S-33
50-348/364-CIVP
2/19/92

Staff Exh. 33

QUALIFICATION TESTING OF RAYCHEM ENVIRONMENTAL SEALS FOR ALABAMA POWER COMPANY JOSEPH M. FARLEY NUCLEAR PLANT

Docket No. SD 348/324-Civ P Official Exh. No. 33

In the matter of Alabama Power Company

MARKED V IDENTIFIED 12:18 p.m. 2/11/92

ADMITTED RECEIVED 12:23 p.m. 2/19/92

WITHDRAWN REJECTED

RECALLED

CONTINUED DATE 2/19/92

Other Witness

Reporter L Estes

Qualification Testing of
Raychem Environmental Seals for
Alabama Power Company
Joseph M. Farley Nuclear Plant

I. INTRODUCTION

When NAMCO CONTROLS environmentally qualified their model EA 180 series limit switches, the interior of the switch was sealed against the test environment by using rigid conduit to bring the conductors outside the test chamber. As a result, when the switch is installed in a safety-related system in a harsh environment, means must be provided to seal the switch internals from that environment, and at the same time provide electrical connections to the switch.

As a result of NRC's I & E Bulletin 79-01A, Alabama Power Company committed to replace all Class 1E limit switches in Unit 1 containment during the first refueling outage. Since time was limited, it was decided to develop a switch seal with materials that had already been environmentally qualified. The Raychem heat shrink cable breakout boot was selected as a seal method, and working with Raychem, a kit (1) consisting of fully qualified material was developed and installed on all Class 1E limit switches in the containment, and subsequently in the main steam room.

Subsequently, Raychem performed some developmental tests on a seal configuration similar (but not identical) to the Farley configuration. As a result of the tests, a failure mode was established which might apply to the Farley installation.

The failure mode identified by Raychem occured when the seal was at elevated temperature and pressure. Because of the elevated temperature (in excess of 300°F) the heat-shrink material undergoes a phase change wherein the mechanical strength is reduced. In addition the adhesive becomes fluid and starts to flow. As a result, the unrestrained conductors of the Raychem test specimen were forced through the breakout due to the pressure. In some cases, the breakout legs were inverted. Also, the seal boundry was breached due to overstressing the breakout material.

After being informed of the matter, Alabama Power Company requested that tests be performed to establish the adequacy of the Farley configuration (2).

II. TEST PHILOSOPHY

The Raychem breakout material has been environmentally qualified (3), including accelerated aging to the equivalent of 40 years, irradiated, and LOCA tested. However, the configuration was associated with a cable. The Farley approach was to use the breakout at the end of a pipe nipple which was attached to the switch. The conductors were

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then brought through the breakout legs.

Since the breakout had been qualified previously, the Farley configuration needed only to be tested for pressure and temperature with time dependent variations approximating the postulated Farley LOCA profile(4).

III. TEST APPARATUS

The test apparatus consisted of a test specimen fabricated in accordance with instructions issued for construction (2), and consisted of a 1 inch pipe nipple (which in the plant is attached to the limit switch), the Raychem breakout kit, two compression fittings, a 1¼ inch pipe coupling, and a short length of flex conduit.

The test specimen was installed in the test chamber, shown in figures 1 and 2. The chamber was pressurized with air through a supply header shown in figure 3, in which the pressure could be regulated using a Hammel pressure regulator.

The chamber was heated with heaters of a type normally used for post weld heat treatment (stress relief) in Weldaments. The temperature of the test chamber was controlled with a Honeywell Temperature controller/recorder with heater power supplies shown in figure 4.

The air supply-leak detection piping was fabricated according to the arrangement shown in figure 5.

Because of the thermal inertia of the test chamber, the rapid temperature rise required by the test profile could not be achieved. It was decided to modify the test chamber to permit its heating prior to inserting the test specimen. A hole was cut in the top flange, and a specimen mounting plate was fabricated. The mounting plate was held in position on the flange with four bolts. A cover plate was installed while the chamber was brought to temperature. In addition, a thermowell was added to more accurately determine the internal temperature of the chamber. The arrangement is shown in figure 6.

IV. TEST PROCEDURE

The test was conducted as described in the attached test procedure(5). As discussed in section III, the temperature of the test chamber could not be brought to the required temperature rapidly. As a result, the test specimen was exposed to elevated temperatures for as long as 45 minutes prior to the application of air pressure. Figure 6 shows a test specimen prior to heat up and testing.

A change was made to the test chamber which permitted its being brought to temperature prior to inserting the test specimen and applying pressure, more closely simulating the required temperature-pressure profile.

V. TEST RESULTS

Two test specimens, assembled as installed in the plant, failed the test. The first specimen, which was tested prior to the chamber modification, failed two minutes after pressure was applied. In this instance, the specimen (shown in Figure 7) was subjected to temperatures above 200°F for 30 minutes prior to reaching the required peak temperature and application of pressure. During this period the heat-shrink material was softened, permitting a blow-through in the center of the breakout 2 minutes after pressure was applied. Figure 8 shows this specimen after it was removed from the chamber, and Figure 9 shows how the specimen failed.

A second specimen was prepared and this time the chamber was heated with just an insulation blanket covering the top. When the interior of the chamber reached the required temperature, the top flange, together with the specimen was installed. This time, the breakout failed after 5 minutes into the test in much the same way as the first one failed. In this case, it merely took longer for the breakout to become heated enough for failure to occur.

After modifying the test chamber as described in section III, a third specimen was prepared. After bringing the chamber to temperature, the specimen was quickly installed and the chamber pressurized. The seal failed after 17 minutes into the test.

