50-275/323-OLA-2
I-MFP-14
8/17/93

MFP Exhibit 14
8/17/93 Dallie Feigel
Reptr.

NCR DC1-93-EM-N010, D3
July 28, 1993

'93 OCT 28 P6:15

MANAGEMENT SUMMARY

February 5, 1993: Unit 1 was ramped to 46% power and an unusual event declared when a ground alarm was received on Circulating Water Pump (CWP) 1-1. While the ground alarm was in, smoke was reported in the Unit 1 12kV switchgear room. The California Department of Forestry (CDF) was called to assist in fighting the potential fire. The smoke lasted less than 10 minutes, there were no personnel injuries, and no equipment was damaged. The CWP 1-1, phase-B, cable was found to have failed. Note: The CWP is not a tech spec item.

During the power reduction, the digital rod position indications (DRPI) did not follow the control rod indicators as control rods were inserted into the core. Control Bank "D" was declared inoperable.

An Immediate (less than one-hour) emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(1)(i).

A twenty-four hour Unusual Event summary report was made to San Luis Obispo County in accordance with the requirements of NUREG-0654, Revision 1, Appendix 1.

The TRG reconvened on 3/19/93, and agreed that the 3/12/93 similar event on CWP 1-2 would be included in the scope of this NCR.

March 12, 1993: Unit 1 was ramped to 50% power when a ground alarm was received on Circulating Water Pump (CWP) 1-2. While the ground alarm was in, smoke was reported in the Unit 1 12kV switchgear room. The smoke lasted less than 10 minutes and there were no personnel injuries. No equipment in the room was damaged. CWP 1-2, phase-C (of circuit "B"), cable was determined to have failed.

This draft, dated July 28, 1993, contains minutes from the July 21, 1993, TRG meeting. The TRG will reconvene on September 14 to review the IPRT report and determine final root cause and corrective actions.

Root Cause: TBD

Contributory Cause: TBD

Corrective Actions to Prevent Recurrence: TBD

NCR DC1-93-EM-N010
CWP 1-1 and CWP 1-2 CABLE FAILURES

I. Plant Conditions

Unit 1 was in Mode 1 (Power Operation) at 100% power at the time of occurrence for both events.

II. Description of Event

A. Summary:

Event 1; February 5, 1993: Unit 1 was ramped to 46% power and an unusual event declared when a ground alarm was received on Circulating Water Pump (CWP) 1-1. While the ground alarm was in, smoke was reported in the Unit 1 12kV switchgear room. The California Department of Forestry (CDF) was called to assist in fighting the potential fire. The smoke lasted less than 10 minutes and there were no personnel injuries. No equipment in the room was damaged. CWP 1-1, phase-B, cable was determined to have failed.

A one-hour, emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(1)(i).

A twenty-four hour Unusual Event summary report was made to San Luis Obispo County in accordance with the requirements of NUREG-0654, Revision 1, Appendix 1.

During the power reduction, the digital rod position indications (DRPI) did not follow the control rod indicators as control rods were inserted into the core. Control Bank "D" was declared inoperable resulting in entry into a limiting condition of operation in accordance with Tech Spec 3.1.3.1.

Event 2; March 12, 1993: Unit 1 was ramped to 50% power and when a ground alarm was received on Circulating Water Pump (CWP) 1-2. While the ground alarm was in, smoke was reported in the Unit 1 12kV switchgear room. The smoke lasted less than 10 minutes and there were no personnel injuries. No equipment in the room was damaged. CWP 1-2, phase-C, cable was determined to have failed.

B. Background:

Event 1; February 5, 1993: Emergency Procedure G-1 - "Accident Classification and Emergency Plan Activation", requires a NUE be declared when assistance of an off-site agency (i.e. CDF) is requested.

NUREG-0654, Revision 1, Appendix 1, requires a written summary of the event be submitted to San Luis Obispo County government by the end of the first work day following the declaration of any emergency class.

Tech Spec 3.1.3.1 states; "All full-length shutdown and control rods shall be OPERABLE and positioned within plus or minus 12 steps (indicated position) of their group demand position." Control Bank "D" was declared inoperable. Tech Spec 3.1.3.1 requires restoration of Bank "D" to operable status within 72 hours or place the Unit in at least hot shutdown mode within the following 6 hours.

Cable Construction

The 12kV cables are rated for up to 15kV applications. The cables are a shielded single-conductor cable design, constructed in concentric layers. There are four cable layers of interest: (1) the insulation layer, which is approximately 220 mils of black EPR; (2) the tinned copper shield tape, which acts to equalize the electrical stress; (3) the wax coated synthetic binder tape, which holds the copper shield against the cable, thereby allowing the outer jacket to be extruded over the cable during manufacture; and (4) the outside layer, which is a neoprene jacket. The function of the outer neoprene jacket is to protect the cable during installation (impact and abrasion resistance) and to act as a physical barrier between the outside environment and the shield once the cable is installed. The cable jackets are not bonded to the cable shield or insulation layers.

Duct Bank Construction

The 12kV motor-driven circulating water pump (CWP) feeders consist of six separate single-conductor cables (two for each phase), routed as two separate three phase circuits in two single side-by-side conduits (two circuits).

The subject cables are routed in two separate sets of duct bank conduits, one for each unit, between the turbine building and the intake structure. Concrete vaults are located at various intervals to serve as pull boxes for the circuits. These duct bank conduits are directly buried in sand and are covered for their entire length by a six-inch thick concrete cap. The duct bank conduits include 12kV, 4kV, and 480V power cables, 120V ac control cables, 125V dc control cables, and instrument cables.

The pull boxes immediately outside of the turbine building have drains, which are routed to common sump manholes for Units 1 and 2. These manholes are equipped with automatic submersible Class II sump pumps.

The Unit 1 and Unit 2 trenches are similar, except that the Unit 1 duct bank rises to cross over the circulating water discharge tunnel and then slopes downhill towards the intake structure. This design makes the Unit 1 section of cable conduits near the turbine building susceptible to submergence if the pull box sump pumps are not functional and if the water within the pull boxes rises above the conduit openings.

Cable Testing

In accordance with applicable industry standards, DCPP performs direct-current, high-potential testing (hi-pot testing) as a maintenance activity each refueling outage. Normal practice for hi-pot testing of motors is to hi-pot the motors from the switchgear end of the circuit, through associated cables and motor terminations. The 12kV motors, due to hi-pot test equipment limitations, are hi-pot tested locally at the motor with the cables disconnected. The cables are hi-pot tested separately from the motor. The maximum voltage level used for the in-service 12kV cables is 30 kV dc.

C. Event Description:

Event 1

On February 5, 1993, Unit 1 was ramped down from 100 to 46 percent power due to a ground current alarm for CWP 1-1. While the ground alarm annunciated, smoke was reported in the 12kV switchgear room due to ground resistor bank heating of accumulated dust, as is expected during ground fault conditions. An Unusual Event was declared at 2156 PST due to a precautionary assistance request to an offsite agency. An immediate emergency report was made to report the declaration of an Unusual Event in accordance with 10 CFR 50.72(a)(1)(i).

