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~~E.Q. DOCUMENTATION~~
~~File No.~~
~~Item No.~~

E.Q. DOCUMENTATION
File No. MISCEQ
Item No. 18

REVIEWED BY
VB | 9/20/85

Analysis Report

SCE-ANO-06

Aging Evaluation of Electrical Cables

November 15, 1984

5059x

J. A. MURPHY
Prepared by

Reviewed by

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1. Purpose

The purpose of this report is to describe the processes involved in the aging of electrical cable insulations used in ANO units 1 and 2 and to describe a method for evaluating the extent of age-related degradation occurring in the insulation of the installed cables.

2. Materials Used for the Insulations of Cables Installed in the Containments of ANO Units 1 and 2

a. Ethylene Propylene Rubber (EPDM) supplied by Anaconda, Okonite and Eaton (formerly Samuel Moore).

b. Chlorosulfonated Polyethylene (Hypalon) supplied by Boston Insulated Wire (BOSTRAD[7])

c. Cross-Linked Polyolefin supplied by Raychem Corporation.

In addition, the high range radiation monitors use Rockbestos (RSS-6-104) coaxial cable.

3. Aging of Ethylene Propylene Rubber (EPDM) Cable Insulation

In chemical terms the material is a terpolymer of ethylene, propylene and non-conjugated diene. This basic material is compounded with coloring agents and flame inhibitors. The compound is extruded over a copper conductor and then vulcanized to form the finished insulated wire.

The primary mode of degradation of EPDM at the temperatures encountered during plant operation is oxidation. Dupont (the developer of EPDM under the trade mark Nordel), as well as other cable manufacturers, have run extensive accelerated and natural aging tests on the material with the following general results.

Property	Behavior
Tensile Strength	Increases slightly with age
Elongation	Decreases with age
Shore A Hardness	Increases with age
Dielectric Strength	Increases with age
Insulation Resistance	Increases with age
Flexibility Retention	No change to slight decrease

3. Aging of Ethylene Propylene Rubber (EPDM) Cable Insulation (cont'd)

In general, the property of a hydrocarbon-based elastomer (of which EPDM is one) used as wire insulation which shows the most change as a result of oxidation resulting from aging is the elongation. As a result, elongation changes are commonly used by ICEA and cable manufacturers to measure age-related degradation. A conservative limit of 40% retention of initial elongation is accepted as the standard for accelerated aging tests.

Figure 3-1 shows accelerated aging test data for typical EPDM cable insulations. The longest test duration was 5,300 hours at 120°C (248°F). Figure 3-2 shows the results of natural aging conducted by Dupont for a period of 10 years (87,600 hours) at 120°F and 80% relative humidity.

No useable data on dielectric properties as a function of the age of the cable insulation has been found.

4. Aging of Chlorosulfonated Polyethylene (Hypalon)

Chlorosulfonated Polyethylene (Hypalon) cable insulation is only used at ANO on Boston Insulated Wire Company (BIW) cables under the trade name BOSTRAD[7]. Hypalon is commonly used as a cable jacket material by several manufacturers. The chlorine provides flame resistance and oil resistance for the cable insulation and jacket.

The primary mode of degradation of Hypalon insulation is oxidation at the temperatures to which the cables are subjected in the ANO plant. At temperatures above 250°C outgassing of Hydrochloric Acid (HCL) is the predominant mode of degradation. BIW has performed extensive accelerated aging tests on their Hypalon insulation (BOSTRAD[7]) with the following results.

Property	Behavior
Tensile Strength	Erratic
Elongation	Decreases
Dielectric Strength	Negligible change
Insulation Resistance	Increases
Power Factor (TANΔ)	Increases

4. Aging of Chlorosulfonated Polyethylene (Hypalon) (cont'd)

As is the case for other cable insulations, the property of Hypalon, which shows the most consistent results for age-related degradation is the elongation. BIW uses a 50% retention of original elongation as the basis for developing life vs. temperature curves for BOSTRAD[7] (Hypalon). Figure 4-1 shows the life/temperature relationship for BOSTRAD[7]. The data predicts a 40 year life at 150°F. EPRI NP-1558 on page 7-24 indicates that Hypalon showed no degradation after 5 years at 70°F (21°C).

No useable data on the effect of aging on the electrical properties of BOSTRAD[7] (Hypalon) have been located.

5. Cross-Linked Polyolefin Cable and Splices (Raychem Flamtrol and Thermofit WCSF-N)

The Raychem Flamtrol cable insulation, is a radiation cross-linked polyolefin material. The manufacturing process uses polyolefin chips, coloring agents, and oxidents and flame retardants which are compounded and hot extruded over the copper conductor. The insulated wire is subjected to radiation by electrons from linear accelerators to accomplish the cross-linking.

There are 2 modes of degradation of cross-linked polyolefin insulation, both of which occur simultaneously; they are:

1. Oxidation
2. Continuing molecular polymerization

Extensive accelerated aging tests have been conducted both by Rockbestos and by Raychem on cross-linked Polyolefin insulation. (Raychem developed the insulation material in the early 1970's. The process, including the manufacturing equipment was sold to Rockbestos in 1976). The results of the aging tests indicate the following property behavior.

Property	Behavior
Tensile Strength	Increases
Elongation	Decreases
Insulation Resistance	Increases
Dielectric Strength	Increases

5. Cross-Linked Polyolefin Cable and Splices (Raychem Flamtrol and Thermofit WCSF-N) (cont'd)

The property which shows the most consistent results in accelerated aging tests is the retention of elongation. The criterion for satisfactory performance selected for the testing was 60% retention of initial elongation. Figure 5-1 shows the results of thermal aging tests on cross-linked polyolifin insulation.

The data available on electrical property changes associated with the accelerated aging tests indicates changes in insulation resistance from 1.5×10^{13} ohms to 1×10^{14} ohms. On most megohmeters such differences are within the accuracy of the instrumentation and cannot be considered as useable data.

The same type of accelerated thermal aging tests were conducted on the Raychem WCSF-N cross-linked Polyolefin heat shrinkable splices. All of the testing indicated slightly better retention of properties than the cross-linked polyolefin cable insulation.

6. Aging of Cables Installed in ANO

a. Mechanism - The insulation on the cables installed in ANO units 1 and 2 is primarily subject to age-related degradation caused by temperature. While there is some effect caused by radiation inside containment, the 40 year integrated dose is less than 10^6 rads and the effects are not measurable. Qualification testing of the ANO cable insulators and splice sleeves have been performed in sequences based on:

- Thermal aging followed by radiation
- Radiation followed by thermal aging

To evaluate possible synergisms. No differences were found in the performance of the cable insulations installed in ANO units 1 and 2 and described in this report.

6. Aging of Cables Installed in ANO (cont'd)

The temperature induced aging degradation is the result of the combination of ambient temperature and the temperature rise resulting from any I^2R losses in the conductors. For instrumentation and control cables, the currents are so low that heating due to I^2R losses is negligible and any age related degradation is caused by the ambient temperature. For safety-related power cables, the current loadings are less than half of the ampacity ratings of the conductors resulting in a temperature rise of 25°C. (Although EPRI NP-1558, Section 7.1.3.3 indicates that the heating caused by current loading has a negligible effect on insulation life, the effects are considered in this evaluation because the duration of the tests was less than 20 days. It is considered that longer current loading times would eventually cause degradation similar to what would occur in an aging oven. In the aging oven, the air is circulated over the outside surface insulation causing a rapid initial oxygen diffusion which saturates after a short time at any specific temperature. Eventually, the same degree of oxidation will occur as a result of heating from the conductor. It just takes longer because the outside surface of the insulation is at a lower temperature than the insulation closer to the copper conductor).

If it is assumed that the insulation temperature of I&C circuits is at the maximum ambient temperature of 120°F (48.8°C) and that the insulation temperature of power cables is at 48.8°C + 25°C = 73.8°C (165°F), it is concluded that some change in elongation will occur over the life of the plant.

