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July 9, 1988

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

Gentlemen:

Subject: Docket No. 50-206
Environmental Qualification of Electrical Equipment
San Onofre Nuclear Generating Station
Unit 1

During this extended mid-cycle outage, SCE has been resolving concerns with the environmental qualification program at San Onofre Unit 1. As part of this effort, SCE has provided the NRC staff with updates of the progress made. The purpose of this letter is to provide a further update of these efforts. The last information transmitted to the NRC staff was by letter dated May 27, 1988. The enclosed tables from the May 27, 1988 letter have been updated. Changes are identified by change bars. Table 1 lists the b(1) equipment identified during the review which required some corrective action. Tables 2 and 3 list the b(2) equipment identified as a result of the review and fuse coordination study, respectively.

The May 27, 1988 letter also indicated that SCE would be evaluating the environmental qualification status of cable which would be exposed to a harsh environment. As a part of this evaluation, approximately 1100 cables were walked down in the plant. These walkdowns have resulted in replacing 53 cables which were of indeterminate qualification.

In addition, it has been determined that two cable types require a justification for continued operation (JCO) to be established prior to returning the unit to service. These JCOs are provided as Enclosures 1 and 2 for your information. Enclosure 1 addresses cable associated with the Nuclear Instrumentation System. Enclosure 2 addresses cable associated with one of the two refueling water pumps which is used for containment spray. The current schedule for replacement of this cable is during the upcoming refueling outage.

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1/1

Therefore, with the exception of the cable associated with the enclosed JCOs and the modifications identified in our November 20, 1987 letter regarding the single failure issues, San Onofre Unit 1 will comply with 10CFR50.49 at the time the unit returns to service.

If you have any questions regarding this information, please call me.

Very truly yours,

M O Medford

M. O. Medford
Manager of Nuclear Engineering
and Licensing

ACL:0028n
Enclosures

cc: J. B. Martin, Regional Administrator, NRC Region V
F. R. Huey, NRC Senior Resident Inspector, San Onofre Units 1, 2 and 3

Table 1

10 CFR 50.49 b(1) Equipment

Device	Description	Corrective Action
MOV 1202	AFW Pump Discharge Valve	Added to EQML
MOV 1204	AFW Pump Discharge Valve	Added to EQML
HY 1304	Charging Pump to Loop A Isolation Valve CV 304, Actuator	Replaced and Added to EQML
ZSO/C 1304	Limit Switches for CV 304	Replaced and Added to EQML
HY 1305	Charging pump to Press Aux. Spray Isolation CV 305 Valve, Actuator	Replaced and Added to EQML
ZSO/C 1305	Limit Switches for CV 305	Replaced and Added to EQML
PT 459	Mainsteam line Pressure Input to Steam-Feed Mismatch Trip	Added to EQML
FY 1112	Charging Pump Flow Control Valve FCV 1112, I/P Transducer	Added to EQML
SV 1112	Solenoid Actuator for FCV 1112	Replaced and Added to EQML
TS 34, 35	Feedwater Pump Lube Oil Temperature Elements for Cooler Fans	Added to EQML
E-17A, B	Feedwater Pump Lube Oil Cooling Fans	Added to EQML
SV 17, 17A	Feedwater Pump Miniflow to Condensor, Isolation Valve Actuators	Replaced and Added to EQML
SV 18, 18A	Feedwater Pump Miniflow to Condensor, Isolation Valve Actuators	Added to EQML, Replaced and Added to EQML
SV 524, 5, 6, 7, 8, 9, 30, 31	Pneumatic Supply Solenoids For Feedwater Pump SI Alignment Valves	Replaced and Added to EQML
SV 875A, B	Feedwater Pump SI Miniflow to Refueling Water Storage Tank, Isolation Valve Actuators	Replaced and Added to EQML

