

U. S. NUCLEAR REGULATORY COMMISSION

REGION V

Report Nos.: 50-275/91-17 and 50-323/91-17

Docket Nos.: 50-275 and 50-323

License Nos.: DPR-80 and DPR-82

Licensee: Pacific Gas and Electric Company
77 Beale Street, Room 1451
San Francisco, California 94106

Facility Name: Diablo Canyon Units 1 and 2

Meeting at: Region V Office, Walnut Creek, California

Report Prepared by: B. J. Olson, Project Inspector

Approved by:

P. J. Morrill
P. J. Morrill, Chief
Reactor Projects Section 1

6/28/91
Date Signed

Meeting on May 28, 1991 (Report Nos. 50-275/91-17 and 50-323 91-17)

A meeting was held in the Region V Office, Walnut Creek, California to discuss the licensee's efforts in resolving failures of main condenser steam dump valves and to discuss the findings of the licensee's Event Investigation Team regarding a total loss of Unit 1 off-site power which occurred on March 7, 1991.



DETAILS

1. Meeting Attendees

a. Licensee Attendees

- J. Shiffer, Senior Vice President and General Manager, Nuclear Power Generation Business Unit
- J. Townsend, Vice President, Diablo Canyon Operations and Plant Manger
- W. Fujimoto, Vice President, Nuclear Technical Services
- R. Anderson, Manager, Nuclear Engineering and Construction Services
- L. Womack, Manager, Nuclear Operations Support
- J. Tomkins, Director, Nuclear Safety Assessment and Regulatory Affairs
- B. Giffin, Manager, Maintenance Services
- K. Bych, Sr. Nuclear Engineer, Nuclear Operations Support
- K. Herman, Group Supervisor, Nuclear Engineering and Construction Services
- M. Davido, Engineer, Nuclear Engineering and Construction Services
- A. Nicholson, Engineer, Nuclear Safety Assessment and Regulatory Affairs

b. NRC Attendees

- J. Martin, Regional Administrator
- R. Zimmerman, Director, Division of Reactor Safety and Projects
- K. Perkins, Deputy Director, Division of Reactor Safety and Projects
- D. Kirsch, Chief, Reactor Safety Branch
- S. Richards, Chief, Reactor Projects Branch
- P. Morrill, Chief, Reactor Projects Section I
- P. Narbut, Senior Resident Inspector
- P. Galon, Reactor Inspector
- M. Miller, Reactor Insepctor
- W. Ang, Project Inspector
- B. Olson, Project Inspector

2. Details

Mr. Shiffer opened the meeting by presenting the subjects to be discussed: failures of main condenser steam dump valves, and findings from PG&E's Event Investigation Team regarding a total loss of Unit 1 off-site power which occurred on March 7, 1991. Mr. Shiffer turned the discussion over to Mr. Fujimoto.

Mr. Fujimoto described the construction and operation of the main condenser steam dump valves. The steam dump valves are manufactured by Copes-Vulcan, and twelve dump valves are installed in each unit at Diablo Canyon. The valves are eight inch, air opened, spring closed, reverse seated globe valves with a main and inner plug. The main plug



is free to slide in a surrounding cage, while the inner plug is threaded and pinned to the valve stem. Steam pressure, acting on the underside of the main and inner plugs, holds the valve closed. Additional closing force is provided to the inner plug by spring pressure against the valve stem. To open the valve, air is admitted into the air operator and exerts a force against a diaphragm. The diaphragm moves the valve stem which unseats the inner plug and equalizes the steam pressure on the suction and discharge sides of the valve. As the stem continues to move, contact is made with the main plug, and the main plug unseats.

Mr. Fujimoto described the failures of the main condenser steam dump valves. Since December 1990, six Unit 1 valves have failed. The failures were categorized into two areas: tensile failure of the inner plug (2 failures), and stripped threads with pullout of the inner plug from the valve stem (4 failures). Additionally, almost all of the failed valves had a bent stem. Two possible failure mechanisms were explained. Mr. Fujimoto stated that PG&E believed the main plug microwelds to the cage. When the valve was called upon to open, the air operator pressure would need to increase to allow the stem to break the bond between the main plug and cage. When the main plug finally moves, the increased air pressure would cause the valve stem and attached inner plug to accelerate and reach the bottom stop. The main plug would continue to travel and impact the inner plug, resulting in failure. The second failure mechanism involved condensate accumulating under the main plug and resulting in a situation where air operator pressure would also need to increase to move the valve. Of the two postulated mechanisms, Mr. Fujimoto indicated that microwelding of the main plug to the cage was considered to be more probable than condensate accumulation under the main plug. Mr. Fujimoto indicated that engineering had calculated the forces required to break the inner plug, and that the air operator could develop the necessary force. Once the valve failed, engineering had also calculated that there was sufficient steam pressure to bend the valve stem. Mr. Fujimoto turned to Mr. Anderson for a discussion of the calculated forces and why microwelding was thought to occur.

Mr. Anderson stated that the valve would fail if the main plug impacted the inner plug with a force of 20,000 lbs. Calculations indicated that the 20,000 lb. force could be generated if the air operator provided a pressure of 58 psi to move the valve stem. While testing had shown that smooth operating valves only required an air operator pressure of 15 psi, the operator was capable of providing up to 85 psi. The air system would provide the operators 85 psi if the valves were called upon to open quickly, such as after a reactor trip. It was noted that most of the valve failures were discovered after reactor trips. After a question by Mr. Martin, more details of the calculations were provided.

Mr. Anderson then provided a history of steam dump valves at Diablo Canyon. Until 1988 and 1989, the main plug and cage had been lapped to provide a broad seating surface. In March 1990 the licensee had implemented a procedure change to not lap the seating surfaces unless needed. The procedure change was a result of a vendor recommendation to reduce possible leakage past the main plug. In April 1990, a weld on a valve stem broke, and PG&E decided to replace the internals of all



condenser steam dump valves. The seating surfaces of the replaced internals were not lapped, in accordance with the new procedure. Six steam dump valves had failed since December 1990. Mr. Anderson stated that by not lapping the seating surfaces of the main plug and cage, a single line of contact results when the valve is closed. Due to the material type, the closing forces on the main plug and cage, and the single line of contact, microwelding was considered to occur. Past efforts to lap the seating surfaces would have resulted in a larger area of contact and not have led to microwelding.

The discussion next turned to PG&E's efforts to determine if similar problems existed at other facilities, and the vendor's knowledge of any similar failures. Mr. Fujimoto answered various questions, indicating that PG&E had not been able to find evidence of similar failures at other facilities. The vendor had also informed PG&E that Diablo's steam dump configuration differed from that of other facilities with the same type of valve.

Valve design changes, as a result of the failures, were explained. The thickness of the inner plug was increased, the inner plug length was increased, and a harder material was used to fabricate the main plug and the cage. Mr. Fujimoto indicated that the harder material would eliminate microwelding, and the inner plug changes would add strength. Mr. Zimmerman asked, and was told, that no other facility had used the new valve internals.

Mr. Giffin indicated that two of the new valve internal kits have been installed in Unit 1. It was expected that the remaining kits would be shipped to Diablo by the end of May 1991. Shipment of new valve internal kits for Unit 2 was expected to commence in July 1991. Until the new valve kits are installed, Mr. Giffin stated that the seating surfaces of existing valves were being lapped to reduce the possibility of microwelding.