Investigation determined that the ground was located on one cable between the first pull box outside the turbine building and the next pull box at the discharge structure elevation. When the cables were removed, the neoprene jacket was found to be separating from all three cables of the circuit for a distance of approximately 200 feet.

The faulted portion and a similar length of the other two cables for this circuit were removed, the water was pumped out of the pull box, a mandrel was passed through the conduit several times to remove standing water, and new cables were installed. When the new cable sections were spliced in, no visual degradation was found at the splice locations. Cable samples were sent to Okonite, the PG&E TES laboratory, and Altran Materials for comprehensive examination and testing. Interim progress reports indicate that the outer neoprene jacket had been chemically degraded and the copper shield shows evidence of corrosion. However, electrical properties of the cable are acceptable, no evidence of manufacturing defects has been identified, and no indication of an installation problem or abnormal operating conditions can be found. The root cause investigation for this event is in progress.

While removing the failed CWP 1-1 cable from the conduit, water was introduced into the conduit from the discharge structure elevation pull box in order to lubricate the cables for removal. No water came out the pull box at the turbine building end of the conduit run. Investigation determined that the six-inch acrylonitrile-butadiene styrene (ABS) conduit was broken, and that this damage had resulted from the initial attempts to remove the cable.

Conditions prior to event, STP M-16N had just been completed (test switch placed in "reset").

TIME	DESCRIPTION
2045.52	12kV STUP OR AUX XFMR 1-1 GRD OC CWP 1-2 FDR GRD and CWP 1-1 FDR GRD
2045.56	CWP 1-2 FDR GRD out
2047.36	SMOKE DETECTED (alarm)
2048	SFM orders CO to ramp unit at 100 MW/min.
2050.08	LTB ACTUATION
2051.22	BEARING PEDESTAL CURRENT LOOP ALARM
2051	SFM orders ramp rate increased to 200 MW/min
2051.54	ROD POS IND URGENT, ROD POS IND ROD BOTTOM, ROD POS IND RODS AT BOTTOM.
2052.42	At approx 60% turbine load, SFM orders CWP 1-1 shut down. CWP 1-1 FDR GRD cleared.
2053.35	ROD POS IND NON-URGENT

Between 2052 and 2054, SFM authorizes DRPI placed in "Data A Only". Control Bank D position indication returns, but General Warning and Rod Bottom lights on all of DRPI come on. CO pull rods OUT and notices DRPI showing rods going IN. When tried again, no rod motion was noted on DRPI although rod step counters operated properly. A few minutes later, DRPI was placed in A + B, and all DRPI indications returned to normal, no alarms.

2103 CDF called out to assist with potential fire in the 12kV Switchgear room. Smoke is reported and IFO requesting CDF backup.

2106 Unusual Event (NUE) was declared based on CDF response.

2110 SLO County Sheriff notified of the UE.

2114 California Office of Emergency Services notified of the UE.

2114 Fire brigade reports 12kV SWGR room is being ventilated and is clearing. "Fire" is declared out.

2156 Immediate (within one-hour) emergency report made to the USNRC Operations Center in accordance with 10 CFR 50.72(a)(1)(i).

2232 The NUE was terminated.

Unit 1 was ramped to 46% power and an unusual event declared when a ground alarm was received on Circulating Water Pump (CWP) 1-1. While the ground alarm was in, smoke was reported in the Unit 1 12kV switchgear room. CWP 1-1, phase-B, cable was determined to have failed and is the subject of this nonconformance. Note: CWP is not a tech spec item.

The California Department of Forestry (CDF) was called to assist in fighting the potential fire. The smoke lasted less than 10 minutes and there were no personnel injuries. it was determined that the electrical ground in CWP 1-1 motor caused the load bank in the 12kV cable spreading room to heat up, burning paint, dirt, and dust. There was no actual flame; only smoke in the room caused the alarm. No equipment in the room was damaged.

During the power reduction, the digital rod position indications (DRPI) did not follow the control rod indicators as control rods were inserted into the core. Control Bank "D" was declared inoperable. Tech Spec 3.1.3.1 requires restoration of Bank "D" to operable status within 72 hours or to place Unit 1 in at least hot shutdown mode within the following 6 hours.

Event 2

On March 12, 1993, intermittent ground current alarms annunciated for Unit 1 CWP 1-2. The Unit was ramped to less than 50 percent power and the pump was secured. Investigations determined that one cable was shorted to ground between the first pull box outside the turbine building and the next pull box at the discharge structure elevation. When the cables were removed, the neoprene jacket was found to be separating from all three cables of the circuit for a distance of approximately 200 feet. There was evidence (pull box water marks) that the cables had previously been submerged in water.

The faulted portion and a similar length of the other two cables for this circuit were removed, a mandrel was passed through the conduit several times to remove standing water, and new cables were installed. When the new cable sections were spliced in, no visual degradation was found at the splice locations. Cable samples were sent to Okonite, the PG&E TES laboratory, and Altran Materials for examination and testing. Interim progress reports indicate that the outer neoprene jacket has been chemically degraded and the copper shield shows evidence of corrosion. However, electrical properties of the cable are acceptable, no evidence of manufacturing defects has been identified, and no indication of installation or abnormal operating conditions can be found. The root cause investigation for this event is in progress.

TIME	DESCRIPTION
1812.18	12kV STUP OR AUX XFMR 1-1 GRD OC CWP 1-2 FDR GND ALARM CWP 1-1 FDR GND ALARM
1812.19	CWP 1-1 FDR GND ALARM cleared
1815.33	Smoke alarm in 12kV cable spreading room

1816.24 Commenced Unit 1 rampdown

1823.52 CWP 1-2 FDR GND ALARM cleared. CWP 1-1 selected

1824.02 12kV STUP OR AUX XFMR 1-1 GRD OC cleared

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

SM-1 and SM-2 are the pull box drain systems and associated sump pumps for Units 1 and 2, respectively, for the pull boxes immediately outside of the turbine building. Investigation determined that water had accumulated in the pull boxes as a result of the pull box drain systems and associated sump pumps not being functional for a period of time preceding the cable failure events.

E. Dates and Approximate Times for Major Occurrences:

1. February 05, 1993; 2045 PST: First event date
2. February 05, 1993; 2045 PST: Discovery date.
3. February 05, 1993; 2106 PST: Declaration of NUE.
4. February 05, 1993; 2156 PST: An immediate (within one-hour), non-emergency report was made to the NRC in accordance with 10 CFR 50.72(a)(1)(i).
5. February 08, 1993; Twenty-four hour unusual event report made to San Luis Obispo County in accordance with the requirements of NUREG-0654, Revision 1, Appendix 1.
6. March 12, 1993; 1812 PST: Second event date.

F. Other Systems or Secondary Functions Affected:

Event 1, February 5, 1993: During the power reduction, the digital rod position indications (DRPI) did not follow the control rod indicators as control rods were inserted into the core. Control Bank "D" was declared inoperable. Tech Spec 3.1.3.1 requires restoration of Bank "D" to operable status within 72 hours or to place Unit 1 in at least hot shutdown mode within the following 6 hours.

