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AUTH.NAME AUTHOR AFFILIATION
HUNTER,R.S. Indiana & Michigan Electric Co.
RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. Office of Nuclear Reactor Regulation, Director

SUBJECT: Updates 820611 response to NRC 810526 safety evaluation &
SA Varga 820503 ltr re equipment qualification.
"see 50-315 for enclosures"
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NEW YORK, N. Y. 10004

November 3, 1982
AEP:NRC:0578H

Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
UPDATE TO EQUIPMENT QUALIFICATION RESPONSE

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denton:

This letter and its Attachments are an update of our submittal No. AEP:NRC:0578B, dated June 11, 1982. That submittal responded to the NRC's Safety Evaluation Report issued on May 26, 1981, and to Mr. Steven A. Varga's letter of May 3, 1982.

A description of the Attachments to this letter follows:

(1) Attachment A. Revised Summary Sheets

Pages CI4-1, -2, -3 (Unit 1), CI6-1, -2, -3 (Unit 2), and CI10-1, -2, -3 (Units 1 and 2) are the qualification summary sheets for Continental Wire Cable, Items #3075 and #3077. In reviewing the operating time qualification for these cables, it was determined that the test report previously quoted for these cables (Ref #33) was not totally adequate, in that the test had lasted for only 22 hours. Since the same cables had also been qualified under Conax Corporation's Test Reports No. IPS-326 and No. IPS - 327 (total test duration 9½ days), we are revising the summary sheets to indicate qualification under the more complete test.
Pages CP9-1, CP9-3, CP11-1 and CP11-3 (Unit 1) and CP11-1 and CP11-3 (Unit 2) reflect newly received information on Kerite Cable, Item #3127.
Page TC10-1 (Unit 1) is being submitted to incorporate minor editorial corrections.

A048

(2) Attachment B. Required Time Qualification Analysis

This attachment constitutes equipment qualification reference packet #63. It replaces Item "R" attached to the

AEP:NRC:0578B submittal. This attachment was revised to include more detail and new information.

(3) Attachment C. Reference List

The list of references has been revised, primarily to account for changes due to the FSAR update.

(4) Attachment D. Upper Compartment Temperature

This attachment replaces Attachment 9 of the AEP:NRC:0578B submittal. This attachment was revised to account for changes due to the FSAR update.

(5) Attachment E. General Notes

This attachment replaces Attachment No. 15 to AEP:NRC:0578. It is being replaced to incorporate changes due to the FSAR update.

A copy of this submittal including all of the attachments is being transmitted to your Consultant, the Franklin Research Center.

This document has been prepared following Corporate Procedures which incorporate a reasonable set of controls to insure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

R. S. Hunter
Vice President

/os

cc: John E. Dolan - Columbus
M. P. Alexich
R. W. Jurgensen
W. G. Smith, Jr. - Bridgman
R. C. Callen
G. Charnoff
Joe Williams, Jr.
NRC Resident Inspector at Cook Plant - Bridgman
C. J. Crane - Franklin Research Center

8211090146

Attachment A to AEP:NRC:0578H
Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Update to AEP:NRC:0578B
Revised Summary Sheets

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: VARIOUS	Operating Time	4 MO.	>4.4 MO	101	63 17, 18	COMBINATION	NONE See Ex/63
PLANT ID NO: VARIOUS	Temperature (^0F)	230	340	107	17, 18 33	SEQ	NONE
COMPONENT: INSTRUMENT CABLE MANUFACTURER: CONTINENTAL	Pressure (PSIA)	26.2	114.7	107	17, 18 33	"	"
MODEL NUMBER: ITEM # 3075	Relative Humidity (%)	100	100	107	17, 18 33	"	"
FUNCTION: VARIOUS ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	NA	2500 ppm boron	NA	17 18	"	NA
SERVICE: VARIOUS	Radiation (10^6 rads)	NA	10	106	33	SEQ	NA
LOCATION: Outside Containment	Aging (years)						
FLOOD LEVEL ELEV: NA ABOVE FLOOD LEVEL: NA	Submergence	NA	Submerged	NA	^	Sequential	NONE

*Documentation References:

Notes:

From Reference #33

FIRL Test Report F-C 2935, excerpt from

Type of Test: Sequential
Gamma Radiation
Steam

0.45 MRad/Hr ; 10.0 MRad
$340^{O}F$; 100 psig ; 2 Hrs.
$160^{O}F$; ; 20 Hrs.

Item #3075, 3077; Continental Wire & Cable Co.

Reference #17 Conax Corporation Test Report IPS-326

Phase I : $250^{o}F$; 12 psig for 1 Hr
Phase II: $190^{o}F$; 12 psig for 201 Hrs
*Submerged during Phase II in 2500 ppm boron solution.

Reference #18 Conax Corporation Test Report IPS-327

Phase I : $340^{o}F$; 12 psig for 1 Hr
Phase II : $250^{o}F$; 12 psig for 5 Hrs
Phase III: $190^{o}F$; 12 psig for 21 Hrs
*Submerged during Phase III in 2500 ppm boron solution.

DONALD C. COOK NUCLEAR PLANT UNIT NO. 2 DOCKET NO. 50-316 LICENSE NO. DPR-74

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS	
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.			
SYSTEM: VARIOUS	Operating. Time	4 Months	74.4 Mths	101	17, 18, 63	Combination	None See Ref. #63	14-16 I5 58-59 I10
PLANT ID NO: VARIOUS	Temperature (^0F)	230	340	107	17, 18, 33	Sequential	None	102-104 I29 106-107 175-178 I4
COMPONENT: INSTRUMENT CABLE MANUFACTURER: CONTINENTAL WIRE AND CABLE CO.	Pressure (PSIA)	26.2	114.7	107	17, 18, 33	"	"	201 S9 204 S9 227-228
MODEL NUMBER: ITEM #3075	Relative Humidity (%)	100	100	107	17, 18, 33	"	"	
FUNCTION: VARIOUS ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	NA	2500 ppm boron	NA	17, 18	"	"	
SERVICE: VARIOUS	Radiation (10^6 rads)	NA	10	NA	33	Sequential	None	
LOCATION: OUT OF CONTAINMENT	Aging (years)							
FLOOD LEVEL ELEV: NA ABOVE FLOOD LEVEL: NA	Submergence	NA	Submerged	NA	17, 18	Sequential	None	

*Documentation References:

Notes:

Form EGQ #97-2

From Reference #33

FIRL Test Report F-C 2935, excerpt from

Type of Test: Sequential :

Gamma Radiation

Steam

0.45 MRad/Hr ; 10.0 MRad

$340^{O}F$; 100 psig ; 2 Hrs.

$160^{O}F$; ; 20 Hrs.

Item #3075, 3077: Continental Wire & Cable Co.

Reference #17 Conax Corporation Test Report IPS-326

Phase I : 250°F ; 12 psig for 1 Hr

Phase II: 190°F ; 12 psig for 201 Hrs

*Submerged during Phase II in 2500 ppm boron solution.

Reference #18 Conax Corporation Test Report IPS-327

Phase I : 340°F ; 12 psig for 1 Hr

Phase II : 250°F ; 12 psig for 5 Hrs

Phase III: 190°F ; 12 psig for 21 Hrs

*Submerged during Phase III in 2500 ppm boron solution.

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS	
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.			
SYSTEM: VARIOUS	Operating Time	4 MO.	>4.4 MO	101	63 17 18	COMBINATION	NONE See Ref 63	25- 73-
PLANT ID NO: VARIOUS	Temperature (°F)	230	340	107	17, 18 33	SEQ	NONE	
COMPONENT: INSTRUMENT CABLE MANUFACTURER: CONTINENTAL	Pressure (PSIA)	26.2	114.7	107	17, 18 33	"	"	
MODEL NUMBER: ITEM #3077	Relative Humidity (%)	100	100	107	17, 18 33	"	"	
FUNCTION: VARIOUS ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	NA	2500 ppm boron	NA	17 18	"	"	
SERVICE: VARIOUS	Radiation (10^6 rads)	NA	10	106	33	SEQ	NA	
LOCATION: Out of Containment	Aging (years)							
FLOOD LEVEL ELEV: NA ABOVE FLOOD LEVEL: NA	Submergence	NA	Submerged	NA	17 18	Sequential	NONE	

*Documentation References:

Notes:

From Reference #33

FIRL Test Report F-C 2935, excerpt from

Type of Test: Sequential
Gamma Radiation
Steam

0.45 MRad/Hr ; 10.0 MRad
340°F ; 100 psig ; 2 Hrs.
160°F ; ; 20 Hrs.

Item #3075, 3077: Continental Wire & Cable Co.

Reference #17 Conax Corporation Test Report IPS-326

Phase I : $250^{o}F$; 12 psig for 1 Hr
Phase II: $190^{o}F$; 12 psig for 201 Hrs
*Submerged during Phase II in 2500 ppm boron solution.

Reference #18 Conax Corporation Test Report IPS-327

Phase I : $340^{o}F$; 12 psig for 1 Hr.
Phase II : $250^{o}F$; 12 psig for 5 Hrs
Phase III: $190^{o}F$; 12 psig for 21 Hrs
*Submerged during Phase III in 2500 ppm boron solution.

DONALD C. COOK NUCLEAR PLANT UNIT NO. 2 DOCKET NO. 50-316 LICENSE NO. DPR-74

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: VARIOUS	Operating Time	4 Months	74.4 Mths	101	17, 18, 63	Combination	None See Ref. #63
PLANT ID NO: VARIOUS	Temperature (°F)	230	340	107	17, 18, 33	Sequential	None
COMPONENT: INSTRUMENT CABLE MANUFACTURER: CONTINENTAL WIRE AND CABLE CO.	Pressure (PSIA)	26.2	114.7	107	17, 18, 33	"	"
MODEL NUMBER: ITEM #3077	Relative Humidity (%)	100	100	107	17, 18, 33	"	"
FUNCTION: VARIOUS ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	NA	2500 ppm boron	NA	17, 18	"	"
SERVICE: VARIOUS	Radiation (10^6 rads)	NA	10	NA	33	Sequential	NA
LOCATION: OUTSIDE CONTAINMENT	Aging (years)						
FLOOD LEVEL ELEV: NA ABOVE FLOOD LEVEL: NA	Submergence	NA	Submerged	NA	17, 18	Sequential	None

13 I5
17-20 S3
76-81 I6, 11, 12
105 I30
173-174 I4
179-180 I4
189-191 I15, 16
192-200 I15, 16
202-203 S9

*Documentation References:

Notes:

FORM EGQ #97-2

From Reference #33

FIRL Test Report F-C 2935, excerpt from

Type of Test: Sequential
Gamma Radiation
Steam

0.45 MRad/Hr ; 10.0 MRad
340^{o}F ; 100 psig ; 2 Hrs.
160^{o}F ; ; 20 Hrs.

Item #3075, 3077: Continental Wire & Cable Co.

Reference #17 Conax Corporation Test Report IPS-326

Phase I : $250^{o}F$; 12 psig for 1 Hr
Phase II: $190^{o}F$; 12 psig for 201 Hrs
*Submerged during Phase II in 2500 ppm boron solution.

Reference #18 Conax Corporation Test Report IPS-327

Phase I : $340^{o}F$; 12 psig for 1 Hr
Phase II : $250^{o}F$; 12 psig for 5 Hrs
Phase III: $190^{o}F$; 12 psig for 21 Hrs
*Submerged during Phase III in 2500 ppm boron solution.

DONALD C. COOK NUCLEAR PLANT UNIT NO. 1 DOCKET NO. 50-315 LICENSE NO. DPR-58

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: Various	Operating Time	14 days	100 day	118	76	SEQUENTIAL	NONE
PLANT ID NO: Various	Temperature (°F)	328.2	340	102	76	"	"
COMPONENT: Power Cable MANUFACTURER: Kerite	Pressure (PSIA)	29.1	113 psig	103	76	"	"
MODEL NUMBER: item # 3116	Relative Humidity (%)	100	100	102 103	76	"	"
FUNCTION: Power Cable ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	2000 ppm B 1.14 wt % B.A. PH 8.5-11	2609 ppm B 1.5 % wt B.A. PH 8.5-11	114	76 72 7	Combination	NONE See Ref # 72
SERVICE: Provide power to valve motors	Radiation (10^6 rads)	81	200	105	76	SEQUENTIAL	NONE.
LOCATION: Inside Containment	Aging (years)						
FLOOD LEVEL ELEV: 614' ABOVE FLOOD LEVEL: No	Submergence	Submerged	Steam + Spray	117	68 76	Eng. Review	NONE See Ref 68 & 76

57-60 V1
82,83 V2
92A V1
111,112 V4
202,203 V1
214 V5
229-231 V9
87-88 V2

*Documentation References:

Notes:

Form EGQ #97-1

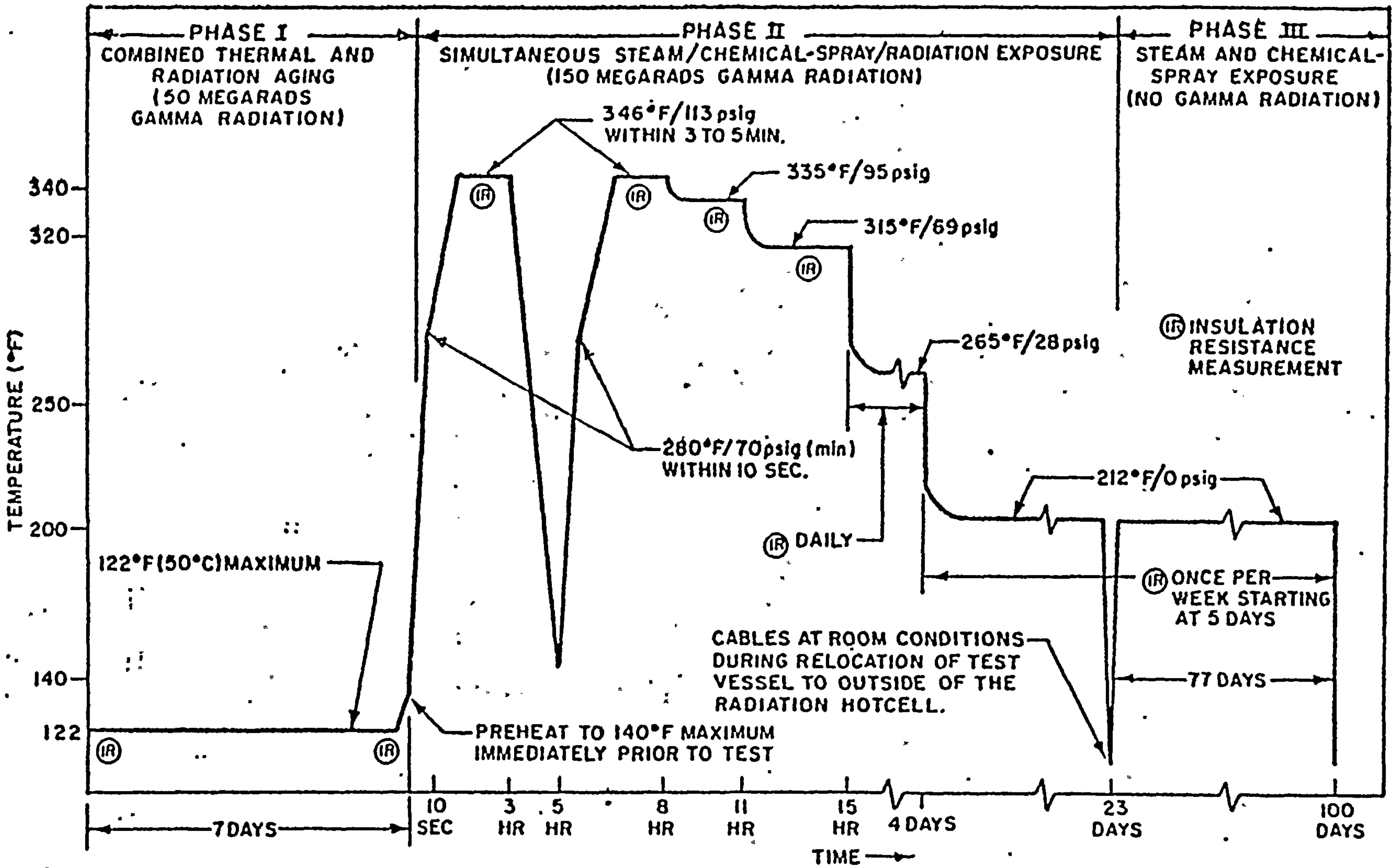


Figure 1. Specified Temperature, Pressure and Radiation Test Profile

PAGE CP9-3
UNIT 1

DONALD C. COOK NUCLEAR PLANT UNIT NO. 1 DOCKET NO. 50-315 LICENSE NO. DPR-58

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: VARIOUS	Operating Time	1 year	>1.1 yr	109	63 76	Combination	NONE See Ref 63 & 76
PLANT ID NO: VARIOUS	Temperature (°F)	328.2	340	102	76	SEQUENTIAL	NONE
COMPONENT: Power Cable MANUFACTURER: KERITE	Pressure (PSIA)	29.1	113 psig	103	76	"	"
MODEL NUMBER: Item # 3127	Relative Humidity (%)	100	100	102 103	76	"	"
FUNCTION: Power cable ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	2000 ppm B 1.14 wt % BA PH 8.5-11	2600 ppm B 1.5 wt % BA PH 8.5-11	114	7 72 76	Combination	NONE See Ref # 72
SERVICE: Provide electric Power to Fan motors	Radiation (10^6 rads)	135	200	105	76	SEQUENTIAL	NONE
LOCATION: Inside Containment	Aging (years)						
FLOOD LEVEL ELEV: 614' ABOVE FLOOD LEVEL: YES	Submergence	NA	NA	NA	NA	NA	NA

