TEXAS UTILITIES GENERATING COMPANY
SKYWAY TOWER • 400 NORTH OLIVE STREET, L.B. 81 • DALLAS, TEXAS 75201

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August 10, 1984

Director of Nuclear Reactor Regulation
Attention: Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 AND 50-446
ENVIRONMENTAL QUALIFICATION OF
BIW CABLE

REF: B.J. Youngblood letter to M.D. Spence
dated July 19, 1984.

Dear Sir:

The referenced letter request that Texas Utilities address certain concerns that resulted from an NRC inspection of the qualification report of BIW silicone insulated cable. As an alternative to addressing these concerns directly, summaries of two additional qualification reports are attached. These summaries when considered in concert with the original report should make the concerns moot and show that the cable is adequately qualified for use as the Comanche Peak Steam Electric Station.

Respectfully,

J B Marshall for
H.C. Schmidt

DRW/gj
Attachment

Original + 5 copies

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Qualification of Prefabricated 600V Single and Multiconductor BIW Cables with Silicone Rubber Insulation G&H Specification 3232-ES-13D CPSES P.O. CP-0465-4

TESTS PERFORMED

The Franklin Institute Research Laboratories (FIRL) Test Report F-C4497-4 - Qualification Tests of Electric Cables Under Simulated Reactor Containment Service Conditions Including Loss-of-Coolant Accident, date March 1977, documents results of tests made for General Electric Company on GE supplied speciments of Silicone insulated electric cables. GE supplies the silicone rubber insulation materials to BIW for fabrication of cables supplied to CPSES. However, there is no additional information available to verify that the cables tested by FIRL are fabricated similarily to the cables BIW supplied to Comanche Peak.

Included within the FIRL Report is a section from BIW's qualification Report 761039 - Cable Tray Fire Propagation Test With Vertical Tray Flame Test Data. This test specimen, Type No. LSS-1989B, was for cable constructed of:

Conductors	- 2/C #16 AWG 7/0.0192" tinned copper
Insulation	- Flame retardant silicone rubber, 30 mil wall
Binder Type	- Flame retardant
Shield	- Aluminum/Polyester tape with #18 AWG drain wire
Outer Jacket	- Flame retardant silicone rubber, 45 mil wall

Also included in the report was a statement to the effect that the cables for Report F-C4497-4 were furnished to Franklin Institute Research Laboratories by the supplier of the silicone rubber insulation and are similar to those which will be supplied by BIW to CPSES.

These reports were reviewed by G&H and TUGCO and judged acceptable for qualifying prefabricated 600V single and multiconductor cables with silicone rubber insulation to be used to transmit control signals to Class 1E equipment located outside and inside the CPSES containment.

To further substantiate that BIW silicone rubber insulated cables are acceptable for safety related application, reference is now made to other testing, for both inside and outside containment use, that has been performed on sections of BIW silicone rubber insulated cables associated with the qualification testing of Litton electric connectors to connect control and power cables (also obtained under specification ES-13D). Tests were performed by both BIW and by the Veam Division of the Litton System. The following pages provide summaries of these tests.

I. BIW Report #82E080-TU, Rev. 1 - <u>In-Containment Prefabricated Cables Assemblies</u>

A. INTRODUCTION

Two (2) assemblies consisting of 3 conductor #16 AWG cable, BIW Part No. 14329-B003 in 15'7" of American BOA 3/4" flexible conduit, with a Litton CIR-00-PV-20-33P plug on each end were connected to mating Litton CIR-06-PV-20-33S receptacles mounted in the wall of the autoclave. (At CPSES all silicone rubber cables are installed in conduit.) The cable has silicone rubber insulation, aluminum-polyester tape shield with drain wire and silicone rubber outer jacket. The silicone rubber insulation and jacket have glass braid covering. This assembly was subjected to the LOCA cycle defined in the table below.

TABLE 1 - TEST CYCLE

TIME	TEMPERATURE (^{o}F)	PRESSURE (psig)
0-10 seconds	Room Temp - 370	0-155
10 seconds - 4 minutes	370	155
4 minutes - 10 minutes	350	120
10 minutes - 3 hours	300	55
3 hours - 5 hours	300 - 140	55-0
5 hours - 5 hours 10 seconds	140 - 370	0-155
5 hours 10 seconds - 5 hours 4 minutes	370	155
5 hours 4 minutes - 5 hours 10 minutes	350	120
5 hours 10 minutes - 24 hours	300	55
************************************		
24 hours - 30 days	300	55
30 days - 30 days 4 hours	300 - 100	55-0

The samples tested were aged 750 hours at 160°C followed by 50 megarads gamma radiation (Cobalt 60). Aging and irradiation were performed prior to the LOCA cycle. The thermal aging was performed in circulating air ovens and is equivalent to 40 years at 90°F.