ZSO/C 1875A, B	Limit Switches for SV 875A, B	Replaced and Added to EQML
SV 955, 6, 7	Primary System Sample Containment Isolation Valve Actuators	Replaced and Added to EQML
SV 1115DA, DB, EA, EB, FA, FB	Containment Recirculation Flow Control Valve Pheumatic Supply Solenoids	Replaced and Added to EQML
SV 2900, 3900	Bonnet Vent Solenoid for Feedwater Pump SI Alignment Valves	Added to EQML
SV 520, 1, 2, 3	Pneumatic Supply to Feedwater Pump SI Alignment Valves	Replaced with check valves
SV 135	Service Water to AFW Pump Bearing Solenoid Valve	Replaced with check valve
CV 2145	Charging Pump Discharge Sample Valve	Replaced and Added to EQML
FT 2114B, C, 3114A	Containment Recirculation Flow Transmitters	Added to EQML
FY 1115D, E, F	Containment Recirculation Flow Control Valve Transducers	Added to EQML
T 14A, B	Residual Heat Removal Pump Thermal Overload Devices	Relocated
T 45A	Containment Recirculation Pump Thermal Overload Device	Relocated
X07, 8	Station Service Transformers	Added to EQML

Table 2

10 CFR 50.49 b(2) Equipment

(b)(2) Device	(b)(2) Device Description	b(1) Equipment	(b)(1) Equip Description	Corrective Action
VPS-1	Transformer for SV 702B, D	Position Indication for SV702B, D	Containment Isolation, valve position indication	Fuse Isolation/ Removal
VPS-2	Transformer for SV 702A, C	Position Indication for SV702A, C	Containment Isolation valve position indication	Fuse Isolation/ Removal
SV 600 ZSO/C2600	Spray Hydrazine Isolation Valve and Limit Switches	SV533A ZSO/C 2533 SV537A ZSO/C 2537	Service Water and Makeup Water Containment Isolation Valves and Limit Switches	Fuse Isolation
FV-2077, 3078	Service Water to Recirculation Pump Bearings	G45A, B Control Circuits	Containment Recirculation Pumps	Fuse Isolation
SV 601 ZSO/C 2601	Spray Hydrazine Isolation Valve and Limit Switches	SV126 ZSO/C 3115 SV532 ZSO/C 1532 SV 534A ZSO/C 3534	Service Water, Nitrogen and Makeup Water Containment Isolation Valves and Limit Switches	Fuse Isolation
SV 951	Primary System Sample Containment Isolation Valve Actuator	ZSO/C 2951	Position Indication	Fuse Isolation
SV 953	Primary System Sample Containment Isolation Valve Actuator	ZSO/C 2953	Position Indication	Fuse Isolation
SV 962	Primary System Sample Containment Isolation Valve Actuator	ZSO/C 2962	Position Indication	Fuse Isolation
PCV430C, H, HCV 1117	Pressurizer Aux. Spray and Excess Letdown Isolation Valves	HY 1304	Charging Pump Discharge Isolation Valve Actuator	Fuse Isolation
Humidity Bridge and Amplifier	Containment High Humidity Alarm	SV28, 9, 30	Containment Ventilation Isolation Valve Actuators	Fuse Isolation
FY 5112	Charging Pump Discharge Isolation Valve Actuator	FCV 1112	Charging Pump Discharge Isolation Valve	Open Breaker
PY 5530, 5546	PORV and Block Valve Actuators	CV 530, 546	PORV and Block Valve	Open Breaker
FY 1115A, B, C	Containment Recirculation Flow Control Valve Transducers	FY 1115D, E, F	Containment Recirculation Flow Control Valve Train A Transducers	Replaced, Added to EQML
SV20, PS-80	Turbine Plant Cooling Water Hx Flow Control Valve Solenoid and Pump Discharge Pressure Switch	G6N (Note 1)	Turbine Plant Cooling Water Pump	Install Fuse, Isolate
SV21, PS-81	Turbine Plant Cooling Water Hx Flow Control Valve Solenoid and Pump Discharge Pressure Switch	G6S (Note 1)	Turbine Plant Cooling Water Pump	Install Fuse, Isolate

