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AUTH.NAME AUTHOR AFFILIATION
MORGAN,H.E. Southern California Edison Co.
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SUBJECT: LER 89-012-01:on 890701,Foxboro transmitter mounting configuration discrepancies caused by environ qualification.
W/8 ltr.

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Southern California Edison Company

SAN ONOFRE NUCLEAR GENERATING STATION

P O BOX 128

SAN CLEMENTE, CALIFORNIA 92672

H. E. MORGAN
STATION MANAGER

TELEPHONE
(714) 368-6241

August 18, 1989

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

Subject: Docket No. 50-361
Revised Report
Licensee Event Report No. 89-012, Revision 1
San Onofre Nuclear Generating Station, Unit 2

Reference: Letter, H. E. Morgan (SCE) to USNRC Document Control Desk, dated April 7, 1989.

The referenced letter provided a 30-day Licensee Event Report (LER), No. 89-009, for an occurrence involving the environmental qualification of safety-related instrumentation inside Containment. This submittal provides information regarding root cause and corrective actions resulting from our investigation into this event.

If you require any additional information, please so advise.

Sincerely,

R W Krieger for H E Morgan

Enclosure: LER No. 89-012, Revision 1

cc: C. W. Caldwell (USNRC Senior Resident Inspector, Units 1, 2 and 3)
J. B. Martin (Regional Administrator, USNRC Region V)
Institute of Nuclear Power Operations (INPO)

IE22

LICENSEE EVENT REPORT (LER)

Facility Name (1)	Docket Number (2)	Page (3)
SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 2	0 5 0 0 0 3 6 1	1 of 0 20

Title (4)

FOXBORO TRANSMITTER MOUNTING CONFIGURATION DISCREPANCIES CAUSED BY ENVIRONMENTAL QUALIFICATION AND DESIGN CONTROL PROGRAM WEAKNESSES

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
Month	Day	Year	Year	Sequential Number	Revision Number	Month	Day	Year	Facility Names	Docket Number(s)
									SAN ONOFRE UNIT 3	0 5 0 0 0 3 6 2
0 7	0 1	8 9	8 9	0 1 2	0 1	0 8	1 8	8 9	SAN ONOFRE UNIT 1	0 5 0 0 0 2 0 6

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11)

OPERATING MODE (9): 1

POWER LEVEL (10): 1 0 0

___ 20.402(b)	___ 20.405(c)	___ 50.73(a)(2)(iv)	___ 73.71(b)
___ 20.405(a)(1)(i)	___ 50.36(c)(1)	___ 50.73(a)(2)(v)	___ 73.71(c)
___ 20.405(a)(1)(ii)	___ 50.36(c)(2)	___ 50.73(a)(2)(vii)	X Other (Specify in Abstract below and in text)
___ 20.405(a)(1)(iii)	___ 50.73(a)(2)(i)	___ 50.73(a)(2)(viii)(A)	
___ 20.405(a)(1)(iv)	___ 50.73(a)(2)(ii)	___ 50.73(a)(2)(viii)(B)	
___ 20.405(a)(1)(v)	___ 50.73(a)(2)(iii)	___ 50.73(a)(2)(x)	Voluntary Report

LICENSEE CONTACT FOR THIS LER (12)

Name	TELEPHONE NUMBER	
	AREA CODE	
H. E. Morgan, Station Manager	7 1 4	3 6 8 - 6 2 4 1

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SUPPLEMENTAL REPORT EXPECTED (14)

	Expected Submission Date (15)	Month	Day	Year
___ Yes (If yes, complete EXPECTED SUBMISSION DATE) XX NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On 6/1/89, a Non-conformance Report (NCR) was issued which identified that Foxboro transmitters inside Unit 1 Containment had been installed with a mounting configuration different than that specified by the environmental qualification (EQ) test report. On 6/2/89, since Unit 2 was shutdown, an inspection was performed which identified similar discrepancies, and another NCR was issued. In order to determine the significance of these discrepancies, detailed calculations were performed which demonstrated the acceptability of the as-found installations and provided acceptance criteria for additional Unit 2 and 3 inspections. On 7/1/89, inspections of all EQ-related Foxboro transmitters at Units 2 and 3 were completed which resulted in additional NCR's for 52 Foxboro transmitters (26 in each Unit 2 and Unit 3 Containment). Based upon the observed configurations and new analytical data, 16 transmitters (5 in Unit 2 and 11 in Unit 3) were declared inoperable, Technical Specification Action Statements were followed and immediate actions were taken to correct the transmitter configurations. Follow up laboratory testing ultimately confirmed that the calculations were conservative and that original configurations were adequate to meet all safety functions. Therefore, none of the EQ discrepancies resulted in a reportable condition.

The root cause of these errors is associated with weaknesses in SCE's engineering support functions which are the subject of major efforts to make improvements as described in SCE's letter to the NRC dated October 3, 1988. Investigation findings specifically point to past and current weaknesses in the implementation of the design process and the EQ program. Planned corrective actions to be integrated into the overall plans to improve the quality of engineering support include: 1) upgrade of design procedures to ensure that design change activities comply with EQ configuration requirements; 2) rework of EQ Document Packages (EQDP) to improve focus and clarity; 3) field verification of configuration requirements given in the EQDP's; and 4) EQ training of design, maintenance and station engineers who interface with the EQ Program.

Plant: San Onofre Nuclear Generating Station
Units: Two and Three
Reactor Vendor: Combustion Engineering
Event Date: 07-1-89

A. CONDITIONS AT TIME OF THE EVENT:

Mode: Unit 2 operating in Mode 1 at 100% reactor power
Unit 3 in Mode 4 (Hot Shutdown, RCS Temp. < 350 °F)

B. BACKGROUND INFORMATION:

Regulations pertaining to the environmental qualification (EQ) of electrical equipment important to safety are given by 10CFR50.49. 10CFR50.49(d) requires the licensee to maintain environmental qualification (EQ) files to demonstrate compliance with the rule. The rule specifies in subsection (f)(1) that if testing was used to justify qualification, the test sample must be identical or sufficiently similar to the installed equipment to have a valid EQ basis. The Environmental Qualification Documentation Packages (EQDP) serve to fulfill this requirement. The complete list of EQ-related electrical equipment is found in the Environmental Qualification Master List (EQML).