It was then apparent the breakout material was being overstressed in its weakened (heated) condition, and there was no physical support for it at the end of the nipple. It was then decided to fabricate a fourth specimen the same as before, except that in this case, the Crouse-Hinds potting product CHICO "A" was poured into the nipple after the breakout and keeper sleeve were shrunk on.

After the CHICO "A" had cured, the specimen was placed into the modified test chamber which had been pre-heated, and pressure applied. The seal held, and the prescribed temperature/pressure profiles were followed for the next twenty four hours. This configuration successfully passed the test.

VI. CONCLUSIONS

The failure of the first two test specimens indicate that the limit switch seals as they are presently installed in units 1 and 2 will require additional work. The simplest "fix" requires that the cover plate of the limit switch be removed, and liquid CHICO "A" injected with a syringe into the nipple attached to the switch. After the CHICO "A" has cured, the switch cover plate is replaced.

CHICO "A" is not the only material that may be used, however, qualification documentation is available and CHICO "A" is stocked in the FNP warehouse.

VII RECOMMENDATIONS

Although the CHICO "A" fix is the most expediant, there are some disadvantages that must be considered. First, once the conductors are sealed in the CHICO "A" they cannot be removed. If switch gaskets and seals are being replaced, and a conductor becomes damaged, all conductors must be replaced. Second, in some cases, the switch may be in a position such that the CHICO cannot be injected. In such a case, the switch must be unmounted, positioned such that the nipple points downward, and then injected with CHICO "A".

It may be desirable to utilize pressure tight flex-pipe to connect the switch and the pressure boundry at a remote, more accessible location.

Pressure tight couplings may provide for greater ease in switch replacement or maintenance.

It is recommended that for the present, the CHICO "A" fix be used until the switches reach the end of their qualified life when gaskets and seals must be replaced. At that time consideration may be given to alternative sealing methods, if available.

Submitted:

G. M. Langford 12/30/81

G. M. Langford
Engineering Specialist

Approved:

Jesse E. Love 12/30/81

J. E. Love
Engineering Supervisor

References

(1) Raychem part 502A823-52/144 WCSF Cable Breakout with Keeper sleeve (Raychem Kit #NCBK-04-04)

(2) Drawing A-177541 shts. 23K, Rev. 0; 23L, Rev. 0, and 23P, Rev. 0

(3) Raychem Energy Division Report EDR 5033 dated April, 1981 (Wyle Report No. 58442-2)

(4) FNP FSAR Figures 6.2-4 and 6.2-6

(5) Bechtel letter AP-6559, File E-91 dated November 24, 1981 to O. T Kingsley

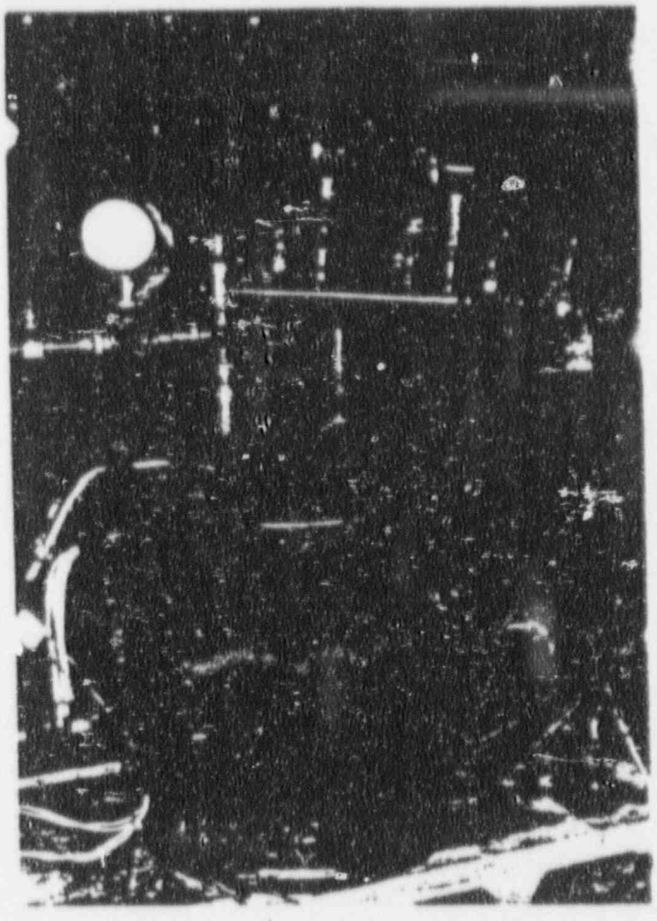
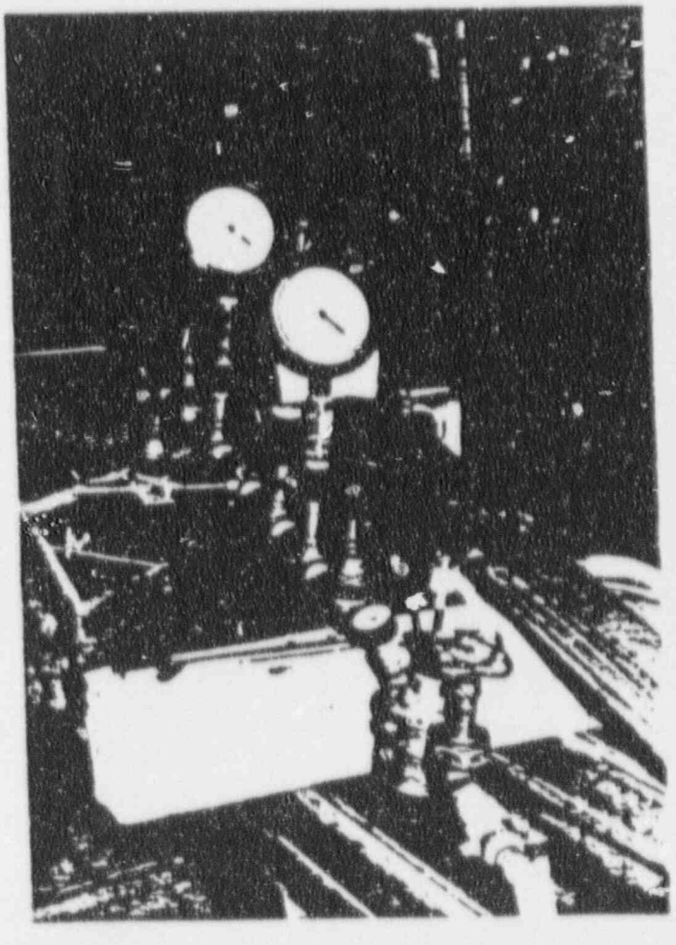