(b)(2) Device	(b)(2) Device Description	b(1) Equipment	(b)(1) Equip Description	Corrective Action
SV26	Circulating Water Pump Discharge Control Valve Solenoid	G4A (Note 1)	Circulating Water Pump	Install Fuse, Isolate
SV27	Circulating Water Pump Discharge Control Valve Solenoid	G4B (Note 1)	Circulating Water Pump	Install Fuse, Isolate
SV-62,PS-53, PS-56,TS-15	Service Air System Solenoid Valve, Pressure Switch and Temperature Switch	K1A (Note 1)	Air Compressor	Install Fuse, Isolate
SV-63,PS-54, PS-57,TS-16	Service Air System Solenoid Valve, Pressure Switch and Temperature Switch	K1B (Note 1)	Air Compressor	Install Fuse, Isolate
SV-64,PS-55, PS-58,TS-17	Service Air System Solenoid Valve, Pressure Switch and Temperature Switch	K1C (Note 1)	Air Compressor	Install Fuse, Isolate
PS-1,dps-9 SV-7,PS-26 SV-41,SV-69	Condenser Vacuum Pump Pressure Switches and Solenoid Valves	X7A (Note 1)	Condenser Vacuum Pump	Install Fuse, Isolate
PS-2, dps-10 SV-8, PS-27 SV-42,SV-70	Condenser Vacuum Pump Pressure Switches and Solenoid Valves	X7B (Note 1)	Condenser Vacuum Pump	Install Fuse, Isolate
LS-8, LS-10	Feedwater Heater Level Sensors	G36A, G36B (Note 1)	Heater Drain Pump	Install Fuse, Isolate
PS-136, PS-44	Turbine Lube Oil Pressure Switches	G29 (Note 1)	Turbine Aux. Lube Oil Pump	Install Fuse, Isolate
86-M3-1, 86-M-3-2 86-M3-3, 86-M3-4, SD-1-6	SIS-LOP Lockout Relays	B03 (Note 1)	MCC #3	Install Fuses; Isolate and remove automatic cross connect with Switchgear 2 on SIS - LOP
LT-451 LT-455	Wide and Narrow Range SG Level Transmitter	FT 458, 462	Feedwater and Steam Flow Transmitters	Add fuse
LT-452 LT-453	Wide and Narrow Range SG Level Transmitter	FT 456, 460	Feedwater and Steam Flow Transmitters	Add fuse
LT-450 LT-454	Wide and Narrow Range SG Level Transmitters	FT 457, 461	Feedwater and Steam Flow Transmitters	Add fuse
TIC-1110 TIC-1108N FT-1102B	Boric Acid System Temperature Controller, Heater Switch and Flow Controller	FY 1112, FY 1115 D, E, F	Transducers for FCV 1112 and FCV 1115 D, E and F	Add fuse

Notes

1. Equipment identified is not b(1), but is de-energized on a SIS-LOP. The b(2) device failure could impact this tripping function and therefore emergency diesel generator loading under a SIS-LOP condition.

Table 3

10 CFR 50.49 b(2) Equipment
from Fuse Coordination Study

(b)(2) Equipment	Associated (b)(1) Equipment	Fuse Coordination Resolution
LCV 1112	FY 1203, ZSO/C 1203, HY 1304, ZSO/C 1304, FY 1202, ZSO/C 1202, FY 1204, ZSO/C 1204	Coordinated
SV 225	FY 1203, ZSO/C 1203, HY 1304, ZSO/C 1304, FY 1202, ZSO/C 1202, FY 1204, ZSO/C 1204	Replaced
SV 276	HY 1287, ZSO/C 1287, HY 1305, ZSO/C 1305	Coordinated
SV 288	HY 1287, ZSO/C 1287, HY 1305, ZSO/C 1305	Coordinated
TCV 1105	HY 1287, ZSO/C 1287, HY 1305, ZSO/C 1305	Replaced
LCV 1100A	HY 1287, ZSO/C 1287, HY 1305, ZSO/C 1305	Replaced
SV 544	HY 1305, ZSO/C 1305, HY 1287, ZSO/C 1287	Coordinated
SV 412	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Coordinated
SV 413	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Replaced
SV 414	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Replaced
RCV 605	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Coordinated
HCV 602	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Coordinated
TCV 601A	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Coordinated
TCV 601B	SV 411, ZSO/C 1411 SV 410, ZSO/C 1410	Replaced