113, 114 F1

*Documentation References:

Notes:

Form EQQ #97-1

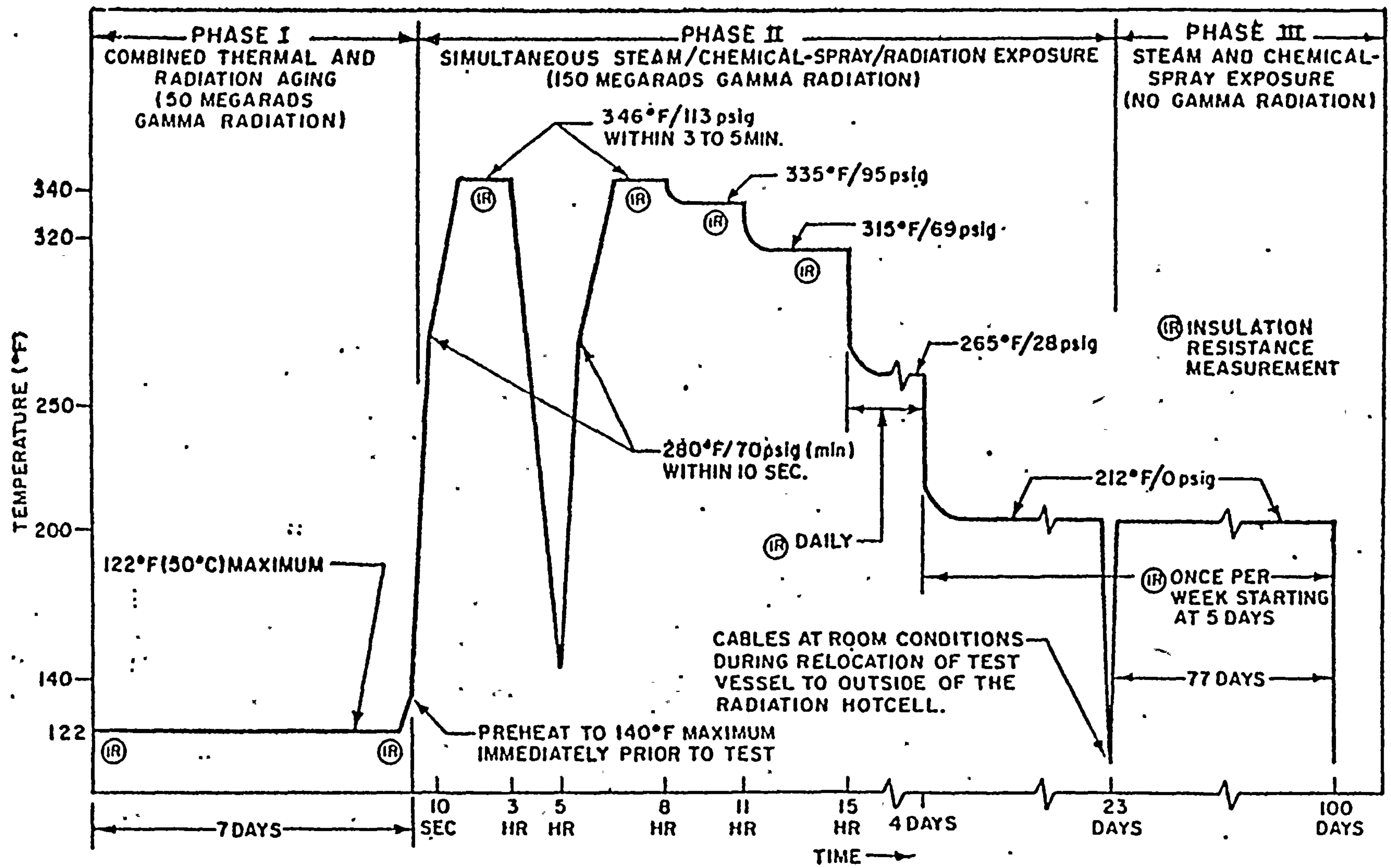


Figure 1. Specified Temperature, Pressure and Radiation Test Profile

DONALD C. COOK NUCLEAR PLANT UNIT NO. 2 DOCKET NO. 50-316 LICENSE NO. DPR-74

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: Various	Operating Time	14 day	100 days	118	76	Sequential	NONE
PLANT ID NO: Various	Temperature (°F)	328.2	340	102	76	"	"
COMPONENT: Power Cable MANUFACTURER: Kerite Co.	Pressure (PSIA)	29.1	113 psig	103	76	"	"
MODEL NUMBER: Item # 3116	Relative Humidity (%)	100	100	102 103	76	"	"
FUNCTION: Power Cable ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	2000 ppm B 1.14 % wt Boric Acid pH 8.5 – 11	2600 ppm B 1.5 % WT Boric Acid pH 8.5 – 11	114	76 7 72	Combination	NONE See Ref # 72
SERVICE: Provide Power to valve motors	Radiation (10^6 rads)	81	200	105	76	Sequential	NONE
LOCATION: In and out of containment	Aging (years)						
FLOOD LEVEL ELEV: 614' ABOVE FLOOD LEVEL: No	Submergence	Submerged	Steam & Spray	117	76 68	Eng. Review	NONE See Ref # 68, 76

85 V2
90 V2
94-95 V2
118, 119 V4
217 V5
229-231 V9
60-63 V1
99A V1
205, 205 V1

*Documentation References:

Notes:

Form EQ #97-2

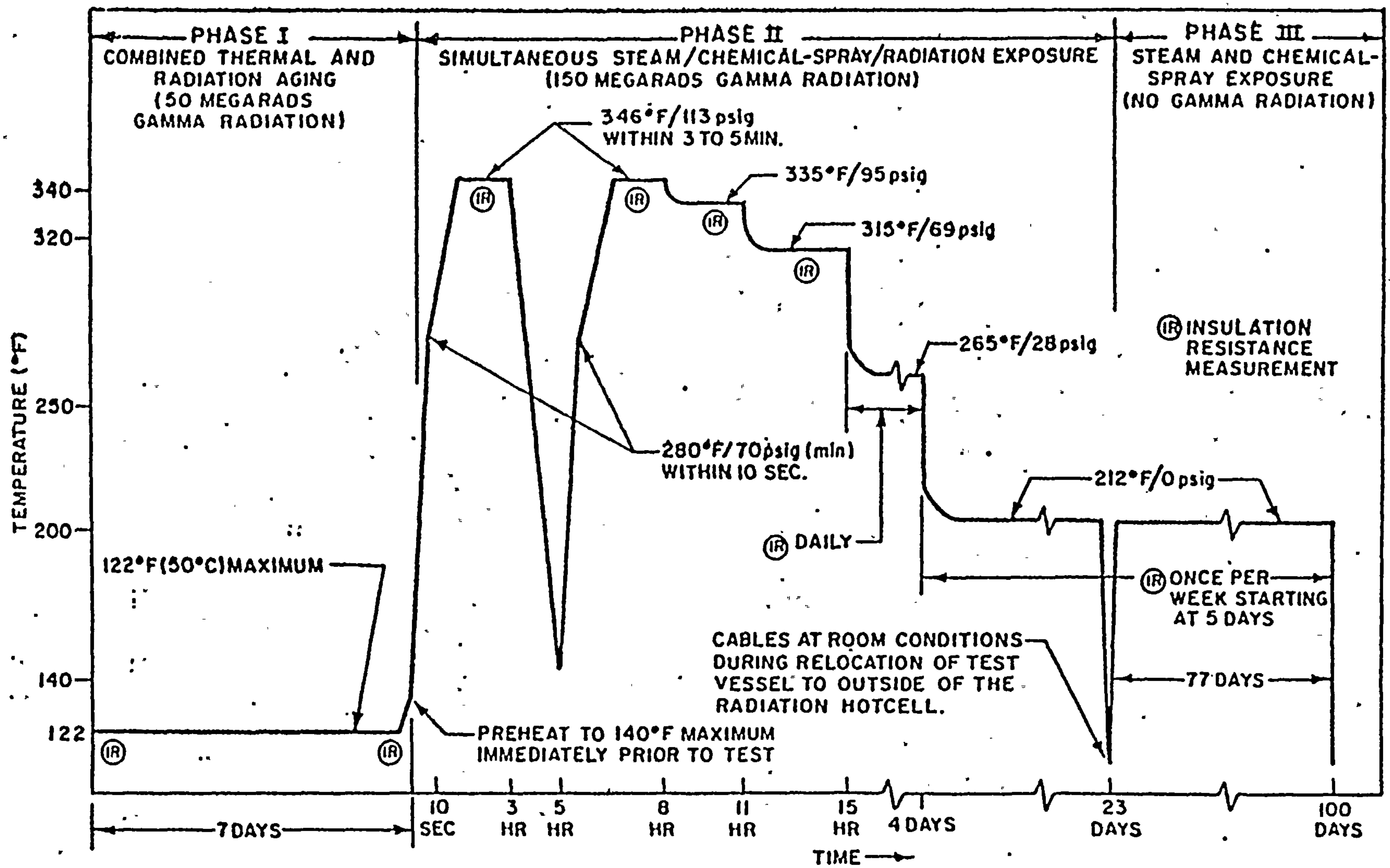


Figure 1. Specified Temperature, Pressure and Radiation Test Profile

F-C4020-2

PAGE CP11-3
UNIT 2

DONALD C. COOK NUCLEAR PLANT UNIT NO. 1 DOCKET NO. 50-315 LICENSE NO. DPR-58

EQUIPMENT DESCRIPTION	ENVIRONMENT			DOCUMENTATION REF.*		QUALIFICATION METHOD	OUTSTANDING ITEMS
	PARAMETER	SPEC.	QUAL.	SPEC.	QUAL.		
SYSTEM: VARIOUS	Operating Time	1 DAY	30 DAY	110	23	Sequential	NONE
PLANT ID No. VARIOUS	Temperature (°F)	230	340	107	23	"	"
COMPONENT: CONTROL CABLE TERMINATION MANUFACTURER: N/A	Pressure (PSIA)	26.2	119.7	107	23	"	"
MODEL NUMBER: VARIOUS	Relative Humidity (%)	100	100	107	23	"	"
FUNCTION: TERM. AT VALVE MOTOR OPERATOR ACCURACY: SPEC: NA DEMON: NA	Chemical Spray	NA	2600 ppm B 1.5 wt % Boric acid PH≥5-11	NA	23 72	COMBINATION	NONE See Ref 72
SERVICE: VARIOUS	Radiation (10^6 rads)	4	204	106	23	Sequential	NONE
LOCATION: OUTSIDE CONTAINMENT	Aging (years)						
FLOOD LEVEL ELEV: NA ABOVE FLOOD LEVEL: NA	Submergence	NA	Submergence	NA	23	Sequential	NA

81-90 V7
101-108 V7

*Documentation References:

Notes:

Attachment B to AEP:NRC:0578H
Donald C. Cook Plant Unit Nos. 1 and 2
Update to AEP:NRC:0578B
Required Time Qualification Analysis

AMERICAN ELECTRIC POWER SERVICE CORPORATION

DATE: August 19, 1982

SUBJECT: Class IE Electrical Equipment in Harsh Environment Required Time Qualification Analysis

FROM: L. F. Caso

TO: NRC IE Bulletin 79-01B Central File

This memorandum addresses the qualified time for electrical devices inside the reactor containment for which the duration of the qualification test was less than the required time during which the device may be called upon to operate following a Design Basis Event (DBE).

The first thing to consider is that the relevant parameters are not the required operation time versus the test duration, but rather the post accident environment profile versus the test profile. What is required is that the equivalent intensity test environment envelops with margin (10%) the required post-accident environment. Figure I, FSAR figure 5.3-10 App.N, and extrapolation to figure 022.9.1 (FSAR Appendix Q), attached, show the D. C. Cook Plant post-accident reactor containment environment. Figure I shows the water temperature following a LOCA accident and flooding of the containment; Figure 022.9.1 shows the air temperature during worst case conditions (steam line break). According to Figure I, equipment flooded after a Loss of Coolant Accident (LOCA) will see an initial temperature of approximately 250°F. Approximately one half-hour later, water temperature will be reduced to 160°F. After ten hours, the water temperature will be reduced to approximately 106.5°F.

Air temperature at 100,000 seconds (approximately 28 hrs.) following a LOCA will be about 148°F and decreasing very rapidly (see FSAR appendix N, figure 5.3-10). SLB temperatures, though initially higher (328°F), decrease more rapidly than LOCA temperatures and therefore represent less of a long term challenge to the operation of the electrical devices. Figure 022.9-1 of Appendix Q to the FSAR shows a temperature decrease to approximately 225°F after one minute, hold there for about 600 sec., then again decrease very rapidly so it will be about 175°F after 1000 sec. (about 17 Min.).

Type tests under which the electrical equipment in

question has been qualified (referenced in the qualification summary sheets) demonstrated the ability of the subject equipment to operate in the abnormal post-accident containment environment. The postulated inside containment environment after 28 hrs. (as discussed above), does not represent a challenge to the electrical devices (cable and cable terminations material) since they are rated at 90°C (194°F). Hydrogen skimmer fan motors and hydrogen recombiners are located in the upper compartment. Upper compartment temperatures after 28 hrs. are about 110°F (see figure 14.3.3.10 and 14.2.5.-9 attached).