Mr. Martin indicated that PG&E's presentation of their failure analysis and valve design changes sounded convincing, but he pointed out that, as stated during the discussion, some of the work is science and some is based on experience. He went on to say that it might be wise to operate for a few weeks with a new valve internal kit installed and then inspect the valve prior to replacing the internals in all valves. Mr. Anderson followed by saying that many factors influenced the decision to replace the valve internals with a new design, but the primary reason was that no additional failures were desired.

This portion of the meeting concluded after a discussion of the testing to be performed on valves with new internals, and PG&E's review process that justified continued plant operation after experiencing the valve failures.



Following a short break, the licensee presented their findings from an investigation into the loss of off-site power at Unit 1 on March 7, 1991. The loss of off-site power occurred after a crane, operating in close proximity to 500 kV power lines, caused a short-to-ground. This event resulted in the formation of an NRC Augmented Inspection Team (AIT) and a PG&E Event Investigation Team (EIT). The AIT's report of this event was documented in NRC Inspection Report 50-275/91-09. Mr. Womack, the EIT team leader, initiated the presentation.

The event was reviewed, along with PG&E's immediate and short term corrective actions. Mr. Womack then compared the Diablo event with a loss of off-site power that occurred at Vogtle. Included in this discussion was the application of lessons learned from the Vogtle event. Mr. Womack indicated that PG&E put principal interest in mitigating the consequences of a loss of off-site power, as they believed that potential events could not be controlled. Mr. Townsend added that too much confidence was placed in the worker training program, and more barriers could have been in place to prevent the event. Mr. Martin indicated that an argument could be made either way as to mitigating the consequences or preventing the event, but the tie was broken by the crane operator, and the event could have been prevented. Mr. Richards stated that it appeared there was too much reliance on the crane crew's experience and asked if the work instructions called for a crane to be in the area. Mr. Womack indicated that cranes were not controlled in the area nor were they controlled in other areas outside the main plant buildings. Both Mr. Womack and Mr. Townsend stated that cranes had probably operated in the area in the past and possibly closer to the power lines than allowed by PG&E accident prevention rules, but the cranes had never been directly under the lines as was the case in this event.

Mr. Womack reviewed the root cause of the event - personnel error. Mr. Martin said that if personnel error was the cause then it would be appropriate that similar activities get some type of review rather than relying on the worker's knowledge of accident prevention rules. Mr. Perkins added that the root cause placed responsibility on the workers and did not appear to place responsibility on work planning. Mr. Shiffer said that two fundamental areas needed to be addressed: personnel going to work on a system should not trust others to ensure that the system is safe to work on, and workers need to be better trained on activities around conductors. To answer these comments, Mr. Womack pointed out that PG&E's corrective actions to prevent recurrence provided for written instructions prior to work in the area around the power lines. The instructions would take into account the need for a work order and the need for a safety review to identify any appropriate work practices. Mr. Womack added that another corrective action was to revise the training program to emphasize electrical safety issues. The status of all corrective actions was also discussed.

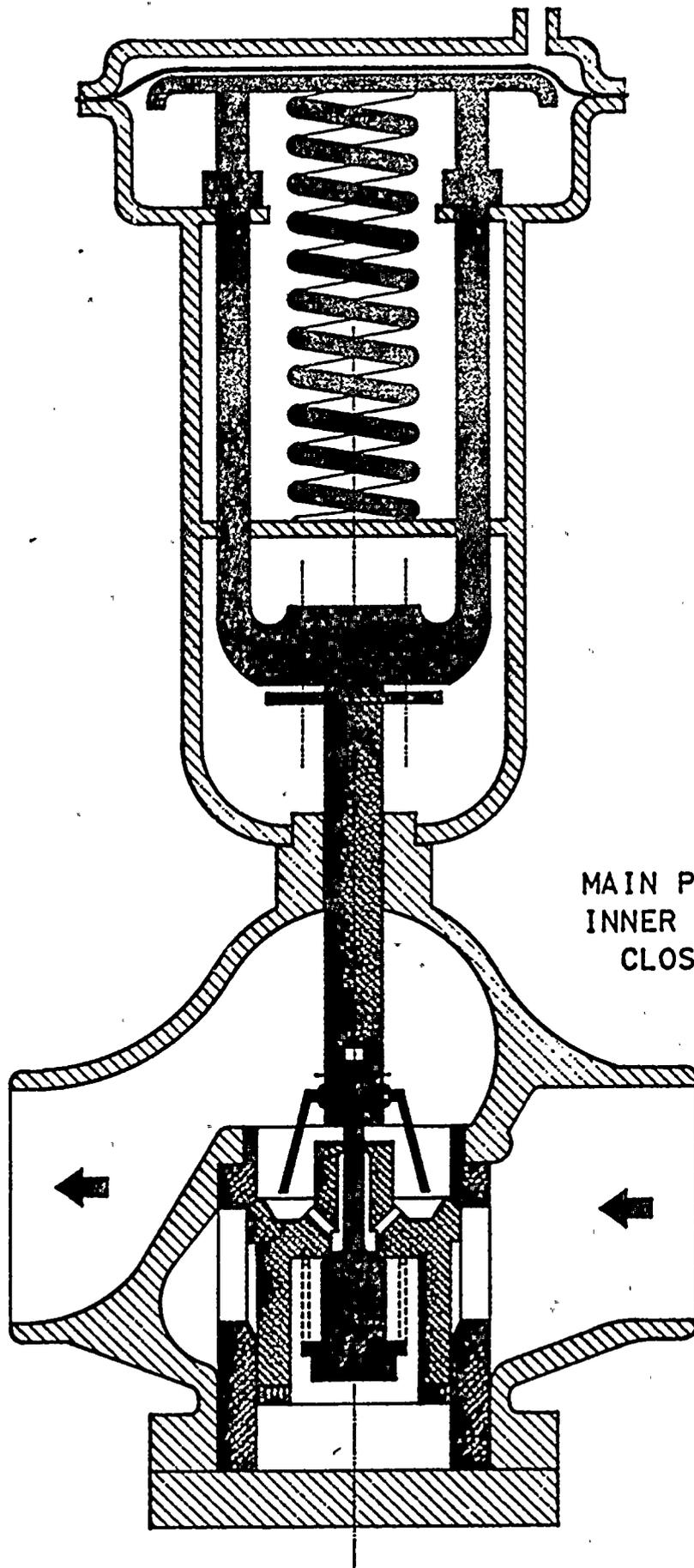
After Mr. Narbut described some past problems with cranes and rigging of equipment, Mr. Martin asked if it might be wise for Quality Assurance to perform an audit on rigging and handling practices. Mr. Townsend stated that there already was an open nonconformance report regarding specific.



rigging and handling practices, and its resolution would also address general issues.