(b)(2) Equipment	Associated (b)(1) Equipment	Fuse Coordination Resolution
PO 1, 2, 3, 4, 5, 6, 7, 8	ZSO/C 2009, ZSO/C 2010, SV 28, SV 29, SV 30	Coordinated
PO 13, 14, 15, 16, 21	ZSO/C 2009, ZSO/C 2010, SV 28, SV 29, SV 30	Coordinated
PCV 1115A	HY 1305, ZSO/C 1305, HY 1287, ZSO/C 1287	Replaced
PCV 1115B	HY 1305, ZSO/C 1305, HY 1287, ZSO/C 1287	Replaced
PCV 1115C	HY 1305, ZSO/C 1305, HY 1287, ZSO/C 1287	Replaced
SV 99	ZSO/C 2009, ZSO/C 2010, SV 28, SV 29, SV 30	Coordinated
SV 2001, 2, 3, 3001, 2, 3	AEH22001, 3001, PE 2001, 3001, TE2001, 3001, SV 2004, 3004, LE 2001, 3001, 2002A, B, C, LE 3002A, B, C, PT 2001, 3001	Coordinated
SV 150, 151 SV 457, 458 Timer 62-1	HV 851A, 852A, 853A, 854A SV 524, 525, 526, 527 (Note 1)	Relocated
LCV 1112 SV 225 SV 406A, B	FY 1202, 1203, 1204 HY 1304 (Note 1)	Coordinated
SV 149 SV 427A, B, C SV 456	HV 851B, 852B, 853B, 854B SV 528, 529, 530, 531 (Note 1)	Coordinated

Notes

1. Failure of b(2) device could impact b(1) loads fed from the same breaker position.

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Enclosure 1

Memorandum for File

July 7, 1988

Subject: Operability of Nuclear Instrumentation System (NIS) Components Following a Mainsteam Line Break (MSLB) Outside Containment San Onofre Nuclear Generating Station Unit 1

References: A. WCAP-11294, "SCE SONGS UNIT 1 STEAMLINE BREAK OUTSIDE CONTAINMENT MASS/ENERGY RELEASE ANALYSIS"

B. Memorandum for File by W. G. Flournoy, dated 6/13/88; Subject: Equipment Qualification of the Nuclear Instrument System (NIS), San Onofre Nuclear Generating Station, Unit 1

C. Memorandum G. J. Stawniczy to R. L. Phelps, dated 5/31/88; Subject: Project Work Notification No. 14WD-NIS Cables

D. Chaung, A.; "A Simplified Heat Transfer Method to Evaluate the Temperature Profile of Rockbestos Cable Subjected to a LOCA Environment; "Sorrento Electronics; 1987

E. Impell Calculation 0310-201-001 "120VAC & 125VDC (b)(2) Fuse Coordination Study" dated 5/26/86, SCE Number M85010

Purpose: To evaluate the operability of NIS cable in a steam environment following a MSLB outside containment; to provide a reactor trip signal as assumed in the Safety Analysis for these events.

Conclusion: The subject cable is considered operable to provide a reactor trip as required, based on the limited required operating time and objective evidence that the cable will not experience a significant increase in temperature during that time.

Discussion: The NIS is required to provide reactor trip for selected mainsteam line breaks outside containment. Reference A identifies breaks between 2.66 ft^2 and .4 ft^2 at 103% power which credit high neutron flux trip at between 9.2 and 36 seconds post-accident. Reference B further defines the maximum time required to generate a high neutron flux trip for any break outside containment, as less than 1 minute post-accident.

The NIS detectors which input to the Reactor Protection System High Neutron Flux Trip (NE 1205A, B; NE 1206A, B; NE 1207A, B; NE 1208A, B) are located inside containment, as shown on drawing 458591-0. For an MSLB outside containment, only the cable is subjected to a harsh environment. The cable for the power and intermediate range channels was walked-down in Reference C. The NIS cable is shown on drawing 568436 to be in conduit in those areas outside containment which are subjected to steam post-accident.

Based on the short operating time requirement (less than one minute), and the fact that the cable is in conduit when running through a steam environment, the cable is considered to be operable without environmental qualification testing. The cable is not expected to experience a significant increase in temperature above normal operating conditions during the short period required to generate a reactor trip. This conclusion is further substantiated by the thermal response analysis of radiation monitoring cable in conduit performed in Reference D. This analysis indicated that the mid-plane of the cable jacket for the cable analyzed would experience virtually no increase in temperature in less than one minute when subjected to a reference LOCA profile.