Figure 2. Test chamber showing heaters and instrumentation

Figure 3. Air supply header and gages



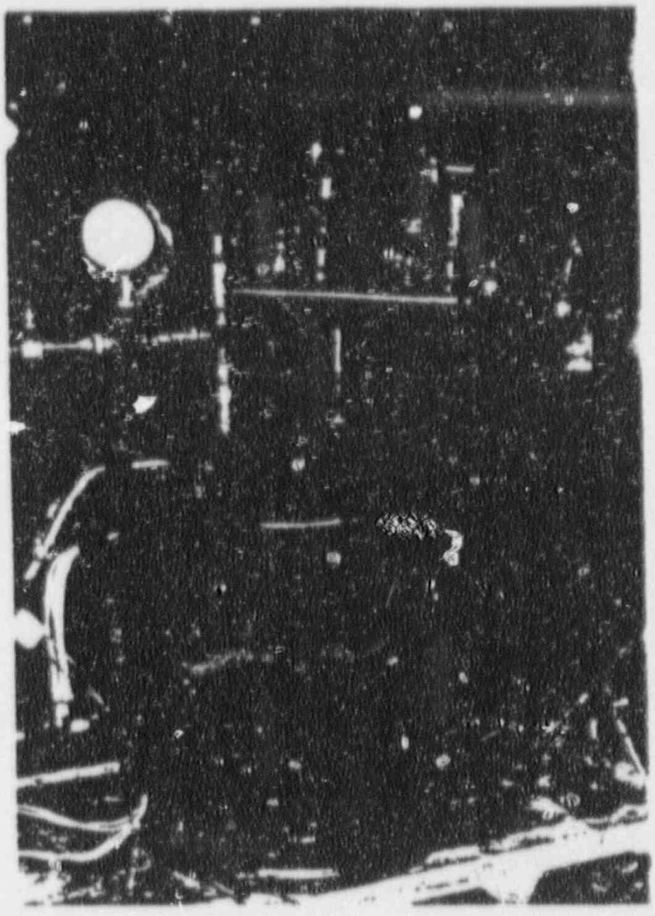
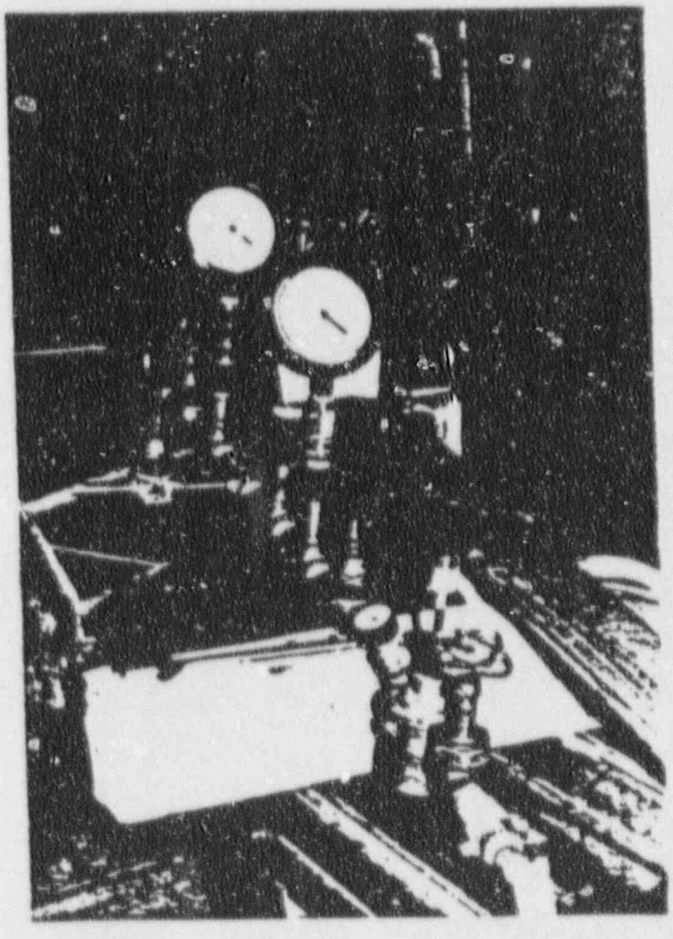