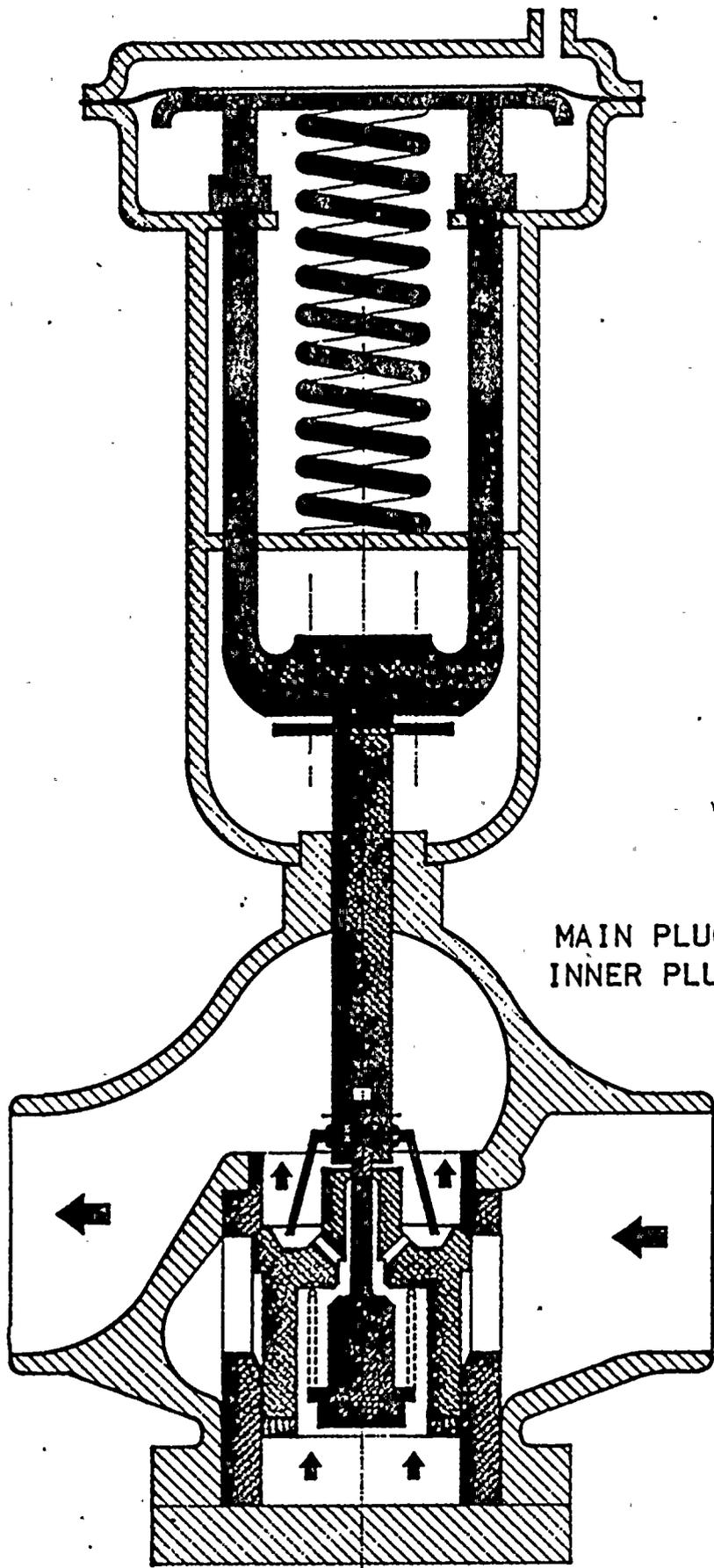
In closing the meeting, Mr. Martin said that his first concern was one of a more general work control issue and that he had developed an uneasy feeling about general work practices. He added that it would be unfortunate to have another crane incident, and that maybe Quality Assurance needs to look at the area.