Initial Development of the SONGS EQ Program:

The initial Units 2 and 3 EQ documentation was coordinated or developed by the major contractors, Combustion Engineering (CE) and Bechtel Power Corporation. These companies collected information from their subcontractors documenting the testing or analysis performed in support of the IEEE Standard 323-1974 requirements, formatted the information in their format, and submitted it to SCE where it was reformatted into the NUREG-0588 response format and transmitted to the NRC.

Walkdowns were conducted by the cognizant engineer at Units 2 and 3 for the purpose of confirming manufacturer and model number consistency between the field and the EQML. After the field portion of the NRC audit was completed and the NRC accepted SCE's EQ Program, a program of documentation consolidation was begun. The CE and Bechtel document submittals were incorporated into SCE EQDP's. The control of the EQML and EQDP's, and their relationship with design and maintenance activities is prescribed through Engineering and Construction Quality Assurance (E&C QA) procedures. The EQ program was then applied to Unit 1 and EQDP's prepared for Unit 1 EQML equipment in accordance with the schedule set forth in the EQ rule.

Foxboro Transmitter Mounting Configuration Requirements:

All EQ-related Foxboro transmitters at Units 1, 2 and 3 are either "E10" or "N-E10" series transmitters.

In accordance with the EQ Test Report for the Foxboro N-E10 Series transmitters, the terminal block junction box (TBJB) [JBX] conduit entry is to be oriented in a downward direction and the flexible condulet [CDT] leading to the TBJB is to be looped below the TBJB and have a 1/4-inch drain hole provided at its lowest point. The purpose of this configuration is to provide a drainage path for any moisture that might be present in the condulet or TBJB. Following a Loss of Coolant Accident (LOCA) or Main Steam Line Break (MSLB) inside containment, with an elevated temperature and pressure atmosphere along with Containment spray, moisture enters the conduit [CND] due to condensation on the inside walls of the conduit or junction box, or by chemical spray or steam intrusion. The collection of moisture inside the TBJB could eventually result in the terminals being submerged, thereby rendering the transmitter inoperable. Moisture entry into the transmitter housing is precluded by an electrical conduit seal assembly (ECSA) between the TBJB and the transmitter.

Foxboro originally provided E-10 series transmitters for nuclear application. Foxboro E10 Series Instruments manufactured and modified with the MCA/RRW option by Foxboro were purchased for installation at Units 2 and 3 in Nuclear Service areas. This product line was superseded by their N-E10 series in the early to mid-1980's, and future replacements for E10 Series were fulfilled by the N-E10 series transmitter. Installation requirements of the E10 series differ from those of the N-E10 series. The EQ tests for the E10 and N-E10 series transmitter differed in that configuration requirements were specified for the N-E10 test samples (i.e., conduit entry in the 6 o'clock position) while the E10 EQ tests did not require this particular orientation. The N-E10 series EQ test was also used by SCE and the utility industry to upgrade the E-10 series qualification package.

C. DESCRIPTION OF THE EVENT:

1. **Event:**

On May 30, 1989, with Unit 1 in cold shutdown, a walkdown of Unit 1 Steam Generator (SG) [SG] water level transmitters [LT] [JB], located inside Containment [NH], was performed to evaluate various design change alternatives to correct a power dependent decalibration phenomenon experienced with six Foxboro level transmitters (LT-2400 A, B and C and LT-3400 A, B, and C) which caused a spurious emergency feedwater [BA] actuation (as reported in LER 89-015, Docket No. 50-206). As a result of this walkdown and a review of the EQDP, EQ Test Report and the manufacturer's installation instructions for the Foxboro transmitters, it was determined that the configuration of five of these six transmitters did not conform to their qualified configuration.

A Non-conformance Report (NCR) was issued on June 1, 1989, which documented that, contrary to the EQ Test Report for the Foxboro transmitters, five of the six SG level transmitters did not have the correct downward orientation of the condulet entry to the TBJB, as well as, a weep hole at low point of the condulet.

On June 1, 1989, with Unit 2 in Mode 4 (Hot Shutdown), an informal walkdown of Unit 2 EQML Foxboro transmitters inside Containment was conducted. From this walkdown, 8 transmitters were identified as having an incorrect TBJB condulet entry orientation.

On June 3, 1989, the balance of Unit 1 EQML Foxboro transmitters inside Containment were inspected. This inspection showed that only one other transmitter TBJB was oriented incorrectly, however, none had the prescribed weep hole. A preliminary engineering assessment of the EQ configuration determined that significant margin existed which would support an analysis justifying the alternative configurations with reduced or a lack of drainage. Action was initiated to demonstrate the acceptability of the various installed configurations by development of a justification for continued operation (JCO) based on rigorous calculations and vendor data. Although the Unit 1 transmitters were judged to be operable, it was planned to complete a formal JCO prior to Unit 1 returning to service.

Unit 2 entered Mode 3 on June 5, and Mode 1 on June 7, 1989.

From discussions with Foxboro, the amount of moisture that the housing could hold before the transmitter would become inoperable was identified. Initial calculations had identified a relatively small condensation rate. Depending on the length of conduit run above the transmitter and the length of conduit looped below the TBJB, the non-conformances (discussed above) would not result in the submergence of terminals inside the TBJB during and following a MSLB or LOCA. The intrusion of external moisture into the TBJB due to chemical spray or direct steam impingement was not considered credible because the cover and threaded connections are vapor tight. Moisture intrusion into the TBJB through the field run conduit or pull boxes [PBX] was not considered credible due to Unit 1 construction techniques which prevents direct entry. A walkdown of field run conduit for all Unit 1 Foxboro EQ transmitters confirmed this to be the case.