Figure 2. Test chamber showing heaters and instrumentation

Figure 3. Air supply header and gages



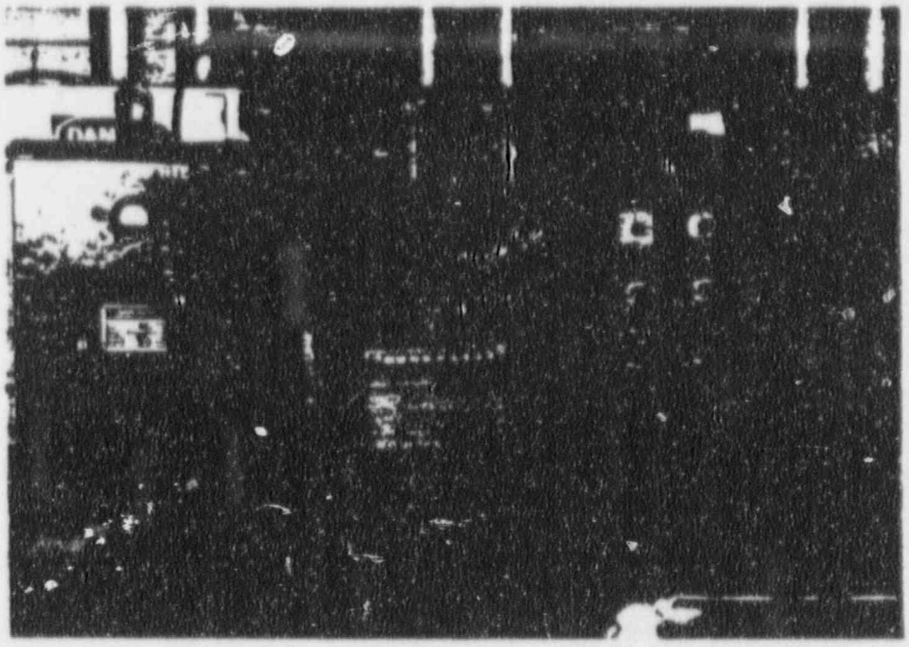


Figure 4. Heater rectifier, temperature recorder and heater controller

CALCULATION SHEET

CALC. NO. _____ REV. NO. _____