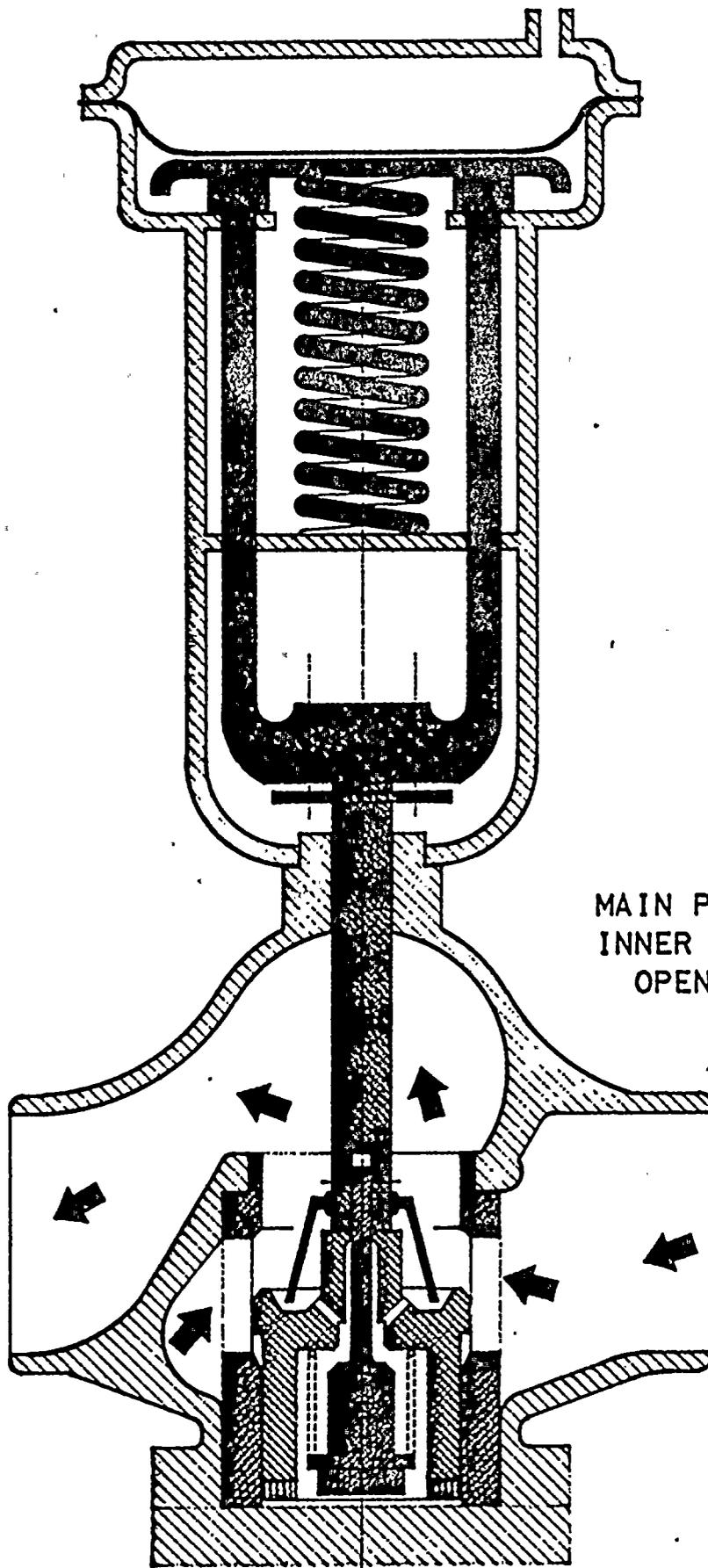
MAIN PLUG/
INNER PLUG
CLOSED





MAIN PLUG CLOSED
INNER PLUG OPENED

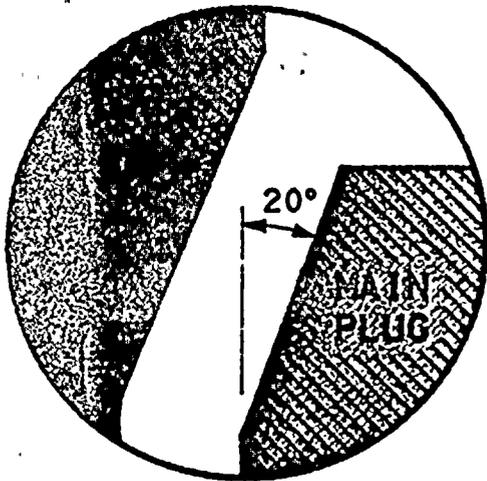




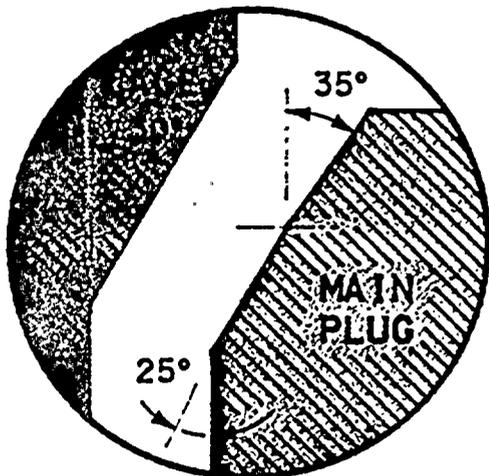
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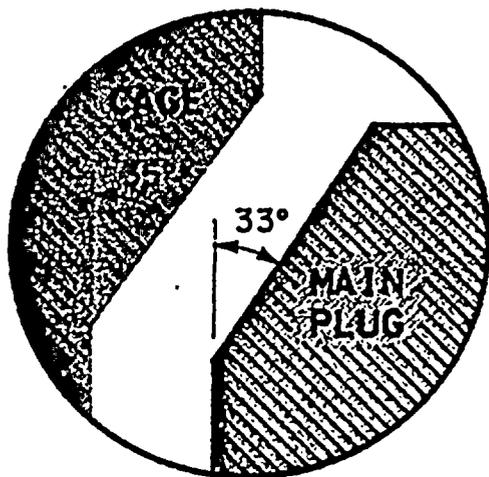
SEAT DETAILS



PRE - 1975



1975 TO 1991



NEW DESIGN



UNIT 1 LOSS OF OFFSITE POWER

MARCH 7, 1991

PRESENTATION TO NRC/REGION V
May 28, 1991





UNIT 1 LOSS OF OFFSITE POWER *AGENDA*

1. INTRODUCTION
2. EVENT DESCRIPTION
3. PLANT RESPONSES
4. COMPARISON TO VOGTLE EVENT
5. SAFETY SIGNIFICANCE
6. ROOT AND CONTRIBUTORY CAUSES
7. CORRECTIVE ACTIONS



UNIT 1 LOSS OF OFFSITE POWER ELECTRICAL DISTRIBUTION SYSTEM

- Two transmission systems
 - 500 kV for normal operation and backfeed during outages
 - 230 kV for standby and startup
- One main 500 kV transformer per Unit
 - 25 kV main generator with 3 single-phase 25 kV/500 kV transformers
- One 230 kV standby startup transformer per Unit
- Two EDGs per Unit/ one "swing" EDG

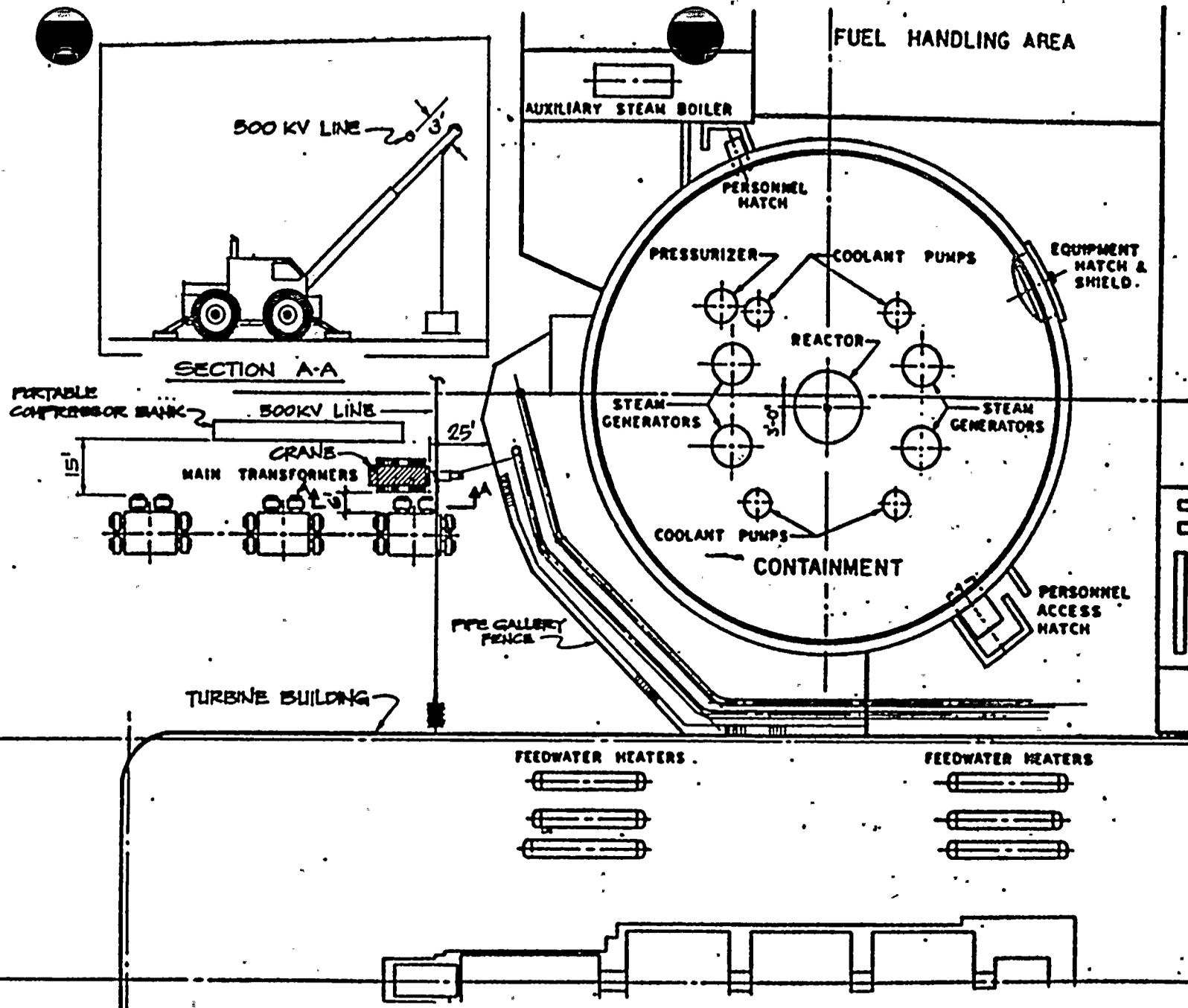




UNIT 1 LOSS OF OFFSITE POWER *CONDITIONS PRIOR TO EVENT*

- Unit 2 at 100% power
- Unit 1 in fourth refueling outage
 - Core reload in progress
 - Power from 500 kV (backfeed)
 - 230 kV in maintenance
 - 3 EDGs available