Although the analyzed cable and temperature-pressure profile are different than those considered here, it is apparent from this case that no significant temperature increase is expected for the SONGS-1 condition, in the required operating time. The Reference D analysis is conservative in that the outside surface temperature of the conduit is assumed to be the same as the ambient temperature (as high as 340^{o}F) at that pressure. For the limiting outside containment mainsteam line break at SONGS 1, the pressure profile reaches a maximum of 2 psi and returns to 0 psi in approximately 0.2 seconds post-accident. During the first several minutes of the event, condensation heat transfer will be the dominant heat transfer mechanism. Therefore, the maximum outside surface temperature under these conditions will be the saturation temperature (213^{o}F). A plot of the Reference D LOCA profile, the limiting SONGS-1 profile for area 2.2 and the analyzed cable jacket temperature is attached. This plot shows the minimal effect of the temperature excursion without the above noted conservatism of condensation heat transfer.

The cable heatup rate in the SONGS-1 case will be slower than the Reference D analysis, considering the saturation temperature as the driving force; further substantiating the conclusion that the cable will not experience a significant temperature increase during the required operating time.

In addition, the potential for adverse electrical interactions due to subsequent failure of the NIS components was evaluated in Reference E, and found not to exist. The NIS is not required for long term post-accident monitoring; primary system sampling is used to verify subcriticality. NIS failure will not mislead the operator, since the NIS is not relied upon for any long term post-accident recovery scenario.

R. L. PHELPS

cc: G. Stawniczy
D. F. Pilmer
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E. J. Donovan
W. Flournoy
S. D. Root
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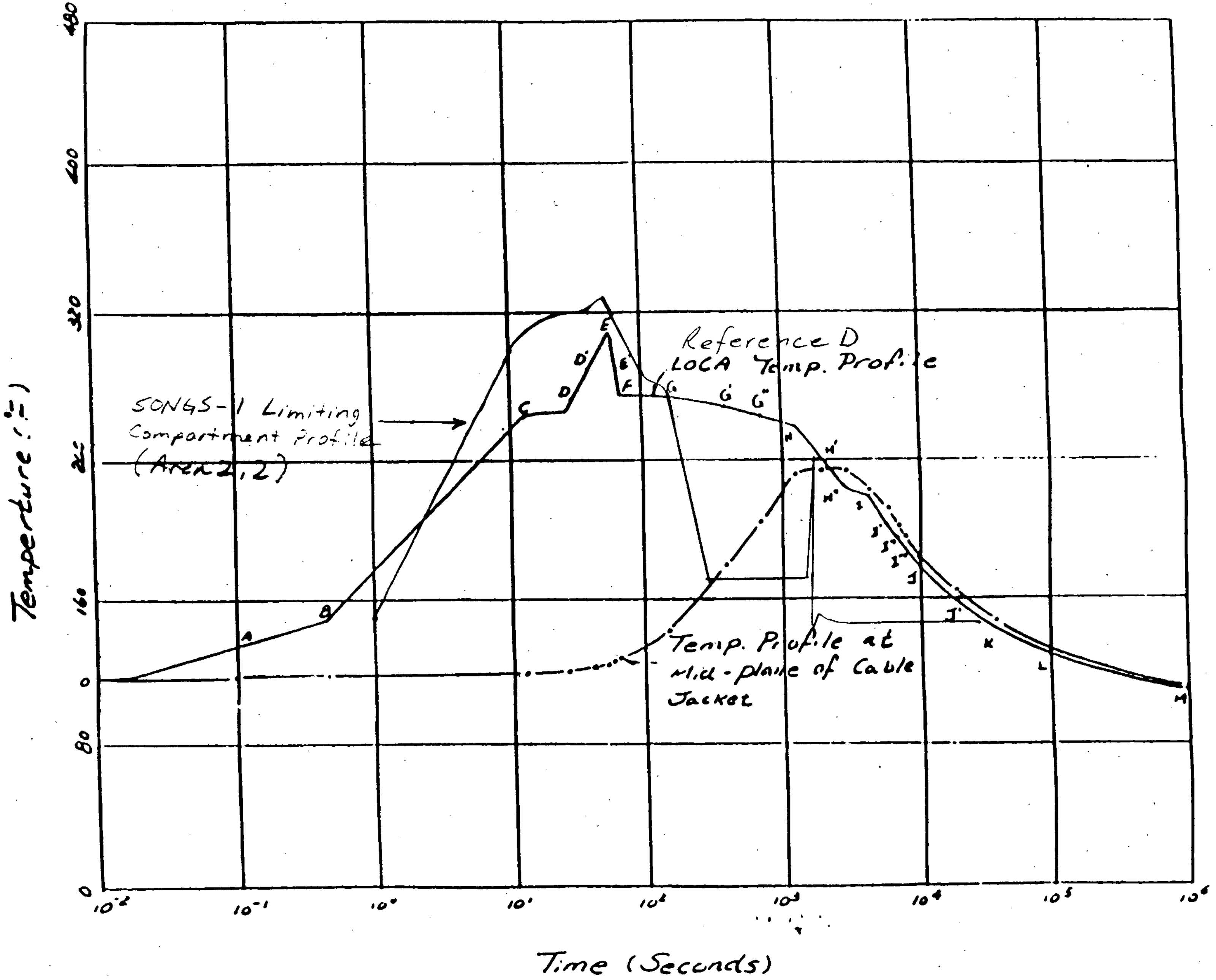