To complete the assessment, the condensation calculation needed to be formally issued and Foxboro was requested to issue a final position on the moisture capacity of the housing. Units 2 and 3 conduit lengths were researched by reviewing raceway drawings, and conduit lengths were required to be verified for a few cases. At this time, none of the data inferred a problem existed for any of the Unit 1 transmitters, except the LT-2400 and 3400 transmitters which were already being reconfigured as a result of changing their lower tap locations (as discussed in LER 89-015), nor did any of the data imply any of the Unit 2 transmitters were inoperable. Pending completion of the formal calculations and receipt of confirmatory housing capacity data from Foxboro, the preliminary conclusion was that insufficient condensation would accumulate inside the housing to render the equipment inoperable. In the interim, the Unit 1 and Unit 2 transmitters were considered to be operable.

Further walkdown of conduit configurations for the 52 Units 2 and 3 EQML Foxboro transmitters inside containment (26 for each unit) were scheduled for the next shutdown of either Unit 2 or 3.

On June 19, 1989, vendor information was sent to SCE which established the maximum acceptable volume of water collection in the TBJB for various orientations of the conduit entry (note that flooding of only the lower terminal, whether it is the positive or negative lead, will not affect the transmitter output). The worst case was identified as having an orientation of midway between the 9 o'clock and 12 o'clock position, in which case only 55 cc of internal volume existed below the upper terminal. On June 23, 1989, a formal calculation (Design Calculation DC 3219) was completed which established a maximum post-LOCA condensate water volume (in cubic centimeters) for each linear foot of conduit and for the TBJB.

On June 24, 1989, following receipt of vendor information and completion of the calculations, a formal JCO was issued which established operability of all Unit 1 Foxboro EQML transmitters inside Containment. Transmitter operability was determined by comparing: (1) the maximum credible volume of moisture intrusion into the TBJBs, and (2) the minimum credible volume of moisture in the TBJB that could prevent the transmitters from operating. On June 25, Unit 1 entered Mode 4 and on June 27, Unit 1 entered Mode 1.

When the JCO and the design calculation for the Unit 1 NCR was provided on June 24, 1989, the instruments identified on the Unit 2 NCR were re-evaluated for operability. At this time, both a computed condensation rate per linear foot of conduit and TBJB housing capacity for various orientations were known. Taken together, this information was used to develop screening criteria (later issued as a formal calculation, Engineering Calculation N-4080-021) for evaluating transmitter operability for various configurations. No credit was taken for the available reservoir volume associated with conduit loops below the instrument. By applying the screening criteria to data known for the Unit 2 transmitters (i.e., TBJB orientation from the Unit 2 NCR and conduit lengths from construction design data), 7 of the 26 transmitters were identified as requiring specific configuration measurements and would require a walkdown to complete the evaluation. A power entry into the Unit 2 containment was planned for June 30, 1989.

In the interim, Unit 2 operability was assessed with respect to each of these seven transmitters. The Reactor Protection System (RPS) [JC] and Engineered Safety Features Actuation System (ESFAS) [JE] functions associated with each of the seven would be completed before the housings would fill with moisture for large break events, and other, redundant trip features existed for smaller break events. Even though condensation calculations for the smaller break events had not been performed, it was concluded that the instruments would perform their desired RPS or ESFAS functions before being disabled by smaller break events. As no more than two instruments per parameter were of concern, the Post Accident Monitoring Instrumentation (PAMI) [IP] requirements were met, and Unit 2 operations remained acceptable.

On June 30, Unit 3 was shut down to repair a Low Pressure Safety Injection Pump (LPSI) [P] [BP] mechanical seal [SEAL] (reference LER 89-008, Docket No. 50-362). On July 1, with Unit 3 in Mode 4, a walkdown of the 26 EQML Foxboro transmitters inside containment was completed. This walkdown identified that for all 26 transmitters, there was the absence of a conduit low point drain and/or an incorrect TBJB orientation.

During the walkdown, the length of conduit above the transmitter to the local pull box [PBX] was measured to ensure the calculated maximum conduit lengths for condensation were not exceeded. Of the 26 transmitters, there were 3 instances in which conduit lengths were determined to be greater than the acceptance (screening) criteria for each particular TBJB orientation.

The Unit 3 inspections also revealed an additional non-conformance with respect to protection against implosion of electrical pull boxes. Units 2 and 3 construction specifications (SCE Drawing No. 39406) require electrical pull boxes (Type NEMA 4) to have bottom vent holes installed for implosion consideration. The inspection identified pull box implosion vent holes associated with 11 transmitters which had been plugged with a bolt/washer assembly, contrary to construction drawings. The inspection also identified that conduits for 3 transmitters were found to be configured in a manner which was contrary to the construction drawing (SCE Drawing No. 39407) that provides criteria for precluding direct spray intrusion into conduits.

On July 1, 1989, with Unit 2 in Mode 1 at 100% power, walkdowns inside Unit 2 Containment were initiated to examine transmitter configurations. The Unit 2 walkdown revealed similar EQ configuration discrepancies. Specifically, the walkdown identified: 1) all 26 transmitters as having an incorrect TBJB orientation and/or the absence of a conduit low point drain; 2) 7 instances in which conduit lengths were greater than the screening criteria for each particular TBJB orientation; and 3) that drain holes were inappropriately plugged on pull boxes associated with 11 transmitters.

NCRs were immediately written and dispositioned for the various non-conformances. (See Additional Information, Section G, for a function summary description of the Units 2 and 3 EQML Foxboro transmitters). Actions taken for each NCR is described below.