Event 1, February 5, 1993: During troubleshooting activities, the problem was determined to be with the multiplex select signal path from the logic cabinet to the "IBD" and "2BD" power cabinets. Two potential logic cards were suspect. After replacement of both logic cards, both "1BD" and "2BD" power cabinets properly indicated "Group B" selected. The bank overlap unit was reset to zero and incremented to 144 in accordance with GRPI step counter. The 144 steps was determined by flux map results and verified by DRPI indication. Operations verified proper rod motion by performing STP R-1A and by the effect of rod motion (i.e. Tavg, Delta-I, NI's, etc.).

Event 1, February 5, 1993: Based upon the evidence from the PPC traces and testing of the suspected "Bad" cards, a malfunction that prevented Control Bank D rod motion did not exist. The PPC traces indicated that Control Bank D did in fact move when GPRI and DRPI showed rod movement. DRPI was indicating properly only above 138 steps. This may not have been readily apparent to operators since it was at the end of a rapid load reduction, complicated by the DRPI and P-A malfunctions. One would have to detect very subtle, but distinct changes in NI power due to rod motion, while NI power is changing due to the normal ramp down transient response.

Event 1, February 5, 1993: Investigation indicates that these are random, independent failures and are not a result of the CWP 1-1 Ground event. The root cause analysis and corrective actions to prevent recurrence associated with the DRPI system problems are being addressed in Quality Evaluations 10404 and 10405, and will not be dispositioned in this NCR.

G. Method of Discovery:

The events were immediately apparent to plant operators due to alarms and indications received in the control room.

H. Operator Actions:

Event 1, February 5, 1993: The Unit was ramped to 50% reactor power and CWP 1-1 was secured.

Event 1, February 5, 1993: The rod control system was not fully operational following the ramp to 50% reactor power. Tech Spec 3.1.3.1, for inoperable but tripable rods, was entered.

Event 2, March 12, 1993: The Unit was ramped to 50% reactor power and CWP 1-2 was secured.

I. Safety System Responses:

None.

III. Cause of the Event

A. Immediate Cause:

The immediate casue was a conduction path to ground, which resulted in sufficient current to flow through the ground detection circuitry.

B. Determination of Cause:

See attached root cause analysis (Reference __)

Extens:·· root cause investigation has been conducted since the first cable failure in 1989. The most probable root cause for the 12kV cables is chemical degradation of the neoprene jacket, resulting in subsequent corrosion of the copper shield and failure of the EPR insulation due to excessive electrical stress. All six cables for both CWP circuits were severly degraded for a distance of approximately 200 feet.

The cables demonstrate good voltage withstand test capability and show no evidence of significant voids or impurities in the EPR insulation material. The following potential root cause categories have been investigated:

1. Manufacturing Defects

Based on evidence evaluated to date, PG&E believes that the failures in the 12kV cables are not caused by manufacturing defects. Extensive cable dissection, wafer slicing and staining, and examination have not identified any significant voids in the cable insulation that would result in cable failure. No impurities or contaminants have been detected in the cable insulation. Potential that point defects, which would be isolated incidents, existed in the cable insulation has not been ruled out. No basis to assume imminent failure due to point defects based on outage frequency hi-pot testing.

Based on voltage breakdown testing (in excess of 80kVAC), no common mode failure mechanism has been identified for the 12kV cables.

2. Installation Related Problem

Cable pulling tensions for the 12kV cables routed between the turbine building and the intake structure were evaluated. The evaluation concluded that the vendor specified pulling tension and sidewall pressure limits were not exceeded.

Based on video probe inspections and the ease of cable replacement, the duct bank is intact, except for the conduit section damaged during CWP 1-1 cable removal, which is no longer used.

There is no visual evidence of damage to the cable shield, insulation, or conductor to indicate installation damage.

Installation activities have been eliminated as a potential root cause for the 12kV cable failures.

3. Aging Related Problem

The mechanical properties of the jacket and insulation for the chemically degraded portions of the cable are poor.

The electrical properties of the 12kV cables have been described as "good".

4. Design

The cable design and application has been reviewed and determined to be adequate for the assumed environment. The assumed environment was expected to be dry with occasional short-term submergence. However, based on the documented extended submergence conditions experienced at DCPP, a neoprene jacket may not be the best selection.

The cable was sized based on ampacity requirements for the CWP motors. Therefore, the 12kV motor feeder cables are operating at the upper end of their temperature rating (approximately 80°C, worst case, compared to the design rating of 90°C). However, per Okonite, the copper shield binding tape is designed to melt at approximately 85°C, which provides indication of misapplication of the cable. The DCPP 12kV cables show no evidence of binding tape melting. Therefore, the cables are operating within their design rating.

The duct bank design has been reviewed. Based on cable pulling tension calculations, the pull boxes have appropriate spacing for cable installation. The ABS plastic conduits are acceptable for underground installations.

The pull boxes immediately outside of the turbine building have drains, which are routed to common sump manholes for Units 1 & 2. These manholes are equipped with automatic submersible Class II sump pumps. The Start-up Feeder cable pull box, the pull boxes associated with the circuits to the intake structure, and the diesel fuel oil piping trench, all drain into this common sump.

The Unit 1 and Unit 2 trenches are similar, except that the Unit 1 duct bank rises to cross over the circulating water discharge tunnel and then slopes downhill towards the intake structure. This design makes the Unit 1 section of cable conduits near the turbine building susceptible to submergence if the pull box sump pumps are not functional and if the water within the pull boxes rises above the conduit openings. Video probe inspections show that the 12kV circuit conduits have low spots with standing water.

Pull box inspections between the turbine building and the intake structure for both Unit 1 and Unit 2 indicate that pull box flooding is only a concern for the Unit 1 section between the turbine building and the discharge structure elevation. All other pull boxes show the water line has only reached the bottom of the first level of conduits for the Unit 2 section between the turbine building and the discharge structure elevation and have not reached any conduit elevations for the remainder of the pull boxes between the discharge structure elevation and the intake structure (2" drain conduit at bottom of pull boxes).

Based on the concrete duct and pull box design, there are no low spots for the 12kV Unit 2 startup power circuits routed along the turbine building between Unit 1 (incoming 230kV power location) and Unit 2. These 12kV circuits have also been exposed to water, but show no evidence of degradation. This is postulated to be a result of the circuits being energized, but not loaded, and therefore, similar to the 4kV cables, are operating substantially below their conductor design temperature of 90°C.

5. Maintenance

Hi-pot testing does not appear to be a contributor. DCPP hi-pot test levels are below Okonite recommended levels for the DCPP cables and does not electrically overstress the cable. DCPP will continue outage frequency hi-pot tests (better to force failure during outage than have an in-service failure).

Both Unit 1 & 2 common pull box sump systems were not adequately maintained, and had been out of service for a number of years (i.e. since 1987). Both Unit 1 and Unit 2 sump systems are now back in service.

6. Environment

Extensive cable dissection and analysis has been performed. Based on the documented water in the pull boxes, specific analysis for water related degradation was performed. There was no evidence of water tracking in the EPR insulation. In addition, there is no evidence of foreign chemicals in either the neoprene jacket nor in the EPR insulation. The copper shield shows no evidence of corrosion. Therefore, there is no evidence that water is a contributor. The removed 4kV cable jacket is stronger than uninstalled 1972 vintage 12kV cable jacket that was in the warehouse. The 4kV cable has better crosslinking than the 12kV cables and therefore better resistance to moisture and chemicals.