While an exact value cannot be predicted with any accuracy, the accelerated aging data for the materials indicates that the cables installed in ANO will retain between 60% and 80% of their original elongations.

b. Evaluation of Age-Related Degradation of the Cables Installed in ANO

The amount of age-related degradation occurring in the cables installed in ANO units 1 and 2 can be determined by tests conducted on short sections cut from the end of spare cables installed inside containment. The requirements are as follows:

b. Evaluation of Age-Related Degradation of the Cables Installed in ANO (cont'd)

- Size of sample......8 inches.
- Type of sample......1 sample of each material.
- Sample frequency... First set of samples 15 years after initial operation; second set of samples 25 years after initial operation; third set of samples 33 years after initial operation; fourth set of samples 40 years after initial operation.
- The spare cables selected should have at least 2 conductors.
- The spare cables selected should be tagged and the same cables used for the initial tests should be used for all subsequent tests.
- The vendor certified data for the spare cables selected for test should be checked and the original tensile strength and elongation at break should be recorded.
- One end of each of the cables to be tested should be untaped and an 8 inch long piece cut off. The remaining cable end should be retaped.
- The cable jacket of each sample should be carefully split and stripped to avoid damaging the conductor insulation.
- The insulated conductors from each cable should be tagged with the information necessary to identify them with the spare cable from which the sample was cut.

The following steps may be performed by AP&L or by a qualified test laboratory. The equipment needed to perform the testing is:

a. Special tools to slit and strip the insulation from the conductors. (Most cable manufacturers have this equipment in their test labs).

b. An Instron tester calibrated to NBS standards.

The testing steps are:

- The insulation should be slit and stripped from each conductor. The tags affixed by AP&L to the conductors should be kept with the proper insulation specimens.
- Each 8 inch specimen should be tested on a calibrated Instron tester. The tensile strength and elongation at break of each specimen should be recorded together with the sample identification from the AP&L tag.

b. Evaluation of Age-Related Degradation of the Cables Installed in ANO (cont'd)

To evaluate the data AP&L should:

a. Determine the arithmetric average for elongation for the number of test samples for each cable sample.

b. The arithmetic average of the elongations for each cable should be divided by the original elongation data from the vendor certification. The resulting number should be multiplied by 100 to determine the % retention of elongation.

It is expected that the data should be in the following ranges:

Time	% Retention Elongation
15 years	65% to 90%
25 years	60% to 85%
33 years	50% to 80%
40 years	40% to 75%

Should any of the averaged initial (15 years after operation) samples show values lower than 65% retention of elongation. Subsequent samples from that cable should be taken at 5 year intervals.

If the retained elongation goes below 30% at any time during life, all of the cables represented by the samples should be replaced within the 5 year period following the test.

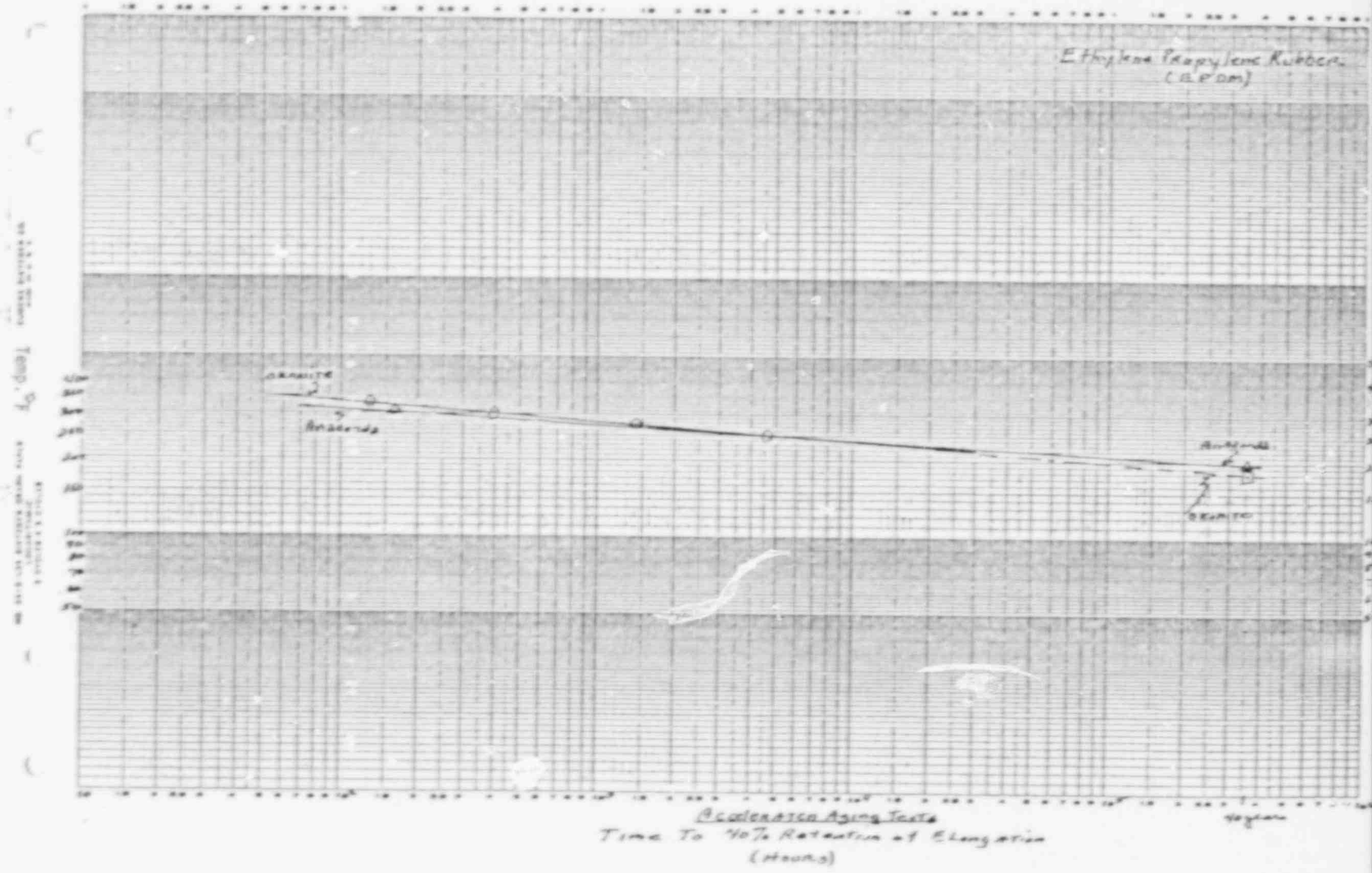
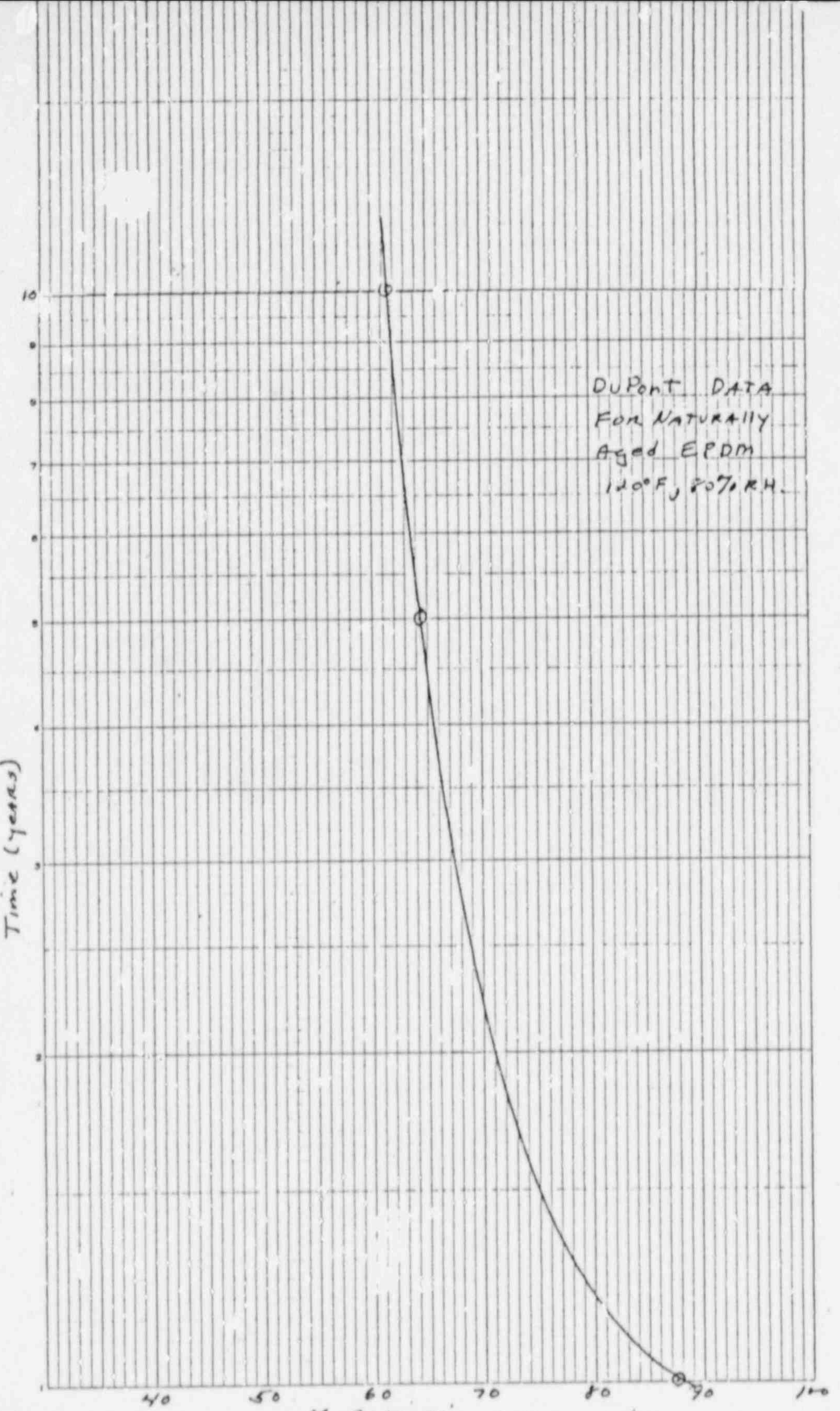