Unit 2 NCRs:

Three NCRs identified seven instruments as having conduit lengths in excess of the allowed for its TBJB orientation. All seven instruments were removed from service and repairs were performed to restore them to their configurations shown in the EQ Test Report. In doing so, the appropriate Technical Specification (TS) action statements were entered.

Five of the seven instruments (PT-0105-3, PT-1013-3, PT-1023-3, LT-1113-3, and LT-1123-3) were declared inoperable for the purposes of post-accident monitoring and the appropriate TS action statement entered. At the time the NCRs were dispositioned, the instruments were considered operable with regard to their ability to perform their RPS and ESFAS functions. Engineering judgement concluded that during a design basis event these functions would be actuated before sufficient water could accumulate in the TBJB to render the instrument inoperable. Testing at Wyle Laboratory, as discussed below, later confirmed this initial operability assessment.

The remaining two instruments, FT-1011 and FT-1021, were evaluated as operable. These are Main Steam System (MSS) [SB] flow instruments on the main steam lines connecting to the steam generators. They serve as PAMI which provide main steam flow indication as called for in Regulatory Guide 1.97. In addition, as part of SCE's response to Final Safety Analysis Report Question 222.43, Concerns on Controls Systems HELBA Interactions, the environmental qualification of both FT-1011 and FT-1021 was required to preclude a coincident failure of these instruments during a MSLB inside containment. The analysis concluded that failure of both instruments would result in the generation of a quick open signal to the Steam Bypass Control System (SBCS) [JI]. However, when credit is taken for the quick open block signal that would occur when Reactor Coolant System (RCS) [AB] average temperature is below 566 degrees F (which closes the turbine bypass valves), the consequences of the event remain bounded by the FSAR analysis. As such, both instruments were considered operable. PAMI operability was not a concern as alternate indication (i.e., valve limit switch position) was available.

One NCR identified seven local pull boxes associated with 11 Foxboro instruments which did not have implosion vent holes. Although the operability assessment (discussed below) indicated that all instruments were operable, all instrument pull boxes were immediately reworked to provide vent holes in accordance with the criteria specified in SCE Drawing No. 39406.

Credit was taken for the fact that all boxes were vented via multiple open ended conduit connections. Subsequent evaluations have demonstrated that, in addition to the vented conduit connections, the boxes would undergo an inward bending which would create additional vent openings. Adequate vent paths would be provided before cables or splices of nuclear circuits would be damaged; therefore, no adverse effects would occur as a result of the lack of implosion vent holes.

The operability assessments considered the impact this condition had on the environmental qualification of each of the 11 instruments in question. Acceptance was based upon the ability of each instrument to satisfy the spray intrusion and internal steam condensation criteria discussed previously. Since all conduit configurations at the raceways were either appropriately shielded or sealed, containment spray intrusion was not an issue.

With regard to internal steam condensation, credit was taken for the fact that the hard conduit connections at the bottom of the pull box are not leak tight. The hard conduit enters the bottom of the pull box through an oversized hole that provides approximately 1/32" radial clearance. The conduit is held in place, from the inside of the box, with a scalloped "belleville spring" shaped lock washer. The conduit extends a minimum of 1/2" above the bottom of the box. Adequate drainage would be available to drain any condensation from the pull box and other incoming conduits. Consequently, only the length of conduit between the transmitter and the local pull box is a moisture source due to steam condensation.

The operability assessment assumed that all connections at the bottom of local pull boxes were made in this manner. A review of the walkdown data sheets indicated that this assumption was not correct for one of the pull boxes. Rather than hard conduit, the connection at the bottom of this pull box was made with flexible conduit. As configured, it is questionable as to whether adequate drainage for condensing steam would be available. Consequently, the length of conduit above the transmitter pull box must also be considered as a source of moisture from condensed steam.

The instrument with the flexible connection at this pull box is LT-1113-4. Since this condition was not recognized, the field walkdowns did not determine the length of installed conduit above the local pull box. The operability assessment compared only the length of conduit between the transmitter and the bottom of the local pull box against the length allowed by Calculation N-4080-021. However, based on results from the laboratory testing and the identification of another pull box to LT-1113-4 which provided sufficient drainage, the transmitter was later confirmed to have been operable.

LT-1113-4 provides 1 of 4 channels of steam generator narrow range level. Engineering judgement concluded that, even without knowing the actual length of conduit above the local pull box, that during a design basis event the RPS and ESFAS functions for LT-1113-4 would be actuated before sufficient water could accumulate in the TBJB to render the instrument inoperable.

Unit 3 NCRs:

Two NCRs identified that the amount of undrained conduit above the instrument terminal boxes for FT-1021 and LT-1123-1 exceeded the length allowed by Calculation N-4080-021. In addition, the local conduit pull boxes were not vented in accordance with the junction box venting criteria specified in SCE Drawing No. 36406. Both instruments were evaluated as inoperable, and restored to their tested configurations. Vent holes were installed in the associated local pull boxes.

One NCR identified 5 instruments which were not installed in the EQ test configuration (PT-1013-1, PT-1013-2, PT-1023-1, PT-1023-2, and PT-1023-4). The length of undrained conduit above the transmitter terminal box for PT-1013-1 and PT-1013-2 was not acceptable. Both instruments were declared inoperable and repairs were made, restoring them to their tested configuration. The evaluation criteria for both steam condensation and spray intrusion could be satisfied for PT-1023-1, PT-1023-2, and PT-1023-4 in their installed configuration.

The local pull boxes for PT-1023-2, LT-0110-2 and LT-1113-2 were also found not to be properly vented. These instruments are connected to their respective pull box with a rigid conduit connection. As such, adequate drainage was available for moisture that might accumulate in the pull box due to steam condensation.