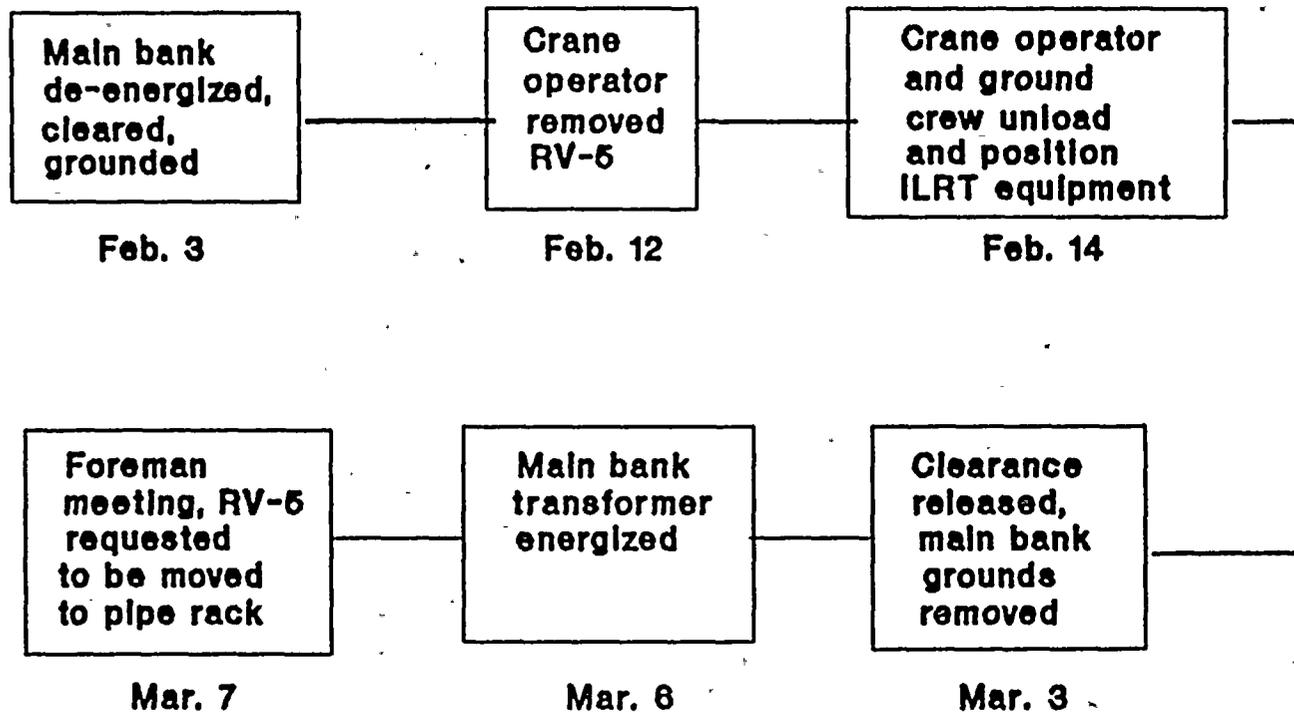




PG 4 E PLAN AND SECTION OF
 LOSS-OF-POWER OFFSITE EVENT
 3/7/91

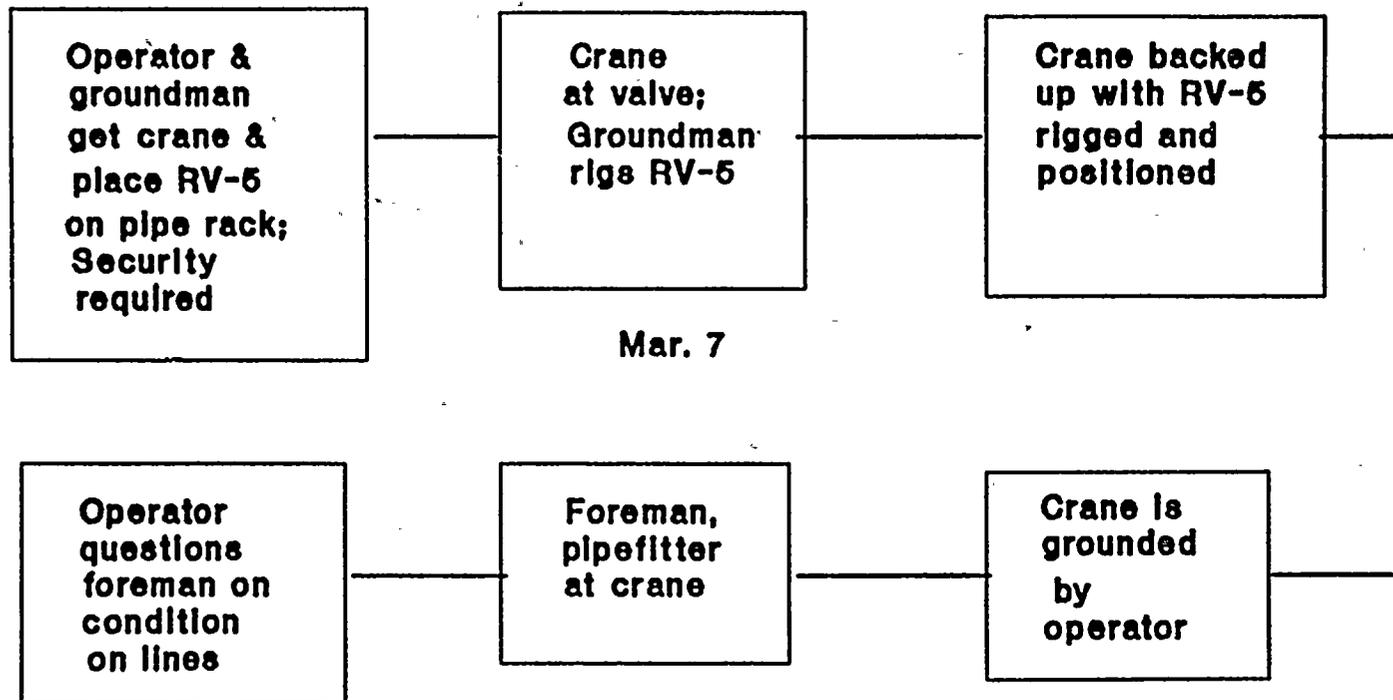


UNIT 1 LOSS OF OFFSITE POWER TIMELINE