ORIGINATOR G. M. LANGFORD DATE _____ CHECKED _____ DATE _____

PROJECT FARLEY NUCLEAR PLANT JOB NO. 7597-03/20

SUBJECT LIMIT SWITCH SEAL TEST SHEET NO 10

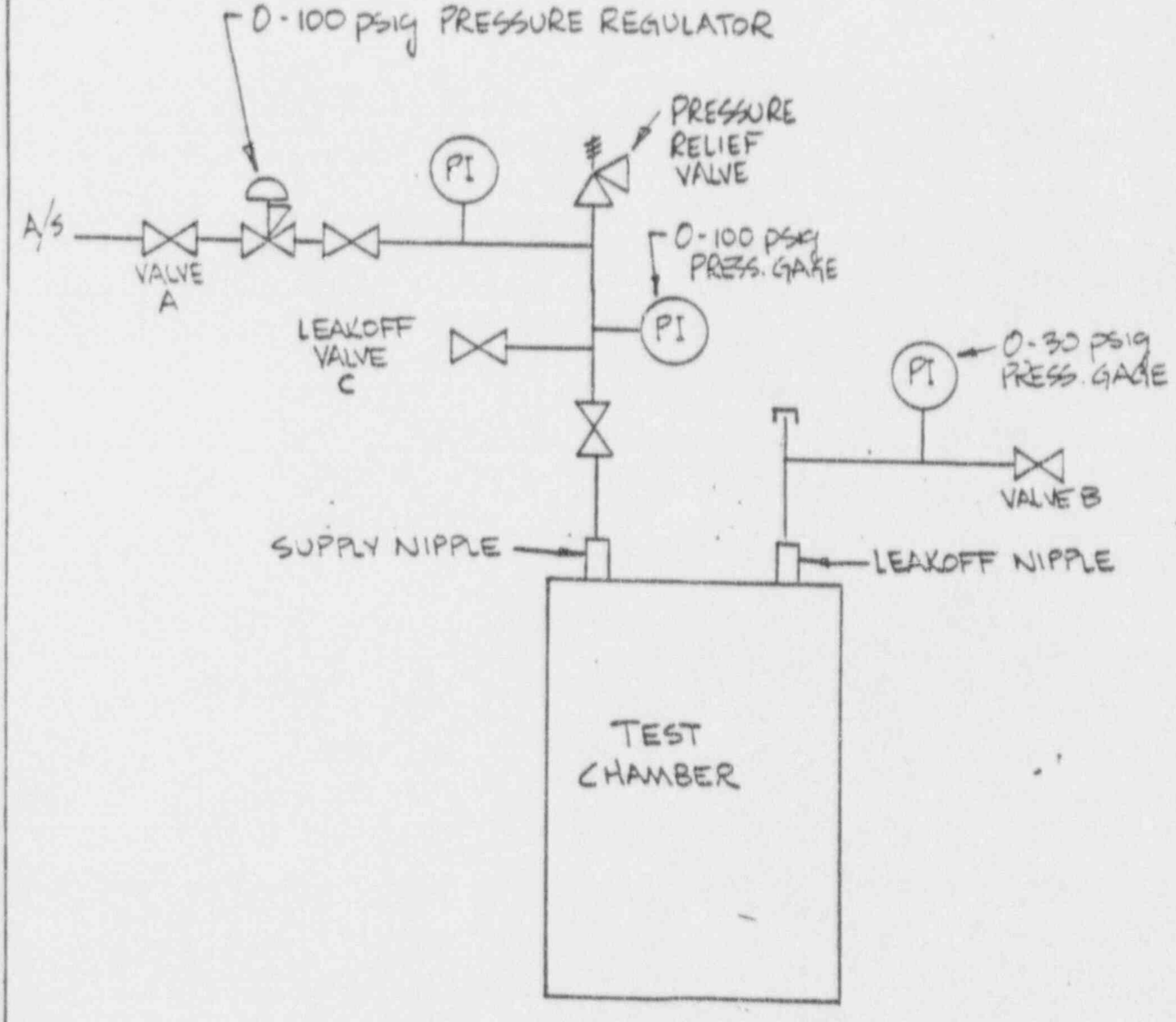


figure 5

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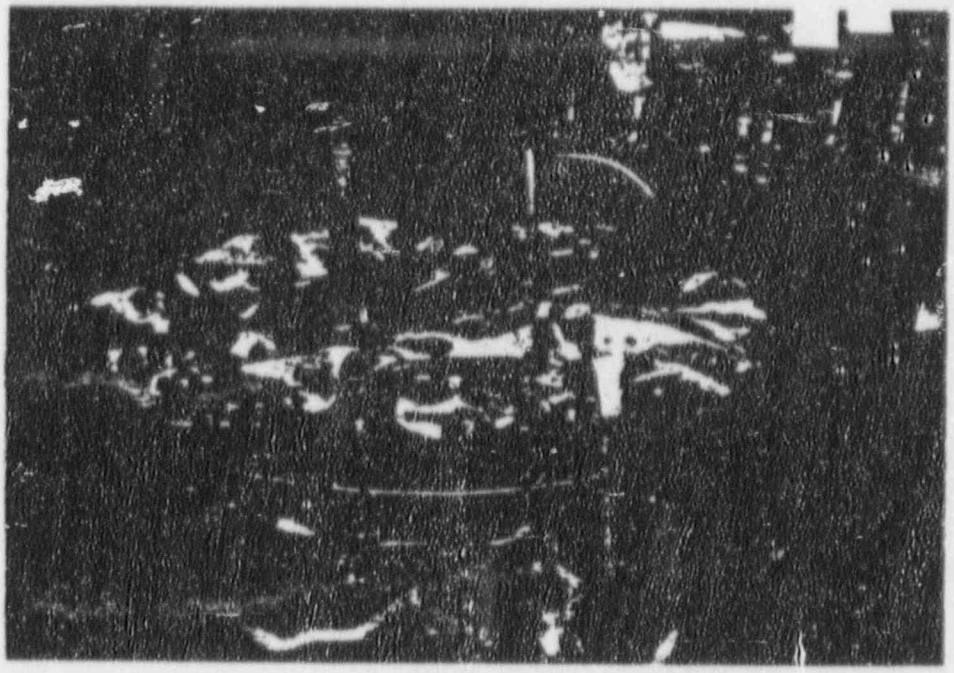