FIGURE 4

Mid-plan Temperature Profile Obtained by Manual Calculations

A. Chung
3/9/91

ATTACHMENT

Memorandum for File

June 28, 1988

CAROL CABLE

SUBJECT Justification for Continued Operation for Carol Cable (ID #1GBS219P2).

PURPOSE The purpose of this memorandum is to document the evaluation which provides the Justification for Continued Operation for Carol Cable located in Area 14 until the refueling outage of 1989.

BACKGROUND During the recent SONGS-1 b(2)/b(1) equipment analysis, EQ cables routed through harsh environments were identified. Walkdowns were then performed to identify all cable jacket markings. From this effort, one of the cables identified was Carol Cable (1GBS219P2) [3]. Cable 1GBS219P2 is routed from the 480 Volt Switchgear Room directly to the Refueling Water Storage Tank Area (Area 14) and powers refueling water pump motor G27S. The motor only operates a total of 1,040 hours in 40 years including the entire 120 days post accident [16, attachment 15] which means that in its qualified life of 40 years, the Carol cable is only energized for a total of 1,040 hours. The 480 Volt Switchgear Room is a mild environment. Area 14 is a harsh environment due to only radiation and relative humidity [13]. During recent walkdowns (PWN 10, item 82), Carol Cable ID number 1GBS219P2 was identified. The cable is described as 3/c, 550kcmil copper conductor, type W, non-shielded, supervutron, 90 ^{o}C from [3]. The insulating material was identified to be Ethylene Propylene Rubber (EPR) [3], an elastomer produced from ethylene and propylene monomers. Their maximum continuous service temperature is around 350 ^{o}F [1,2]. The jacket was identified as Chlorinated Polyethylene (CPE) [3].

DISCUSSION The following considerations as stated in 10CFR50.49, paragraph i, will be analyzed to ensure that the plant can be safely operated pending completion of equipment qualification:

(1) Accomplishing the safety function by some designated alternative if the principal equipment has not been demonstrated to be fully qualified.

The safety function of Carol cable (1GBS219P2) is to supply power to safety related pump G-27S. If G-27S were to fail caused by a failure in Carol cable (1GBS219P2), an alternative would be pump G-27N. G-27N is fully qualified along with its associated cabling.

(2) The validity of partial test data in support of the original qualification.

There is no specific testing done for Carol Cable which uses EPR insulation; however, several other cable manufacturers use Ethylene Propylene Rubber (EPR) insulation and have environmental test reports which qualify their cable for Nuclear Power Plant applications.

Anaconda manufactures a 600 Volt power cable which uses EPR insulating material. This cable had been tested under postulated Design Basis Accident (DBA) and qualified for 385 ^{O}F, 66 psig, 2.0E8 rads (gamma), chemical spray, and 100 percent relative humidity. This cable had been thermally pre-aged for 168 hours @ 150 ^{O}C (302 ^{O}F) [4].

GE cable also uses an Ethylene Propylene Rubber (EPR) insulating material and a Neoprene jacket for their 600 Volt power/control cables. This cable had been tested under postulated Design Basis Accident and qualified for 340 ^{O}F (LOCA maximum), 113 psig (LOCA maximum), 100 percent relative humidity, chemical spray, 2.2E8 rads (gamma), and submergence. This cable had been thermally pre-aged for 130 hours @ 150 ^{O}C (302 ^{O}F) [5].