Arrhenius analysis done for the D. C. Cook Plant electrical penetrations (see letter of 7/31/81, from C. H. Shih to L. F. Caso) predicts that the electrical penetrations should last indefinitely in the inside containment post-accident environment. Arrhenius analysis were also performed for those electrical cables for which we had Arrhenius plot information. We assumed a forty-year life at 110°F plus a Design Basis Accident (DBA); we further assumed a final ambient temperature of 120°F after the accident. The Arrhenius analysis results are summarized below:

Device #	Component Description	Calculated Life After DBA	Req'd. Oper. Time	Test Duration
CI2	Rockbestos Cable	839 years	NA	30 days
CI3	Samuel Moore Cable	402 years	4 mos.	30 days
CI8	Cerro Wire & Cable	377 years	4 mos.	30 days
CPI2	Cyprus Cable	74 years	3 mos.	20 days
CP5	Anaconda Cable	48 years	1 yr.	13 days

Attachment I hereto lists all the devices for which the required time of operation is longer than the test duration. The component materials for each device have also been listed. Of particular importance in this list regarding the ability of the components to function for the required time of operation are the component materials and the length of qualification tests. Bulletin 79-01B appendix C. table C1 shows that Ethylene Propylene Rubber (EPR) has a potential for significant aging after 10 years. Attachment I shows that the following items use EPR insulation:

Plant Unit	Item	Test Duration	Req'd. Oper. Time	Comments
2	CC-4	9.5 days	14 days	Difference between test duration and required oper. time not significant

Plant Unit	Item	Test Duration	Req'd. Oper. Time	Comments
				considering the margin between the test environment and the DBA environment.
1 2	CI3 CI5	1 month	4 months	Arrhenius analysis yields calculated life after DBA of 402 years.
1,2	CI9	1 month	4 months	Same as CI3
2	CP2	7 days	30 days	Outside containment environment only. Arrhenius Analysis yields calculated life after DBA of 74 years.
1 2	CP3 CP1	7 days	30 days	Outside containment environment only.
2 1	CP4 CP12	20 days	1 year	Arrhenius analysis calculated life after DBA of 74 years.
2 1	CP5 CP13	13 days	1 year	Arrhenius analysis yields a conservatively estimated life after DBA of 48 years.
2	CP7	7 days	30 days	Arrhenius analysis yields calculated life after DBA of 74 years.
2	CP8	130 days	1 year	Outside containment (radiation only environment) qualified for 200 mrads.

Items CP1, CP10, and CP12 appearing in Attachment I

(also with EPR insulation) need not be justified since the test duration for these items was equal to or greater than the required time of operation.

Considering the tests by which these devices have been qualified, the environment in which they will function, and the Arrhenius analysis that have been performed, it is my conclusion that these devices are qualified for their required time of operation.

Attention is hereby called to the two items in Attachment I qualified by very short tests (in one instance, without a test). These items are listed below.

Plant Unit	Item	Test Duration	Req'd. Oper. Time	Comments
2	CI-14	No Test	1 day	Outside containment environment
1,2	TI-10	40 1/2 Hrs.	4 months	Outside containment, No radiation environment

CI-14 is a crosslinked-Polyethylene (XLPE) insulated cable rated for 190°F used outside containment only. The high Energy Line Break (HELB) environment this cable will see (230°F for 15 secs.) probably will not raise the temperature at the surface of the cable up to its rated 190°F. Also, Bulletin 79-01B appendix C, table C1 allows credit to XLPE insulation for 10 Mrads and 40 years of life.

TI-10 was tested for 40 1/2 hours. This test more than demonstrates the ability of the termination to survive the HELB environment outside the reactor containment. Therefore, I conclude that items CI-14 and TI-10 are qualified for their application outside containment.

The Kerite Company does not Divulge the Chemical composition of its cable. For this reason. some discussion on why this cable is qualified for its application inside containment is warranted.

Kerite Company cable, summary sheet # CP-11 (AEP item #3127), was qualified by a 7 1/2 days test. This cable serves the Containment Recirculation Fan (CRF) motor that is required to operate following a LOCA. The LOCA environment at D. C. Cook Plant, as previously discussed, will be 148°F and decreasing

after 28 hours. The cable was qualified for 325°F for 13 hours and 228°F for 7 days. Radiation qualification amounts to 200 Mrads. Clearly, the cable testing time did not last one year. However, the severity of the test was greater than that of the postulated accident environment since after 28 hours ambient temperature will be well below cable temperature rating.

The CRF (Hydrogen skimmer) motors nameplate Full Load Amps (FLA) is 88 amps. The cable 40°C ambient rating in the D. C. Cook installation configuration is 119 amps. This indicates we have ample margin in this application and do not expect to overheat the cable from its load duty. These motors are not operated during start up, normal plant operation, or shutdown conditions. They are operated only during surveillance testing or after an accident. Cable temperatures will therefore be low, i.e., mild aging conditions.

The remainder of the devices in Attachment I are comprised of materials with good aging characteristics and have been tested for a sufficient length of time (by comparison with the D. C. Cook past-DBA environment profile. Therefore, the general arguments initially developed in this review memo can be readily applied to them.

Considering the information included in the qualification summary sheets, where the post-accident environment for the devices in Attachment I (except as noted) are presented, the Arrhenius analysis performed for some of these devices, and the engineering review performed herein, I conclude that these devices are qualified to operate in their locations after an accident for the required length of time.

L. F. Caso

LFC:mb

Approved

J. M. Intrabartola

Attachments

1. List of equipment for which the Test Duration was less than the Required Time of Operation.

2. Figure I. Water temperature inside D. C. Cook Nuclear Plant Post-Accident Reactor Containment

3. Figure 14.2.5.-9, FSAR — Compartment Temparature.

4. Figure 14.3.4.10, FSAR — Design Basis Accident Long Term Temperature Transient.

5. Electrical Penetrations Arrhenius Analysis. Letter of 7/31/81 from C. H. Shih to L. F. Caso.

6. Electrical Cable Arrhenius Analysis.

   A. Letter of 9/23/81 from E. A. Howard/R. M. Hayes to L. F. Caso.

   B. Letter of 10/5/81 from L. F. Caso to E. A. Howard.

   C. Letter of 10/8/81 from E. A. Howard/R. M. Hayes to L. F. Caso.

7. Input Information for the Performance of the Arrhenius Analysis in Item 6 above:

   A. Letter of 8/5/81, L. F. Caso to C. H. Shih.

   B. Letter of 8/7/81, L. F. Caso to C. H. Shih.

   C. Letter of 8/27/81, L. F. Caso to R. M. Hayes.

8. Raychem Corporation Heat Aging Study of WCSF Compound. Report #EDR-2001 of 8/10/78.

9. Kerite Cable

   A. Memo of September 28, 1982 from L. F. Caso to 79-01B Central File

   B. Letter of September 21, 1982 from N. H. Dube to T. J. Massar.

Attachment I

Ref #63

List of equipment for which the test duration was less than the required time of operation after an accident.

Equipment Description (item #)	Component material	Arrhenius Info Avail.	EQ Test Ref #	Plant Units (Ref 63)	Test Duration	Req. Oper. Time
CC1 Continental (3119)	XLPE/Asbestos		8	1,2	116 hrs (5 days)	14 days
CC2 " (3120)	"		8	2	"	14 "
CC3 General Electric (3120)	"		8	2	"	14 "
CC4 Anaconda (3120)	EP/CSPE/CSPE		5	2	9½ days	14 "
CC5 Continental (3121)	XLPE/Asbestos		8	1,2	116 hrs	14 "
CC6 GE (3121)	"		8	1,2	"	14 "
CC7 Continental (3122)	"		8	1	"	14 "
CC8 GE (3122)	"		8	1	"	14 "
CI2 Rockbestos (3064)	XLPE/CSPE	✓	34	NA	30 days	5 secs
CI3 Samuel Moore (3075)	EPDM/CSPE	✓	10	1, CI5 Unit 2	30 days	4 months
CI4 Continental (3075)	XLPE/CSPE		17,18	1, CI6 Unit 2	229 hrs (9½ days)	4 "
CI5 BIW (3075)	CSPE/CSPE		8	1, CI7 Unit 2	116 hrs	4 "
CI8 Cerro (3077)	XLPE/CSPE	✓	12	1,2	30 days	4 "
CI9 Samuel Moore (3077)	EPDM/CSPE	✓	10	1,2	30 days	4 "

Equipment Description (item #)	Component Materials	Generic Info. Avail	EQ Test Ref #	Plant Units (Ref 63)	TEST Duration	Req Oper Time
CI10 Continental (3077)	XLPE /CSPE		17, 18	1, 2	229 hrs (9½ days)	4 months
CI11 BIW (3077)	CSPE/CSPE		8	2	116 hrs	4 "
CI14 Continental (3069)	XLPE type SISX-12		65	2	—	1 day
CP1 Okonite (324)	EPR/Neoprene (okonite/okoprene)	✓	49	1 (NA)	130 days	1 month
CP2 Cyprus (324)	EPR/Neoprene		40	2	168 hrs	1 month
CP3 Essex (324)	EPR/Neoprene		65	1, CP1 Unit 2	7 days	1 month
CP4 Cyprus (347)	EPR /CSPE	✓	35	2, CP12 Unit 1	20 days	1 year
CP5 Anaconda (347)	EP/CSPE		5	2, CP13 Unit 1	13 days	1 year
CP6 Okonite (399)	silicone rubber/asbestos (okotherm/asbestos)		6	2	152 days	3 months
CP7 Cyprus (3102)	EPR/CSPE	✓	41	2 same as CP4	168 hrs	1 month
CP8 Okonite (3102)	EP/CSPE (okoguard/okolon)	✓	37	2, CP6 Unit 1 (NA)	130 days	1 year
CP10 Anaconda (3103)	EPR/CSPE		36	1, CP13 Unit 2	30 days	1 month

Equipment Description (item #)	Component Materials	Arrhenius Info. Avail.	EQ Test Ref#	Plant Units (Ref 63)	Test Duration	R[illegible] Oper. Time
CP11 Kerite (3127)	HTK/FR		7	1	7½ days	1 year
CP11 Kerite (3116)	"		7	2	"	14 days
CP12 Anaconda (3102)	EP/CSPE		36	2, CPS unit 1	30 days	1 month
F1 Westinghouse Fan motor	See class F Insulation mat list		21	1,2	190 hrs	1 year
H1 Westingh. Hydrogen Recombiner	See material List		20	1,2	80 cycles of heatup and cooldown plus 87 hrs of LOCA test plus 200 mrad	3 months
M1 Westingh. Pump motors	See class F Insul. mat. list		21	1,2	190 hrs	1 year
TC6 Splice in Floodup tubes (control)	See material List		13	1,2	116 hrs	14 days
TC7 Splice in Floodup boxes (control)	"		8	1,2	116 hrs	14 days
TC8 Splice in Term. boxes (control)	"		8	1,2	"	14 days
TI1 Barton Instr. Conn.	"		62	1,2	116 hrs minimum	4 months
TI2 RTD Instr. Conn	"		62	1,2	"	4 months

Equipment Description	Component materials	A[illegible]ivs Information Avail.	Plant Units (Ref 63)	EQ Test Ref.	Test Duration	Re[illegible] Opr Time
TI3 Splice in Floodup tubes (Instrument)	See material List		1,2	62	116 hrs minimum	4 months
TI4 Splice in Floodup boxes (Instr.)	"		1,2	62	"	4 months
TI9 Same as TI1						
TI10 Foxboro Instr. connections	See material List		1,2	62	40½ hrs	4 month
TP1 Splice in Floodup tubes (power)	"		1,2	13	116 hrs	1 yr
TP2 Splice in Floodup boxes (power)	"		1,2	13	"	1 yr
TP3 Terminations at motors & Hydr. Recomb.	"		1,2	13	"	1 yr
TP4 Terminations at Pump motors	"		1,2	13	"	1 yr

Component materials listing for Westinghouse class F motor insulation; Westinghouse Hydrogen Recombiners; power, control, and instrument cable splices; power cable termination at motors and Hydrogen Recombiners.

1. <u>Class F motor Insulation Materials</u>:

a. magnet wire insulation: Heavy film and single dacron glass

b. Coil ground insulation: Nomex, Mica

c. Tape wrapper : Glass tape outer type

d. Resin : Epoxy, vacuum pressure impregnated.

e. Leads : Hypalon

2. <u>Hydrogen Recombiners</u>

300-series stainless steel
carbon steel
Inconel-600
Incoloy-800 sheath
magnesium oxide insulation (sheathed in Incoloy 800

3. <u>Power cable splices</u>

a. cable insulation and jacket material has already been identified in the table

b. Splicing material is Raychem WCSF compound. See Raychem Heat Aging Study EDR-2001.

4. <u>Control cable splices</u>

Same as 3a and 3b above

5. <u>Instrument cable splices</u>

a. same as 3a above

b. Same as 3b above

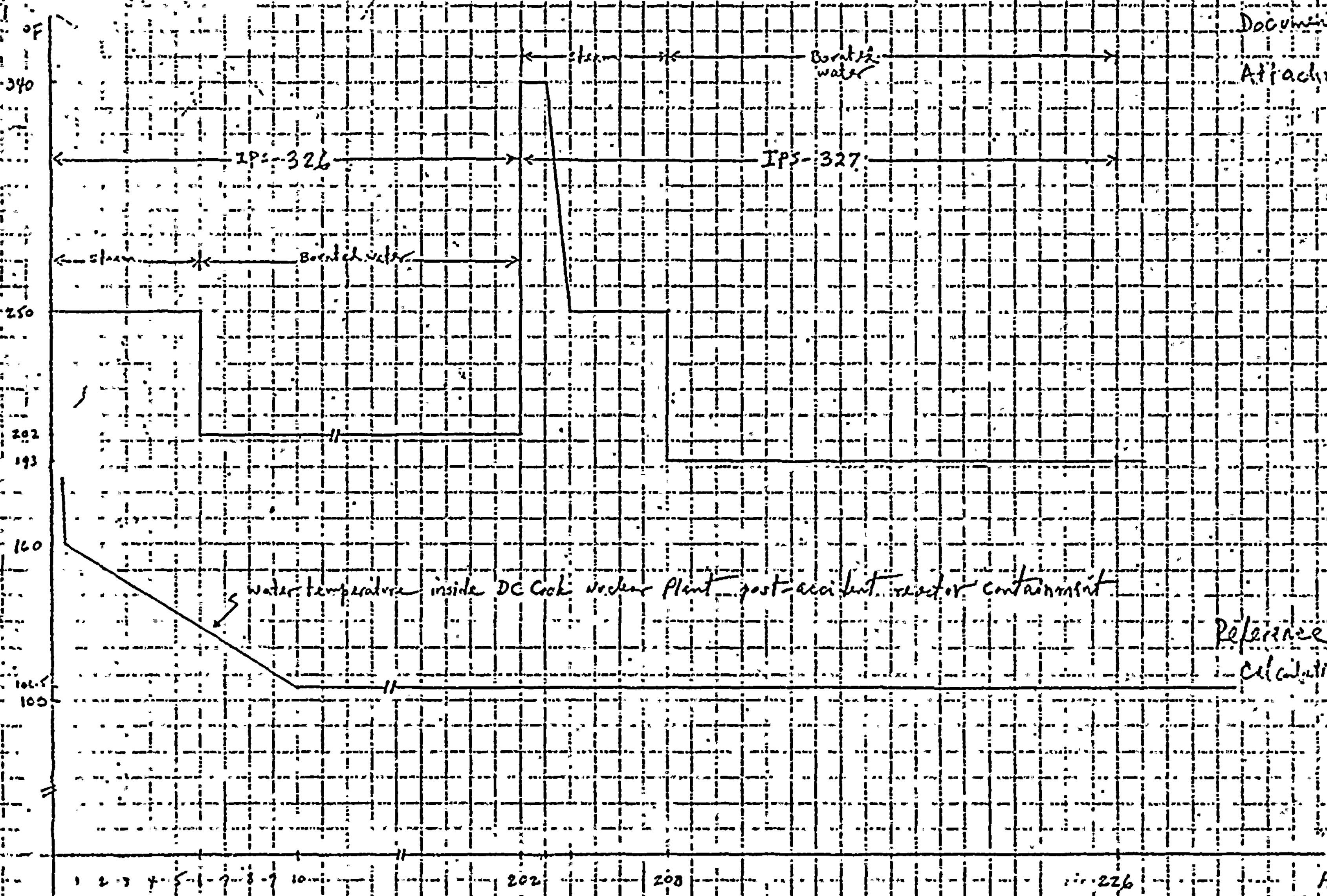
c. Chemelex RTVW sealant

6. <u>Power cable terminations at motors and Hydrogen Recombiners</u>

a. Same as 3a above

b. Scotch #23 tape or Bishop W732 tape

Document U# 63
Attachment # 2



Reference: NS&L
Calculation # OA-81-05

FIGURE I

Document Ref #63
Attachment 3

As of the time of this update (July, 1982), no figure for the 4.6 ft^2 break is available. It is expected to include such figure in a future update. However, as Table 14.2.5-4 indicates, the differences between the 1.4 ft^2 and the 4.6 ft^2 breaks results are small.