Figure 6. Top of test chamber after modifications

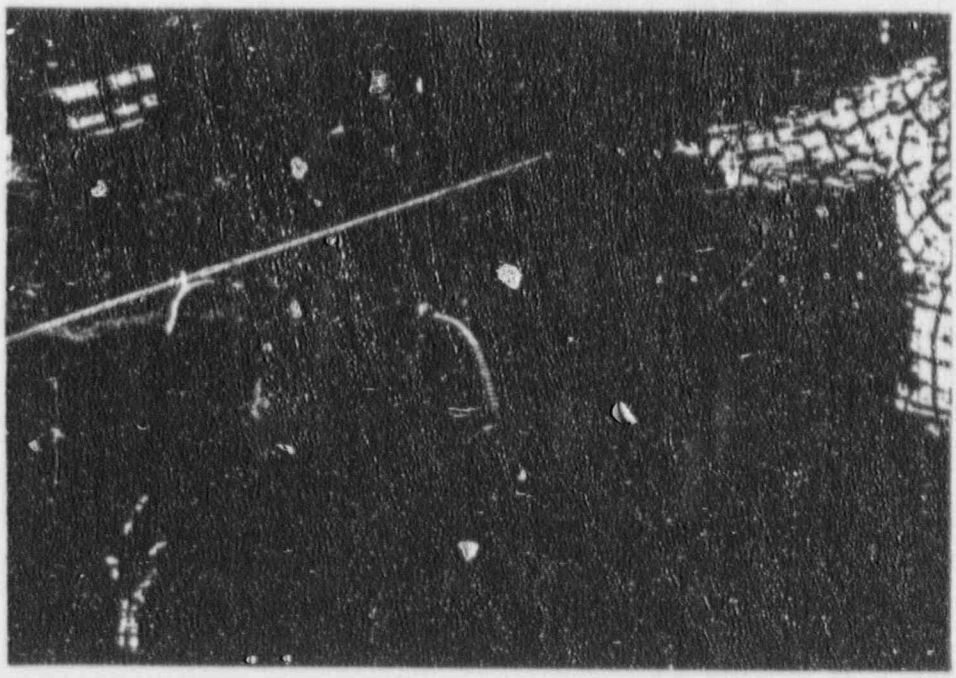

Figure 7. Top of test chamber showing method of installing test specimen

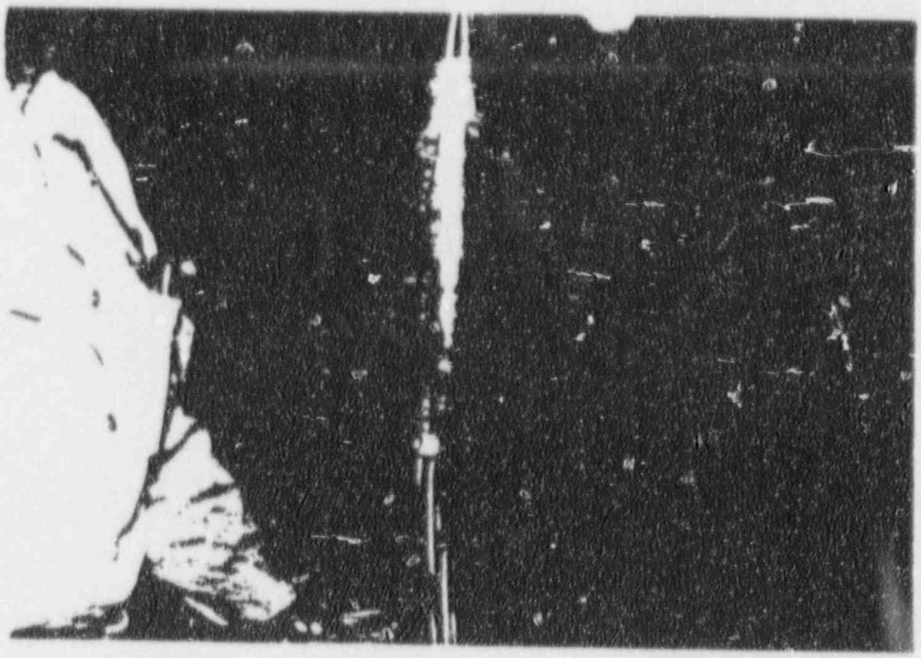

Figure 8. Failed test specimen after removal from chamber

Figure 9. Breakout boot showing hole in center where failure occured

Appendix A

Test Procedure

Limit Switch Cable Encrance Seal Test

BECHTEL EASTERN POWER COMPANY

JOB NO. 7597 -03	ACCESSION NO.
UNIT 1	U- 400947

TITLE: LIMIT SWITCH CABLE ENTRANCE SEAL TEST AND APPENDIX B APCO QC TEST LOG

JOB: JOSEPH M. FARLEY NUCLEAR PLANT
ALABAMA POWER CO.

Supplier:	
CROUSE HINDS COMPANY (010079)	P.O. APCO Req. APCO PCN No. (If Applic.) ES-87-890

SUPPLIER DOCUMENT REVIEW STATUS

STATUS NO.

1. ☐ REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
2. ☐ REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.
3. ☐ WORK MAY PROCEED.
7. ☐ VOID OR SUPERSEDED.
8. ☒ REVIEW NOT REQUIRED. WORK MAY PROCEED.

Permission to proceed does not constitut[e] acceptance or approval of design details, calculation[s] analyses, test methods or materials developed or [to be performed] by the supplier and does not relieve supplier [of] full com-pliance with contractual obligations.

BY Robert O'Neal DATE 9/21/87

A Unit of Bechtel Power Corporation REPC-13898-V Rev. 9/87

FOR INFORMATION ONLY

RECORD COPY

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7597-03-E91-22-1

3/13/82

J. M. Farley Nuclear Plant
Units 1 and 2

Limit Switch Cable Entrance Seal Test

I. Purpose

The purpose of this test is to demonstrate the capability of the Raychem Breakout Seal Assembly, when installed in accordance with Reference 1, to withstand simulated DBA pressure and temperature without loss of function or breach of pressure boundry. In addition, the adequacy of the conductor seal method, as specified in Reference 2, to prevent migration through conductor interstices will also be demonstrated.

II. Background

Informal tests conducted by Raychem on a similar (but not identical) configuration of the seal suggests a possible failure mode due to prolonged elevated temperature with the subsequent application of pressure. Although the Raychem breakout is fully environmentally qualified, the configuration employed by FNP is somewhat different than the qualification configuration. This test will demonstrate the adequacy of the FNP configuration.

III. Test Requirements

1.0 Test Specimen

1.1 1" pipe nipple (4" long)

1.2 Raychem CB4-2/502A823-52/144 WCSF Cable Breakout with keeper sleeve (Raychem Kit #NCBK-04-04)

1.3 1½" Pipe coupling

1.4 Greenfield compression fitting (or equivalent)

1.5 Greenfield 1" flex conduit (approx. 8" long)

1.6 T & B insulated ring tongue lugs (#12 AWG)

1.7 4 - 1/C #12 Cable (Cable Code JC-2)

1.8 Raychem WCSF Heat Shrink sleeving for #12 AWG

2.0 Test Equipment

2.1 Test Container used for test per 2BE-1049-3 or equivalent (See Fig. 1)

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RECORD COPY

FOR INFORMATION ONLY

7597-03-E91-22-1

BECHTEL EASTERN POWER COMPANY

JOB NO. 7597-20	ACCESSION NO.
UNIT 2	U- 406400

TITLE:
LIMIT SWITCH CABLE ENTRANCE SEAL TEST AND APPENDIX B- APCO QC TEST LOG

JOB: JOSEPH M. FARLEY NUCLEAR PLANT
ALABAMA POWER CO.

Supplier:	
CROUSE-HINDS COMPANY (010079)	P.O. APCO Req. APCO PCN No (If Applic.) ES-87-690

SUPPLIER DOCUMENT REVIEW STATUS

STATUS NO.

1. ☐ REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
2. ☐ REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.
3. ☐ WORK MAY PROCEED.
7. ☐ VOID OR SUPERSEDED.
8. ☒ REVIEW NOT REQUIRED. WORK MAY PROCEED.

Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve supplier from full compliance with contractual obligations.

