able to take electrical equipment out of service for maintenance. The overall strategy in dealing with this situation was described as to protect against a loss of off-site power and a subsequent single failure when it is important to do so. Licensee representatives noted that compliance with the Technical Specifications alone does not provide protection against a subsequent single failure.

The licensee appears to have generally met or exceeded its criteria for providing electrical power sources during outages. For example, all three diesels and startup power were operable when reactor core reloading was initiated. Three diesels and auxiliary power were available immediately prior to the event.

Mid-Loop Operations and Core Cooling

1. Mid-loop Operations

The licensee has avoided mid-loop operation in Unit 1 for the last three refueling outages, and has followed a practice of complete core off-loading during which many of the activities are conducted that would normally be conducted during mid-loop. For example, all steam generator (SG) work has been accomplished with the core off-loaded. Conversely, the licensee does go to mid-loop operation when it is perceived to be operationally expedient to do so. For example, Unit 2 was taken to mid-loop in 1988 to repair SG manway leaks. Plans existed for going to mid-loop during the present refueling outage if SG problems had been encountered, but no problems were found.

Avoiding mid-loop as a philosophy is essentially an unwritten policy dating from the loss of RHR event in 1987 (Reference 14). It is incorporated into the schedule that is approved by the Plant Manager, and the team understands the Plant Manager's approval would be necessary to voluntarily enter a mid-loop condition.

Licensee personnel described several benefits that are achieved by avoiding mid-loop operations and the installation of SG nozzle dams:

- More dose is required for installation of nozzle dams than installing covers whose function is to prevent material from falling into the open legs.

- Restrictions incorporated into operating procedures make it difficult to perform work during mid-loop.

- It is considered to be a morale booster not to use mid-loop since mid-loop is an operator intensive operation.

- This is a safer operating approach (which was the original reason for avoiding mid-loop and nozzle dams).

- The licensee believes avoiding mid-loop saves time and manpower.

2. Core cooling during the event

Although the decay heat generation rate was similar to that at Vogtle during their event of March 20, 1990, the Diablo Canyon event initiated with a full refueling cavity in contrast to Vogtle's mid-loop condition.

The team identified no significant problems with core cooling during or following the event. Restart of an RHR pump within approximately a minute of event initiation was appropriate. Conducting a careful restoration of off-site power appeared to be appropriate since the plant was stable, and three sources of onsite electrical power were operating, any one of which was sufficient for extended core cooling. Occurrence of the event with a full refueling cavity and a low heat generation rate further moderated the plant heatup response to a loss of RHR, should an extended loss have occurred.

Application of Industry Experience

1. Licensee's Review of the Vogtle Event

The Vogtle event is described in NUREG-1410. This material is known to the licensee and its importance was clearly understood as evidenced by a licensee report evaluating the event (Reference 3), by interviews with licensee personnel, and by such statements in Reference 3 as:

"The Vogtle event has widespread impact."

"There are many issues resulting from the Vogtle event."

"... nuclear power plants in Modes 5 and 6 have the potential for severe accidents that may be unbounded by existing analysis and are not limited by existing Technical Specifications."

Selected aspects of the licensee's evaluation have been considered by the team and have been discussed with the licensee.

a. Overview

The team has found many areas of excellence in the licensee's conduct of this outage, including some implementation of Vogtle lessons learned. There are also many areas where improvement appears warranted.

Areas of good performance include identification of the need for concise management outage guidance, identification and implementation of selected safety principles, and avoidance of mid-loop operation.

The licensee apparently concluded that there were no lessons to be learned from the Vogtle event regarding the Diablo Canyon switchyard, off-site electrical power connections to the plant, and switchyard equipment control. With respect to both the switchyard and selected other areas, the team found:

- There are many identical areas between Vogtle and Diablo Canyon.
- Many Vogtle "lessons learned" are directly applicable to Diablo Canyon.
- Some of the Vogtle lessons learned may have been overlooked or may have not been properly applied by the licensee.
- The team concluded that the Diablo Canyon event would not have occurred had the licensee properly evaluated and applied the lessons learned at Vogtle.

b. Selected Vogtle Issues

The Reference 3 licensee evaluation of Vogtle does not use the NUREG-1410 identified topics, but instead provides interpretations of Vogtle issues. The team used the Reference 3 issues, assigned titles, and reviewed the licensee's disposition of the issues. Selected issues are discussed below.

ISSUE 1 <u>Safety Principles</u>

The licensee evaluation stated "... management expectations have not been clearly identified and formally communicated to plant workers with respect to reactor safety during an outage." The team agrees. This is an important finding on the part of the licensee and is better stated than in NUREG-1410. Some licensee work has been accomplished in this area (Reference 9), but the team was not provided evidence that the licensee's top management had recognized the importance of this statement, nor did the team find that clear management direction had been provided. The team believes this is a generic industry concern.