Ethylene Propylene Rubber
(EPDM)
Okonite
Anaconda
Anaconda
Kerite
Temp. °F
Accelerated Aging Tests
Time To 40% Retention of Elongation
(Hours)
40 years

Figure 3-1



DuPont DATA
For Naturally
Aged EPDM
120°F, 80% RH.

Figure 3-2

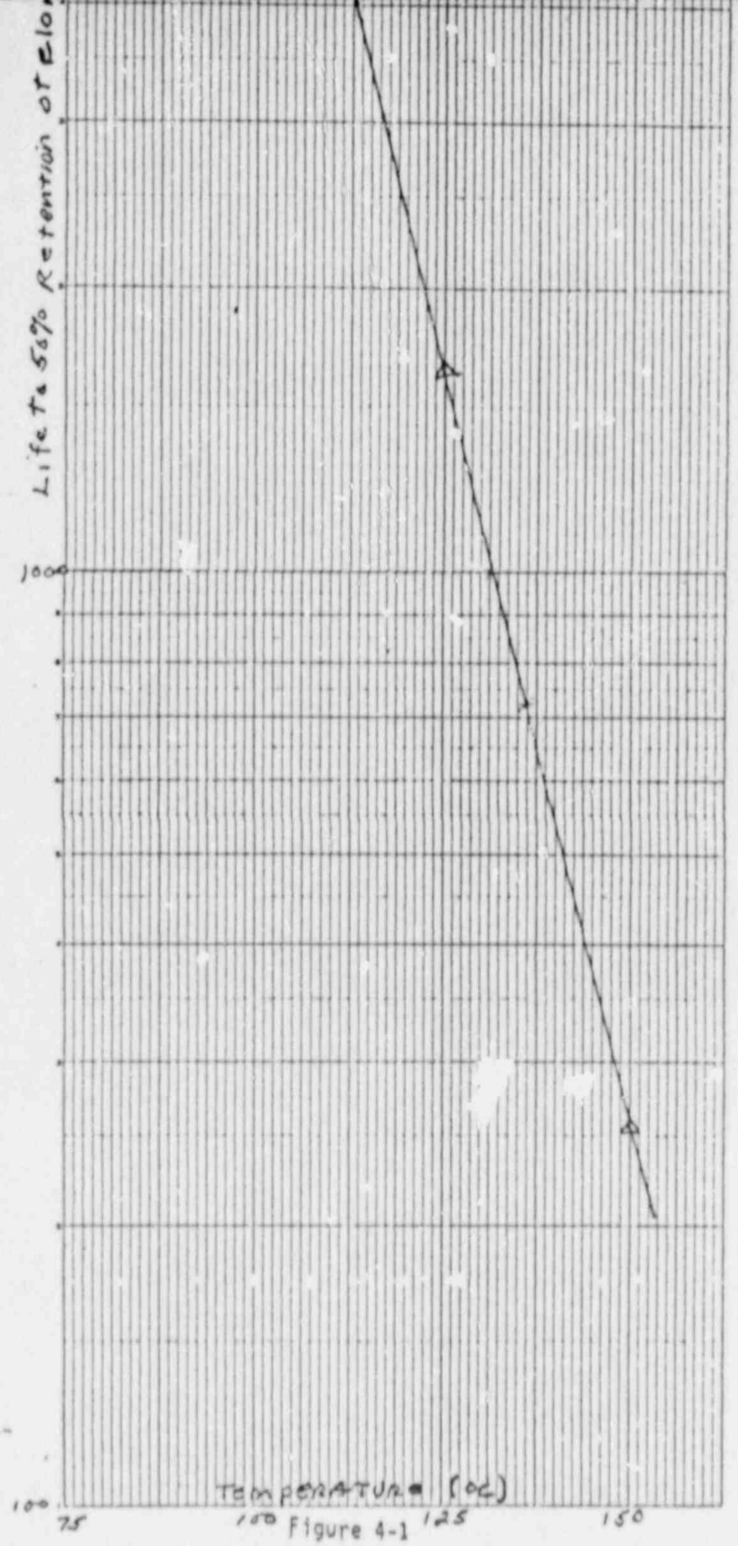
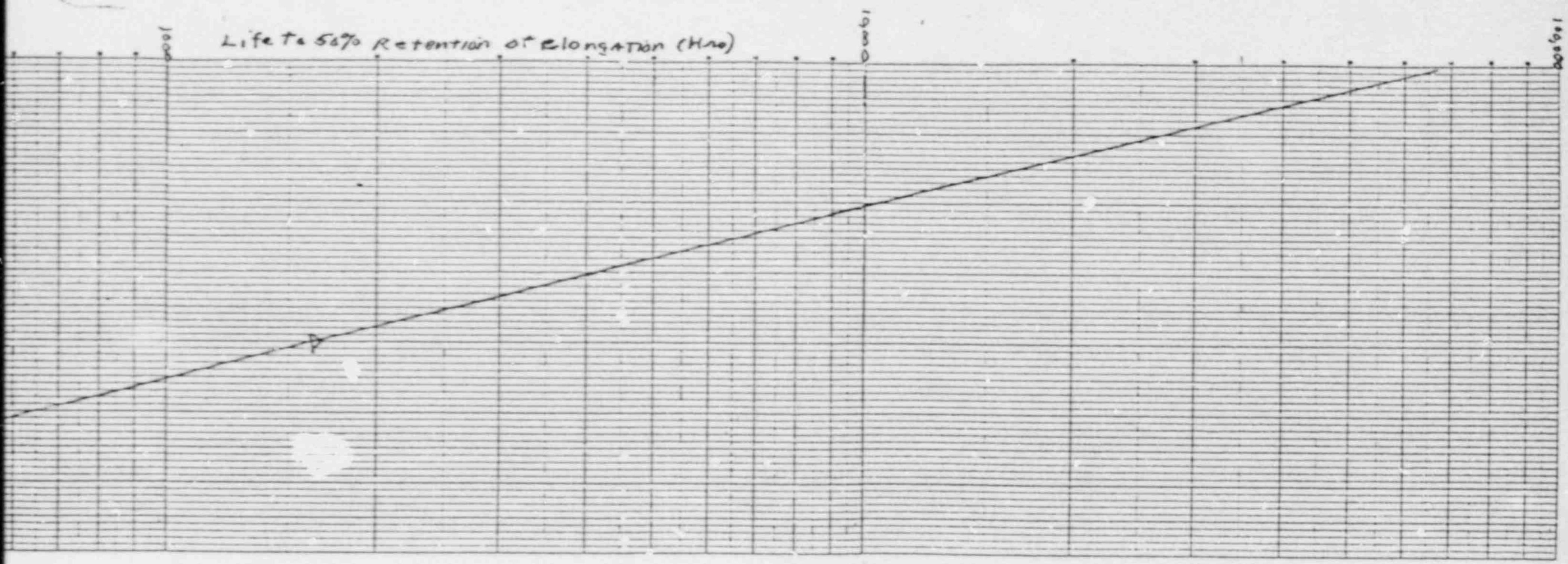