MAIN STEAM LINE BREAK
DONALD C. COOK NUCLEAR PLANT FSAR

13370-1

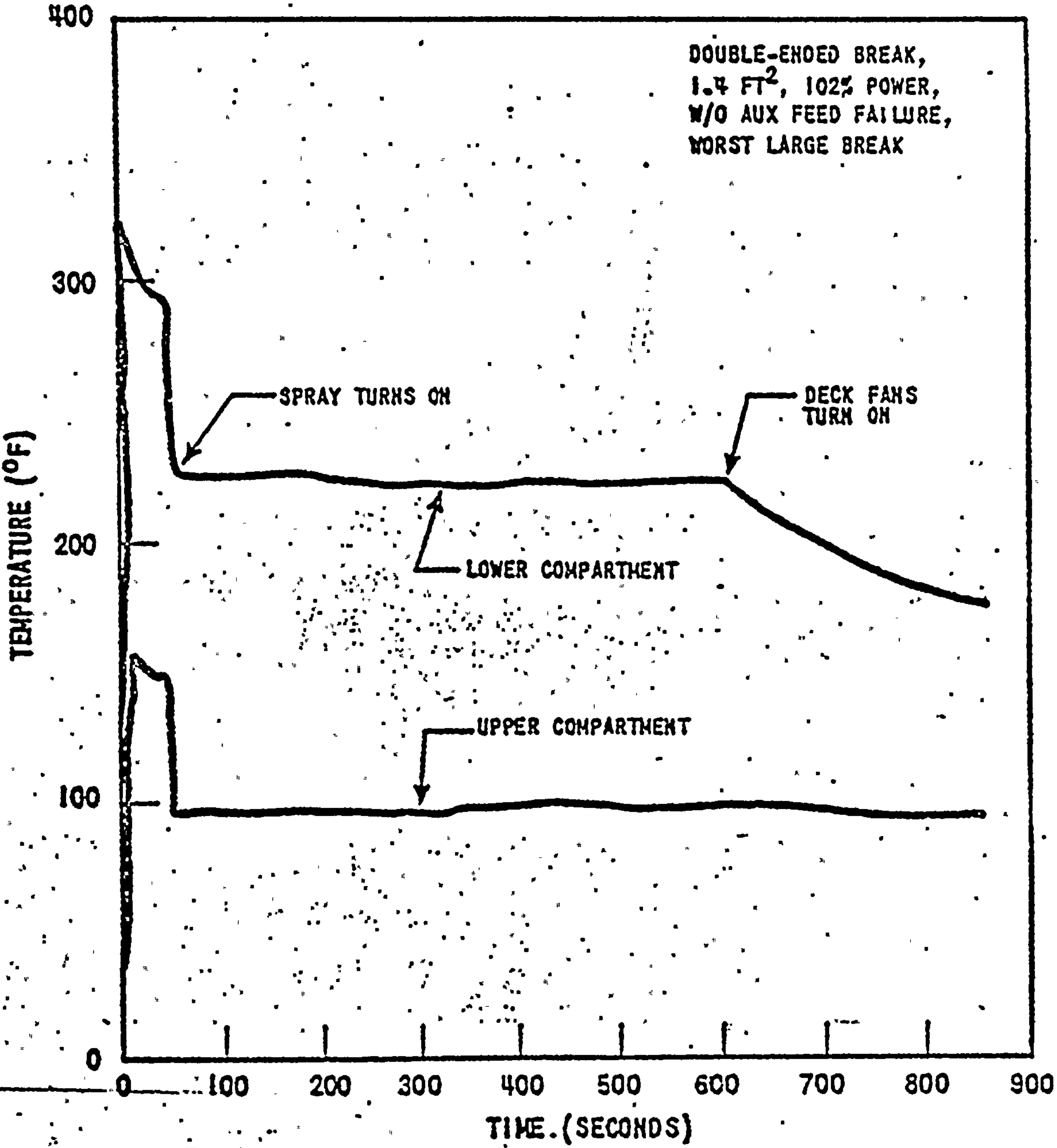


Figure 14.2.5-9 Compartment Temperature

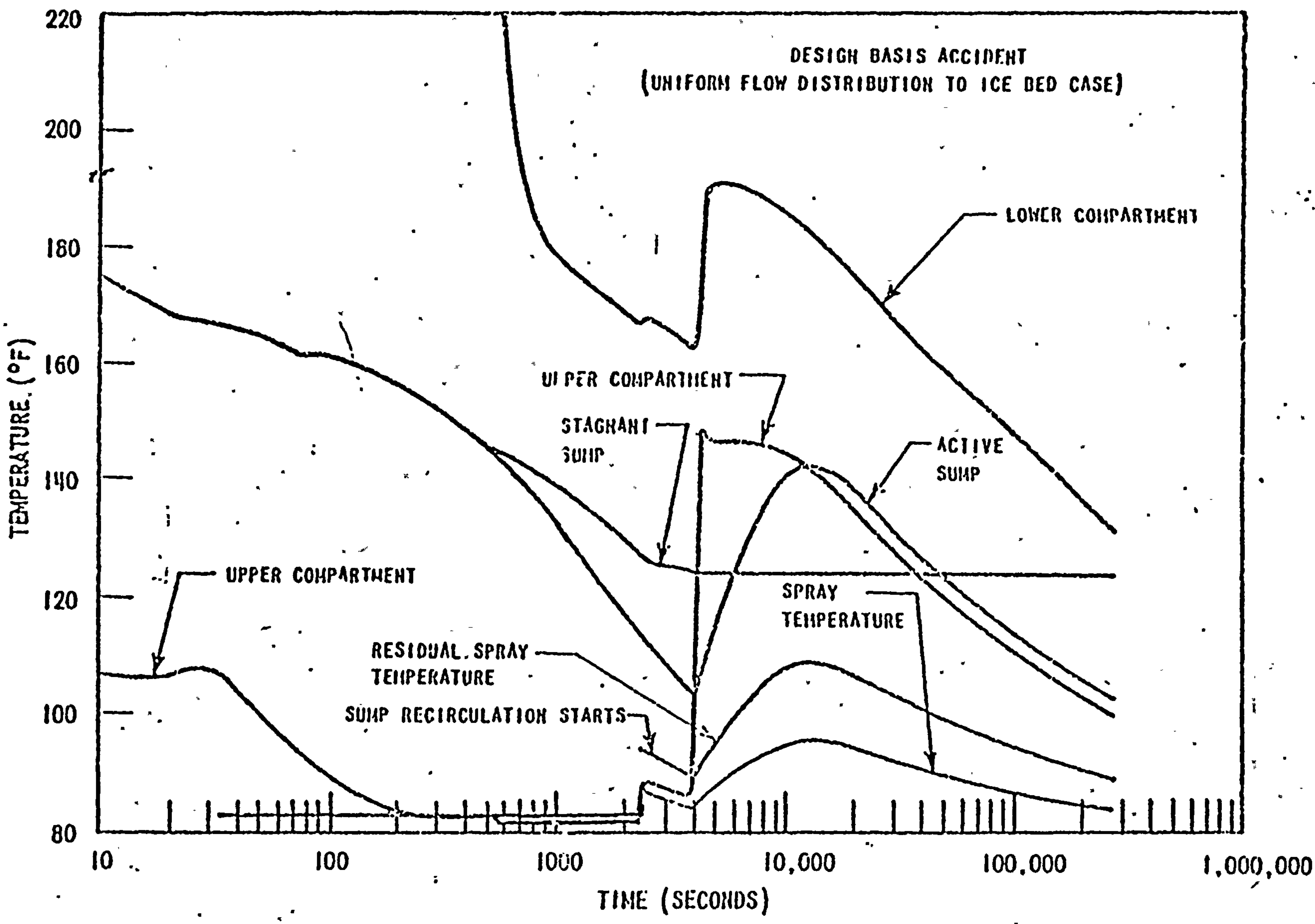


Figure 14.3.4.10 Design Basis Accident Long Term Temperature Transient

Document Ref #63
Attachment 4

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

DATE: July 31, 1981

SUBJECT: Electrical Penetrations

Document Ref # 63
Attachment # 5

FROM: C. H. Shih

TO: L. F. Caso

According to the Arrhenius equation described in your letter to me dated July 17, 1981, C. W. Yi has estimated the life time equivalence. His memo is attached. It contains a detailed analysis, using both the Arrhenius equation and the so-called "10 degree C" rule. As one can see, both predicted long life times. The 1.1 year time required is well exceeded. A few observations are made as follows:

1. The 10°C rule is far more conservative than the Arrhenius prediction. Using the coefficient of 19718, one would find that at around 1000°F, the life time is halved for every 10°C increase of temperature. It can be shown that below such a temperature level, the Arrhenius equation gives a much longer equivalent life.

2. The long life (10^{18} hours) predicted by the Arrhenius equation does not have any practical significance. The result simply means that the material should last indefinitely at 106.5°F. This is not a surprise because this post accident temperature is not a high temperature (only about 40 F above room temperature). Even ordinary material should not "fail" at this temperature.

3. The Arrhenius equation itself predicts a longer time, 3×10^{19} hours. Since the IPS-326 and 327 tests were not performed till the material failed, the two tests did give a relatively shorter life time equivalence, 2×10^{18} hours. The life time equation is expressed in logarithm. It is supersensitive to temperature. As the equation shows that at 340°F, the material would last less than one day. On the other hand, at room temperature 68°F, it would last 10^{24} hours.

Chin has the detailed computer printout and is familiar with the computational procedure. Should you need more help, please call him or me.

Dan Shih
C. H. Shih

CHS:jll

Attachment

cc: S. H. Horowitz w/attachment
B. J. Ware "
C. W. Yi "
T. E. King "

AMERICAN ELECTRIC POWER SERVICE CORPORATION AEP

DATE: July 30, 1981

SUBJECT: Equivalent Age Calculations of
D. C. Cook Plant Electrical Penetrations

FROM: C. W. Yi

TO: C. H. Shih

In response to L. F. Caso's memos of July 16 and 17, 1981, the equivalent age of the D. C. Cook Plant electrical penetrations is calculated based on the given Arrhenius equation and the temperature profiles of IPS-326 and IPS-327 tests and of reactor containment during the post-accident period.

From the mathematical viewpoint, if a certain test is conducted at temperature T_1 and the material fails after L_1 hours, then the equivalent life at reference temperature T_{ref} can be derived as follows:

If $L = 10^{(B/T-C)}$ is given, then

$$L_{ref} = L_1 10^{B(1/T_{ref} - 1/T_1)}$$

where L = expected life in hours

B, C = constants, 19718 and 43.208 respectively

T = absolute temperature in ^{o}Kelvin

Thus, if the test is conducted for Δt_1 hours, the equivalent age at reference temperature will be:

$$\text{Equi. Age} = \Delta t_1 \ 10^{B(1/T_{ref} - 1/T_1)}$$

$$\text{Total Equi. Age} = \sum_{i=1}^{n} \Delta t_i \ 10^{B(1/T_{ref} - 1/T_i)}$$

With the given temperature profiles of IPS-326 and IPS-327 tests, then the equivalent ages of the subject material at 106.5^{o}F are as follows:

Test	Duration	Total Equivalent Age
IPS-326	202 hours	2.92×10^{13} hours (3.33×10^{9} years)
IPS-327	24 hours	2.08×10^{18} hours (2.37×10^{14} years)
Combined	226 hours	2.08×10^{18} hours (2.37×10^{14} years)

To illustrate the validity of above calculations, let's consider the test lasted for one hour at 340°F as indicated at the beginning of IPS-327 test:

Expected life at 340°F (444.1°K) = 15.56 hours

$$\frac{\text{Age of one hour}}{\text{Expected life}} = \frac{1}{15.56} = .0643$$

and, the equivalent age at 106.5°F (314.4°K) = 2.07×10^{18} hours.

Expected life at 106.5°F = 3.22×10^{19} hours

$$\frac{\text{Equivalent age}}{\text{Expected life}} = \frac{2.07 \times 10^{18}}{3.22 \times 10^{19}} = .0643$$

Thus, both calculations show agreement although the total equivalent ages at 106.5°F for both tests are astronomical. Furthermore, it can be shown that the contribution in aging by the one hour exposure at 340°F is dominant as shown below:

$$\frac{\text{Equivalent age at 106.5°F for 1 hour test at 340°F}}{\text{Total equivalent age from IPS-327 test}}$$

$$= \frac{2.07 \times 10^{18}}{2.08 \times 10^{18}} = .995$$

To examine the case further, a widely used 10°C rule is applied to calculate the equivalent ages--that is, for every increase of 10°C, the life of material is halved. The results are shown below:

Test	Duration	Total Equivalent Age at 106.5 F $\left(\sum_{i=1}^{n} \Delta t_i \, 2^{(T_i - T_{ref})/10}\right)$
IPS-326	202 hours	9190 hours (1.05 years)
IPS-327	24 hours	10910 hours (1.25 years)
Combined	226 hours	20100 hours (2.29 years)

Also, the equivalent age for the one hour exposure at 340°F = 8020 hours

$$\frac{\text{Equivalent age at 106.5°F}}{\text{Total equivalent age from IPS-327 test}} = \frac{8020}{10910} = .735$$

Again, the age contribution by the one hour exposure at 340°F to the total equivalent age at 106.5°F is dominant as shown above. Although the 10°C rule is not equivalent to the Arrhenius equation, it can be a good approximation to it over a limited temperature range.

As a conclusion, the equivalent age of the electrical penetrations exceeds well beyond 1.1 year criteria based on the Arrhenius method with the given temperature profile information of IPS-326 and IPS-327 tests.

If you have questions, please let me know.

C. W. Yi

CWY:jll

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

Document Ref #63
Attachment 6a

DATE: September 23, 1981

SUBJECT: Arrhenius Analysis

FROM: E. A. Howard/R. M. Hayes

TO: L. F. Caso

Enclosed is a revised list of the devices and their calculated lives at T_{set} = 120 degrees Fahrenheit. Listed are those numbers which produced the shortest life at the LOCA Profile given.

Also enclosed are printouts of all LOCA and Test Profiles used. Figures 1 and 2 are examples of how two of the six LOCA Profiles were reached and the other four were done in the same manner. Test Profile data came from previously given data from your office. These data files are similarly created and stored on the computer. The ARAN program used to do the calculations and an explanation of it should already be in your possession.

If you need further information or more detailed documentation, please contact me in Columbus at extension 1054.