Three instruments (PT-1013-2, LT-0110-2 and LT-1113-2) were found to have vertical (upward) open ended conduit configurations at their respective raceways. The operability of these instruments with regard to spray intrusion was reviewed in detail. In the case of LT-0110-2, an intermediate pull box (between the conduit cable tray and the local pull box) was located with an implosion vent hole located on the bottom of the box. Additionally, all conduit open ends were located below a concrete deck which provides adequate protection from direct spray impingement.

One NCR identified 6 local pull boxes associated with 7 transmitters which were not vented in accordance with the junction box venting criteria specified in SCE Drawing No. 39406. With Unit 3 shutdown, these instruments were conservatively evaluated as being inoperable. However, as discussed above for the Unit 2 pull boxes lacking vent holes, subsequent evaluations have demonstrated that adequate vent paths would be provided before cables or splices of nuclear circuits would be damaged; therefore, no adverse effects would occur as a result of the lack of implosion vent holes. All pull boxes were reworked to install implosion vents.

By July 3, 1989, all priority repair activities to restore conduits and TBJBs to their EQ test configuration were completed. TBJB orientation and conduit low point drain holes were not restored to their tested configuration for 18 Unit 2 transmitters and 19 Unit 3 transmitters, since it was determined that these configurations were acceptable based on Calculation N-4080-021. On July 4, 1989, a formal JCO was issued for these transmitters.

Modified LOCA Testing at Wyle Laboratories:

On July 11, 1989, modified LOCA tests were completed by Wyle Laboratories to confirm the accident and post-accident functional integrity of Foxboro's N-E10 Series transmitters when configured as described below. This was accomplished by subjecting two N-E10 Series (4-20 mA) transmitter TBJB's to simulated Units 2/3 LOCA conditions (300 F and 60 psig) excluding chemical spray, and verifying operability during and after exposure to the maximum specified service conditions. The test did not include exposing the equipment to chemical spray conditions because the installed configuration would preclude chemical spray from entering the conduit system. In those instances where field walkdown of the transmitters identified that the conduit was not sealed and/or vent holes were not in the bottom of cable pull/junction boxes, the installation has been appropriately corrected.

To ensure that testing would adequately address the "as installed" configurations of all SONGS Foxboro transmitters, field walkdown information was utilized to determine test configurations. After obtaining the necessary field data, a study was made of the various conduit lengths and TBJB orientations, and their effect on potential condensation within the Foxboro TBJBs. This study determined that the worst case as-installed configuration in Unit 1 was LT-2400A (50 feet of conduit installed above transmitter TBJB and conduit entry oriented at 12 o'clock), in Unit 2 was LT-1123-3 (42 ft. of conduit installed above transmitter TBJB and conduit entry orientated at 12 o'clock), and in Unit 3 was PT-1013-2 (13 ft. of conduit installed above transmitter TBJB and conduit entry orientated at 10:30 o'clock). Based on the results of these efforts, the test specimen mounting orientations were selected to encompass the worst case mounting orientations for the Units 2/3 transmitters. Overall, four different specimen configurations were evaluated during two individual steam tests. Test specimens were appropriately grounded to simulate a short in one leg of the circuit, which could possibly occur in between the cable and conduit. During the testing, the required saturated temperature and pressure conditions were maintained for three hours. During this period, transient temperatures and pressures were recorded at levels exceeding the maximum SONGS requirements and the margins recommended by IEEE 323-1974. Several hours after completion of the test, the covers of the transmitters were removed and the TBJBs were inspected for signs of moisture. The junction box and internals of both test specimens appeared dry and there was no evidence of moisture. All test samples remained fully functional throughout the test sequence.

Reportability:

The Foxboro configuration deficiencies were initially evaluated as being reportable pursuant to 10 CFR 50.73(a)(2)(i)(B) for a condition prohibited by Units 2 and 3 TS 3.3.3.6 for PAMI, as indicated in the Revision "0" of this LER. Although TSs were met with redundant PAMI channels, it was reasonable to assume that at some point in time, a combination of redundant channels could have been removed from service for maintenance such that TS 3.3.3.6 was not met. However, the laboratory testing discussed above ultimately confirmed that the calculations were conservative and that original configurations were adequate to meet all safety functions. Therefore, this LER is being submitted as a voluntary report as none of the EQ discrepancies resulted in a reportable condition.

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

None.

3. Sequence of Events:

Not applicable.

4. Method of Discovery:

The inoperable transmitters on Units 2 and 3 were identified during planned inspections/walkdown of Foxboro transmitter TBJB orientations and conduit configurations. These inspections were conducted as a result of ongoing investigation into the Foxboro EQ transmitter discrepancies identified at Unit 1. The Unit 1 discrepancies were discovered by a QA inspector during an informal walkdown of SG level transmitters.

5. Personnel Actions and Analysis of Actions:

Engineering personnel properly assessed Units 2 and 3 equipment operability based on the information known at the time. Subsequent investigation identified that the operability assessment for one Unit 2 transmitter, LT-1113-4, was non-conservative. This was because the engineer assumed that the rigid conduit connection to the pull boxes permitted sufficient drainage, as discussed under C.1.a.2), above. This assumption was valid for all but one pull box, which later was determined to have a flex conduit connection instead of a rigid conduit connection. However, based on results from the laboratory testing and the identification of another pull box to LT-1113-4 which provided sufficient drainage, the transmitter was later confirmed to have been operable.

Operators took appropriate action in accordance with Technical Specification Action Statements upon the identification of any inoperable transmitters.

6. Safety System Responses:

Not applicable.

D. CAUSE OF THE EVENT:

The root cause of these errors is associated with weaknesses in SCE's engineering support functions, as given in SCE's August 1988 Task Force Report on its Independent Assessment of Technical and Engineering Support, which are the subject of major efforts to make improvements as described in SCE's letter to the NRC dated October 3, 1988. The Foxboro transmitter mounting configuration experience specifically points to past and current weaknesses in the implementation of the design process and the EQ program. The following are discussions regarding specific findings/conclusions resulting from SCE's investigation.