Life to 50% Retention of Elo
1000
100
TEMPERATURE (°C)
75
100
125
150

Figure 4-1

0002507433 9



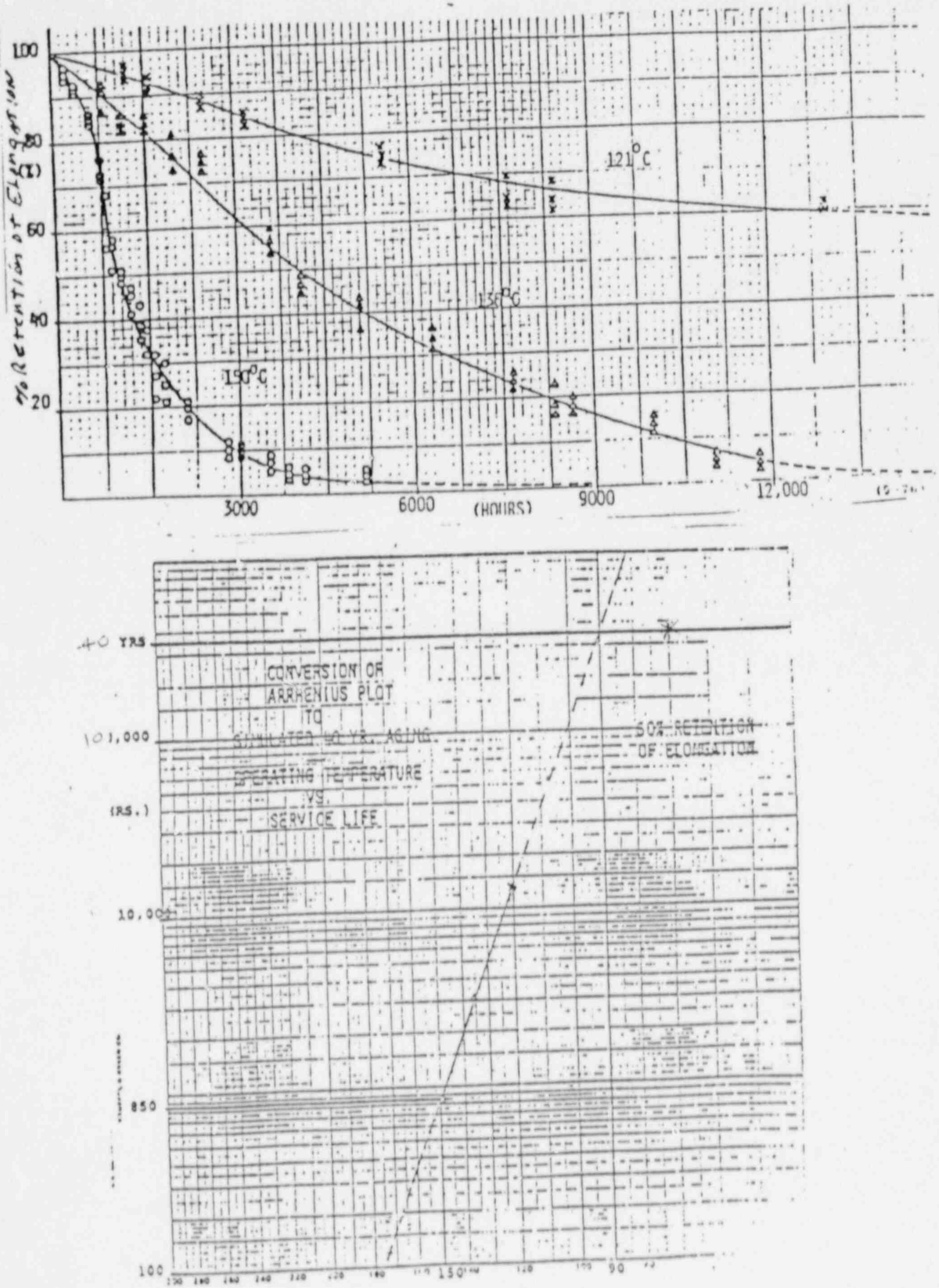

% Retention of Elongation (%)
100
80
60
40
20
121°C
130°C
150°C
3000
6000
9000
12,000
(HOURS)
40 YRS
100,000
(HRS.)
10,000
850
100
CONVERSION OF ARRHENIUS PLOT TO SIMULATED 40 YR. AGING
OPERATING TEMPERATURE VS. SERVICE LIFE
50% RETENTION OF ELONGATION
150
120
90
(°C)

Figure 5-1

7. References

1. Okonite Report G-3
   September 7, 1977.
2. Anaconda-Continental Report No. 79118.
3. Boston Insulated Wire Report B-901.
4. Boston Insulated Wire Report B-902.
5. Franklin Institute Research Laboratory Reports F-C4033-1,
   F-C4033-2, F-C4033-3.
6. Rockbestos Report QR#1806, 1981.
7. Dupont Report, Nordel Engineering properties and applications.

Appendix A

Precautions Regarding
Cable Insulations

ANO Units 1 and 2

1. Purpose

The purpsoe of this appendix is to identify certain adverse environmental conditions which could result in damage to the cable insulation. Such damage could drastically shorten the cable life and compromise LOCA performance.

2. Ethylene Propylene Rubber (EPDM)

Certain organic liquids will cause rapid deterioration of EPDM. To ensure the validity of the aging evaluation and the qualification test results, it is necessary to ensure that the following materials do not come into contact with the cable insulation.

- Lubricating oils
- Carbon tetrachloride
- Benzene
- Cyclohexane
- O-Dichlorobenzene
- N-Hexane

The above materials will virtually destroy the mechanical and electrical properties of EPDM in less than 28 days at 75^{O}F.

3. Chlorosulfonated Polyethylene (Hypalon)

The mechanical and electrical properties of Hypalon, as well as its radiation resistance, are adversely affected by long term contact with aromatic or chlorinated hydrocarbon solvents. Typical among solvents that damage Hypalon are:

- Benzene
- Carbon tetrachloride
- Trichloro-ethylene
- Perchloro-ethylene
- O-Di-chlorobenzene
- Methyl-ethyl Ketone

3. Chlorosulfonated Polyethylene (Hypalon) (cont'd)

The rate of attack of the various aromatic and chlorinated hydrocarbons depends on the specific organic solvent. In general, contact with Hypalon by such solvents should be avoided.