T_{set} = Final steady state temperature after an accident.

Pre-aged at 110°F for 40 yrs.

E. A. Howard

E. A. Howard

R. M. Hayes

R. M. Hayes

EAH/RMH:jll

Attachments

cc: C. H. Shih
C. Yi

Data #	Coefficient B	Test Profile	LOCA Profile	Calculated Life After LOCA at 120°F (Hours)
1	6693	CI2.2	L22.9.2L	7,332,922
2	6264	CI8-2	L22.9.2L	3,302,725
3	6000*	CI1.2	L13.1L	122,033
4	6000*	CI3.2	L22.9.2L	759,115
5	6000*	CI4.2	L22.9.2L	101,397
6	6000*	CI5.2	L22.9.2L	364,223
7	5747	CP1.2	L13.1L	1,900,142
8	6000*	CI3.3	L22.9.2L	1,259,497
9	6000*	CP11.2	L22.9.2L	960,151
10	6000*	CP13.2	L22.9.2L	734,562
11	6000*	CP4.3	L22.9.2L	2,014,603
12	6000*	CP4.2	L22.9.2L	188,394
13	6000*	TI1.2	L22.9.2L	354,138
14	6000*	TI1.5	L22.9.2L	3,010,520
15	6000*	CP10	L22.9.2L	1,427,614
16	6000*	F1.2	L22.9.2L	1,723,308
17	6000*	H1.2	L22.9.2L	69,465
18	6000*	TI5.2	L22.9.2L	84,226
19	6000*	TP1.2	L22.9.2L	293,062

*: 6000 used as an assumed B

Test Profile	=>	Equivalencies
CI2.2	=>	CI2-2; CI8-2; TI1-8; TI2-8; TI4-8
CI1.2	=>	CI1-2
CI3.2	=>	CI3-2; CI9-2; TI1-6; TI2-6; TI4-6
CI4.2	=>	CI4-2; CI10-2
CI5.2	=>	CI5-2
CP1.2	=>	CP1-2; CP2-2; CP6-2
CI3.3	=>	CI3-3; CI9-3; TI1-7; TI2-7; TI4-7
CP11.2	=>	CP11-2
CP13.2	=>	CP13-2
CP4.3	=>	CP4-3
CP4.2	=>	CP4-2
TI1.2	=>	TI5-3,4; TI1-2,3,4; TI2-2,3,4; TI4-2,3,4
TI1.5	=>	TI1-5; TI1-9; TI2-5; TI2-9; TI4-5; TI4-9
CP10	=>	CP10
F1.2	=>	F1-2
H1.2	=>	H1-2
TI5.2	=>	TI5-2; TI-10 (LFC, C/U/R)
TP1.2	=>	TP1-2; TI3-2; TP2-3; TP3-1

```
LIS L22.9.1U

L22.9.1U    08:45EDT    09/22/81
```

LOCA Profile L22.9.1U

```
100 4
105 316.33,350400
110 311,.00361
120 339,.00972
130 311,.209
140 321.89
```

$T_A \rightarrow T_{set}$ in °K

Format:
100 # of data pts.
105 T_A, Δt_A
110 T_1, Δt_1
120 T_2, Δt_2
130 T_3, Δt_3
140 T_{SET}

100 4
105 110°F, 40 yrs
110 100°F, 13 sec
120 151°F, 35 sec
130 100°F, 750 sec
140 120°F

```
READY
```

$\Delta t_A \rightarrow \Delta t_3$ in hrs

```
LIS L22.9.1L

L22.9.1L    08:46EDT    09/22/81
```

LOCA Profile L22.9.1L

```
100 5
105 316.33,350400
106 421.89,.0075
110 405,.00583
120 380,.155
130 [illegible],.2167
140 321.89
```

$T_A \rightarrow T_{set}$ in °K

Format:
100 # of data pts
105 T_A, Δt_A
106 T_1, Δt_1
110 T_2, Δt_2
120 T_3, Δt_3
130 T_4, Δt_4
140 T_{SET}

100 5
105 110°F, 40 yrs
106 300°F, 27 sec
110 270°F, 21 sec
120 226°F, 550 sec
130 151°F, 888.12 sec
140 120°F

See Figure 1 to know where we got these numbers

```
READY
```

$\Delta t_A \rightarrow \Delta t_4$ in hrs

```
LIS L22.9.2U

L22.9.2U    08:46EDT    09/22/81
```

LOCA Profile L22.9.2U

```
100 4
105 316.33,350400
110 [illegible],.0167
120 309,.15
130 303,.1111
140 321.89
```

$T_A \rightarrow T_{SET}$ in °K

Format:
100 # of data pts
105 T_A, Δt_A
110 T_1, Δt_1
120 T_2, Δt_2
130 T_3, Δt_3
140 T_{SET}

100 4
105 110°F, 40 yrs
110 148°F, 60 sec
120 96°F, 540 sec
130 86°F, 400 sec
140 120°F

```
READY
```

$\Delta t_A \rightarrow \Delta t_3$ in hrs.

```
LIS L22.9.2L
```

LOCA Profile L22.9.2L

```
L22.9.2L    08:46EDT    09/22/81

100 4
105 316.33,350400
110 439,.0167
120 381,.15
130 [illegible],.3055
140 321.89
```

$T_A \rightarrow T_{SET}$ in °K

Format:
100 # of data pts.
105 T_A, Δt_A
110 T_1, Δt_1
120 T_2, Δt_2
130 T_3, Δt_3
140 T_{SET}

100 4
105 110°F, 40 yrs.
110 330°F, 60 sec
120 226°F, 540 sec
130 151°F, 1100 sec
140 120°F

```
READY
```

$\Delta t_A \rightarrow \Delta t_3$ in hrs.

```
LIS L13.1U

L13.1U      08:46EDT      09/22/81

100 6
105 316.33,350400
110 307,.00025
120 324,.0025
130 326,.0055
140 316,.019444
150 301,.25
160 321.39
```

$T_A \rightarrow T_{SET}$ in °K
$\Delta t_A \rightarrow \Delta t_5$ in hrs.

```
READY
LIS L13.1L
```

LOCA Profile L13.1U

Format

100 # of data points
105 T_A, Δt_A
110 T_1, Δt_1
120 T_2, Δt_2
130 T_3, Δt_3
140 T_4, Δt_4
150 T_5, Δt_5
160 T_{SET}

⇐

100 6
105 110°F, 40 yrs
110 93.2°F, .9 sec
120 123.8°F, 9 sec
130 127.4°F, 20 sec
140 109.4°F, 70 sec
150 82.4°F, 900 sec
160 120°F

See Figure to know where we got these numbers

```
L13.1L      08:47EDT      09/22/81

100 3
105 316.33,350400
110 327,.0033
120 342,.822
130 321.39
140
```

$T_A \rightarrow T_{SET}$ in °K
$\Delta t_A \rightarrow \Delta t_2$ in hrs

```
READY
```

LOCA Profile L13.1L

Format

100 # of data points
105 T_A, Δt_A
110 T_1, Δt_1
120 T_2, Δt_2
130 T_{SET}

⇐

100 3
105 110°F, 40 yrs
110 237.2°F, 30 sec
120 156.2°F, 2960 sec
130 120°F

LOCA Profile #	Graph from which data was obtained	Enclosed
L22.9.1U	Figure 022.9.1 Comp. Temp (Upper Comp.)	
L22.9.1L	Figure 022.9.1 Comp. Temp (Lower Comp.)	→ Figure 1
L22.9.2U	Figure 022.9.2 Comp. Temp (Upper Comp.)	detai[led] exam[ple]
L22.9.2L	Figure 022.9.2 Comp. Temp (Lower Comp.)	
L13.1U	Figure 13.13-1 (Upper Comp.)	→ Figure 2
L13.1L	Figure 13.13-1 (Lower Comp.)	

```
LIS CP13.2

CP13.2        14:30EDT     09/24/81

100 4
110 444,3
120 433,3
130 394,06
140 372,216

READY
LIS CI3.3
```

Test Profile CP13.2

General Test Profile format:

100 # of data points = N
110 T_1, Δt_1
120 T_2, Δt_2
130 T_3, Δt_3
T_N, Δt_N

$T_1 \rightarrow T_N$ in °K
$\Delta t_1 \rightarrow \Delta t_N$ in hrs

```
CI3.3         14:30EDT     09/24/81

100 8
110 444,3
120 416,1
130 361,1
140 444,3
150 433,3
160 422,4
170 394,81
180 366,624

READY
LIS CP1.2
```

Test Profile CI3.3

```
CP1.2         14:31EDT     09/24/81

100 8
110 447,3
120 419,1
130 362,1
140 447,3
150 441,3
160 430,1
170 402,81
180 373,5024

READY
LIS CI2.2
```

Test Profile CP1.2

```
CI2.2         14:31EDT     09/24/81

100  8
110  447,3
120  419,1
130  362,1
140  447,3
150  441,3
160  430,4
170  402,81
180  373,624

READY
```

Test Profile CI2.2

```
DIS CP10

CP10            14:17EDT     09/24/81
```

Test Profile CP10

```
100 3
110 447,5
120 402,96
130 375,624

READY
DIS F1.2

F1.2            14:17EDT     09/24/81
```

Test Profile F1.2

```
100 2
110 433,24
120 394,168

READY
DIS H1.2

H1.2            14:18EDT     09/24/81
```

Test Profile H1.2

```
100 3
110 427,4
120 399,20
130 382,1

READY
DIS TI5.2

TI5.2           14:18EDT     09/24/81
```

Test Profile TI5.2

```
100 3
110 433,3333
120 377,132
130 405,24

READY
DIS TP5.2
File not saved

READY
DIS TP1.2
```

Test Profile TP1.2

```
TP1.2           14:19EDT     09/24/81

100 3
110 394,113
120 412,1
130 422,1

READY
```

```
LIS CI1.2

CI1.2          14:32EDT     09/24/81        Test Profile CI1.2

100 2
110 416,12
120 377,168

READY
LIS CI3.2

CI3.2          14:32EDT     09/24/81        Test Profile CI3.2

100 4
110 444,3
120 455,3
130 394,90
140 366,624

READY
LIS CI4.2

CI4.2          14:33EDT     09/24/81        Test Profile CI4.2

100 2
110 444,2
120 344,20

READY
LIS CI5.2

CI5.2          14:33EDT     09/24/81        Test Profile CI5.2

100 3
110 447,1
120 397,9
130 396,109

READY
BYE
00011.70  CRU    0000.29  TCH     0004.73  KC
OFF AT 14:33EDT 09/24/81
```

```
DIS CP4.3

CP4.3          14:19EDT     09/24/81
```

Test Profile CP4.3

```
100 8
110 447,3
120 419,81
130 362,1
140 447,3
150 441,3
160 430,4
170 402,81
180 373,648


READY
DIS CP4.2

CP4.2          14:20EDT     09/24/81
```

Test Profile CP4.2

```
100 5
110 394,12
120 334,6
130 386,18
140 389,120
150 400,24


READY
DIS TI1.2


TI1.2          14:20EDT     09/24/81
```

Test Profile TI1.2

```

100 5
110 447,1
120 397,6
130 396,109


READY
DIS TI1.5


TI1.5          14:21EDT     09/24/81
```

Test Profile TI1.5

```

100 3
110 450,10
120 408,106
130 373,624


READY
DIS CP11.2


CP11.2         14:22EDT     09/24/81
```