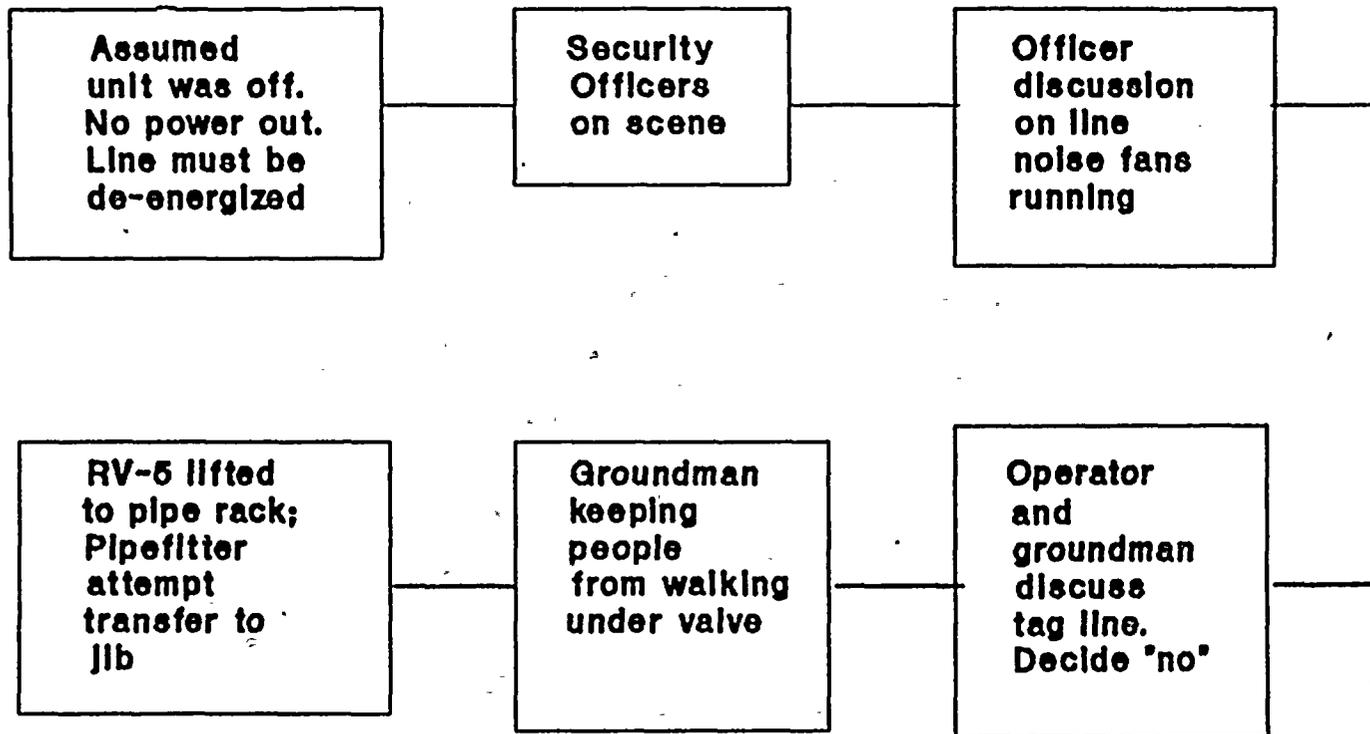


UNIT 1 LOSS OF OFFSITE POWER TIMELINE (CONT'D)



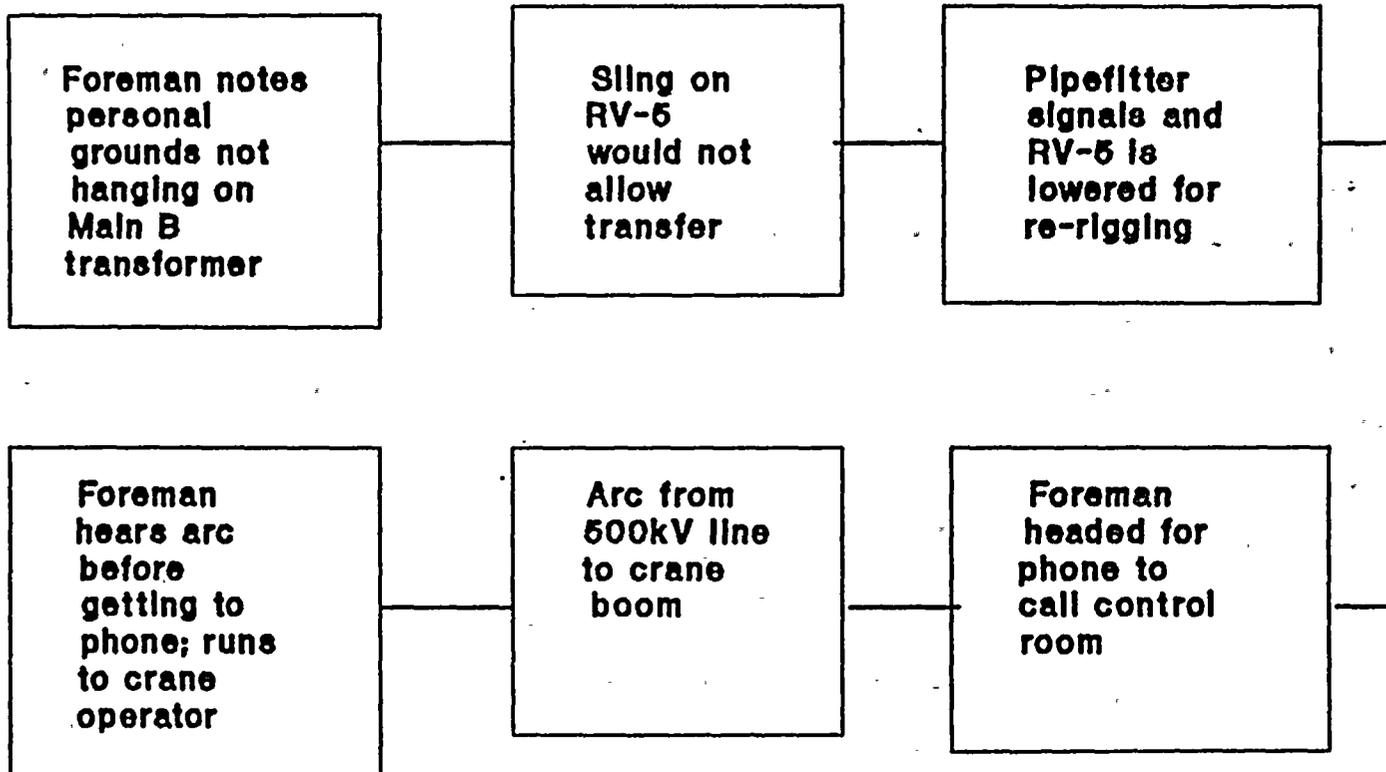


UNIT 1 LOSS OF OFFSITE POWER TIMELINE (CONT'D)