A comparison of these conditions and Specification 2323-ES-13D, Paragraph 3.4.3 environmental conditions is given in Figure I.

B. PROCEDURE

The sample of 15'7" with connector couplings at each end was placed in an autoclave chamber with the Litton CIR connectors mounted into a stainless steel flange. An additional length of cable outside the autoclave chamber was fastened to the Litton CIR connectors for purposes of test measurements. The sample was exposed to the LOCA cycle as described in Table 1.

STEP 1: After 24 hours the samples were removed and subjected to a post-LOCA test consisting of (1) bend around a 50X mandrel after which a 750 VAC potential was applied to each conductor for 5 minutes.

STEP 2: Remaining 29 days of cycle.

FIGURE I

ANALYTICAL COMPARISON OF

SPECIFICATION 2323-ES-13D AND SECTION A LOCA ENVIRONMENTAL CYCLES

Using the Arrhenius technique, analysis may be used for a comparison of the Specification 2323-ES-13D LOCA with the profile of Section A. Referring to Figure VIIIC for a similar (not identical) General Electric silicone rubber compound, it is seen that for every 8.5oC (15.3oF) change in temperature the aging time is either halved or doubled (Line A). Mathematically this can be expressed as follows:

$$T_1 = \frac{T_2}{2^{\left(\frac{t_1 - t_2}{15.3}\right)}}$$

Where: T_1 = time at temperature t_1
T_2 = time at temperature t_2
T1 and t_2 are in ^{o}F

For convenience the elapsed times at each temperature may be related to an equivalent exposure at 150^{o}F (the long term temperature in Specification 2323-ES-13D, Paragraph 3.4.3 using the above equation).

Example: Calculation for 30 minutes (0.5 hr.) at 280^{o}F

$$T1 = \frac{0.5}{2^{\left(\frac{150-280}{15.3}\right)}} = \frac{0.5}{2^{(-3.497)}} = \frac{0.5}{.00277} = 180.5 \text{ hrs.}$$

Specification 2323-ES-13D Profile (Section 3.4.3)

0.5 hr at 280^{o}F	is equivalent to	180.5	hr	at	150^{o}F
9.5 hr at 240^{o}F	" " "	558.8	"	"	150^{o}F
86 hr at 200^{o}F	" " "	826.9	"	"	150^{o}F
8664 hr at 150^{o}F	" " "	8664.0	"	"	150^{o}F
	Total is equivalent to	10230.2	hr	at	150^{o}F

Qualification of Prefabricated 600V Single and Multiconductor
BIW Cables with Silicone Rubber Insulation
G&H Specification 3232-ES-13D
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Binder Type	- Flame retardant
Shield	- Aluminum/Polyester tape with #18 AWG drain wire
Outer Jacket	- Flame retardant silicone rubber, 45 mil wall

Also included in the report was a statement to the effect that the cables for Report F-C4497-4 were furnished to Franklin Institute Research Laboratories by the supplier of the silicone rubber insulation and are similar to those which will be supplied by BIW to CPSES.

Section A Profile*

.0638 hr. (3.83 min)	at 370°F	is equivalent to	1360.3	hr. at 150°F
0.1 hr. (6 min)	at 350°F	" " "	862.1	" " 150°F
2.83 hr.	at 300°F	" " "	2526.8	" " 150°F
.0638 hr. (3.83 min)	at 370°F	" " "	1360.3	" " 150°F
0.1 hr. (6 min)	at 350°F	" " "	862.1	" " 150°F
18.83 hr.	at 300°F	" " "	16182.5	" " 150°F
		Total is equivalent to	23784.1	hr. at 150°F(1)

696.0 hr. (29.days) at 300°F is equivalent to 621428.6 hr. at 150°F(2)

Total for 30 days is equivalent to 645212.7 hr. at 150°F

*10 second heat-up times and 2 hour cooldown times are omitted from this comparison and consequently provide additional margin.

(1) The assemblies passed the post-LOCA test after a equivalency of 23,784.1 hours at 150°F, exceeding the Specification 2323-ES-13D profile equivalency of 10,320.2 hours at 150 F by a margin of over 100%. The higher pressures in the Section A profile compared with the Specification 2323-ES-13D requirements provide additional margin.

(2) The equivalency of 621,428.6 hours at 150°F after the post-LOCA test provides additional margin.

Except during those intervals when insulation resistance was being measured, the samples were energized at 600 volts RMS conductor to conductor with a current of 1 amphere flowing through each. The samples were sprayed with a chemical solution consisting of 6,200 PPM Boron mixed with 50 PPM Hydrazine. This solution was recirculated for the duration of the test with its pH being maintained between 8.6 and 10 by the addition of trisodium phosphate. The spray rate was 0.15 (gal/min)/ft^2.