BY Robert O Smith DATE 9/21/87

A Unit of Bechtel Power Corporation

BEPC-13899-V Rev. 8/87

FOR INFORMATION ONLY

005548

7597-20-E91-13-1

J. M. Farley Nuclear Plant
Units 1 and 2

Limit Switch Cable Entrance Seal Test

I. Purpose

The purpose of this test is to demonstrate the capability of the Raychem Breakout Seal Assembly, when installed in accordance with Reference 1, to withstand simulated DBA pressure and temperature without loss of function or breach of pressure boundry. In addition, the adequacy of the conductor seal method, as specified in Reference 2, to prevent migration through conductor interstices will also be demonstrated.

II. Background

Informal tests conducted by Raychem on a similar (but not identical) configuration of the seal suggests a possible failure mode due to prolonged elevated temperature with the subsequent application of pressure. Although the Raychem breakout is fully environmentally qualified, the configuration employed by FNP is somewhat different than the qualification configuration. This test will demonstrate the adequacy of the FNP configuration.

III. Test Requirements

1.0 Test Specimen

1.1 1" pipe nipple (4" long)

1.2 Raychem CB4-2/502A823-52/144 WCSF Cable Breakout with keeper sleeve (Raychem Kit #NCBK-04-04)

1.3 1¼" Pipe coupling

1.4 Greenfield compression fitting (or equivalent)

1.5 Greenfield 1" flex conduit (approx. 8" long)

1.6 T & B insulated ring tongue lugs (#12 AWG)

1.7 4 - 1/C #12 Cable (Cable Code JO-2)

1.8 Raychem WCSF Heat Shrink sleeving for #12 AWG

2.0 Test Equipment

2.1 Test Container used for test per 2BE-1049-3 or equivalent (See Fig. 1)

2.2 Air pressure regulator 0-100 g

2.3 Air pressure gage, 0-30 psig ± 0.25%

2.4 Air pressure gage, 0-100 psig ± 0.25% (2)

2.5 ¼" stainless steel tubing and fitting as required to connect gages and regulators

2.6 Temperature regulated vessel; stress relief heating blanket with temperature controls

2.7 Iron-Constantan thermocouple with readout meter and data logger

IV. References

1. Drawing A-177541 shts 23K, Rev. 0 and 23P, Rev. 0

2. Drawing A-177541 shts 23I, Rev. 0 and 23P, Rev. 0

V. Procedure

1.0 Test Specimen Preparation

1.1 Assemble the Raychem seal configuration as shown in Reference 1 and Figure 1.

1.2 Terminate conductors on the pressure side of the seal as specified in Reference 2.

1.3 Bend conductors on the pressure side of the seal leaving the flex conduit and attach to the side of the flex conduit with Ty-wraps Conductors should not extend more than ¼" beyond the end of the flex conduit.

1.4 Insert the 1" nipple with seal attached into the 1" coupling at the pressure boundry and tighten.

2.0 Test Assembly Preparation

2.1 Assemble the test container as shown in Figure 1.

2.2 Attach ¼" pressurization/instrumentation tubing.

2.3 Connect the tubing as shown in Figure 2.

2.4 Cut conductors in leakoff nipple approximately ¼" beyond the end of the nipple and install pipe cap.

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3.0 Operational Test

Note: The test specimen temperature shall be monitored at 5 minute intervals throughout the test, using the test specimen thermocouple and the data logger. Times of changes of all test parameters shall be recorded.

3.1 Adjust temperature controller on vessel to 305 degrees Farenheit and energize.

3 When vessel temperature has stabilized at 305 degrees Farenheit, place test specimen, with all tubing attached, in the oven and allow test specimen temperature, as read on thermocouple, to reach 305 degrees Farenheit.

3.3 When test specimen reaches 305°F, pressurize the test chamber as follows: (Refer to Figure 2)

3.3.1 Set pressure regulator for minimum pressure.

3.3.2 Close Valves B and C.

3.3.3 With Valve A connected to a service Air Supply not exceeding 150 psig, slowly open Valve A.

3.3.4 Using the pressure regulator, increase the test chamber pressure rapidly to 60 psig.

3.4 After test chamber pressure has reached 60 psig, immediately set vessel temperature control to 180°F and allow vessel to cool at a rate of about 13°F in ten minutes until the vessel temperature is 180°F. Continuously monitor Pressure Gage B for evidence of leakage.

3.5 Allow test chamber pressure to remain at 60 psig for 7 minutes, at which time slowly reduce pressure at the rate of 5 psi in 10 minutes until the test chamber pressure is 15 psig.

3.6 Maintain test chamber pressure at 15 psig for 5 hours, at which time reduce pressure to 5 psig and maintain 5 psig for 19 hours. At the same time set vessel temperature control for 120°F and allow vessel to cool to that temperature.

3.7 Terminate the test approximately 24 hours after initially pressurizing test chamber to 60 psig.

Note: The test shall be terminated any time pressure gage "B" shows an increase in pressure, indicating the pressure seal boundry has been breached.

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3.8 The test shall be terminated as follows:

3.8.1 Remove power to heating blanket.

3.8.2 Close Valve "A", and set pressure regulator for minimum pressure.

3.8.3 Slowly open Valve "C", allowing pressure to bleed off.

3.8.4 Open Valve "B".

3.8.5 Allow Test chamber to cool.

4.0 Post Test Examination

4.1 Disassemble test chamber and remove test specimen.

4.2 Carefully examine test specimen for gross deformations of the seal, or evidence of conductor migration into the nipple in which they pass.

5.0 Conclusions

5.1 The test shall be deemed to be acceptable if:

5.1.1 There are no gross deformations of the seal system, and,

5.1.2 There is no evidence of a breach of the pressure boundry, as indicated by a buildup of pressure in the leakoff nipple.as indicated by pressure gage "B".