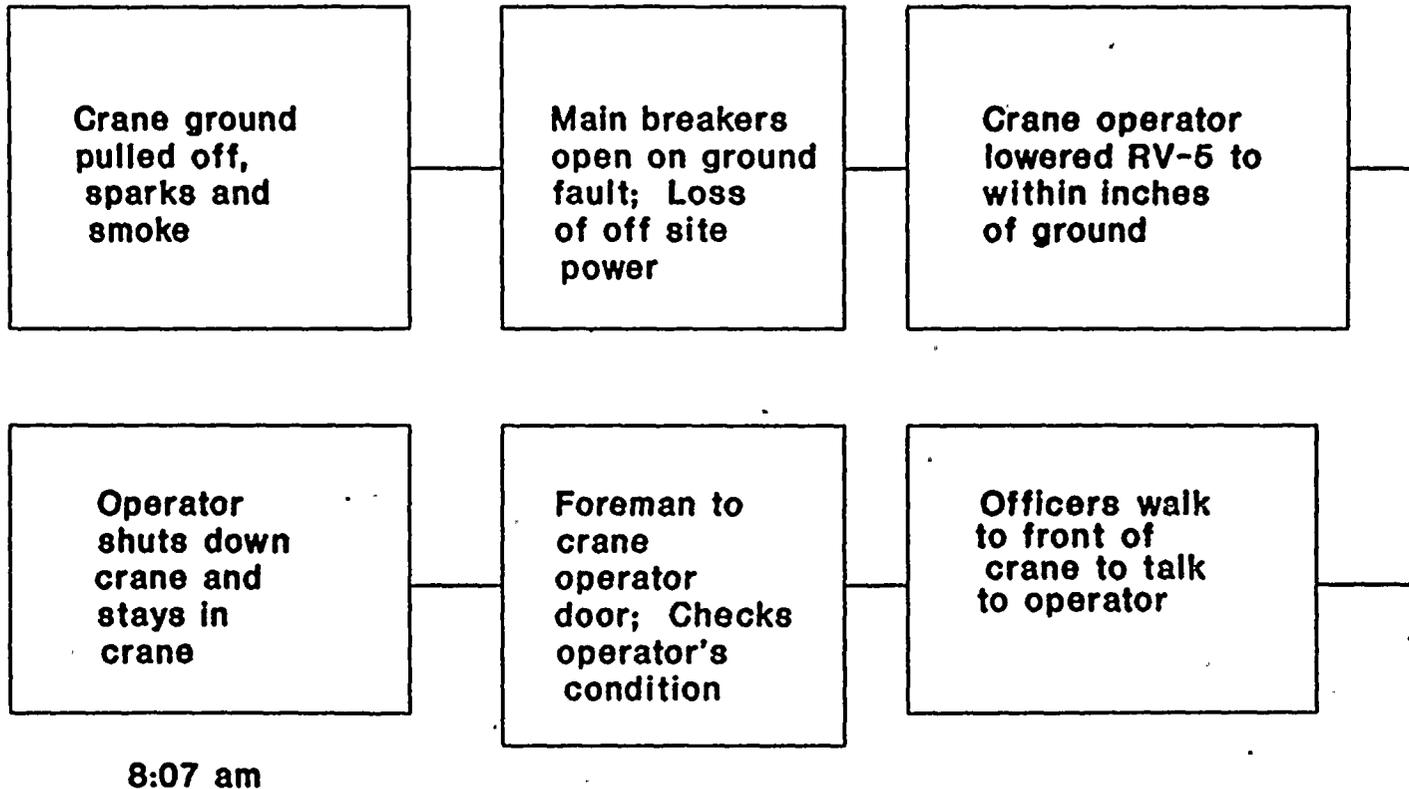


UNIT 1 LOSS OF OFFSITE POWER TIMELINE (CONT'D)



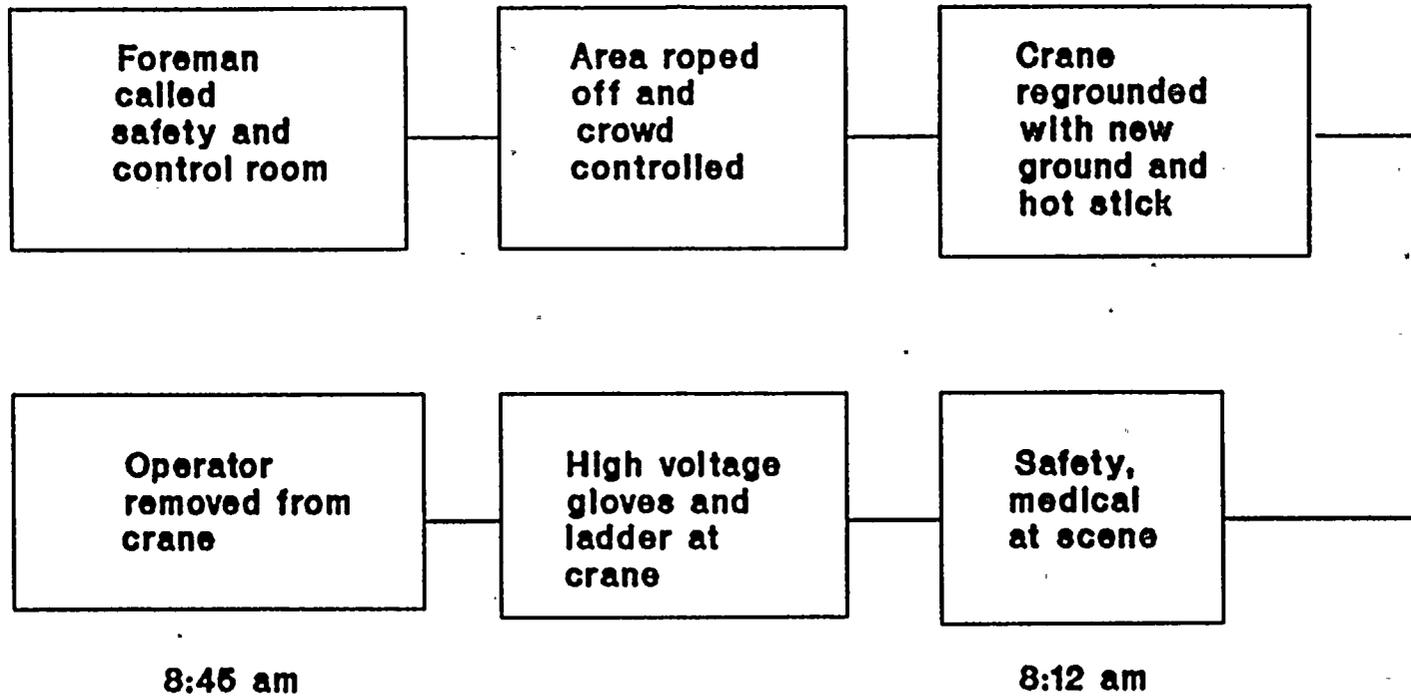


UNIT 1 LOSS OF OFFSITE POWER TIMELINE (CONT'D)





UNIT 1 LOSS OF OFFSITE POWER TIMELINE (CONT'D)





UNIT 1 LOSS OF OFFSITE POWER

IMMEDIATE ACTIONS

Thursday, 3/7/91

- Loss of offsite power at 0807 PST
- RHR Pump 1-2 manually restarted by 0808 PST
- Fuel movement suspended
- Unusual Event declared at 0830 PST
- Event Investigation Team convened - Event Response Plan formulated - offsite power restored to Unit 1 transformer at 1228 PST





UNIT 1 LOSS OF OFFSITE POWER

EIT COMPOSITION

The EIT was composed of personnel from:

- Nuclear Operations Support
- Human Performance Evaluation
- Safety, Health, and Emergency Svcs
- Operations
- Training
- Nuclear Regulatory Affairs
- Instrumentation and Controls
- Quality Assurance
- Quality Control
- Electrical Maintenance
- Mechanical Maintenance
- Nuclear Engineering and Construction Svcs
- Onsite Safety Review Group