C. MEASUREMENTS

The insulation resistance was measured using a General Radio Model 1862C Megohmeter at a potential of 500 VDC.

POST LOCA TEST

Upon their removal from the autoclave, each sample was subjected to a post-LOCA test consisting of the following:

1. 1 bend around a 50X material.

2. 750 VAC conductor to conductor and drain wire for 5 minutes.

Results as follows:

SAMPLE #1

Conductor A (Black) - Pass
Conductor B (White) - Pass
Conductor C (Red) - Pass

SAMPLE #2

Conductor A (Black) - Pass
Conductor B (White) - Pass
conductor C (Red) - Pass

TEST RESULTS

Sample #1 and #2 held 600 volts RMS conductor to conductor with a current of 1 ampere flowing through each conductor throughout the 30 day test cycle. Pass-fail criteria are based on the ability to function electrically by holding rated voltage and carrying rated current throughout the LOCA environmental cycle in accordance with IEEE 383-1974, Section 2.4.3.2. The assemblies passed this requirement.

II. Qualification Test of Electric Connectors Under A Simulated LOCA/DBE By Sequential Exposure to Environments of Thermal Aging, Background Radiation, Containments Pressurization, Vibration, Radiation (Accident Level), Steam and Chemical-Spray - Performed for Litton Precision Products by Component Testing Division of Isomedix, Inc., dated November 1978

Description - Test Sample #BC1/BC2

The sample connector set was assembled by Boston Insulation Wire and Cable Co. utilizing silicone rubber jacketed single conductor of their own manufacturer.

Cable: BIW Type LSS 2182A - Similar to the type LSS-1989B for which cable tray fire propagation and vertical tray test were performed and documented in BIW report 761039.

SECTION 3. TEST PROCEDURES

3.1 Purpose

The purpose of the program is to provide qualification tests on electrical connectors in accordance with the suggestions contained in IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations", IEEE 383-1974, "IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations", and IEEE 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations".

SECTION 4. CONNECTOR PREPARATION AND ELECTRICAL TESTING

4.1 Connector and Cable Mounting

The connector and associated cable were coiled, suspended and secured inside the pressure vessel. Wire was used to support and secure the sample in place.

The ends of the cable were brought through the vessel hed penetrations and connected to the energizing lead wires. The terminating stainless steel tubing (housing the cable) was secured to the vessel by standard tube fittings.

4.2 Electrical Energizing and Interconnections

The cable ends were secured to terminal blocks mounted on the vessel head. Lead wires were used to connect the energizing switch box with the samples' cable. The switch box consisted of two knife switches arranged so that the four conductors of the cable and connector could be monitored, removed from the circuit if failure occurred, or isolated during measurements of insulation resistance.

During the LOCA simulation the four conductors were energized at 600 Vac and 20 amperes.

4.3 Measurements of Insulation Resistance (IR)

IR measurements were made periodically during the test program as a means of monitoring the relative performance of the test sample.

Specifically, IR measurements were made at the following times during the program.

1. Upon receipt at Isomedix.
2. At the middle and end of Phase I - Thermal Aging.
3. At the end of Phase II - Radiation Aging.
4. At the end of Phase III - Containment Pressurization.
5. Upon reciept at Isomedix after Phase IV - Vibration

Endurance/Seismic Simulation.

6. At the end of Phase V - Accident Radiation.
7. At each dwell during the high temperature phases of the steam/chemical-spray exposure period.
8. Once each day during the four-day dwell.
9. Twice weekly during the balance of the 30-day steam/chemical-spray exposure period.
10. At the conclusion of the LOCA exposure cycle.

The measurements were made after application of 500 Vdc for one minute, by reading between the conductor and ground.

During the LOCA simulation, when IR measurements were taken, prior to actually making the measurments, the current and voltage potential load were removed from the conductors. At the conclusion of the IR measurements, the conductors were put back into the circuit.

4.4 High Voltage Withstand Tests (HI-POT)

At the conclusion of the exposure period, the sample was removed from the vessel, the cable straightened and wound into a coil 40 times its diameter. The sample was submersed in water and each conductor, in turn, was subjected to a potential relative to that conductor and the other conductors connected to ground. The potential applied was 2200 volts ac (twice the rated voltage plus 1000).

SECTION 5. ACTUAL TEST CONDITIONS

5.1 Phase I - Thermal Aging

The sample was thermally aged at 160°C for a period of 15 days simulating an ambient temperature of 140°F over the 40 year design life. A forced air circulating oven as used to age the sample. The heater controls on the oven were adjusted to automatically maintain the temperature at 160°C.

The measurements of insulation resistance were made at the middle and end of the thermal exposure at room ambient conditions.