5.1.3 Minor deformations are acceptable if there is no evidence of a breach of the seal boundry.

5.2 Test results indicate that the Raychem Seal System, when installed in accordance with references 1 and 2 (is) (is not) acceptable for its design function.

Test Performed by:

_____ Date_____

Test Witnessed by:

_____ Date_____

Test Results accepted by:

_____ Date_____

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Appendix B

APCo QC Test Log

A 24 HOUR LIMIT SWITCH CABLE ENTRANCE SEAL TEST WAS CONDUCTED BEGINNING AT 0845 ON DEC. 17, 1981 AND TERMINATING AT 0845 ON DEC 18, 1981. THIS TEST WAS CONDUCTED IN ACCORDANCE WITH THE TEST PROCEDURES DEVELOPED BY BECHTEL POWER CORPORATION. THE TEST SPECIMEN WAS PREPARED PER SECTION II PARAG 1 EXCEPT THAT AFTER THE RAYCHEM SEAL WAS INSTALLED, CHICO A4 SEALING COMPOUND (MANUFACTURED BY CROUSE-HINDS CO.) WAS POURED INTO NIPPLE AND ALLOWED TO CURE. AFTER PREHEATING OF TEST CONTAINER THE SPECIMEN WAS INSTALLED AND TEST BEGAN AT 0845 DEC 17, 1981 LISTED BELOW ARE TEMPERATURE, TIME AND PRESSURE READINGS.

0845 VESSEL TEMP 310°, TEST SPECIMEN INSTALLED
0847 VESSEL TEMP 310°, VESSEL PRESSURIZED TO 60 PSIG
0854 BEGAN PRESSURE DECREASE

	INLET AIR GAUGE	TEMP	LEAK DETECTION GAUGE
0855	55 PSIG	290°	0.4 PSIG
0905	50 PSIG	285°	0.6 PSIG
0915	45 PSIG	280°	0.8 PSIG
0925	40 PSIG	270°	0.9 PSIG
0935	35 PSIG	254	1.0 PSIG

TIME	INLET AIR GAUGE	TEMP	LEAK DETECTION GAU
0945	30 PSIG	235°	0.8 PSIG
0955	25 PSIG	215°	0.8 PSIG
1005	20 PSIG	205°	0.7 PSIG
1015	15 PSIG	200°	0.5 PSIG
1030	15 PSIG	200°	0.4 PSIG
1130	15 PSIG	200°	0.2 PSIG
1230	15 PSIG	200°	0.6 PSIG
1330	15 PSIG	200°	0.5 PSIG
1430	15 PSIG	180°	0.4 PSIG
1515	15 PSIG	180°	0.6 PSIG
1615	5 PSIG	140°	0.4 PSIG
1715	5 PSIG	120°	0.2 PSIG
1815	5 PSIG	120°	0.2 PSIG
1915	5 PSIG	150°	0.4 PSIG
2015	5 PSIG	150°	0.2 PSIG
2115	5 PSIG	140°	0.2 PSIG
2215	5 PSIG	130°	0.2 PSIG
2315	5 PSIG	130°	0.2 PSIG
0015	5 PSIG	120°	0.2 PSIG
0115	5 PSIG	140°	0.2 PSIG
* 0215	0 PSIG	128°	0.2 PSIG
0230	5 PSIG	125°	0.1 PSIG
0315	5 PSIG	130°	0.1 PSIG
0415	5 PSIG	125°	0.2 PSIG
0515	5 PSIG	130°	0.1 PSIG
0615	5 PSIG	130°	0.2 PSIG

TIME	INLET AIR PRESSURE	TEMP	LEAK DETECTION GAUGE
0715	5	140°	0.2 PSIG
0815	5	145°	0.2 PSIG
0845	5	140°	0.2 PSIG

TEST TERMINATED AT 0846 DEC 18, 87

* PLANT AIR LOST AT 0215. INSPECTION OF GAUGES AND VALVE ASSEMBLY REVEALED THAT THE AIR PRESSURE BLED BACK THROUGH FEED LINE THROUGH THE REGULATOR, AND RETURNED TO NORMAL WHEN AIR WAS RESTORED.

TEMPERATURE HEAT CONTROL WAS TURNED OFF AND PRESSURE BLED OFF.

TEST SPECIMEN WAS REMOVED AND INSPECTED AND WAS FOUND TO BE INTACT. THE TEST SPECIMEN WAS CUT INTO TWO PIECES LENGTHWISE AND THE CROSS SECTION SHOWED THAT THE SEAL WAS INTACT AND THAT THE CHICO A4 HAD PENETRATED DOWN TO BREAKOUT SEAL AND HAD ACTED AS A BACKING TO THE SEAL AS WELL AS HAD SEEPED AROUND THE CABLES IN THE NIPPLE. IT WAS NOTED THAT THE BASCHEM WEST HEAT SHRINK SLEEVING HAD SHRANK A SMALL AMOUNT.

TEST EQUIPMENT

THERMOCOUPLES

INTERNAL	TC#8	CAL DUE 11-7-83
OUTSIDE	TC#6	CAL DUE 11-7-83

TEMP RECORDER	MR5	CAL DUE 1-29-82

HEATER CONTROL UNIT	APCO #E2
HEATER RECTIFIER	APCO #E3

GAUGES

INLET GAUGE (0-200 PSIG)	PG187	DUE 6-15-82
LEAK DETECTION (0-30 PSIG)	PG134	DUE 6-15-82

RELIEF VALVE RV42 SET 80 LBS 12-17-81 J HUR

ATTACHED ARE COPIES OF TEST PROCEDURE AND TEMP CHART.