Test Profile CP11.2

```

100 2
110 456,15
120 382,162
```

Figure 1

LOCA Profile
C22.9.1L

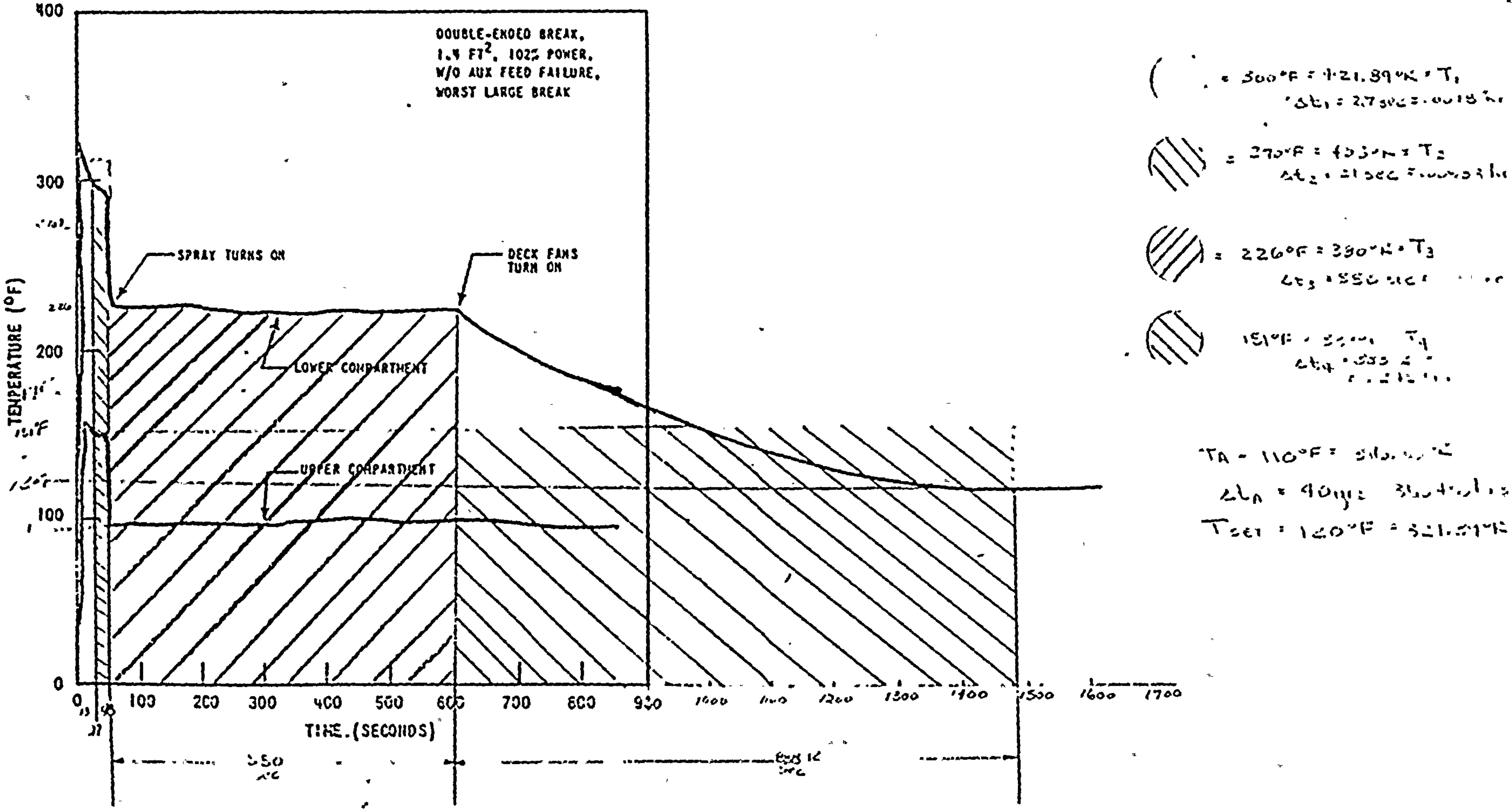


Figure C22.9-1 Compartment Temperature

Figure 2

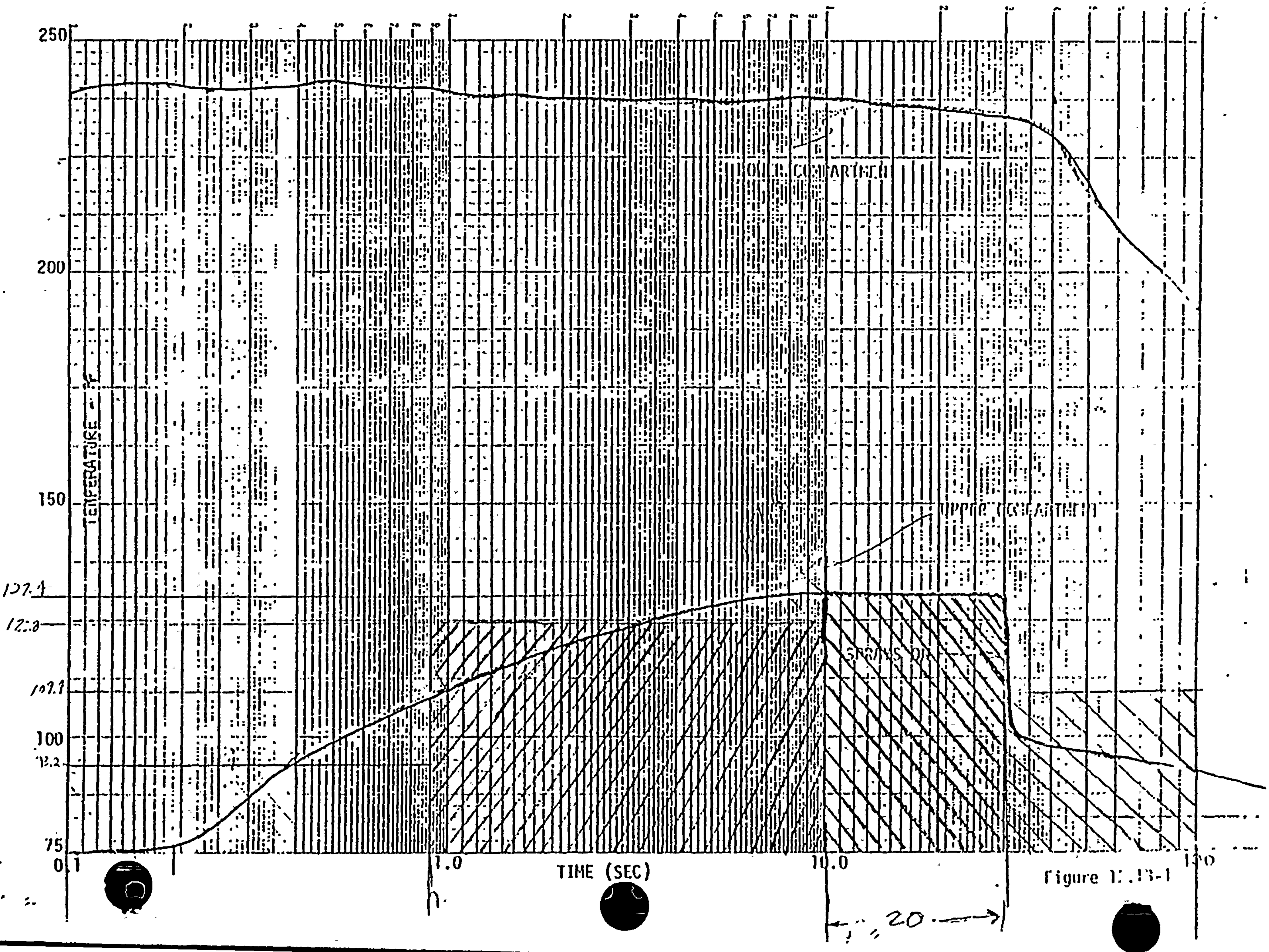


Figure 12.13-1

LOCA Profile

L13.1U

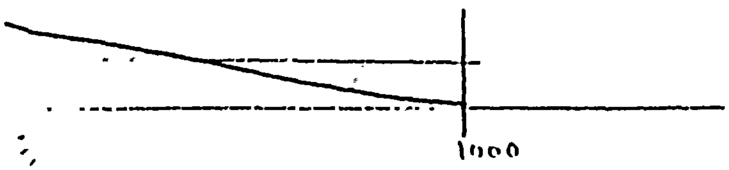
= 93.2°F = 307°K = T_1
Δt_1 = .00025 hr = .9 sec

= 123.8°F = 324°K = T_2
Δt_2 = .0025 hr = 9 sec

= 127.4°F = 326°K = T_3
Δt_3 = 20 sec = .0055 hr

= 109.4°F = 316°K = T_4
Δt_4 = .019444 hr = 70 sec

= 82.4°F = 301°K = T_5
Δt_5 = .25 hr = 900 sec



Computer Program ARAN

Arrhenius Analysis of remaining life of a component after a thermal shock. The Arrhenius Equation is of the form

$$\text{Life} = 10^{\frac{B}{T} - A} \tag{1}$$

where T = an exposure temperature (absolute scale). By testing a material at various temperatures, T_j, for various amounts of time, Δt_j, accelerated thermal aging occurs. To compare aging rates at different temperatures,

$$\text{Life at } T_1 = L(T_1) = 10^{\frac{B}{T_1} - A} \tag{2}$$

$$\text{Life at } T_2 = L(T_2) = 10^{\frac{B}{T_2} - A}$$

so, testing at T_2 for time Δt_2 gives an equivalent aging Δt_1 at T_1 such that

$$\Delta t_1 = \Delta t_2 \cdot \frac{10^{(\frac{B}{T_1} - A)}}{10^{(\frac{B}{T_2} - A)}} = \Delta t_2 \cdot 10^{B(\frac{1}{T_1} - \frac{1}{T_2})} \tag{3}$$

If we use one reference temperature, T_o, to compare aging at any other temperature and then test the material at n temperatures T, each for a time Δt, then the equivalent life at reference temperature, T_o, =

$$L(T_o) = \sum_{j=1}^{n} \Delta t_j \cdot 10^{B(\frac{1}{T_o} - \frac{1}{T_j})} \tag{4}$$

If the material is then subjected to some temperature profile, such as a normal operation followed by a LOCA, aging occurs,

which will shorten the remaining life at T_o. The remaining life at $T_o = L_r(T_o)$ =

$$L_r(T_o) = L(T_o) - \sum_{j=1}^{N} \Delta t_j \cdot 10^{B\left(\frac{1}{T_o} - \frac{1}{T_j}\right)} \qquad (5)$$

where N = the number of temperature steps from the time the material was first installed until the end of the LOCA.

After the LOCA, the temperature settles down to some TSET, and the remaining life at TSET, for safety reasons, must be known.

$$L_r(TSET) = L_r(T_o) \cdot 10^{B\left(\frac{1}{TSET} - \frac{1}{T_o}\right)} \qquad (6)$$

Program ARAN calculates the expected life at T_o by looking at a test temperature profile performed by the manufacturer and converting this accelerated aging to equivalent life at T_o. The LOCA profile is then converted, one step at a time, into equivalent life at T_o. If the LOCA profile equivalent life at T_o exceeds the test profile equivalent life at T_o at any step, a message will be displayed indicating failure during LOCA.

If not, the remaining life at T_o after the LOCA will be converted to life at the settled temperature and this will be displayed. The mentioned LOCA profile is to include the time before an actual LOCA (i.e., the material may have operated for 10 years at some average temperature T_A), then a set of temperatures (T_j, Δt_j) during a LOCA, then settled down to TSET. ARAN prints out the expected life at TSET, unless failure occurs before or during the LOCA.

Using ARAN:

The program requires three inputs from the user:

1. The test temperature profile

2. The LOCA temperature profile

3. The Arrhenius Parameter, B.

1. The Test Temperature Data File:

The user creates a test temperature data file which will give ARAN the necessary information to establish total life at T_o. This looks like:

```
100    NOT
110    T1, Δt1
120    T2, Δt2
130    T3, Δt3
 :
 :
```

where NOT = Total number of temperature steps during the test.

Each set of $(T_j , \Delta t_j)$ goes on one line, and the last line of the data file contains T_{NOT}, Δt_{NOT} . T = ^oK, Δt = hours.

2. The LOCA Temperature Data File:

The user also creates a LOCA temperature data file, giving ARAN information about the temperature history of this material, from installation through LOCA to the settled temperature, TSET.

```
100    NOL
110    TA, Δt1
120    T2, Δt2
130    T3, Δt3
 :
 :
Last   TSET
```

NOL = Number of temperature steps to which the material is subject. Each set of $(T_j, \Delta t_j)$ goes on one line. The 1st $(T_A, \Delta t_A)$, is the Average Temperature before the LOCA and the time of operation before the LOCA. The rest are the LOCA temperature profile, broken into discrete steps. $T = {}^{o}K$, Δt = hours.

3. The Arrhenius Parameter, B.

By staged temperature tests, the manufacturer establishes the Arrhenius Parameters A & B (see Eq. (1)). Because we are relating time at one temperature to time at another temperature, the Parameter A drops out and only B is needed (Eq. (3)).

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

DATE: October 5, 1981

Document Ref #63
Attachment 6b

SUBJECT: Arrhenius Analysis for D. C. Cook Plant Class IE Cable

FROM: L. F. Caso

TO: E. A. Howard - Columbus

As per our telephone conversation of 10/2/81, attached find the post-accident temperature profile outside the reactor containment to be ~~issued~~ used on the Arrhenius analysis for cable CI-4.

Attached also find Arrhenius plots for cables CI-3, CI-9, and CP-12.

Should you have any questions, please do not hesitate to call me.

L. F. Caso

LFC/jal
APPROVED J. M. INTRABARTOLA

cc: R. Hayes - Columbus
S. H. Horowitz
T. E. King

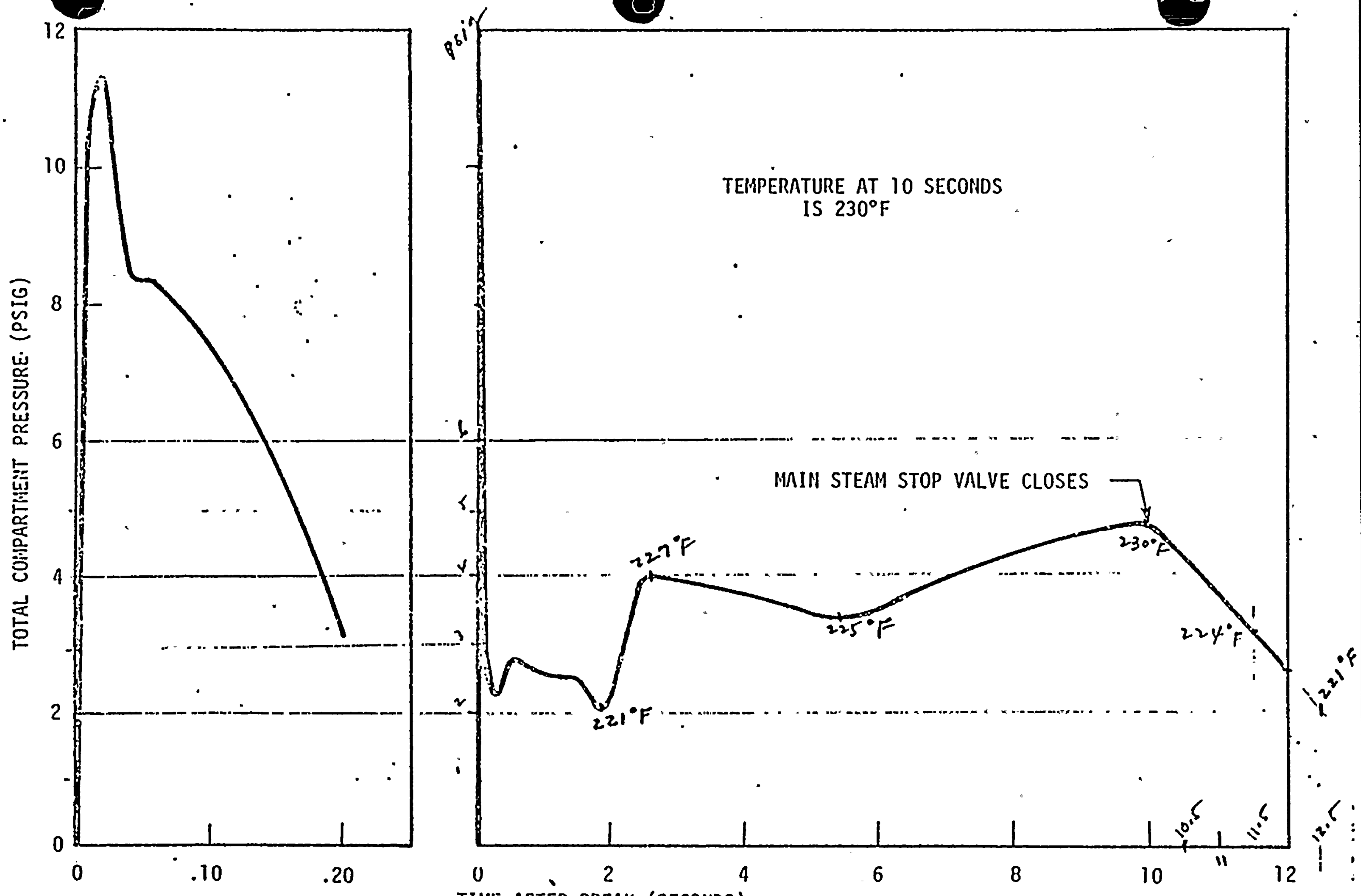


Figure 9-27 West Steam Enclosure Main Steam Line Break (Element 3), Pressure vs. Time

FORM GE-8

ENGINEERING DEPT.

AMERICAN ELECTRIC POWER SERVICE CORP.