5.2 Phase II - Background Radiation Aging

For radiation aging, the mated pair, with its associated lead wire, was placed in a radiation facility and subjected to a Cobalt-60 source of gamma radiation at an exposure rate of 0.58 megarads per hour. The sample was removed after it had recieved an accumulated dose of 70 megarads.

At the conclusion of this phase, insulation resistance measurements were made at room ambient conditions.

5.3 Phase III - Containment Pressurization

The mated pair connector was placed in a pressure vessel and the vessel sealed. Air was admitted to the vessel to raise the pressure inside the vessel to 65 psig. This pressure was maintained for five minutes before being reduced to atmospheric pressure.

The pressure inside the vessel was raised and lowered in this manner for a total of 15 cycles. At the end of the 15th cycle, the mated pair was removed from the vessel and insulation resistance measurements were taken.

5.4 Phase IV - Vibration Endurance/Sesimic Simulation (Applicable to Connector only).

5.5 Phase V - Accident Radiation

The mated pair connector, with its lead wire, was placed in a radiation facility and subjected to a Cobalt-60 source of gamma radiation at an exposure rate of approximately 0.3 megarads per hour. The sample was removed from the radiation facility after it had received an accumulated dose of 40 megarads.

Insulation resistance measurements were made on the connector at room ambient conditions.

5.6 Phase VI - Loss-of-Coolant Accident (LOCA) Simulation

The sample connector was placed in a vertical pressure vessel for exposure to steam and chemical-spray. The lead wires of the connector were electrically energized at 600 volts ac and 20 amperes prior to the start of the exposure.

To initiate the exposure, steam was rapidly admitted into the vessel, raising the temperature and pressure to 340°F/105 psig. These conditions were maintained for one hour before being reduced to 135°F at 0 psig over a one hour period. This temperature and pressure (135°F/0 psig) were maintained for a one hour period.

For the initiation of the second transient, steam was rapidly admitted into the chamber raising the temperature and pressure to 340°F/105 psig. The temperature and pressure were held at this point for a period of three hours. At that time, the conditions were reduced to 320°F at 75 psig and maintained for three hours. After this time period, the temperature and pressure were reduced to 300°F/55 psig and maintained for four hours.

At this time, the temperature and pressure were reduced to 250°F/15 psig and held at this point for the remainder of four days. After the four-day period, the temperature and pressure were reduced to 200°F at 0 psig and held for the remainder of the 30-day exposure.

Approximately 50 seconds after initiating the steam exposure, a chemical solution consisting of 3000 ppm boron as boric acid in solution with 0.064 molar sodium thiosulfate buffered with sodium hydroxide to a pH of 10 at room temperature was continuously sprayed into the vessel at a rate of 2 gpm. The chemical-spray solution pH was maintained between 9.5 and 10.5 throughout the simulation period. The spray remained on throughout the entire LOCA exposure.

At the total test time of 30 days, the entire system was shutdown and the connector removed from the vessel.

5.7 Post-LOCA Tests

At the conclusion of the simulated LOCA event, insulation resistance measurements were made. Then the sample's lead wires were straightened and recoiled into a coil of 40 times the cable diameter. While so wound, the connector and cable were submersed in water and subjected to a high voltage withstand test at 2200 volts a.c. for a period of five minutes.

SECTION 6. TEST RESULTS AND DATA

6.1 Insulation Resistance Measurements

Measurements of IR were made at the times previously mentioned in Section 3, and the results were all acceptable.

6.2 High Voltage Withstand Test (HI-POT)

Table 4 represents the results of the HI-POT test performed at the conclusion of the test program.

TABLE 4

RESULTS OF HIGH VOLTAGE WITHSTAND TEST
PERFORMED AT CONCLUSION OF 30-DAY LOCA SIMULATION

CONNECTION (conductor)	TIME VOLTAGE HELD (Minutes)	APPLIED AC VOLTAGE (Volts)	LEAKAGE CURRENT (MA)* IN WATER
A	5	2200	<1
B	5	2200	<1
C	5	2200	<1
D	5	2200	<1

* No meter movement observed.

SECTION 7. CONCLUSION

Connector sample BC1/BC2 successfully completed the 30-day LOCA simulation after exposure to a total accumulated dose of 110 megarads of Cobalt-60 gamma radiation, 15 days thermal aging at 160°C, 15 cycles of pressurization at a maximum of 65 psig pressure, and vibration endurance/seismic simulation. Also, the sample held the post-exposure high voltage withstand potential of 2200 volts ac for five minutes.

SUMMARY:

The three test reports discussed above and the type tests associated with these reports properly demonstrate the qualification of BIW silicone rubber insulted cables at CPSES. Any concerns or questions that might arise from examining only one report are satisfied by considering all three reports together.