4. Cross-Linked Polyolefin (Raychem/Rockbestos)

Cross-linked polyolefin insulations are resistant to most of the common organic solvents.

5. Cleaning of Cable Insulation

If it is necessary to clean cable insulations either distilled, demineralized water or denatured alcohol followed by distilled/demineralized water should be used. Other solvents should only be used if compatability tests have been performed.

Appendix B

Effects of Aging

on

LOCA Qualification

In section 6 of this report, a criterion of 30% retention of elongation was identified as the limit for usefulness of the cable insulation materials installed in ANO units 1 and 2. The basis for this criterion is that there is no LOCA test data which would demonstrate qualification of cables having less than 30% retention of elongation.

1. Cross-Linked Polyolefin

In report F-C4033-1 LOCA tests were performed on cables and splices which had been pre-aged for a total of 32 days at 150°C. This amount of pre-aging corresponds to a 30% to 35% retention of original elongation. The cables performed satisfactorily during and after LOCA tests.

2. Ethylene Propylene Rubber (EPDM)

In Okonite report G-3 LOCA tests were performed on cables that had been pre-aged for 21 days at 150°C. This pre-aging corresponds to a 30% retention of original elongation. The cables performed satisfactorily during and after LOCA tests.

3. Chlorosulfonated Polyethylene (Hypalon)

BIW reports B-901 and B-902 report LOCA testing conducted on BOSTRAD[7] (Hypalon) insulated cables with varying amounts of pre-aging results in 30%, 35%, 40%, 50% and 60% of original elongation. The cables performed satisfactorily during and after LOCA tests.

ATTACHMENT 1

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LIMITORQUE
VENDOR
FILE

April 3, 1985

RECEIVED
APR 24 1985
ARKANSAS POWER & LIGHT CO.
Engineering Services/I&C & Elect.

E.Q. DOCUMENTATION
File No. V33
Item No. 32.X

Mr. Charles Turk
Licensing Engineer
Arkansas Power and Light Company
(7th Floor F.C.B.)
P.O. Box 551
Little Rock, Arkansas 72203

Subject: "T" Drains on Limitorque Motorized Valve Actuators

References: 1. Telecon, J. Murphy (SCE), and Tommy Le (NRC, I&E).
Subject: "T" Drains on Limitorque Actuators (Attachment 1)

2. Telecon, K. Iepson (SCE), and J. Drab (Limitorque).
Subject: "T" Drains on Limitorque Actuators (Attachment 2)

Dear Mr. Turk:

Pursuant to my conversation with Jeff Holt (AP&L, ANO Electrical Maintenance Coordinator) and yourself, SCE has investigated the necessity of "T" drains on Limitorque actuators, particularly as they relate to the environmental qualification of these devices. Discussions with the NRC (Ref. 1) have revealed that the primary concern (noted during an EQ audit at Commonwealth Edison's Zion Station) with the "T" drains is not specifically EQ related. These drains are shipped with the actuators by wiring the part with a tag inside the motor housing. A plastic shipping plug protects the installation port. The problem at Zion was that the plugs were never removed and the "T" drains were never installed. In fact, the "T" drains were never removed from the motor housings.

SCE reviewed Limitorque maintenance part lists and drawings and found that the "T" drains are not shown. SCE contacted Limitorque (Ref. 2) and learned that the primary functions of the "T" drain are to allow excess condensate to drain from the motor housing if it collects and to admit the external atmosphere into the motor housing in order to equalize the pressure across the housing. The design philosophy of adding the drain is identified on page 21 of Limitorque Report B0058 and is <u>only</u> applicable to in-containment actuators.

They are enclosed in the Limit Switch compartment not the motor housing per Duke Power personnel.
CH Turk
4/13/85

SCE also learned the following from Joe Drab (Limitorque):

- Limitorque units tested prior to September 1972 had no "T" drain (1/4" pipe plug substituted), but still functioned satisfactorily during Limitorque testing.
- Limitorque units tested by Limitorque after September 1972 had "T" drains installed and operated satisfactorily.

Additionally, FIRL and Westinghouse have both conducted tests on Limitorque Actuators without "T" drains with acceptable results.

Based on a review of the test results and anomalies which occurred during testing of Limitorque actuators during both time frames, SCE concluded that there is no evidence of a difference in performance between actuators using "T" drains and those using pipe plugs. Therefore, it is further concluded that actuators traceable to test reports dated September 1972 or later which do not have "T" drains installed, but do have pipe plugs, are also environmentally qualified and the test reports are still applicable. The actuators should have either a "T" drain or a pipe plug to prevent dirt, etc. from entering during normal operation.

The recent EQ walkdown performed by SCE personnel (as well as an earlier walkdown performed by AP&L) did not detect any plastic shipping plugs or the presence of "T" drains. The walkdown also confirmed that there were no openings into the devices. This included verification that limit switch compartment cover plugs were also installed.

SCE recommends the following based on the discussion presented above:

1. Limitorque actuators supplied to AP&L and traceable to EQ test reports dated prior to 9-72: No action; devices qualified.
2. Limitorque actuators supplied to AP&L and traceable to EQ test reports dated after 9-72: No action; devices qualified.
3. All new actuators supplied for in-containment use: Install the "T" drain in accordance with the shipping/installation instructions. Verify that the motor housing drain port has the "T" drain installed and the tag is removed.
    a. The EQ maintenance data sheets (Form 1025.06C)) on new actuators may be revised to reflect this check point during any maintenance activity.

4. If an actuator in service is found to have the plastic shipping plug installed, the device should be removed from service, the plastic plug removed and the motor housing inspected for the "T" drain and tag. The tag should be removed and the "T" drain installed.
5. Licensing/Engineering should notify ANO Electrical Maintenance/ EQ Coordinator of any specific actions to be taken by ANO as a result of this letter. AP&L licensing/engineering position should be stated for documentation purposes.

The conclusions and recommendations were made by SCE using some information which is not in AP&L EQ file or Limitorque possession. The information base used envelopes both the AP&L and Limitorque information sources and is, therefore, considered to be the best source from which to draw a conclusion.

Should you have any comments or questions, please feel free to contact Mr. Joseph Murphy, Manager - Philadelphia Office or myself.

Thank you.

Very truly yours,

Kevin J Iepson

Kevin J. Iepson
Principal Engineer

KJI/be

Attachments

cc: Mr. Jeff Holt - AP&L

Schneider
Consulting Engineers

MEMORANDUM

Telephone Memorandum

TO: Files

FROM: Kevin J. Jepsen

DATE: April 1, 1985

SUBJECT: Telephone Conversation with Mr. Joseph Drab, Special Projects Engineer, Limitorque Corporation. RE: "T" drains on Limitorque Actuators.

Based on discussions with Mr. Charles Turk (AP&L Licensing) and Mr. Jeff Holt (AP&L, ANO Electrical Maintenance), the question of whether "T" drains were required to be installed to consider the actuators qualified was raised. I contacted Limitorque and learned the following:

- EQ testing prior to September 1972 tested actuators without "T" drains. Results were acceptable. Pipe plugs were used instead of the "T" drain.
- EQ testing after September 1972 tested actuators with "T" drains. Results were acceptable.
- "T" drains are designed to be installed in the motor housing at the lowest point to:
  - Allow condensate to drain out
  - Admit the external atmosphere to enter the motor housing thereby equalizing the pressure across the housing.
- The design philosophy for using "T" drains is stated in Limitorque Report B0058, page 21.
- "T" drains are only an issue on in-containment actuators.
- Limitorque supplies "T" drains with all in-containment actuators. The part is separately wired with a tag inside the motor housing for shipping. The installation port threads are protected with a plastic cap/plug.