Moisture Intrusion: The cable design basis is for wet and/or dry conditions. The cable can be submerged for prolonged periods. Inquiries to other nuclear power plants did not identify any trends for medium voltage EPR insulated cable failures in similar applications. The Okonite black EPR cable is widely used in electric utility distribution systems, including PG&E, and has been highly reliable in similar applications.

Chemical Attack: Laboratory chemical analysis results have established that the 12kV neoprene jacket was attacked by a chloride and/or fatty acid. High ambient temperatures accelerate the chemical related jacket degradation. PG&E has evaluated the cable operating temperature and estimated that, in the worst case, the 12kV CWP cables are operating with insulation temperatures in the range of 80 to 85°C. The hypothesized method of chemical migration and degradation is by way of water that intruded into the conduits through the cable pull boxes that are located immediately outside of the turbine building; the water intrusion resulted from the inoperable sump pumps and associated pull box drainage system.

Electrical transients (i.e. switching) can stress cables during normal operations. The long circuit distance coupled with the high resistance grounding design, could cause voltage transients to be induced due to switching. This is considered to be a remote possibility; however, investigative action #13 was assigned to investigate voltage transient measurement techniques.

Chemical analysis has found no evidence of diesel fuel oil in the jacket or insulation.

The Unit 2 CWP 2-1 cable replacement shows no evidence of chemical attack.

C. Root Cause:

PG&E has concluded that the most probable failure mechanism for the 12kV cable insulation failures is long-term chemical degradation of the neoprene jacket, probably due to chloride and/or a fatty acid, followed by corrosion of the copper shield. When the shield deteriorates, uneven electrical stresses occur, ultimately resulting in a cable ground.

PG&E believes that the 12kV cable failures occurred over an extended period of time (greater than a year). This conclusion is based on the relatively mild pH (approximately 8.5) of the liquid found beneath the neoprene jacket and the copper shield binding tape showing no evidence of high cable operating temperatures (the binding tape melts at approximately 85°C).

D. Contributory Cause:

Analysis indicates that there is substantial moisture present in the ethylene-propylene-rubber (EPR) insulation (2% by weight, versus expected value of approx .7% by weight). Moisture is therefore postulated as a contributory cause since the chloride needs to be in a moist environment for the type of chemical attack experienced by the 12kV cable to occur.

IV. Analysis of the Event

A. Safety Analysis:

The 12kV power and associated control circuits potentially affected by these cable failures are associated with the CWPs.

The motor-driven CWPs are part of the saltwater system which removes energy from the turbine exhaust steam (SG) entering the main condenser by providing cooling water to the condenser. Each unit is provided with two nonsafety-related 12kV motor-driven pumps located in the intake structure. At 100 percent unit power level, both pumps must run to support full load operation.

The 12kV system has high-resistance grounding, which allows continued operation for a limited time in the event of a single-line-to-ground fault. Operators have received simulator training on ground fault incidents. The normal plant procedure, as demonstrated in the past failure incidents, is to declare the associated component inoperable, and then troubleshoot and repair the faulted circuit. The ability to operate for a limited time with a ground on the CWPs ensures that time is available to bring the plant to a stable condition where the affected pump can be removed from service and the circuit repaired without challenging any safety systems.

The previously analyzed condition 2 event described in the plant Final Safety Analysis Update (FSAR) for the loss of offsite power and turbine trip bounds this event. Results of the "Complete Loss of Forced Reactor Coolant Flow" analysis show that for a loss of all AC power, no adverse conditions occur in the reactor core. The departure from nucleate boiling ratio is maintained above 1.30. The reactor coolant system is not overpressurized and no water relief will occur through the pressurizer relief or safety valves. Thus, no cladding damage results and, consequently, there is no release of fission products to the reactor coolant system. Since the February 5, 1993 ground fault alarm (equivalent to loss of power to CWP 1-1) event is bounded by this previously analyzed condition, the health and safety of the public were not affected by this event.

B. Reportability:

1. Reviewed under QAP-15.B and determined to be non-conforming in accordance with Section 2.1.2.

2. Event 1, February 5, 1993: Reviewed under 10 CFR 50.72(a)(1)(i) and determined to require an immediate (within one-hour) notification to the NRC due to the declaration of an Unusual Event. This does not require a 30-day written followup LER. This immediate notification was made at 2156 PST on February 5, 1993.

   NOTE: 10CFR50.72(a)(1)(i), immediate notification requirement is applicable since an Unusual Event was declared, thereby meeting the following criteria: "(a) General Requirements. (1) Each nuclear power reactor licensee licensed under 50.21(b) or 50.22 of this part shall notify the NRC Operations Center via the Emergency Notification System of: (i) The declaration of any of the Emergency Classes specified in the licensee's approved Emergency Plan. (3) The licensee shall notify the NRC immediately after notification of the appropriate State of local agencies and not later than one hour after the time the licensee declares one of the Emergency Classes."

   Event 1, February 5, 1993: A twenty-four hour Unusual Event summary report was made to San Luis Obispo County in accordance with the requirements of NUREG-0654, Revision 1, Appendix 1.

   Event 2, March 12, 1993: Reviewed under 10 CFR 50.72 and 10 CFR 50.73 per NUREG 1022 and determined to not be reportable.

   However, pursuant to Item 19 of Supplement 1 to NUREG-1022, PG&E submitted a voluntary Licensee Event Report No. 1-93-005-00 regarding the failure of certain medium voltage 4kV and 12kV cables.

3. Reviewed under 10 CFR Part 21 and determined that this problem will not require a 10 CFR 21 report, since it is being evaluated under 10 CFR 50.72

4. Event 1, February 5, 1993: This problem has been reported via an INPO Nuclear Network entry.

5. Reviewed under 10 CFR 50.9 and determined to be not reportable since these events do not have a significant implication for public health and safety or common defense and security.

6. Reviewed under the criteria of AP C-29 requiring the issue and approval of an OE and determined that an OE is not required.

V. Corrective Actions

A. Immediate Corrective Actions:

Event 1, February 5, 1993: 3 phases of circuit D05V00A, from BP015 to BP021A, for CWP 1-1 were replaced.

Event 1, February 5, 1993: ERP #93-02 was formed to investigate this event

Event 2, March 12, 1993: all cables for all phases of circuits E06V00A & B, from BP017 to BP039C, for CWP 1-2 were replaced, after examining the conduit with a boroscope to determine if there was potential damage as found previously on CWP 1-1 conduit. In addition, the other cables that were not associated with the February 5, 1993 fault, were replaced as a precaution.

B. Investigative Actions:

1. Event 1, February 5, 1993: ERP 93-2, "CWP 1-1 Ground", was convened to investigate this event.

2. Event 1, February 5, 1993: Provide cable samples to TES, Altran Inc., and Okonite for testing (chemical, electrical, etc).