EQDP Procedural Requirements:

EQDP preparation is covered by E&C QA Procedure 37-30-63, "Development, Issuance, Revision and Cancellation of the Document Package to Establish the Environmental Qualification (EQ) of Electrical Equipment listed on the EQML for SONGS 1, 2&3". This procedure directs the preparer to use a "Environmental Qualification Evaluation Summary" form as a guide in reviewing vendor qualification documentation. The preparer completes the applicable sections of the form for plant specific information, such as function, and enters the appropriate reference to the vendor test or analysis information. Attachments are included in the EQDP format to supplement the Evaluation Summary, and several other forms are included to make up the complete package.

When compared to the regulatory requirements for documenting environmental qualification, the EQ Summary Evaluation form is focused and thorough. If properly completed, it has produced EQDPs which have successfully passed NRC audits. However, the form is not an easily usable reference for personnel unfamiliar with EQ. Additionally, this form has not been revised to reflect emergent EQ issues. Furthermore, it does not provide for adequately detailed verification (during modification or maintenance activity) of as-qualified installation to ensure the EQDPs accurately reflect installations in the plant.

EQ Program Interface Requirements:

E&C QA procedure 37-30-63 addresses certain interface requirements, and requires that information needed for EQ-related maintenance activities be reflected on an "EQ Equipment Maintenance Information Sheet", or MIS form. This form is reviewed by the Maintenance Engineering and Support organization to ensure that the requirements are translated into maintenance orders or procedures. Also, there are provisions in E&C QA procedure 37-30-63 to accommodate feedback from the Maintenance organization to the EQ organization.

The current provisions in the design change procedures are vague as to who is responsible to review applicable EQDPs to ensure configuration requirements are met and that design disclosure documents address EQ equipment configuration requirements. The Nuclear Engineering (NE) discipline is responsible for the EQ program, although the design change Responsible Engineer should ensure the design change meets all required criteria.

Foxboro Transmitter Configurations:

Investigation by the Quality Control (QC) organization determined that the as-found configuration of the Foxboro transmitters existed from the time of their original installation, and was in accordance with the vendor's instructions current at that time. When the SONGS EQ program was initially established in 1981, an EQ test in accordance with the requirements of IEEE Standard 323-1974 had not yet been completed on the Foxboro transmitters. Initially, interim EQDP's were issued for the Foxboro instruments pending completion of their IEEE 323-1974 tests. These EQDP's referenced separate effects test reports which made no mention of configuration criteria. Similarly, the Foxboro installation manual did not specify any configuration requirements. Subsequently, EQ testing was completed to the new regulatory criteria established in 10 CFR 50.49. The resulting test report was issued in 1983 and was used to develop the current Unit 1 and Units 2/3 EQDP's. It did identify a test sample configuration requirement. The N-E10 series technical manual also included the new requirement by specifying that the transmitter TBJB conduit entry be positioned facing downward. In addition, the flex conduit entering the junction box was looped below the junction box and had a 1/4" weep hole at its low point to facilitate condensate drainage.

Revised configuration requirements established during the EQ testing were inadequately incorporated into the EQDPs and were not communicated to design, maintenance or construction organizations, nor were the configuration requirements field verified to ensure the installed configuration met the EQ requirements. Although it was included in an attachment to the EQDP, the installation requirements were not addressed in the required section of the EQDP Summary. As a result, this configuration requirement was not identified to, or addressed in, the maintenance or design control programs.

Nuclear Engineering Organization:

Due to the limited technical guidance provided for preparation of EQDPs, the quality of EQDPs has been strongly dependent upon the skill and experience of the engineer who prepared it. Since the skill and experience of the preparing engineer has been a major factor in the quality of the EQDPs, it is important to consider the limited training provided to EQ engineers as contributor to EQ errors. All work on the EQ Program was initially performed by one engineer, the EQ Coordinator. The EQ Coordinator had a comprehensive overview of the regulatory requirements and industry trends. Thus, he had adequate knowledge to do the work and did not need substantial training. As the workload increased, additional staff engineers were used for EQ assignments. These engineers gained their EQ knowledge by on-the-job training. This practice led to gaps and a lack of breadth in their knowledge, since their focus was on production of EQDPs. Even in the cases in which the engineers developed a considerable body of EQ knowledge, such knowledge was narrowly focused on a range of equipment. These other NE engineers working on EQ did so on a part time basis which further reduced the effectiveness of the "on-the-job" training approach. No significant efforts were made to provide EQ technical training on a widespread basis until November of 1987.

Prior to the recent reorganization which consolidated all engineering design activities within Nuclear Engineering Safety and Licensing (NES&L), engineering activities were split among three different departments. The different jurisdictions and emphasis that existed between these departments inhibited the development of a successful EQ Program.

Measures to Ensure Installations Conform to EQ Tested Configuration:

EQDPs do not include references to installation drawings or document walkdowns of "as-installed" configurations. Systematic, detailed walkdowns of EQ equipment to verify installation features critical to qualification have not been performed. Inspection criteria for EQ equipment installations are not sufficiently detailed to allow verification of as-qualified installation from records generated during normal modification or maintenance activity.

Control of EQDP Generation:

Procedural guidance for generation of EQDPs can be subject to widely diverse interpretations concerning the appropriate level of detail to be provided and appropriateness of assumptions to be used.

EQ Design Control:

EQ personnel did not issue design disclosure documents to communicate requirements for specific equipment installations to other design disciplines or to maintenance and quality control organizations. Attributes critical to qualification of the equipment installation were not flagged for verification.