Okonite manufactures a 600 and 2k Volt power and control cable using an EPR insulating material and Chlorosulfonated Polyethylene (CPSE) jacket. This cable had been tested under postulated Design Basis Accident and qualified for 340 ^{O}F, 114 psig, 100 percent relative humidity, chemical spray and 2.0E8 rads (gamma) and submergence This cable had been thermally pre-aged for 120 hours @ 150 ^{O}C (302 ^{O}F) [6].

The worst DBA environmental parameters which the Refueling Water Storage Tank Area 14 are subjected to are 100 percent relative humidity, 4.0E6 rads (post accident condition) and 104 ^{O}F for 36 minutes and returning to 80 ^{O}F for the remaining 120 days post accident. The normal conditions are 80 ^{O}F, 0 psig, 60 percent relative humidity, and 40 year TID of 1.0E3 rads [13].

From references [4], [5], and [6], an activation energy of 1.22, 1.33, and 1.14 eV respectively were identified for Ethylene Propylene Rubber insulation .

Test data from Okonite Cable (which is the most conservative of the three test reports) with an activation energy of 1.14 eV for Ethylene Propylene Rubber insulation [6] will be used for the following evaluations.

THERMAL AGING AND OPERATING TIME DISCUSSION

A) Normal 40-year Aging

Utilizing the Arrhenius equation defined below, the equivalent life of Ethylene Propylene Rubber insulation tested for 120 hours @150 °C (302 °F) is as follows:

$$t_2 = t_1 \times [\exp(\frac{E_a}{K_b} \times (\frac{1}{T_2} - \frac{1}{T_1}))]$$

where:

exp	=	exponent to base e
E_a/K_b	=	slope of Arrhenius curve = Activation Energy/Boltzman's constant
t_1	=	aging time in hours
t_2	=	equivalent life in hours
T_1	=	aging temperature (degrees K)
T_2	=	normal service temperature (degrees K)

Self heating is a result of resistive losses. The energy dissipated/loss along a cable is dissipated as heat (known as I^2R loss). Cables are designed such that their rated ampacity will result in the conductor reaching the cable/insulation rated temperature (typically 90 °C) at a given ambient temperature.

Thus $\Delta T_{\text{heat rise}} = T_{\text{conductor}} - T_{\text{ambient}}$ is proportional to I^2.

let $\Delta T_1 = T_{\text{conductor}} - T_{\text{ambient}}$

where:

$T_{\text{conductor}}$	=	conductor temperature = 90 °C [15]
T_{ambient}	=	ambient temperature = 30 °C [15]
ΔT	=	actual heat rise, °C
I_1	=	cable ampacity = 210 amps [15]
I	=	maximum rated motor current = 172 amps [16, attachment 5, pg 43]

Then,

$$\frac{T_1}{I_1^2} = \frac{T}{I^2}$$

Therefore, T = actual heat rise = $\frac{I^2}{I_1^2} \times T_1$

Thus the maximum heat rise of Carol cable (1GBS219P2) due to the powering of refueling water pump motor G27S is 60 ^{o}C x $(172amps/210amps)^2$ = 40.25 ^{o}C = 73 ^{o}F.

However, G27S is only run for half an hour every week (1040 hours out of 40 years) [16, attatchment 15]. This means that the cable is de-energized for the remaining 349,360 hours.

The thermal aging qualified life = Pre-aging (normalized to an arbitray number) - Aging due to energization of cable(normalized to an arbitrary number) - Aging when cable is de-energized(normalized to an arbitrary number). For this calculation, 80 ^{o}F will be the arbitrary temperature used.

Using an activation energy of 1.14eV for the Ethylene Propylene Rubber insulation, the EPR insulation pre-aged at 150 ^{o}C (302 ^{o}F) for 120 hours normalized to 80 ^{o}F is as follows:

$$t_2 = 120\text{ hours} \times [\exp(\frac{1.14\text{eV}}{8.61 \times 10^{-5}} \times (\frac{1}{T_2} - \frac{1}{T_1}))]$$

where:

T_1 = (302 ^{o}F + 459.67)/1.8 = 423.15 ^{o}K

T_2 = 80 ^{o}F normalized temperature = 299.82 ^{o}K

t_2 = 5,327 years @ 80 ^{o}F normalized temperature.