   RESPONSIBILITY: R. Hanson
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #01
   STATUS: RETURN

3. Event 1, February 5, 1993: NECS/GC to provide design and asbuilt details, (architectural and electrical) showing original duct bank details and modifications since installation (i.e. I&C Building construction). First priority is details from turbine building to discharge structure, due by 02/18/93. Second priority is details from discharge structure to intake, due by 02/25/93.

   RESPONSIBILITY: C. Hazari
   DEPARTMENT: NECS Electrical Engineering
   Tracking AR: A0293956, AE #02
   STATUS: RETURN

4. Event 1, February 5, 1993: NECS/GC to provide design and asbuilt details, (architectural and electrical) showing original duct bank details and modifications since

installation (i.e. I&C Building construction). First priority is details from turbine building to discharge structure, due by 02/18/93. Second priority is details from discharge structure to intake, due by 02/25/93.

RESPONSIBILITY: G. Villareal
DEPARTMENT: NECS Civil Engineering
Tracking AR: A0293956, AE #03
STATUS: RETURN

5. Event 1, February 5, 1993: Investigate technologies to inspect conduit and/or determine duct bank routing. Requirement is for access to 6" O.D. ABS conduit with approximately 500 foot range. Potential source: Foster Miller Company.

   RESPONSIBILITY: R. Hanson
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #04
   STATUS: RETURN
   NOTE: TES NDE group has 300ft boroscope available.

6. Event 1, February 5, 1993: Provide, to Altran Inc., a sample of the pulling compound utilized by the Oregon contractors while attempting to remove faulted cable. Also provide samples of other cable pulling compounds that may be present to assist in the chemical analysis.

   RESPONSIBILITY: R. Hanson
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #05
   STATUS: RETURN

7. Event 1, February 5, 1993: Provide samples of original, uninstalled cable, for chemical analysis benchmark to TES, Okonite, and Altran.

   RESPONSIBILITY: R. Hanson
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #06
   STATUS: RETURN

8. Event 1, February 5, 1993: Contact the Hazardous Mats group and determine the history of chemical spills in the between the areas of the turbine building cable vault and discharge structure pull boxes.

   RESPONSIBILITY: R. Hanson
   DEPARTMENT: Electrical Maintenance

Tracking AR: A0293956, AE #07
STATUS: RETURN

9. Determine which CWP was aligned to for automatic restart.

RESPONSIBILITY: R. Hanson
DEPARTMENT: Electrical Maintenance
Tracking AR: A0293956, AE #08
STATUS: RETURN
NOTE: CWP 1-2 was selected for restart.

10. Event 1, February 5, 1993: Determine whether the CWP cables have been determinated, partially pulled back, then repulled and reterminated due to past emergent work (i.e. intake structure civil mods, Raychem cable replacement, etc.). Coordinate with electrical maintenance since this has been partially completed due to ASW cable investigation.

RESPONSIBILITY: C. Hazari ECD: 02/18/93
DEPARTMENT: NECS Electrical Engineering
Tracking AR: A0293956, AE #09
STATUS: RETURN
NOTE: No record of re-pulling was found.

11. Event 1, February 5, 1993: Determine whether the DRPI failure is related to this event. Include potential affects of ground potential rise due to the 12kV ground fault current.

RESPONSIBILITY: M. Nowlen
DEPARTMENT: DCPP I&C Maintenance Engineering
Tracking AR: A0293956, AE #10
STATUS: RETURN

NOTE: No other indications that the DRPI failure is related to the ground fault. No other instruments noted with spurious operation.

12. Event 1, February 5, 1993: Determine regularity and scope of ground resistance maintenance. Include history of recent maintenance and ground resistor resistance measurements.

RESPONSIBILITY: R. Hanson
DEPARTMENT: Electrical Maintenance
Tracking AR: A0293956, AE #11
STATUS: RETURN

NOTE: PM's to clean, inspect, and megger every 18 months. Does not presently make resistance checks.

13. Event 1, February 5, 1993: Investigate effectiveness of DCPP cable monitoring and testing program.

    RESPONSIBILITY: R. Hanson
    DEPARTMENT: Electrical Maintenance
    Tracking AR: A0293956, AE #12
    STATUS: RETURN

14. Event 1, February 5, 1993: Develop action plan to inspect failed and/or unfailed conduits to determine their condition.

    RESPONSIBILITY: R. Hanson
    DEPARTMENT: Electrical Maintenance
    Tracking AR: A0293956, AE #13
    STATUS: RETURN

15. Event 1 and Event 2: Obtain samples, for chemical analysis, from within the cable vaults associated with the Unit 1 CWP pump motor feeder cables, located outside the turbine building 12kV switchgear cable spreading room.

    RESPONSIBILITY: R. Hanson ECD: 04/30/94
    DEPARTMENT: PGEM
    Tracking AR: A0293956, AE #18
    STATUS: ASSIGNED

16. Event 1 and Event 2: Obtain samples, for chemical analysis, from within the cable vaults associated with the Unit 2 CWP pump motor feeder cables, located outside the turbine building 12kV switchgear cable spreading room.

    RESPONSIBILITY: R. Hanson
    DEPARTMENT: PGEM
    Tracking AR: A0293956, AE #19
    STATUS: COMPLETE

17. Determine the actual discharge water temperature at the condenser.

    RESPONSIBILITY: R. Hanson
    DEPARTMENT: PGEM
    Tracking AR: A0293956, AE #15
    STATUS: RETURN

18. Obtain Unit 1 conduit temperatures in a spare conduit between the cable vaults outside the turbine building 12kV cable spreading room and the discharge structure elevation.

    RESPONSIBILITY: R. Hanson
    DEPARTMENT: PGEM
    Tracking AR: A0293956, AE #16
    STATUS: RETURN

19. Investigate the feasibility of providing seals for the conduits (turbine building end only) routed between the outside pull boxes in the diesel generator area and the discharge structure. The purpose of the conduit seals would be to prevent potential chemical spills from entering the conduits. All conduits in the bottom five feet of the boxes need to be addressed.

    RESPONSIBILITY: C. Hazari ECD: 10/15/93
    DEPARTMENT: NES-EE
    Tracking AR: A0293956, AE # 22
    STATUS: ASSIGNED

20. Inspect the spare CWP 1-1 potentially broken conduit during 1R6.

    RESPONSIBILITY: R. Hanson ECD: 05/01/94
    DEPARTMENT: Electrical Maintenance
    Tracking AR: A0293956, AE #23
    STATUS: ASIGND

21. Investigate methods for sealing the pull boxes at the turbine building (outside in the DG area) and how this information should be documented for future pull box seal replacment.

    RESPONSIBILITY: R. Hanson ECD: 10/15/93
    DEPARTMENT: Electrical Maintenance
    Tracking AR: A0293956, AE #24
    STATUS: ASIGND

22. Engineering to investigate options available for cable replacement for the 12kV Standby/Startup feeder circuits, routed along the turbine building from Unit 1 side to the Unit 2 side. These feeder circuits consist of one 1500 MCM cable for each phase. The preferred replacement option would utilize 500 MCM cables.