I told Mr. Drab that based on the information he provided and the results of independent tests (FIRL, Westinghouse, etc.) during both time frames, it would appear that the "T" drains are inconsequential with regard to qualification of the device. Mr. Drab would not commit to this statement; he merely stated that this is their current design and that any conclusions concerning the acceptability of other units* is the user's responsibility.

*Units using pipe plugs instead of "T" drains on actuators traceable to reports post September 1972.

cc: Charles Turk - AP&L
Jeff Holt -AP&L

Schneider
Consulting Engineers

MEMORANDUM

Telephone Memorandum

TO: Files

FROM: J. A. Murphy

DATE: April 1, 1985

SUBJECT: Telephone Conversation with Mr. N. B. (Tommy) Le (NRC-I&E).
RE: "T" Drains on Limitorque Actuators. (301-492-9686)

Based on a discussion between K. Iepson (SCE), Mr. Charles Turk (AP&L, Licensing), and Mr. Jeff Holt (AP&L, ANO Electrical Maintenance) and the relatively vague problem identified, I decided to contact Tommy Le in order to define:

- The exact nature of the problem
- The manner in which the problem was discovered
- Where the problem occurred
- What was the impact of the problem on the environmental qualification of the actuators.

Tommy provided the following details concerning the "T" drains on Limitorque actuators:

- During an EQ walkdown (as part of the NRC I&E EQ audit at Commonwealth Edison's Zion Station), it was discovered that the plastic shipping caps for the "T" drain installation ports were still installed even though the device was in service.
- Further investigation found that the "T" drain was still wired inside the motor housing with the installation tag.
- The NRC had not established a clear impact on qualification of the devices. There was a breakdown in the utility/A.E. installation & checkout procedures.
- I informed Tommy that testing of actuators with pipe plugs and with "T" drains both had successful/acceptable results and that I consider either arrangement qualified.

Tommy and I agreed that the importance of the finding is in the procedural breakdown and not in the adequacy of the device to function.

cc: Charles Turk - AP&L
Jeff Holt - AP&L

ATTACHMENT 2

REVISED

1

SYSTEM COMPONENT EVALUATION WORKSHEET	QUALIFICATION CRITERIA: 10CFR 50.49	SYSTEM: CONTAINMENT HRRM UNIT: ANO-1 P&ID:	ID (TAG) NO.: GEN 1030 COMPONENT: ELECTRICAL CABLE LOCATION: RB
	ESP-211F1 EVAL.: ATTACHED		

DESCRIPTION

MANUFACTURER:
ROCKBESTOS

NPRDS CODE:

MODEL NO.:
1/C #22 AWG COAX CABLE (NOTE 1)

FUNCTION:
HIGH RANGE RADIATION MONITORING

SERVICE:
MONITORING

FLOOD LEVEL:
ABOVE

ACCURACY REQ'D:
N/A

DEMO:
N/A

ENVIRONMENT			DOCUMENTATION REFERENCES		QUAL.	OPEN
PARAMETER	REQ'D LEVEL	QUAL. LEVEL	REQUIRED	QUALIFICATION	METHOD	ITEM
OPERATING TIME (HRS)	720	2400	ESMP #71	V42 ITEM 7	SIMULT TEST	NONE
TEMP (F)	280	346	FSAR FIGURE 14-62	V42 ITEM 7	SIMULT TEST	NONE
PRESSURE (PSIG)	53.1	122	FSAR FIGURE 14-61	V42 ITEM 7	SIMULT TEST	NONE
RELATIVE HUMIDITY %	100	100	ESMP # 71	V42 ITEM 7	SIMULT TEST	NONE
CHEMICAL SPRAY (pH AND COMP)	2670 PPM BORON pH 10.5MAX	3000 PPM BORON pH 10.5	ESMP #71	V42 ITEM 7	SIMULT TEST	NONE
RADIATION (RADS)	5.0 E+7	2.0 E+8	ESMP #71	V42 ITEM 7	SEQUENT TEST	NONE
AGING	40 YRS NOTE 2 3	40 YEARS	FSAR	V42 ITEM 7 MISC EQ ITEM 18 87-EQ-0002-31	SEQUENT TEST & ANALYSIS 3	NONE
SUBMERG.	N/A	N/A	N/A	N/A	N/A	NONE

NOTES: 1. FOR FORMULATION RSS-6-113/LE AND RSS-6-113/LD. SEE ATTACHMENT 1 TO ESP-211 EVALUATION. 2. REQUIRED AT AN AMBIENT TEMPERATURE OF 160 F.

3

PREPARED BY:
DATE: 2/17/88
REVIEWED BY:
DATE: 2/23/88
SCEW SHEET NO.: A233
REVISION NO.: 3

IV. Qualification Documentation

A. Qualification References

1. File V42, Item 7, Rockbestos Report #QR-6802 dated March 12, 1986
2. File Misc. EQ Item 18, Aging of Electrical Cable Analysis
3. File V42, Items 19B, 19C, 19D (Similarity of second generation coax only) △2
4. CALCULATION No 87-EQ-0002-31 △3
5. CALC NO. 87-EQ-0002-25 △3

B. Qualification Methods (check all that apply)

x 1. Type Tests

___ 2. Experience

x 3. Analysis - indicate type and the parameters addressed

Aging (see ref. 2) (SEE REF. 4) △3

Similarity of RSS-6-113/LD (second generation) see Ref. 3 △2

C. Test Specimen Description

1. Device Electrical Cable
2. Vendor The Rockbestos Company
3. Model #/ID # Cable "E" on page 5-A
4. Range/Size/Options, etc. Cable "E" on page 5-A
5. Qualified Interfaces None

ARKANSAS NUCLEAR ONE
UNITS 1 AND 2

EQUIPMENT ENVIRONMENTAL QUALIFICATION DOCUMENTATION EVALUATION FORM

DCP No. ________

I. EQUIPMENT DESCRIPTION

A. Device Electrical Cable

B. Tag # GEN-1030

C. SCEW sheet A233

D. System/P&ID

E. Safety Function Transmit signals from safety-related equipment

F. Service High Range Radiation Monitor

G. Vendor The Rockbestos Company

H. Model #/ID # Mfr. Product Code H44-3024

I. Range/Size/Options, etc. 1/C #22 Awg. Coaxial Cable

△2 J. Specification No. RSS-6-113/LE (Third Gen.) and RSS-6-113/LD (second gen.) by similarity

△2 K. Purchase Order No/Date 11406-E-2405-AC/Dec. 1980
General Atomics P.O. 777242/ 8/11/81

V. Qualification Assessment

A. Is the installed equipment (or that being considered for installation) identical to the tested equipment?

____ Yes

△2 _x_ No (justify any difference by similarity analysis, etc.)

See Attachment 1 and items included as reference 3.

B. Were any test failures or anomalies encountered during the test program?

_x_ Yes (list below and justify each)

____ No

Failure/Anomaly	Resolution
Occasional loss of proper temperature/pressure caused by boiler failure	Test extended to 108 days to compensate for "down" time

V. Qualification Assessment (Continued)

H. Was the test sequence properly chosen?

_x_ Yes

___ No (justify)

I. Were the operational modes tested representative of expected plant operational modes (e.g., were normally energized solenoids energized during test)?

_x_ Yes

___ No (justify)

J. Were the functional testing considerations appropriate that is, was device performance properly monitored during the testing (pre-test, test and post-test)?

_x_ Yes (explain)

___ No (justify differences)

For the /LE (third generation) cables, the cables were energized and monitored throughout the LOCA test. IR measurements were made periodically throughout entire test program. Based upon the analysis documented in V42-19B, C, D, the /LD (second generation) cable primary insulation material is identical to the /LE primary insulation and the two cables should therefore perform similarly during and after a DBE.