UNIT 1 LOSS OF OFFSITE POWER

SHORT TERM ACTIONS

Thursday, 3/7/91

- VP/Plant Mgr suspended outage work at 1200 PST for 24 hours
- VP/Plant Mgr held meeting with plant personnel at 1600 PST
- VP/Plant Mgr issued safety memo and letter to NRC

Thursday, 3/14/91

- Senior VP/General Mgr issued letter emphasizing safety on the job



UNIT 1 LOSS OF OFFSITE POWER

SAFETY SYSTEM RESPONSES TO EVENT

- All 3 EDGs autostarted and loaded
- ASW Pump 1-2 restarted on bus transfer (ASW Pump 1-1 cleared for maintenance)
- All containment fan cooling units autostarted
- Centrifugal Charging Pump 1-2 autostarted (Centrifugal Charging Pump 1-1 cleared for maintenance)
- Component Cooling Water Pumps 1-1, 1-2, and 1-3 autostarted





UNIT 1 LOSS OF OFFSITE POWER

PLANT RESPONSES TO EVENT

RESPONSES DUE TO POWER INTERRUPTION

- Control room ventilation system shifted to safeguards/pressurization mode
- Fuel handling building ventilation system transferred to iodine removal mode
- RE-29 alarmed at Office of Emergency Svcs
- H₂ monitors CEL-82, 83 annunciated as failed
- Unit 2 vibration/loose parts monitor alarmed
- Meteorological tower printed failure messages





UNIT 1 LOSS OF OFFSITE POWER PLANT RESPONSES TO EVENT (CONT'D)

EQUIPMENT THAT DID NOT FUNCTION AS EXPECTED

- Auxiliary building fans did not restart
- Unit 1 control room emergency lighting did not function. Portions of auxiliary and containment lighting did not function.
- Plant public address system not available in many areas of Unit 1
- Control room/containment intercom lost power
- Unit 2 turbine inlet high temp alarm actuated



UNIT 1 LOSS OF OFFSITE POWER PLANT RESPONSES TO EVENT (CONT'D)

RESPONSES DUE TO POWER SOURCE CONFIGURATION

- Some Unit 2 equipment lost power (traveling screen wash/CEL-102/digital feedwater system control)
- Auxiliary building control and radwaste panels lost power
- Instrument air compressors powered from Unit 1 lost power
- Containment and spent fuel pool refueling cranes lost power



UNIT 1 LOSS OF OFFSITE POWER

SAFETY SIGNIFICANCE

- Event did not jeopardize nuclear safety
 - 3 EDGs started and loaded
 - RHR loss less than one minute
 - No inventory loss or temperature rise
- Event duration 4 hours, 50 minutes
 - Could have been reduced through "emergency maintenance" practices if necessary
- Spent fuel pool cooling pump interruption had negligible effect



UNIT 1 LOSS OF OFFSITE POWER COMPARISON TO VOGTLE EVENT

INITIAL CONDITIONS

	<u>VOGTLE</u>	<u>DCPP</u>
CONTAINMENT	OPEN	CLOSED
RCS INVENTORY	MID-LOOP	23' ABOVE FLANGE
RCS COOLING	A RHR PP B RHR OOS	RHR 1-2 PP RHR 1-1 AVAIL
POWER	1 OFFSITE 1 OFFSITE OOS 1 EDG AVAIL/1 OOS	1 OFFSITE (AUX) 1 OFFSITE OOS 3 EDG AVAIL
FUEL INVENTORY	CORE FULL	CORE 97% FULL





UNIT 1 LOSS OF OFFSITE POWER COMPARISON TO VOGTLE EVENT

PLANT RESPONSE

	<u>VOGTLE</u>	<u>DCPP</u>
OFFSITE POWER	2 HR, 10 MIN	4 HR, 50 MIN
EDG LOADING	1 EDG 36 MIN	3 EDG Immediately
RHR LOST	41 MIN	< 1 MIN
CORE TEMP	INCREASE 46 F	NO CHANGE
RCS INVENTORY	NO CHANGE	NO CHANGE
SPENT FUEL POOL	N/A	Interrupted 23 MIN (but no impact)



UNIT 1 LOSS OF OFFSITE POWER

PG&E REVIEW OF VOGTLE EVENT

Review of IN 90-25 & NUREG-1410 identified following actions:

- Provide 3 diverse AC sources when 2 RHR pumps required during outages
 - Auxiliary power (500 kV)
 - Startup power (230 kV)
 - Opposite unit
 - EDGs
- Restrict use of mid-loop and minimize number of activities performed during mid-loop operations
- Initiate development of outage management policy
- Review adequacy of procedures with respect to loss of all AC
- Maximize RCS makeup paths
- Careful planning of EDG, vital busses, and RHR pump outages



UNIT 1 LOSS OF OFFSITE POWER

ROOT AND CONTRIBUTORY CAUSES

Root Cause: Personnel error - crane operator and foreman did not follow accident prevention rules and did not recognize electrical safety issues during job planning and execution

Contributory Causes:

- Inadequate work practices in high voltage areas (clearance/work order requirements)
- Insufficient emphasis on electrical safety during training
- Tailboard communication practices
- PG&E evaluation of IN 90-25 and NUREG-1410
 - evaluated but did not adopt traffic control
 - PSRC/final mgmt approval of recommendations not obtained prior to 1R4



UNIT 1 LOSS OF OFFSITE POWER

ACTIONS TO PREVENT RECURRENCE

- 1) Personnel will be retrained on electrical safety portions of PG&E accident prevention rules
- 2) Area in vicinity of high voltage lines and transformers within the protected area has been posted and barriers provided
- 3) AP C-40S3 will be revised to provide guidance for preparing work activities in the vicinity of power lines or transformers
- 4) Precautions and actions involved for safe work activities around high voltage lines, transformers, and switchgear have been included in General Employee Training



UNIT 1 LOSS OF OFFSITE POWER

ACTIONS TO PREVENT RECURRENCE (CONT'D)

- 5) Maintenance training program has been revised to emphasize electrical safety issues when working on or around transformers, high voltage lines, switchgear
- 6) Memorandum will be issued by VP/Plant Mgr to re-emphasize importance of conducting thorough tailboards
- 7) PG&E now performing a team review of operating experience, which prioritizes and scopes responses to ensure timely/complete recommendations
- 8) Procedures will be implemented prior to next outage to control power sources and identify limitations during refueling outages



UNIT 1 LOSS OF OFFSITE POWER

ACTIONS TO PREVENT RECURRENCE (CONT'D)

- 9) Comprehensive set of outage policies will be developed to provide guidance regarding equipment configuration and operability needs during outages (spent fuel cooling included in program) (AIT)
- 10) Equipment control guidelines being prepared to provide Mode operability requirement and configuration information for non-TS equipment. Outage sections will be added as appropriate (AIT)
- 11) Coping strategies will be developed for shutdown conditions, and will include
 - potential conditions (e.g., fuel pool temp rise)
 - discussion of other events during shutdown
 - amount of time available until unsatisfactory conditions occur (AIT)