RESPONSIBILITY: C. Hazari ECD: 10/15/93
DEPARTMENT: NES-EE
Tracking AR: A0293956, AE # 25
STATUS: ASSIGNED

C. Corrective Actions to Prevent Recurrence:

1. Event 1 and Event 2: Clean out the cable vaults and pull boxes for the Unit 1 CWP pump motor feeder circuits to the intake structure, repair the associated sump pumps as necessary, and repair the cable vault and pull box lids to help prevent moisture intrusion.

   RESPONSIBILITY: R. Hanson ECD: 04/30/94
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #20
   Outage Related? Yes OUTAGE: 1R6
   OE Related? No
   NRC Commitment? No
   CMD Commitment? No

2. Event 1 and Event 2: Clean out the cable vaults and pull boxes for the Unit 2 CWP pump motor feeder circuits to the intake structure, repair the associated sump pumps as necessary, and repair the cable vault and pull box lids to help prevent moisture intrusion.

   RESPONSIBILITY: R. Hanson COMPLETE
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #21
   Outage Related? Yes OUTAGE: 2R5
   OE Related? No
   NRC Commitment? No
   CMD Commitment? No

3. Replace ASW 1-1 4kV cables between the pull box in the 12kV Switchgear room and the discharge structure elevation pull box. Send samples of the cable out for electrical and chemical analysis.

   RESPONSIBILITY: R. Hanson RETURN
   DEPARTMENT: Electrical Maintenance
   Tracking AR: A0293956, AE #17
   Outage Related? Yes OUTAGE: 2R5
   OE Related? No
   NRC Commitment? No
   CMD Commitment? No

NOTE: NCR DC2-92-EN-N054 corrective actions establish a preventative maintenance program for the sump pumps and drains associated with both the Unit 1 and Unit 2 cable vaults located outside the turbine building 12kV Switchgear cable spreading rooms.

D. Prudent Actions (not required for NCR closure)

Since a megger test (i.e. insulation resistance measurement) isolates the component from ground, the resistor banks resistance is not evaluated as part of the PM program. Therefore, revise the resistor bank PM's to include resistor bank resistance measurement and evaluation.

RESPONSIBILITY: ______________ ECD: __________
Tracking AR: A0______

VI. Additional Information

A. Failed Components:

None.

B. Previous Similar Events:

NCR DC2-89-EM-N104

On October 29, 1989, ground current alarms associated with the Unit 2 Auxiliary Saltwater (ASW) Pump 2-2 annunciated twice and immediately cleared both times. The pump was removed from service. A ground was found on one cable that runs between the turbine building pull box and the first pull box at the discharge structure. Cables in this pull box were found submerged in water. The faulted portion and a similar length of the other two cables for this circuit were removed, the water was pumped out of the pull box, a mandrel was passed through the conduit several times to remove standing water, and new cables were installed. Visual examination found no obvious physical defects in the removed cables. Cable samples were sent to Okonite and to the PG&E Technical and Ecological Services (TES) laboratory for examination and testing. The cable testing determined that the cable met or exceeded the original mechanical and electrical stress limits set forth in the original purchase specification, except for some minor loss of mechanical strength of the jacket material. The testing laboratories determined the failure to be an isolated event.

QE Q0009710

On May 3, 1992, intermittent ground current alarms were received associated with Unit 1 nonsafety-related 4kV Bus D. The 4kV Bus D was removed from service. The ground was determined to be located on one cable between the pull box located immediately outside of the intake structure and the Bus 14D transformer in the intake structure. The pull box located outside of the intake structure was found to have water inside, which was pumped out to facilitate cable replacement. Approximately 40 feet of the single faulted cable was replaced. Visual examination found no obvious physical defects in the removed cable. Cable samples were sent to Okonite and to the PG&E TES laboratory for examination and testing. The examination and testing determined that the physical properties of the insulation were normal and that the jacket properties displayed some loss of elongation which was considered normal for neoprene installed for almost 18 years. The electrical properties were normal for 18-year old cable. The testing laboratories could identify no definitive reason for the failure.

NCR DC1-92-EM-N054

On October 31, 1992, ASW Pump 1-2 on Unit 1 was removed from service for refueling outage maintenance. As part of the procedure to return the pump to service, a motor hi-pot test was conducted. During the hi-pot test, the cable insulation developed a ground fault at approximately 6kV. Investigation determined that the fault was located on one cable between the first pull box outside the turbine building and the next pull box at the discharge structure elevation. Cables in this pull box were also found submerged in water. The faulted portion and a similar length of the other two cables for this circuit were removed, the water was pumped out of the pull box, a mandrel was passed through the conduit several times to remove standing water, and new cables were installed. Other than at the fault point, visual examination revealed no obvious physical defects in the removed cables. Cable samples were sent to Okonite, the PG&E TES laboratory, and Cable Technologies Laboratory (CTL) for examination and testing. In February 1993, an additional sample was sent to Altran Materials for chemical analysis. Interim progress reports indicate that the electrical properties of the cable are acceptable, no firm evidence of manufacturing defects has been identified, and no indication of installation problems or abnormal operating conditions can be found. The root cause investigation for this event is in progress.

SREF 88-119

INPO Significant Event Report entered 12-SEP-88. DCPP Unit 2 - Ground faults on a 12 kilovolt system. An electrical ground fault at a reactor coolant pump motor terminal connection led to multiple control room annunciator alarms and successive electrical failures. Before the exact location of the fault could be determined, a fire developed in a startup transformer's grounding resistor bank, and the reactor was manually scrammed.

C. Operating Experience Review:

1. NPRDS:

None.

2. NRC Information Notices, Bulletins, Generic Letters:

IE Information Notice No. 86-49: Age/Environment Induced Electrical Cable Failures.

On November 21, 1985, San Onofre Unit 1 experienced a loss of offsite power when a transformer was tripped by its differential relays because of a failed cable to the class 1E 4160-V bus. The most likely cause of the cable failure was determined to be temperature-induced accelerated aging and degradation of the cable insulation. The notice also stated "Another important facet of the periodic maintenance and testing program for cable circuits is the walkdown inspection to identify actual or potential environmental conditions (heat, <u>water</u>, chemicals, etc.) in the immediate vicinity of the cables that could adversely affect cable conditions.

PG&E's response to this notice was that DCPP's class 1E cable outside of the spreading areas and switchgear rooms is run inside rigid iron conduit and is properly routed away from high temperature piping and equipment.

IE Information Notice No. 92-81: Environmental Qualification of Control Cables.

Based on tests conducted by Sandia National Laboratories for the NRC, certain electrical cables with **bonded Hypalon jackets** may not meet environmental qualification requirements. Sandia conducted tests on cables manufactured by three different companies to determine the minimum insulation thickness necessary to perform its intended function should the insulation be damaged during installation, maintenance, or other activities. During LOCA testing, all 10 of the **Okonite-Okolon cable samples failed**. The test specimens were single-conductor, 600 volt, 12 AWG **control** cables insulated with ethylene-propylene rubber (**EPR**) with bonded Hypalon jacket.