349,360 hours de-energized @ 80 ^{o}F ambient normalized to 80 ^{o}F = 40 years.

1,040 hours energized @ 80 ^{o}F ambient + 73 ^{o}F heat rise normalized to 80 ^{o}F = 23 years.

Thus the qualified thermal life = 5,327 years – 40 years – 23 years = 5,264 years.

5,264 years >> 40 years.

Therefore, the EPR insulation material demonstrates thermal aging capability for the entire life of the plant.

Accepted industry practice is that the cable's insulation provides the necessary dielectric barrier between the conductor and the outside environment. The purpose of the jacket is to protect the insulation from damage during cable pulling and initial installation [12]. Therefore, although some of the test cables had a jacket during the testing, it has no impact on the cable qualification at SONGS-1 and does not change the thermal aging test result.

B) Operating Time

The required Design Basis Accident profile for area 14 is conservatively estimated from [13] as follows:

36 minutes @ 104 ^oF(assume 1 hour @ 104 ^oF) + heat rise
120 days - 1 hour @ 80 ^oF(assume 120 days @ 80 ^oF) + heat rise

The tested LOCA profile is estimated from [6] as follows:

2 days @ 300 ^oF
14 days @ 230 ^oF
14 days @ 222 ^oF

Since the first 2 days of the DBA is enveloped by the test profile, the only necessary verification is the remaining 28 days @ 222 ^oF is equivalent to or greater than the remaining 118 days post accident @ 80 ^oF plus heat rise of 73 ^oF = 153 ^oF

$$t_2 = 28 \text{ days } x \ [\exp(\frac{1.14eV}{8.61 \times 10^{-5}} \times (\frac{1}{T_2} - \frac{1}{T_1}))]$$

where:

T_1 = (222 ^oF+459.67)/1.8 = 378.71 ^oK
T_2 = (153 ^oF +459.67)/1.8 = 340.37 ^oK
t_2 = 1,437 days @ 153 ^oF

Since the test enveloped all required condition, the test satisfied the 120 day Post DBA conditions.

Therefore operating time has been satisfied.

RADIATION

The most conservative of the test reports irradiates the EPR insulated cable up to 2.0E8 rads. This is far greater than the required 4.0E6 rads (post accident) + 1.0E3 rads (40 year normal TID). In addition, reference [13] shows an available limit dose for EPR up to 4.0E8 rads.

Therefore EPR is considered qualified for radiation for the life of the plant including 120 days post accident.

RELATIVE HUMIDITY

The Anaconda, GE and Okonite cable which uses EPR insulation all have been tested and qualified for 100 percent relative humidity [4,5,6]. The EPR insulation provides excellent resistance to moisture [9,10].

Therefore, the insulation material of the Carol cable is considered capable of withstanding 100 percent relative humidity.

(3) Limited use of administrative controls over equipment that has not been demonstrated to be fully qualified.

No administrative controls are necessary. The operators will be briefed regarding the qualification status of this equipment and the need to confirm satisfactory operation until it is fully qualified.

(4) Completion of the safety function prior to exposure to the accident environment resulting from a design basis event and ensuring that the subsequent failure of the equipment does not degrade any safety function or mislead the operator.

This cable only supplies power to G-27S and isolation breaker(breaker # 52-1219) will protect other safety-related equipment. This pump is an on/off device whose operation can be independently verified by operators using qualified instruments.

(5) No significant degradation of any safety function or misleading information to the operator as a result of failure of equipment under the accident environment resulting from a design basis event.

This cable only supplies power to G-27S and does not support the operation of any instrumentation and is isolated so no other safety-related equipment will be affected. This pump is an on/off device whose operation can be independently verified by operators using qualified instruments.

CONCLUSION

By the preceeding discussion, the following conclusions are drawn:

1. Alternate equipment and its associated cabling is fully qualified.

2. The cable insulation has suitable material characteristics to withstand and function in the environmental stresses and is considered to be in a justifiable configuration until the refueling outage of 1989.

3. The cable will be replaced in the 1989 refueling outage with fully qualified cable and included in the SONGS-1 EQ program.

W.D. Fargo
Supervising Engineer

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