The licensee identified several safety principles that the team believes have significant merit. These are:

Minimize time at reduced inventory
Maximize pathways for adding water to the RCS
Maximize important support system availability
Minimize activities requiring mid-loop
Maximize time with no fuel in the RV

The team found numerous examples of applying these principles in the licensee's conduct of the present outage.

ISSUE 2 Diesel Procedures

The team understands that the only diesel trips active from the control room are overspeed, low oil pressure, and a severe electrical problem. The licensee correctly concludes that this excludes the actual trip that caused the malfunction at Vogtle. However, NUREG-1410 identified numerous other concerns, including knowledge of both the diesel and the sequencer, and availability of suitable procedures. The licensee did not address these issues. Instead, the licensee report simply recommends the provision of additional power supplies during certain outage activities.

ISSUE 6 Spent Fuel Pool Analysis

Calculations were performed that clearly establish time to boiling of the spent fuel pool. On the basis of these calculations and arguments pertaining to loss of off-site power, the licensee report concluded "... no further actions are necessary." It doesn't appear that consideration was given to problems with fuel building entry if the pool is boiling. Such entry may be part of the performance of operations and for observation of pool water level, given the present licensee philosophy.

ISSUE 7 Activities In Switchyards and Similar Areas

The licensee report stated, "This initiating event for reactor safety is bounded with the electrical power policy DCPP has implemented."

The Vogtle event involved an impact between an electrical bus support pole and a truck. (Neither was damaged and the pole was not replaced following the accident.) There was little control of movement and storage of equipment in Vogtle's switchyard. The Vogtle licensee instituted controls and provided fences to protect the poles following the event.

The team's examination of the plant layout at Diablo Canyon identified the following:

- Almost identical poles (size and insulator concept) are used at Diablo Canyon as are used at Vogtle. The path between poles is more clearly delineated at Diablo Canyon (no surface lines were

provided at Vogtle). Signs in the area warn of the high voltage wires.

- No protective fence or other protection was provided around the poles at Diablo Canyon.

- Heavy equipment (multiple air compressors) was stored between the poles at Diablo Canyon. Had the equipment not been there, the crane involved in the accident could have been maneuvered between these poles.

The NRC Incident Investigation team that investigated the Vogtle event reported the following in NUREG-1410:

- "... the Vogtle staff had no restrictions or access controls prohibiting vehicles or equipment from entering and remaining inside the switchyard except that they be there on official business." (page 10-1)

- "The Vogtle staff had no effective control over ...routine operations in the switchyard." (page 1-3)

- "Though the guidance provided to the industry did not focus on or illustrate loss of power during cold shutdown conditions, it did provide information about preventing such events under these conditions. In retrospect, Vogtle could have more thoroughly implemented the guidance provided and have prevented the incident ...." (page 6-1)

Licensee personnel stated they did not evaluate the electrical pole arrangement and the storage of equipment in the area as part of their evaluation of the Vogtle event. Planning personnel also stated they had considered the "truck" aspects of the Vogtle event, but did not think to extend consideration to other equipment, such as a crane.

Planning personnel indicated they had studied the electrical aspects of the Vogtle event and made a number of planning changes as a result. They also considered their past electrical history and then conducted a second review.

The team concluded that although the loss of power at Diablo Canyon did not involve damage to a pole, the potential existed for an accident identical to the one that occurred at Vogtle. The lessons learned in this area from Vogtle are clearly applicable to the Diablo Canyon configuration and to the Diablo Canyon event that actually occurred. Therefore, the licensee did not fully evaluate and did not well apply the lessons learned from the Vogtle event. The team concluded that the Diablo Canyon event would probably not have occurred had the licensee properly evaluated and applied the lessons learned at Vogtle. Licensee personnel agreed further work was needed in this area.

ISSUE 8 <u>Equipment Hatch Closure</u>

The licensee has evaluated the equipment hatch and found that four bolts are insufficient to provide containment integrity for refueling type events. (Four bolts, equally spaced, result in a quarter inch gap at the top of the hatch.) The team understands every other bolt is used for closure. This information is not reflected in procedures. The team observed the equipment hatch and noted that the ability to close the equipment hatch without electrical power is an advantage.

ISSUE 9 Loss of RHR

The licensee report concluded "... procedures were reviewed and found satisfactory."

The team noted that little guidance is provided regarding loss of AC power in the loss of RHR procedure (Reference 7). What is provided appears to be "buried" in the procedure.