K. Were the applicable IE notices considered in the evaluation?

_x_ Yes (explain)

___ N/A (explain)

ATTACHMENT 1

ROCKBESTOS COAXIAL CABLE RSS-6-~~104~~ 113

PRODUCT CODE H44-~~0104~~ 3024

This cable has been manufactured using three different formulations; namely, RSS-6-~~104~~ 113 (first generation), RSS-6-
3/LD 1~~04/LD~~ (second generation), and RSS-6-~~104/LE~~ 113/LE (third generation). ANO inventory (Rockbestos Reel No. G-11924, Shop Order No. 52102-96) has the first generation, while the General Atomics High Range Radiation Monitor (HRRM) installed inside the Reactor Building is attached to a Rockbestos cable made with the second generation formulation ('/LD').

Kjl 7.10.86

confirmatory letter from Rockbestos expected

According to Rockbestos (letter to Schneider Consulting Engineers dated June 19, 1986 from George G. Littlehales, Manager, Quality Assurance) the first generation formulation is 'not qualified for operation above 230 degrees F.' (See Rockbestos Technical Report TS-1981-YSK-3). It was originally qualified under Rockbestos report 'Qualification of Firewall III Coaxial Constructions' dated March 15, 1979.

The HRRM originally had cable made with the first generation formulation, but it was changed by General Atomics and now has a cable using the '/LD' formulation. This formulation was qualified by Rockbestos in a test program that was the subject of an NRC review, and is of questionable validity.

The third generation formulation has been tested and found to be qualfied (Rockbestos Report No. QR-6802 dated March 12, 1986). The primary difference between the '/LD' and '/LE' formulations is a design change concerning the braid angle. Rockbestos contends that the '/LD' formulation is qualified by similarity to the '/LE' formulation, and is now preparing a similarity analysis to demonstrate qualification.

THIS IS NOT CORRECT. SEE V42-19A, 19B, 19C JC 1/8/~~86~~ 87

Thus, the cable stored in ANO inventory is NOT qualified for use inside the Reactor Building, while new cable purchased with the '/LE' formulation is qualified. Qualification of the '/LD' formulation cable now attached to the General Atomics HRRM is dependent on an acceptable similarity analysis forthcoming from Rockbestos. (REF V42-~~19A~~ 19B,C,D) JC

JC 1/8/~~86~~ 87

THE ROCKBESTOS COMPANY
285 NICOLL STREET, P.O. DRAWER 1102, NEW HAVEN, CT 06504

E.Q. DOCUMENTATION
File No. Y42
Item No. 178

REVIEWED BY
JC 1/8/8

July 17, 1986

Arkansas Power & Light Company
P.O. Box 551
Little Rock, Arkansas 72203

Attention: Mr. J. D. Coleman

Dear Mr. Coleman:

Attached, in response to your request dated March 28, 1986, is a copy of our analysis of similarity between Rockbestos Coaxial insulation types Polymer LD and Polymer LE.

Very truly yours,

THE ROCKBESTOS COMPANY

GGS Littlehales
George G. Littlehales
Manager, Quality Assurance

GGL/dlf

attachment

cc: R. J. Gehm, J. M. Morganelli - Rockbestos

A member of The Marmon Group of companies

ANALYSIS OF SIMILARITY BETWEEN ROCKBESTOS COAXIAL INSULATION TYPES POLYMER LD AND POLYMER LE

The first insulation layer in Rockbestos Class 1E Coaxial, Triaxial, and Twinaxial cables is a high temperature thermoplastic material, Polymer LD for second generation and Polymer LE for third generation. Second and third generation constructions with the same RSS designation are identical in all other respects.

In the first generation design, because of the angle of the shield braid wires, radial expansion of the dielectric (and braid) due to increased temperature caused axial foreshortening of the braid. This caused the center conductor to kink within the dielectric. The purpose of the first dielectric layer was to prevent the center conductor from coming into contact with the braid.

The cables were redesigned with a neutral braid angle which eliminated the foreshortening of the braid and the resulting kinking (2nd generation). Subsequently, a superior material (Polymer LE) became available and was incorporated into the design (3rd generation). Polymer LD and Polymer LE are both high temperature thermoplastics with similar electrical and physical characteristics.

Because of the neutral braid angle of the second and third generation design, the Polymer LD and Polymer LE layers do not play a part in protecting the cable against faulting during a LOCA simulation, but were retained to maintain electrical equivalence with the first generation design. Exhibits A and B show center conductor kinking is not present in either second or third generation cables which have been subjected to a sequence of thermal conditioning, irradiation conditioning and simulation of a LOCA within the guidelines established by IEEE-323-1974 and IEEE-383-1974.

In summary, the dielectric performance of Rockbestos Class 1E Coaxial, Triaxial, and Twinaxial cables is based entirely on the main insulation layer (KXL-100 for solid dielectric or KXL-150 for foam dielectric). We conclude that the LOCA test results obtained using the third generation cables are completely applicable to the second generation cables and vice-versa.

Prepared By: 7/15/85

Approved By: 7/15/85

EXHIBIT "A"