Information Notice 92-81 was issued to address NRC concern with environmental qualification of Okonite cables with bonded Hypalon jackets that have not been qualified for service conditions exceeding 50°C for 40 years. According to the NRC, qualification testing that does not use the actual jacket service configuration may not be representative of actual cable performance. The Staff cautions that the integrity of cables could be affected if the cables are used inside containment, used in continuous power circuits, routed with power cables, or routed close to hot piping.

This information notice is not applicable to the 4kV cable failure since the 4kV cable is does not require environmental qualification, does not use a Hypalon jacket, and the neoprene jacket is not bonded to the cable shield/insulation.

3. INPO SOERs and SERs:

None.

D. Trend Code:

Responsible department __, and cause code __.

E. Corrective Action Tracking:

1. The tracking action request is A0293956.

2. Are the corrective actions outage related? YES

F. Footnotes and Special Comments:

Following the March 12 event, PG&E conservatively replaced all Unit 1 non-failed medium voltage circuits between the pull boxes outside the turbine building and the next pull box at the discharge structure elevation (ASW Pump 1-1 4kV cables and the second 3-phase 12kV circuits for CWPs 1-1 and 1-2). Also, one complete circuit, between the turbine building switchgear and the motor terminations at the intake structure, of the Unit 2 12kV CWP 2-1 motor feeder circuits was replaced. The neoprene jacket on the Unit 1 12kV CWP cables showed evidence of chemical degradation, similar to that on the previously replaced Unit 1 12kV CWP circuits. Visual examination of the ASW 1-1 4kV cables and the CWP 2-1 12kV cables revealed no defects.

G. References:

1. Technical Specification 3.1.3.1.
2. Initiating Action Request A0293569.
3. Unusual Event declaration summary letter, dated February 8, 1993, to SLO County Administrator.
4. Event Response Plan (ERP) 93-02.
5. NCR Tracking Action Request A0293956.
6. Report Tracking Action Request A0293573.
7. Rod Control System problems associated with this event; Action Requests A0293570, A0293576 and A0293578.
8. SREF 88-119.
9. Figures related to the CWP 1-1 and 1-2 Cable Failures

H. TRG Meeting Minutes:

1. On February 10, 1993 the TRG convened and considered the following:

Investigative Actions 1-14 were discussed and assigned. Discussion ensued regarding the similarity between this failure and the recent 4kV ASW Pump 1-2 cable failure. It was agreed that the preliminary failure modes are different since the 4kV cables did not exhibit neoprene jacket degradation like the 12kV CWP feeder. Both the 4kV & 12kV circuits are medium voltage, shielded cables, with EPR insulation and neoprene outer jackets. Therefore, the TRG concurred that the existing safety analysis for DC1-92-EM-N054 is not affected by this event.

TRG discussed the requirements for cable samples to TES, Okonite, and Altran Inc.. Altran requested that three 1-foot pieces be forwarded for analysis. One piece from the failure vicinity, one piece from the "medium" damage area, and one piece from the low damage area. Also requested that some of the liquid, if available, from the conduit be sent for analysis. A 10 foot section of the cable will also be sent to Altran for electrical testing. Additional cable samples will be provided to Okonite and TES.

The TRG discussed the issues related to ground resistor smoking in the 12kV cable spreading room. Initial indication is that these resistors are cleaned every 18 months (outage frequency), but due to inaccessibility, not much other maintenance is performed.

The CWP cables are 500MCM, 15kV, EPR insulated with a neoprene jacket. The faulted cable was not degraded at the pull box ends, then both ends exhibited approximately 80 feet of "mushy" jacket material, and then there was approximately 200 feet of cable in the center portion of the run that had no jacket at all. The fault was in the section of the cable that did not have any jacket present. There was no detectable hydrocarbon odor. The copper foil shielding was extremely corroded in the areas where the jacket was missing. The mushy appearance of the jacket preliminarily indicates a long-term chemical attack.

A small amount of liquid (i.e. drops) was observed between the jacket and the insulation. A litmus paper test of liquid indicated a pH of between 5 and 7. Note: the liquid may have been introduced as part of the cable removal process.

Resistance measurements of the semi-conductor shield material indicated: 10k-ohm/cm for portion of cable with good jacket, approx 300/400k-ohm/cm for the portion of the cable with bad jacket. Expected values for new cable would be approximately 1k-ohm/cm.

The CWP 1-1 cables were last hi-pot tested on 11/5/92 (Reference W.O. R0085212)

During the cable removal process, the cable moved for approximately 75 feet, then jammed and would not move, even with approximately 8000 pounds pulling tension. Normal installation limits are 2000 pounds pulling tension maximum, with normal values measured in the 500 to 1000 pound range. While trying to loosen the cables for final removal, approximately 750 gallons of water was pumped into the conduit, and no water was observed coming out the other end. This indicates a potential conduit break between the Turbine building cable vault and the discharge structure elevation. The CWP conduits are the lowest conduits in the duct bank.

The conduit duct bank construction, i.e. is there a concrete cap, did the I&C building construction potentially interfere with the conduit bank, etc. will be investigated prior to the next TRG.

Based on this failure, and the recent 4kV cable failure, an Integrated Problem Response Team (IPRT) was formed to in accordance with procedure OM7.ID7 to help investigate the medium voltage cable failures and make recommendations.

THE TRG WILL RECONVENE ON WEDNESDAY, 2/24/93 TO DISCUSS INVESTIGATIVE ACTION RESULTS ROOT CAUSE.

2. On February 24, 1993 the TRG convened and considered the following:

   Hazardous Materials responded that there have been DFO spills in the area of the cable vaults. There have been other spills as well. A complete list with dates, etc. is being developed. Past experience indicates that the 2-1/2" DFO stainless steel pipe routed along the turbine building was attacked by microbes, that live within the fuel oil, in the early 1980's. Ate welds from the inside, resulting in leaks. This occurred near the roll-up doors east of the DFO tanks, not in vicinity of the cable vaults.

Preliminary chemical test results indicate no hydrocarbons (DFO) present. The jacket, shield, and water sample were all tested. Lots of halogens (i.e. chlorine) have been detected. Degradation found at the tape overlap point of the copper shield. Green color on the copper shield is galvanic corrosion, red color could be from microbe attack or from overheating during the ground fault.

Preliminary electrical testing shows termination failure at 80kV-AC (i.e. electrical properties acceptable).

The degraded condition of the shield indicates the following hypothesis; Since the shield acts to equalize the potential across the insulation, shield degradation could introduce electrical stress (voltage differential) on the insulation at the point where shield no longer protects the cable, which can result in insulation failure. This is why termination stress cones are used.

Investigative action #14 assigned to examine other duct bank conduits to determine potential for ground water intrusion through broken conduits.

Electrical stresses will concentrate at moisture intrusion portions of the cable. Industry practice shows need to minimize moisture exposure and potential intrusion.