2 BROADWAY

NEW YORK

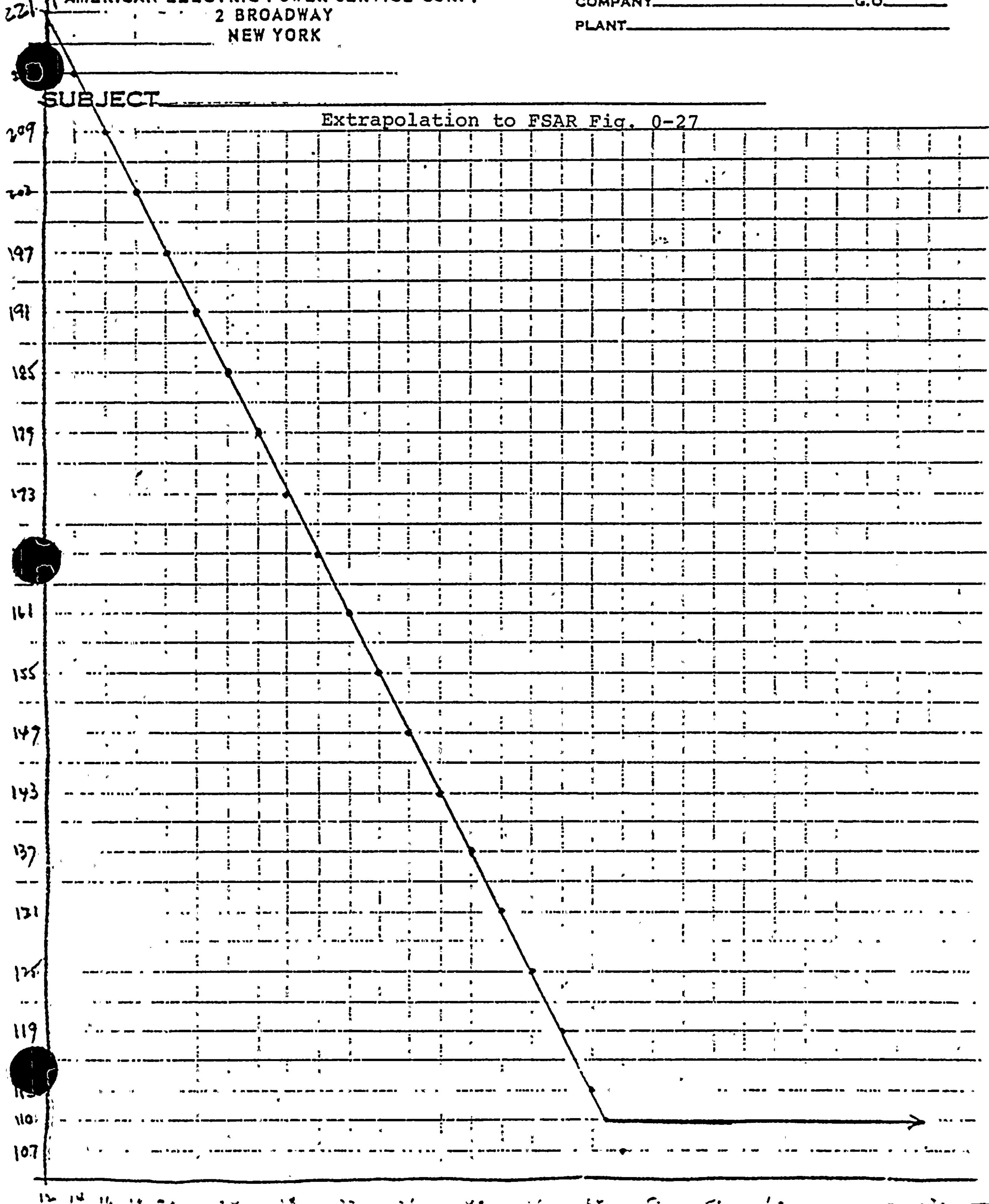
SHEET______ OF______

DATE______ BY______ CK______

COMPANY______ G.O.______

PLANT______

SUBJECT Extrapolation to FSAR Fig. 0-27



CP-12

LONG-TIME AGING DATA

LONG TIME AGING DATA

IEEE-383-1974 and Nuclear Regulatory Commission Guide 1.131 require that aging data be developed to establish the long-term performance characteristics of an insulation. A suggested method for accomplishing this is the Arrhenius technique which consists of placing insulation samples in an air oven for various times at elevated temperatures and measuring the change in a significant insulation property (usually elongation). The time to reach a predetermined value of elongation is then plotted on semilog graph paper vs the reciprocal of absolute temperature in degrees Kelvin. An analysis of the Arrhenius data should demonstrate that the insulation will provide a service life at its normal rated operating temperature (90°C) commensurate with the design life of the installation. This latter figure is normally taken to be 40 years.

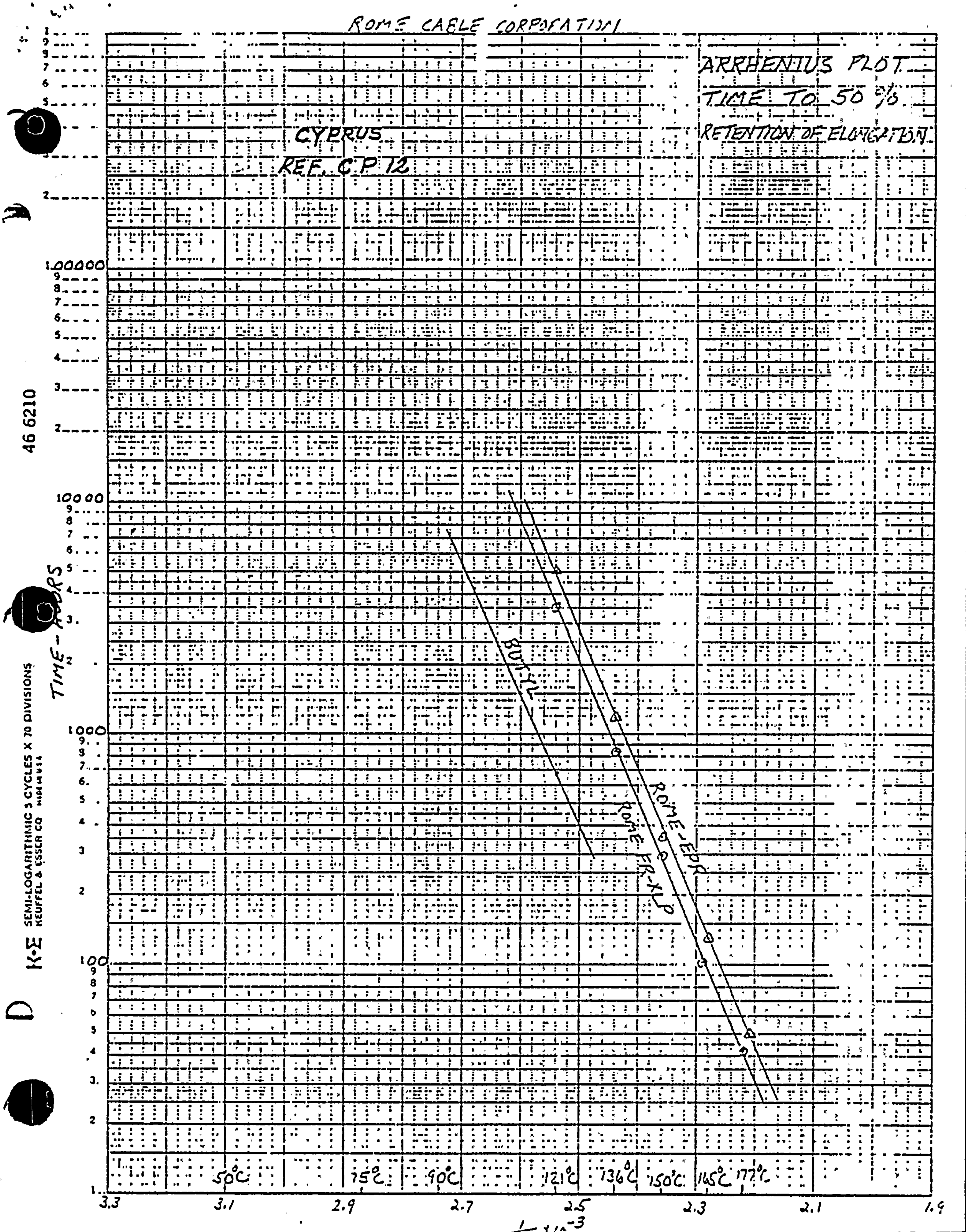
Rome has developed Arrhenius aging data on the insulation compounds recommended for generating station applications and this data is shown on the accompanying Arrhenius plot. Time to reach 50% of original elongation was selected as the basis for the aging plot. Tests on insulation compounds with 50% retained elongation indicate that both the physical and electrical properties are more than adequate for satisfactory performance, thus the test criteria are very conservative and provide a considerable margin of safety.

In developing the Arrhenius plot for Rome-EPR and Rome FR-XLP insulations it was noted that extrapolating the plots to operational temperature ratings results in considerable discrepancies in terms of life. In fact, the extrapolated life obtained is less than actual proven operating experience of older insulations still in service today. This apparent paradox is one of the subjects currently being studied by an IEEE Working Group which has been created to evaluate long time aging characteristics of insulation compounds.

Other ways to evaluate the concept of aging are addressed in the Supplement of the Forward of IEEE Std. 323-1974 which was issued in November, 1975. A portion of this Forward reads as follows: "It is acknowledged that the state-of-the-art regarding aging for some Class IE equipment is more advanced than others. It is expected that known technology will be used in any aging program. Optionally (and particularly where the state-of-the-art is limiting), aging as part of the qualification program may be addressed by operating experience, analysis, combined, or ongoing qualification". This Supplement acknowledges that aging, as part of a qualification program, may be addressed by operating experience, analysis, type tests and/or any combination of these methods.

To assist in its aging qualification program, Rome has obtained cable with Butyl rubber insulation that was removed from service after 15 years of operation. Analysis of the condition of the insulation shows that it has lost an insignificant amount of its original tensile strength and elongation indicating that the cable is capable of providing many more years of service. Other cables with Butyl rubber insulation have been identified in service and are still providing satisfactory performance in electric utility generating stations after more than 20 years.

Again referring to the accompanying graph, data obtained from the same Butyl rubber compound formulation as used on the aforementioned cables is also shown as an Arrhenius plot. Examination of the curves shows that the new Rome-EPR and Rome FR-XLP insulations take greater than 7 times and 5 times longer respectively, to reach 50% retention of original elongation than does the Butyl insulation compound. On the basis of this comparison and the proven operating experience with Butyl rubber, it is logical to expect a life of over 40 years for Rome-EPR and Rome FR-XLP insulations under normal operating conditions.



ROME CABLE CORPORATION
ARRHENIUS PLOT
TIME TO 50 %
RETENTION OF ELONGATION
CYPRUS
REF. CP 12
TIME - HOURS
BUTYL
ROME-EPR
ROME FR-XLP
50°C
75°C
90°C
121°C
136°C
150°C
165°C
177°C
1,00000
10000
1000
100
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
$\frac{1}{T} \times 10^{-3}$
46 6210
K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.

CI-3
CI-9

METHOD FOR DETERMINING 40-YEAR EQUIVALENT AGING

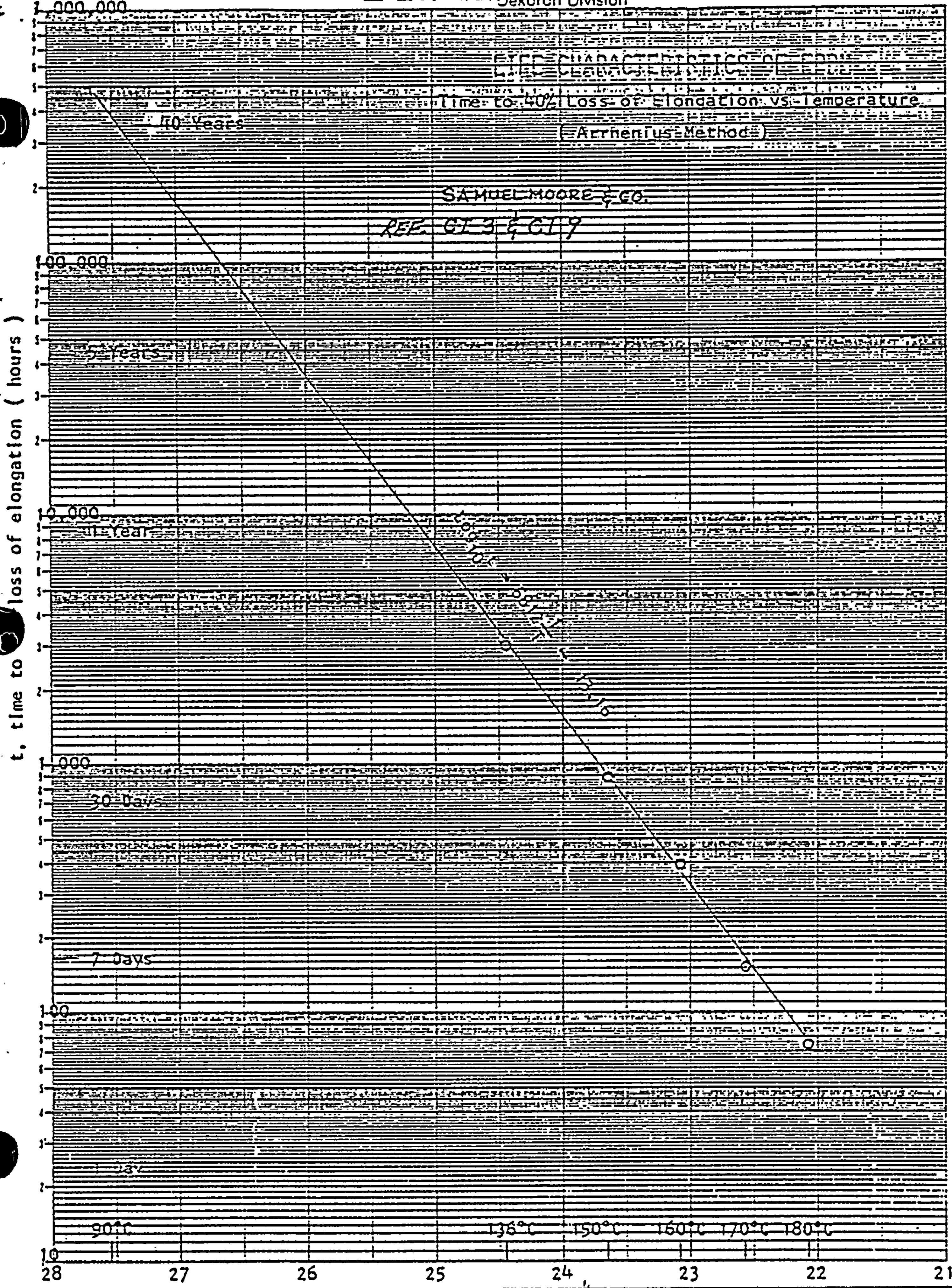
Aging is a phenomenon that all materials inevitably are confronted with. Just as some people "age" at different rates, different materials "age" at different rates.

When posed with the problem of aging a material to a 40-year equivalent life condition, the first determination to be made is at what rate does the material age. One acceptable method of determining this is to age the material at a minimum of three temperatures, one of which is 136°C and the other two at least 10°C apart (ref. IEEE Std. 383-1974, Paragraph 2.3.2). The resultant retention of elongation data can then be evaluated using the Arrhenius technique. This technique will supply an equation with a defined slope, or rate of change, depicting time (to loss of elongation) versus temperature. Once this rate of aging has been established, one needs only to know the anticipated ambient temperature for the 40-year life period to determine an equivalent aging exposure.

When an Arrhenius aging plot line has been determined for a material (see example attached), one need only to draw a parallel line through the desired 40-year ambient temperature point to establish an equivalent aging line. Any point on this new line now defines equivalent time/temperature aging parameter for the given material that simulates 40-year life at this particular ambient temperature.

For the example attached, 60°C was chosen as the anticipated 40-year ambient. The equivalent aging line shows that approximately 650 hrs. or 27 days @ 110°C or 7 days @ 121°C both would result in equivalent aging for this material to simulate 40 years aging to 60°C.

Samuel Moore Operations
Dekoron Division



AMERICAN ELECTRIC POWER SERVICE CORPORATION

Document Ref # 63
Attachment 6C

DATE: October 8, 1981

SUBJECT: Arrhenius Analysis

FROM: E. A. Howard/R. M. Hayes

TO: L. F. Caso

As per our telephone conversations and your letter dated 10/5/81, attached find the most current list of devices and their respective calculated lives after the LOCA at 120°F. This list includes the following updates:

1) Devices 16 and 17 use of upper compartment curve. One run with T_A = 110°F (LOCA file L22.9.1U) One run with T_A = 80°F (New LOCA file L22.9U1)

2) All assumed values of B equal to 6000 were changed to the lowest B of 5747 to be conservative.

3) New LOCA file created for cable CI-4 (LCI4.2) and used in the run.

4) New B of 6812 calculated and used for CI-3, CI-9 in runs on files CI-3.2 and CI-3.3.

5) New test file created for CP-12 and new B coefficient of 6640 used.

Also attached is a copy of the ARAN program requested, the new files created for this latest update, and a summary report of work to date on this project. Any questions may be directed to R. M. Hayes on ext. 1048 in Columbus.