X-RAY PHOTOGRAPH OF RSS-6-104 AFTER BRAID ANGLE CHANGE AND TEMPERATURE EXCURSION TO 180°C

FIRST INSULATION POLYMER LD

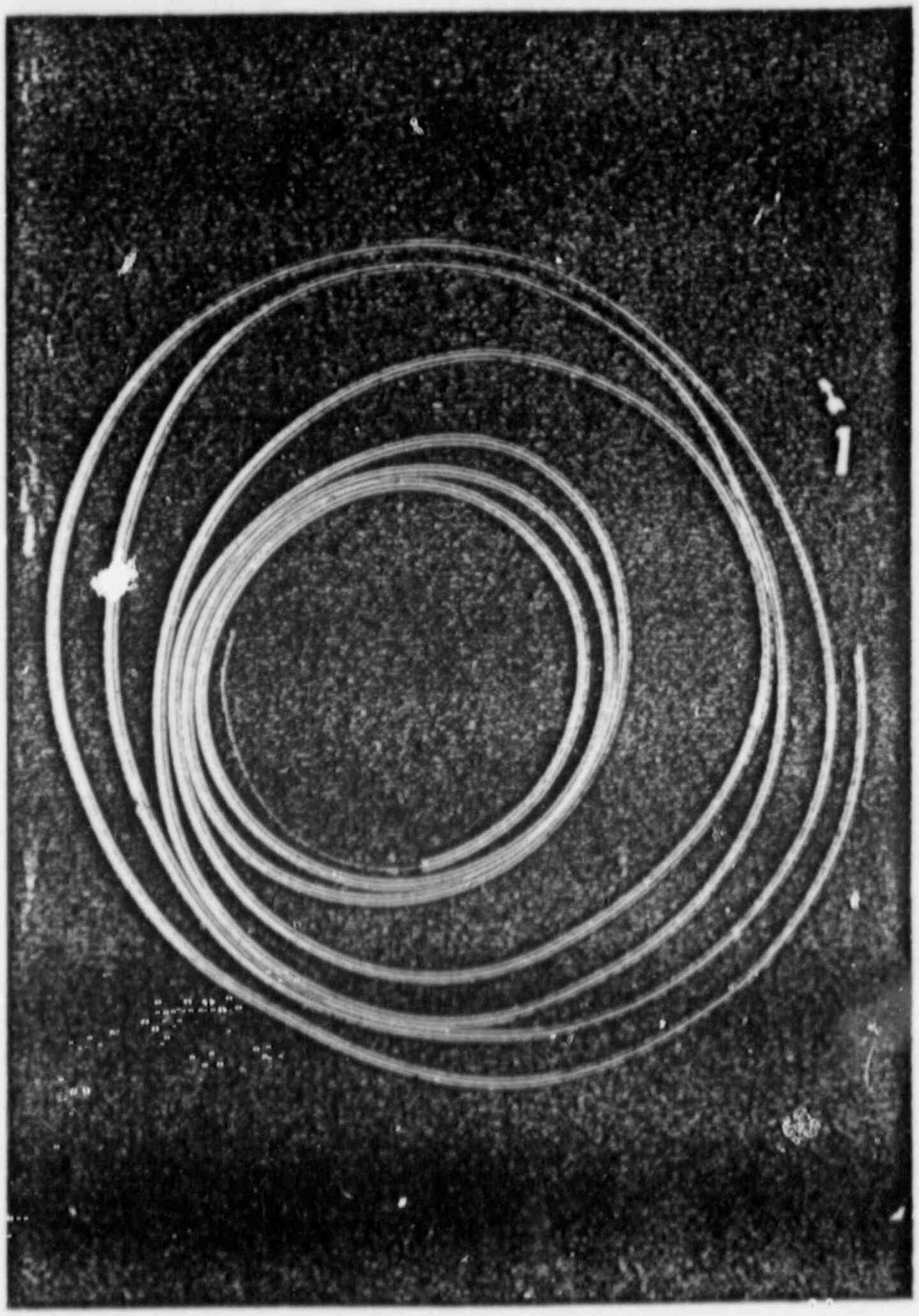
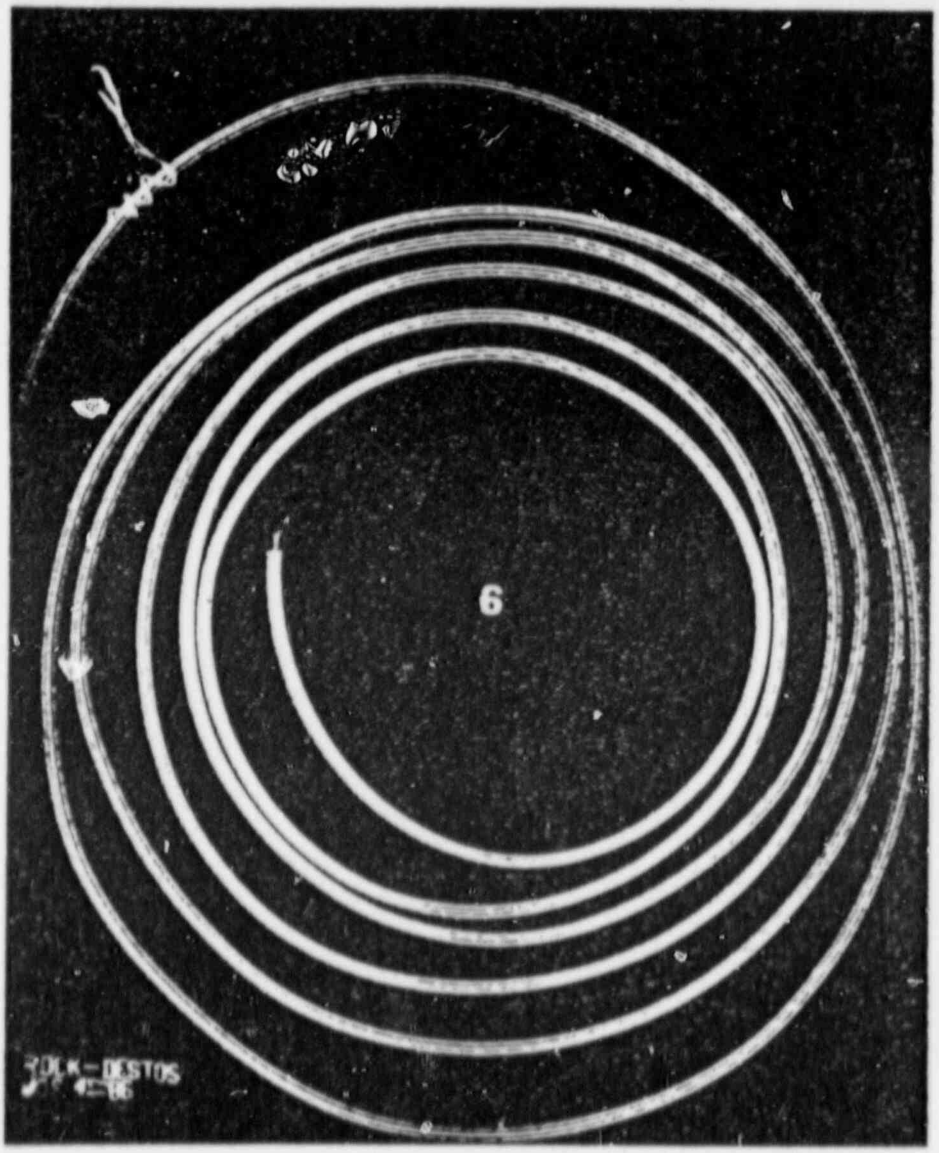


EXHIBIT "B"

X-RAY PHOTOGRAPH OF RSS-6-104 AFTER BRAID ANGLE CHANGE AND TEMPERATURE EXCURSION TO 180°C

FIRST INSULATION POLYMER LE



Kevin Iepson

THE ROCKBESTOS COMPANY
285 NICOLL STREET P.O. DRAWER 1102 NEW HAVEN CT 06504

E.Q. DOCUMENTATION
File No. V42
Item No. 19C

REVIEWED BY
JC | 1/7/87

July 14, 1986

Schneider Consulting Engineers
111 Presidential Boulevard
Bala Cynwyd, PA. 19004

Attention: Mr. Pietro Santavicca

Dear Mr. Santavicca:

This will confirm our discussion regarding the following Rockbestos RSS-6-113 Coaxial cable utilized in radiation monitoring equipment by Arkansas Power & Light Company:

Rockbestos sales order 007/9011
Rockbestos shop order 13101-01
Product Code H44-3024

The cable described above was ordered by General Atomic Company on their P.O. 777242. Our shop order was entered on 7/27/81.

The RSS-6-113 Coaxial cable supplied was second generation, qualified under report QR-2806. Second generation cables employed a Polymer LD inner dielectric.

RSS-6-113 employing a Polymer LE inner dielectric was successfully tested for our recent supplemental qualification test report QR-6802. In the very near future, as we discussed, we will have a similarity analysis available which will relate Polymer LD to Polymer LE constructions. Copies of this analysis will be sent to Mr. J. E. Livingston at Schneider Consulting Engineers and to Mr. J. D. Coleman at Arkansas Power & Light Co.

Although not particularly relevant to your question, I did comment that RSS-6-113 is a cellular dielectric construction which was not affected by the problem of occasional failures at high temperature found in first generation solid dielectric cables.

Very truly yours,

THE ROCKBESTOS COMPANY

GG Littlehales

George G. Littlehales
Manager, Quality Assurance

GGL/dlf

FILE NO.________

E.Q. DOCUMENTATION
File No. V42
Item No. 19D

CONVERSATION MEMORANDUM

☒ TELEPHONE
☐ OFFICE VISIT
☐ MEETING

DATE: Jan. 21, 1987
TIME: 1:05 p.m.
RECORDED BY: Josh Coleman

DISTRIBUTION
Josh Coleman
V42 EW File

REVIEWED BY
JC 1/21/87

PARTICIPANTS: Josh Coleman / APEL
(NAME/COMPANY) R. J. Gehm / Rockbestos

SUBJECT: Similarity of second (1LD) and third generation (1LE) coaxial cables RSS-6-113

SUMMARY: I called Mr. Gehm to obtain a better definition of the differences between first, second and third generation Rockbestos RSS-6-113 coaxial cables.

According to Mr. Gehm, the first generation coax was manufactured with a braid angle that was such that during temperature excursions associated with a LOCA simulation, the center conductor would kink and short to the braid.

Mr. Gehm continued to state that the second generation coax incorporated a nuetral braid angle which did not cause center conductor kinking during LOCA simulation.

(Signature)

CONVERSATION MEMORANDUM, Continued

Relative to third generation coax, Mr. Gehm stated that the primary insulation material (dielectric) did not change from that used with the second generation coax. He stated also that a test had recently been performed in which the thermoplastic /LD and /LE layers were completely omitted from the cable. The test results further documented the unimportance of the thermoplastic layers. He stated that a report documenting the results of the test was forthcoming.

Josh D. Coleman
1/21/87