The shield is grounded at only the switchgear end of the cable. If shield currents are measured, the theoretical current would only be capacitive charging current. With the 3-phases are measured together, the total would be zero. Shield degradation would provide a hi-resistance ground path, and leakage current measurements would be higher. Shield leakage currents have been measured as indicated below: (NOTE: All measurements are in amperes)

	CWP 1-1	CWP 1-2	FDR FOR BUS 14D	FDR FOR BUS 14E
	A1 0.36	A1 0.33	A 0.16	A 0.30
	A2 0.48	A2 0.62		
	*B1 0.39	B1 0.34	B [illegible] 30	B 0.17
	B2 0.77	B2 0.49		
	C1 0.56	C1 0.54	C 0.26	C 0.30
	**C2 1.11	C2 0.43		
	-------	-------	-------	-------
VECTOR SUM:	0.85	0.77	0.06	0.05

* CWP 1-1 15kV cable failure for this NCR.

** This value may indicate potential shield degradation

THE TRG WILL RECONVENE ON THURSDAY, 3/18/93 TO DISCUSS INVESTIGATIVE ACTION RESULTS AND TO CONTINUE THE ROOT CAUSE DETERMINATION PROCESS.

3. On March 19, 1993 the TRG convened and considered the following:

   The TRG agreed that the CWP 1-2 cable failure on March 12, 1993 should be included in the scope of this NCR. Investigative Actions 15-18 and Corrective Actions 1-3 were assigned.

   Duct bank construction (i.e. grade slopes, etc.) were discussed. Refer to Reference 9, "Figures related to the CWP 1-1 and 1-2 Cable Failures".

   No water has been observed leaching from the conduits into the pull boxes, which provides further indication that the water/chemical intrusion is form the cable vaults/pull boxes, and not from a deformation of the conduits.

   Preliminary CWP 1-2 Cable Failure Investigative Action Results (measurements taken at actual time of failure):

   1. Sulfates and constituents of sea water found in the liquid sample obtained from under the CWP 1-2 cable jacket. pH measured at 8.5
   2. Insulation temperature measured at 80°F. Water from within the conduit measured at 93°F.
   3. Boroscope indicates standing water in the conduits.
   4. Hardness measurements were obtained on some of the Raychem Flamtrol cable within the CWP 1-2 cable vault. The hardness, measured at three different locations on the same cable, was approximately 95 durameter "A" hardness scale, which is consistent with "as manufactured" specifications.

   THE TRG WILL RECONVENE ON, 4/8/93 TO DISCUSS INVESTIGATIVE ACTION RESULTS AND TO CONTINUE THE ROOT CAUSE DETERMINATION PROCESS.

4. On May 14, 1993, the TRG reconvened and considered the following;

   The most probable root cause for the 12kV cables is chemical degradation of the neoprene jacket, resulting in subsequent corrosion of the copper shield and failure of the EPR insulation due to excessive electrical stress. All six cables for both CWP circuits were severly degraded for a distance of approximately 200 feet.

The cables demonstrate good voltage withstand test capability and show no evidence of significant voids or impurities in the EPR insulation material. The following potential root cause categories have been investigated (Refer to determination of cause section):

A. Manufacturing Defects
B. Installation Related Problem
C. Aging Related Problem
D. Design
E. Maintenance
F. Environment

Recommended corrective actions will be forthcoming upon completion of the IPRT investigation and report submittal. The TRG will reconvene in July to review the IPRT recommendations and determine corrective actions.

7. On July 21, 1993, the TRG reconvened and considered the following;

A general overview of the failure history and investigation was provided to bring the new TES individuals up to speed.

The preliminary root cause of the 12kV cable failures is chemical degradation of the outer neoprene jacket, leading to shield deterioration.

The TES draft report of electrical and mechanical testing was discussed, in conjunction with the involvement of the TES contracted outside laboratories and Okonite. It is expected that TES will consolidate all TES and Rose conclusions into the TES report.

Okonite partial discharge testing on the dry 4kV cables performed up to approximately 11kV with no indications of partial discharge. Okonite will perform "salt water" cable testing. This is an ongoing effort and will be part of the long term cable aging program (i.e. will not keep NCR open).

The Altran report and Okonite 12kV cable testing will be stand alone and will not be completely covered in the TES final report.

No evidence of abnormal manufacturing process (i.e. excessive voids) or installation damage was detected. The installed cables meet the original production test requirements. Fatty acid esters and chlorides have been detected in the 12kV cable jacket and insulation. The chemical composition resembles that of a light detergent or cleaner type compound (i.e. ivory liquid or borax). Altran has concluded that the cable degradation was experienced over a long time period and may have been exasperbated by high ambient/operating temperatures.

The Unit 2 pull boxes and drains between the turbine building and the intake structure have been cleaned. Unit 1 boxes and drains will be cleaned 1R6.

The inspections of the boxes after significant rain will continue. The TRG and/or IPRT needs to determine whether these rain inspections need to be long term or only until all boxes and drains are cleaned and associated sumps are verfified as operating consistently.

The moisture under the CWP cable jackets was a concentrated sea water type mixture. The pull box samples were a diluted sea water type mixture.

The TRG concurs that it would be prudent to replace one ASW 4kV circuit, from switchgear to motor terminals, for Unit 1 during 1R6. This circuit would then be examined and tested, and used to determine the scope of future actions.

Using a lead sheathed cable for moisture (and chemical) protection would create new reliability problems for the circuits (i.e. splicing), and will not be considered further. A polyethylene jacket may be utilized to provide increased moisture/chemical intrusion resistance.

Consideration is being given to installing a new medium voltage circuit in the failure area and leaving the existing circuit in place as a sample.

Discussion ensued regarding methods to control chemical intrusion into the pull boxes and associated raceways. Consideration will be given to raising/sealing the pull box covers, installing rain gutters on the turbine building to reduce runoff, and to pull box conduit seals. An investigative action was assigned to NES to investigate the feasibility of installing conduit seals. An investigative action was assigned to electrical maintenance to investigate methods of sealing the pull box covers.

In addition, since the Unit 2 12kV standby/startup feeder circuits are routed next to the turbine building and may have been exposed to water and chemicals, an investigative action was assigned to NES to investigate options available for repairing the 1500MCM circuits if one should fail. These cables are considered as being subjected to the same environment as the 12kV failed cables based on deeper pull boxes, drainage of the conduits back toward the pull boxes, the circuits are not normally loaded, and there is no evidence of moisture in interim circuit pull boxes. The TRG recommended a prudent action to obtain a jacket sample for analysis.

To help determine if the same chemical exposure has ever been present in other pull boxes at the turbine building, one 600V spare control circuit sample was taken from the Unit 1 ASW 1-1 pull box (#1/0 cable). Examination of the cable found evidence of fatty acids in the cable insulation and galvanic corrosion of the tinned copper at the tin/copper interface on the cable. This galvanic corrosion has erroded the tin, which does not present a functionality problem, but could complicate attempts to splice circuits together. However, this galvanic corrosion could cause interference problems for instrument cables (i.e. cross talk) if the mylar shield has deteriorated. Since there have not been any problems during instrument loop testing, and the tested sample had exposed cable terminations in the pull box (i.e. spare circuit taped up within the box), this is considered a long term problem consideration. It is recommended that additional control/instrument circuit samples be obtained during 1R6.

Final TES report is expected by 8/2/93, final Altran report expected week of 7/23/93, and final IPRT report is expected to be issued by 8/16/93.

Overall NCR completion date of 7/15/94 was established.

TRG will reconvene on September 14, 1993.

I. Remarks:

None.