Adequacy of Resources Dedicated to EQ Programmatic Improvements:

An EQ Impact Summary (EQIS) has been informally used for several years to aid in identifying EQ impacts created by design changes. Its use has never been formalized by approved procedures. Personnel assigned to the EQ Program and other design engineering personnel interfacing with EQ issues were not adequately trained to recognize the significance of configuration requirements on qualification status. Resources given for training were inadequate for the development of a comprehensive and credible EQ program.

Unit 1 SG Level Transmitters:

In January, 1989, Field Initiated Design Change Notices (FIDCN) were issued against the six Unit 1 Steam Generator narrow range level instruments (LT-2400 A, B & C and LT-3400 A, B & C) to convert them to wide range capability. Relocations of the transmitters was required to accomplish this modification. The change out of the six Foxboro level transmitters was not included in the scope of design changes planned for the Unit 1 cycle 10 refueling outage. When the decision was made to implement these modifications, the FIDCN process was employed for expediency reasons. The design change responsible engineer discussed the transmitters' installation requirements with the vendor during FIDCN preparations, and the vendor confirmed that the mounting instruction configuration was applicable. However, an omission occurred whereby the required EQ mounting configuration was not reflected in the design changes which were implemented.

Pull Box Implosion/Drainage Holes:

Implosion and drainage holes placed in safety related junction/pull boxes were found plugged contrary to the criteria of Drawing Nos. 39406 and 39407. However, at the time of initial installation, no nonconforming conditions for boxes or conduit could be identified given the information contained within the walkdowns. Therefore, the drain holes were most likely plugged sometime after initial installation. An extensive search of documentation was performed to determine a cause for the plugging of drain holes; however, no evidence of a possible cause could be identified. One possible cause is that the type of pull boxes employed (NEMA 4) is designed to be water tight and may have compelled personnel to initiate actions to plug the drain holes. Should our investigation identify any other cause, a supplemental LER will be submitted.

E. CORRECTIVE ACTIONS:

1. Corrective Actions Taken:

   a. Immediate corrective actions were implemented to correct transmitter installed configurations and add pull box drain holes, where appropriate.

   b. For the transmitters whose configurations were not restored to their qualified configuration, testing and analyses were conducted which demonstrate transmitter operability during and after applicable Design Basis Events.

2. Planned Corrective Actions:

   a. Foxboro transmitters not yet restored to their EQDP required configuration will be restored to their EQDP configuration or their EQDP will be revised to reflect their "as-installed" configuration.

   b. Detailed procedures will be developed for reformatting EQDPs to include specific installation requirements, walkdown records to verify installation of equipment in its qualified configuration, and an assumptions section. Specific technical guidance will be included in the procedures concerning the appropriate level of detail to be considered in evaluating technical issues, and concerning appropriateness of assumptions. An improved EQ assessment format to better document installation EQ interface requirements will be developed and implemented.

   c. The EQDP update procedure will be implemented for all Units 1, 2 and 3 EQDPs. Included in this activity will be field verification of as-qualified installations for EQ equipment. A priority list will be used such that those EQDPs most likely to have similar concerns will be upgraded first.

d. Planned corrective actions to address deficiencies in controlling EQ required configurations in the design change process include: 1) the revision of E&C QA procedures to require the use of configuration drawings for each EQML device in the EQDP, unless waived by the NE EQ Supervisor; 2) development of an EQ Design Control Checklist for Nuclear Engineering Design Organization (NEDO) engineers; and 3) establishment of procedures to ensure that manufacturer's installation instructions are included as part of the design change process.

e. Planned corrective actions to address training deficiencies include: 1) training of NE EQ engineers on technical aspects of EQDP preparation; 2) EQ training to all NEDO engineers; and 3) EQ training for engineering and technical personnel in various organizations (i.e., maintenance, procurement, Station Technical, QA/QC, etc.) which interface with the EQ Program.

f. EQ instrument configuration drawings will be established and incorporated into the maintenance program, as appropriate, to ensure qualified configurations are maintained following maintenance activities.

F. SAFETY SIGNIFICANCE OF THE EVENT:

There was no safety significance to this event since subsequent analysis and laboratory testing determined that moisture accumulation inside the TBJB is much less severe than previously calculated and therefore, all transmitters would have performed their safety-related function.

G. ADDITIONAL INFORMATION:

1. Transmitter Function Summary:

<u>PT-0101-1 through PT-0101-4</u>: These are the RCS wide range pressure instruments [PT] (1500 to 2500 psia) located on the pressurizer which initiate a reactor trip on high pressurizer pressure, provide input to the Core Protection Calculator (CPC) [JC], and provide Control Room indication. These instruments are credited in the EQ program for 30 minutes following a Design Basis Accident (DBA) to perform their RPS function. TS 3.3.1, RPS Instrumentation, applies to these instruments.

<u>PT-0103-1 and PT-0105-3</u>: These are the RCS low range pressure instruments [PT] (100 to 750 psia) located on the pressurizer which provide interlock signals to Safety Injection Tank (SIT) [TK] [BP] isolation and Shutdown Cooling System (SDCS) [BP] suction valves, and provide Control Room indication. These instruments are credited in the EQ program with providing the above interlock functions for 120 days post-DBA. Indirectly, TS 3.5.1, Emergency Core Cooling System, applies to these instruments.

PT-1013-1 through PT-1013-4, and PT-1023-1 through PT-1023-4: These are the MSS pressure transmitters [PT] (0-1200 psia) located on the steam generators which initiate a low steam generator pressure reactor trip and a Main Steam Isolation Signal (MSIS) [JE]. These instruments also provide an Emergency Feedwater Actuation System (EFAS) [BA] input and serve as PAMI instruments. They provide Control Room, Remote Shutdown Panel (one channel only) and Post Accident Monitoring [IP] Recorder (one channel only) indication. These instruments are credited in the EQ program for 30 minutes post-DBA for their RPS and ESFAS functions and for 120 days post-DBA for their PAMI functions. TSs 3.3.1, 3.3.2, 3.3.3.5 and 3.3.3.6 for RPS, ESFAS, Remote Shutdown and PAMI instrumentation, respectively, apply to these instruments.

LT-0110-1 and LT-0110-2: These are the RCS level instruments (0 to 100%) located on the pressurizer. They provide Control Room and Remote Shutdown panel indication, provide pressurizer heater control and charging pump controls, and provide input to the plant computer [ID] and qualified Safety Parameter Display System (SPDS). These instruments are credited in the EQ program for 120 days post-DBA to perform their PAMI function. TS 3.3.3.5 and 3.3.3.6 applies to these instruments.

LT-1113-1 through LT-1113-4, and LT-1123-1 through LT-1123-4: These are the MSS narrow range level instruments (0-100%) located on the steam generators. They serve to initiate a reactor trip on either low or high steam generator water level and serve as EFAS input instruments. They also provide Control Room and Remote Shutdown Panel indication and provide input to the Control Room recorder and plant and SPDS computers. These instruments are credited for 30 minutes post-DBA to perform their RPS and ESFAS functions. TSs 3.3.1 and 3.3.2 apply to these instruments.

FT-1011 and FT-1021: These are the MSS flow instruments on the main steam lines connecting to the steam generators. These instruments provide post-accident main steam flow indication as called for in Regulatory Guide 1.97. In addition, as part of SCE's response to Final Safety Analysis Report Question 222.43, Concerns on Controls Systems HELBA Interactions, the environmental qualification of both FT-1011 and FT-1021 was required to preclude a coincident failure of these instruments during a MSLB inside containment. EQ operability requirement is 120 days post-DBA. These instruments are not addressed by TSs.

2. Previous LERs for Similar Events:

LER 87-006, Docket No. 50-206, reported that EQ butt splice connectors for level switches associated with the Wide Range Containment Water Level (WRCWL) instrumentation was found to have been in a non-EQ configuration. The cause was attributed to inadequate design document review. Drawings, installation procedures, and other materials provided by the vendor contained sufficient information to properly install the WRCWL instrumentation. However, the information had not been properly included in the design documents used to install the WRCWL instrumentation in 1984. A training program for personnel performing technical and engineering reviews was initiated. This program emphasizes the responsibilities of technical personnel to ensure technical and engineering reviews are properly conducted by cognizant personnel.

LER 88-001 (Docket No. 50-206) reported that several components requiring environmental qualification (EQ) had been omitted from the Equipment Qualification Master List (EQML), and therefore had never been properly qualified. The cause of the EQML omissions was the incorrect application of the criteria of 10 CFR 50.49 (b)(1) and (b)(2) during the generation of the original EQML in 1980, and/or the failure of SCE's design control process to ensure consideration of environmental qualification requirements during subsequent plant modifications. In 1984, design control processes were implemented to ensure that plant modifications are evaluated for EQ requirements. A complete review of all installed electrical equipment for compliance with the requirements of 10 CFR 50.49 was completed. However, the scope of this review was limited to a review of design documents to ensure completeness of the EQML.

3. RPS and ESFAS Instrument Ground Testing:

During a follow-up review of this event, the NRC resident inspector, noting that the JCO (discussed above) credited the acceptability of submerging one of the two transmitter terminals inside the TBJB, identified a failure to comply with a FSAR-related commitment. Specifically, the Units 2 and 3 Updated FSAR (USFAR) Section 7.2.2.3.2 for the RPS, and Section 7.3.2.1.2 for the ESFAS, requires periodic testing to detect grounds in the RPS and ESFAS instrument loops to ensure that the circuit remains ungrounded. No program was in place to accomplish this periodic testing.

To ensure that the JCO assumption of no pre-existing grounds, the 18 Unit 2 and 19 Unit 3 instruments addressed in the JCO were tested for grounds, and no instrument grounds were found. As long term corrective action, a program for RPS and ESFAS instrument ground testing is under development. In the interim, individual RPS and ESFAS instrument circuits are being tested upon completion of evaluations and development of test procedures for the various instrument loops.

The root cause of this deficiency was the misinterpretation of the technical requirements for performing ground testing. Based on this misinterpretation, it was believed that the existing Technical Specification required surveillances satisfied this FSAR commitment. Consequently, it was decided that no procedural action was necessary to implement periodic ground testing. Individual organizations had reviewed the FSAR for incorporation of commitments in Station procedures during the 1980 to 1981 time frame when procedures and programs were initially developed. While there was no rigorous program in place at that time to ensure complete FSAR commitment compliance, it has been SCE's experience that the instances of missed commitment implementation have been limited. As discussed in previous LERs (see LER 89-034, Docket No. 50-361), a Design Basis Documentation (DBD) program is being implemented which will ensure integration and implementation of SONGS design and licensing bases.

4. Operational Controls for MSS flow instruments FT-1011 and FT-1021:

As a result of SCE's operability assessment for these transmitters, it was realized that FT-1011 and FT-1021, as well as other instruments which are required to be operational for PAMI per Regulatory Guide (RG) 1.97, are not identified in the TSs. The list of Regulatory Guide 1.97 instruments will be reviewed and operational controls will be established, as necessary.

SONGS Units 2 and 3 were licensed prior to issuance of RG 1.97 Revision 2. Subsequently, SCE implemented equipment upgrades to be in conformance with RG 1.97, Revision 2, however, these upgrades were not reflected in TS revisions. Current industry work on Restructured Standard TS (RSTS) will likely change the PAMI TS to incorporate all RG 1.97, Revision 2 Type A, Category I instruments. Therefore, under the CE-RSTS, SCE will review PAMI instrumentation and incorporate appropriate instruments in the TSs.

5. Results of NPRDS Search:

Not applicable.