E. A. Howard

R. M. Hayes

EAH/RMH:jll
Attachments
cc: C. H. Shih
C. Yi

INTRA-SYSTEM

Table I

Device #	Coefficient B	Test Profile	LOCA Profile	Calculated Life After LOCA at 120°F (Hours)
1	6693	CI2.2	L22.9.2L	7,352,922
2	6264	CI8.2	L22.9.2L	3,302,725
3	(1) 5747	CI1.2	L13.1L	29,568
4	6812	CI3.2	L22.9.2L	3,528,303
5	(1) 5747	CI4.2	LC14.2	Failed before LOCA* (2)
6	(1) 5747	CI5.2	L22.9.2L	188,821
7	5747	CP1.2	L13.1L	1,900,142
8	6812	CI3.3	L22.9.2L	5,924,609
9	(1) 5747	CP11.2	L22.9.2L	549,042
10	(1) 5747	CP13.2	L22.9.2L	419,902
11	(1) 5747	CP4.3	L22.9.2L	1,234,953
12	(1) 5747	CP4.2	L22.9.2L	85,571
13	(1) 5747	TI1.2	L22.9.2L	181,660
14	(1) 5747	TI1.5	L22.9.2L	1,846,560
15	(1) 5747	CP10	L22.9.2L	883,129
16	(1) 5747	F1.2	L22.9.U1	1,209,922
	(1) 5747	F1.2	L22.9.1U	1,056,427
17	(1) 5747	H1.2	L22.9.U1	139,747
	(1) 5747	H1.2	L22.9.1U	Failed before LOCA**
18	(1) 5747	TI5.2	L22.9.2L	5,962
19	(1) 5747	TP1.2	L22.9.2L	145,876
20	6640	CP12	L22.9.2L	651,131

Notes: *See explanation in text.
**Used for comparison purposes (110°F normal 40 yrs temp. used; upper compt T = 75°F

(1) Value of B coefficient not available for these cables. B = 5747 used as the most conservative value known from the information received from cable manufacturers. (value for power cable insulation Okonite/Okoprene)

(2) CI-4 Insulation and Jacket is Cross-Linked Polyethylene and Hypalon. Same as CI-2 and CI-8 with B values of 6693 and 6264. Therefore calculations of 9/23/81 where CI-4 B-value of 6000 was used is still conservative.

Report: Arrhenius Analysis

The Arrhenius Analysis of the remaining life of a component after a thermal shock was continued as more information was received from New York.

Many of the devices were not furnished with specific B coefficients and some did not have an established LOCA profile which we could work. Therefore, after two sets of correspondence and many runs of the ARAN program, the enclosed list, Table I, is the most current and complete in information.

Documentation on all LOCA profile data files, test profile data files, and the ARAN program were furnished.

The desired results were those which produced the lowest number of hours of remaining life. These were obtained using the lower compartment curve on graph 22.9.2 and using the lowest B obtained of 5747. Devices 16 and 17 were upper compartment devices, therefore, the upper compartment curves on the graphs were necessary.

Attached to this report are two sample calculations of the remaining life of a component. One calculation is for a device that survived a LOCA and the other is for one that failed during plant operation. The reason that the CI4-2 cable failed the test is because there wasn't sufficient test data to show it would last the life of the plant, 40 years, and therefore might not survive a LOCA at some time during plant operation.

E. A. Howard

Sample Calculation:

Typical Calculation of ARAN program

Device # 6 CIS-2

Test Profile: CIS.2
LOCA Profile: L22.9.2L
B Coefficient: 5747

Test Profile Data:

$T_1 = 447°K$; $\Delta t_1 = 1$ hr.
$T_2 = 397°K$; $\Delta t_2 = 9$ hr.
$T_3 = 396°K$; $\Delta t_3 = 109$ hr.

LOCA Profile Data:

$T_A = 316.33$ °K ; $\Delta t_A = 350400$ hrs $= 40$ yr
$T_1 = 439°K$; $\Delta t_1 = .0167$ hr
$T_2 = 381°K$; $\Delta t_2 = .15$ hr
$T_3 = 340°K$; $\Delta t_3 = .3055$ hr.
$T_{SET} = 321.89°K$

From computer program ARAN:

$$L(T_0) = \sum_{j=1}^{n} \Delta t_j \cdot 10^{B\left(\frac{1}{T_0} - \frac{1}{T_j}\right)}$$

Test Profile:

$$T_{100} = T_A + T_B + T_C$$

$$T_A = \Delta t_1 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_1}\right)}$$
$$= 1 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{447°K}\right)}$$
$$= 355.37 \text{ hrs.}$$

$$T_B = \Delta t_2 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_2}\right)}$$
$$= 9 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{397°K}\right)}$$
$$= 76.86 \text{ hrs.}$$

$$T_C = \Delta t_3 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_3}\right)}$$
$$= 109 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{396°K}\right)}$$
$$= 855.67 \text{ hrs.}$$

$T_{100} = 355.37 + 76.86 + 855.67 =$ <u>1,287.90 hrs. at 100°C</u>

LOCA Profile:

$$L_{100} = T_A + T_B + T_C + T_D$$

$$T_A = \Delta t_A * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_A}\right)}$$

$$= 350400 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{316.33°K}\right)}$$

$$= 608.6 \text{ hrs.}$$

$$T_B = \Delta t_1 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_1}\right)}$$

$$= .0167 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{439°K}\right)}$$

$$= 3.46 \text{ hrs.}$$

$$T_C = \Delta t_2 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_2}\right)}$$

$$= .15 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{381°K}\right)}$$

$$= .316 \text{ hrs.}$$

$$T_D = \Delta t_3 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_3}\right)}$$

$$= .3055 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{340°K}\right)}$$

$$= .0098 \text{ hrs.}$$

$L_{100} = 608.6 + 3.46 + .316 + .0098$ = <u>612.38 hrs. at 100°C</u>

For Calculated Life at T_{SET} = 120°F After LOCA is finished:

$$Life = (T_{100} - L_{100}) * 10^{B\left(\frac{1}{T_{SET}} - \frac{1}{373°K}\right)}$$

$$= (1,287.9 - 612.38) * 10^{5747\left(\frac{1}{321.89°K} - \frac{1}{373°K}\right)}$$

= <u>188,823.81 hrs. at 120°F</u>

From the ARAN program Life = <u>188,821 hrs. at 120°F</u>

Sample Calculation of Failure:

Device # 5 CI4-2

Test Profile: CI4.2
LOCA Profile: LCI4.2
B Coefficient: 5747

Test Profile Data:

$T_1 = 444°K$; $\Delta t_1 = 2$ hrs.
$T_2 = 344°K$; $\Delta t_2 = 20$ hrs.

LOCA Profile Data:

$T_A = 316.33°K$; $\Delta t_A = 350400$ hrs = 40 yrs
$T_1 = 378°K$; $\Delta t_1 = .00056$ hrs
$T_2 = 381.33°K$; $\Delta t_2 = .00222$ hrs.
$T_3 = 383°K$; $\Delta t_3 = .000278$ hrs.
$T_4 = 378°K$; $\Delta t_4 = .010278$ hrs.
$T_{SET} = 321.89°K$

From computer program ARAN:

$$L(T_o) = \sum_{j=1}^{n} \Delta t_j \cdot 10^{B\left(\frac{1}{T_o} + \frac{1}{T_j}\right)}$$

Test Profile:

$$T_{100} = T_A + T_B$$

$$T_A = \Delta t_1 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_1}\right)}$$

$$= 2 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{444°K}\right)}$$

$$= 581.9 \text{ hrs.}$$

$$T_B = \Delta t_2 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_2}\right)}$$

$$= 20 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{344°K}\right)}$$

$$= 1.00 \text{ hr}$$

$T_{100} = 581.9 + 1.00 =$ 582.9 hrs. at 100°C

LOCA Profile:

$$L_{100} = T_A + T_B + T_C + T_D + T_E$$

$$T_A = \Delta t_A * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_A}\right)}$$

$$= 350400 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{316.33°K}\right)}$$

$$= 608.6 \text{ hrs}$$

$$T_B = \Delta t_1 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_1}\right)}$$

$$= .00056 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{378°K}\right)}$$

$$= 8.9 \times 10^{-4} \text{ hrs.}$$

$$T_C = \Delta t_2 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_2}\right)}$$

$$= .00222 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{381.33°K}\right)}$$

$$= 4.8 \times 10^{-3} \text{ hrs.}$$

$$T_D = \Delta t_3 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_3}\right)}$$

$$= .000278 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{383°K}\right)}$$

$$= 7.0 \times 10^{-4} \text{ hrs}$$

$$T_E = \Delta t_4 * 10^{B\left(\frac{1}{373°K} - \frac{1}{T_4}\right)}$$

$$= .010278 * 10^{5747\left(\frac{1}{373°K} - \frac{1}{378°K}\right)}$$

$$= 1.64 \times 10^{-2} \text{ hrs.}$$

$$L_{100} = 608.6 + 8.9 \times 10^{-4} + 4.8 \times 10^{-3} + 7.0 \times 10^{-4} + 1.64 \times 10^{-2}$$

$$L_{100} = \underline{\underline{608.62 \text{ hrs. at } 100°C}}$$

For Calculated Life at T_{SET} = 120°F After LOCA is finished:

$$\text{Life} = (T_{100} - L_{100}) * 10^{B\left(\frac{1}{T_{SET}} - \frac{1}{373°K}\right)}$$

$$= (582.9 - 608.62) * 10^{5747\left(\frac{1}{321.89°K} - \frac{1}{373°K}\right)}$$

$$= \underline{-7,189.35 \text{ hrs at } 120°F}$$

LIS ARAN

ARAN 08:19EDT 09/30/81 ARAN PROGRAM

```
DIMENSION TTE(25),TTI(25),LTE(25),LTI(25)
REAL LENGTH
 REAL LTI,LTE,LIFE,L100,LENGTH
FILENAME TEST,LOCA
PRINT,"ARRHENIUS ANALYSIS OF LIFE  AFTER LOCA"
PRINT," INPUT NAME OF TEST FILE"; INPUT,TEST
 PRINT,"INPUT NAME OF LOCA FILE";INPUT,LOCA
INDEX=1
160 READ(TEST,*,ERR=1000) LINE, NOT, (LINE,TTE(I),TTI(I),I=1,NOT)
  REWIND TEST
IT =1
164 IF(INDEX.NE.1)GOTO 185
170READ(LOCA,*,ERR=1001) LINE,NOL,(LINE,LTE(I),LTI(I),I=1,NOL),LINE,TSET
REWIND LOCA
C ALL AGING WILL BE REFERENCED TO 100 DEGREES CELCIUS OR 373 DEGREES KELVIN
185 L100=0;  TIME=0; LENGTH=0
PRINT,"INPUT COEFFICIENT B"; INPUT,B
 T100=0
DO 1 I=1,NOT
LENGTH= LENGTH + TTI(I)
1 T100=T100+TTI(I)*10**(B/373-B/TTE(I))   <----
IT=0
[illegible]0 DO 2 I=1,NOL
[illegible]00=L100+LTI(I)*10**(B/373-B/LTE(I))
[illegible]E = TIME+ LTI(I)
2 IF(L100.GT.T100) GO TO 260
C LIFE= EXPECTED LIFE AT SETTLED TEMP. AFTER LOCA IS FINISHED
 LIFE=(T100-L100)*10**(B/TSET-B/373)
GOTO 270
260 PRINT 4, TIME-LTI(I), TIME
4 FORMAT(1X,"FAILURE DURING LOCA BETWEEN", F6.2,"AND",F6.2)
GOTO 290
270 PRINT3,TSET-273,LIFE
3 FORMAT(1X,"CALCULATED LIFE AFTER LOCA AT ",F4.0,"DEGREES CELCIUS=",F20.0,"HOURS",//)
290 PRINT,"ANOTHER CASE? (1=YES)"; INPUT,I
IF (I.NE.1) GOTO 400
PRINT," NEW LOCA FILE? (1=YES)"; INPUT, INDEX
IF(INDEX.NE.1) GOTO 330
PRINT,"INPUT NAME OF  LOCA FILE"; INPUT,LOCA
330 PRINT,"NEW TEST FILE? (1=YES)";INPUT,IT
IF(IT.NE.1) GOTO 164
PRINT,"INPUT NAME OF TEST FILE"; INPUT,TEST
GOTO 160
1000 PRINT,"ERROR IN TEST FILE",TEST," LINE#",LINE
GOTO 390
1001 PRINT,"ERROR IN  LOCA FILE",LOCA," LINE#", LINE
390 GOTO 290
400 STOP;END
```

READY

LIS L22.9.U1 LOCA Profile L22.9.U1

L22.9.U1 08:44EDT 09/30/81

```
100 4
110 299.67,350400
120 311,.00361
125 339,.00972
130 311,.209
140 321,.89
```

$T_A \to T_{SET}$ in °K
$\Delta t_A \to \Delta t_3$ in hrs

100 4
110 80°F, 40yrs (normal service life) upper compartment inside containment
120 100°F, 13 sec
125 151°F, 35 sec
130 100°F, 750 sec
140 120°F (steady state after the accident)

READY
LIS L232

232 08:44EDT 09/30/81

LOCA Profile L232

```
100 4
110 299.67,350400
120 337,.0167
130 309,.15
140 303,.1111
150 321,.89
```

$T_A \to T_{SET}$ in °K
$\Delta t_A \to \Delta t_3$ in hrs

100 4
110 80°F, 40yrs (normal service life) upper compartment inside containment
120 148°F, 60 sec
130 96°F, 540 sec
140 86°F, 400 sec
150 120°F (steady state after the accident)

READY

```
LIS CP12

CP12        15:50EDT      10/07/81

100 4
110 423.56,4
120 413.5
130 386.50,47
140 372.[illegible],288

READY
LIS LOCA.2

LOCA.2      15:50EDT      10/07/81

100 [illegible]
110 316.33,350400
120 373,.00056
130 381.55,.00222
140 383,.000278
150 378,.010278
160 327.59

READY
```

→ $T_1 \rightarrow T_4$ in °K
$\Delta t_1 \rightarrow \Delta t_4$ in hrs.

Test Profile CP12

100 # of data points
110 303°F, 4 hr
120 284°F, 3 hr
130 240°F, 47 hr
140 211°F, 12 days (288 hrs.)

→ $T_A \rightarrow T_{SET}$ in °K
$\Delta t_A \rightarrow \Delta t_4$ in hrs

LOCA Profile LOCA.2

100 # of data points
112 T_A, Δt_A (110°F for 40 yrs)
120 221°F, 2 sec
130 227°F, 8 sec
140 230°F, 1 sec
150 221°F, 37 sec
160 T_{SET}.

AMERICAN ELECTRIC POWER SERVICE CORPORATION AMERICAN ELECTRIC AEP POWER SYSTEM

DATE: August 5, 1981

SUBJECT: Arrhenius Analysis to extend test duration to required operating times plus a margin.

Ref # 63
Attachment 7a

FROM: L.F. Caso

TO: C.H. Shih

Please find attached a list of cables, cable terminations, pump motors, fan motor and heater installed at D.C. Cook Plant for which the required operating times (Column 4) are less than the test durations (Column 6). It is requested that you apply the Arrhenius Analysis to these devices so as to extend the test durations to a minim of the required operating times plus 10% margin. Attached, also are the required operating time references (Column 5), and the environmental test profiles (Column 7).

The cable material are listed in Column 3 of the device list. The insulation is listed first followed by the jacket material (Insulation/Jacket Material). The material associated with the acronyms given in Column 3, are as follows:

XLPE - Croslinked Polyethylene
CSPE - Clorosulphonated Polyethylene
EPDM - Ethylene Propylene Rubber
EPR - Ethylene Propylene Rubber
EP - Ethylene Propylene Rubber
HTK - Synthetic Rubber (High temperature Kerite).
FR - Fire Retardant
Okoprene - Neoprene (Synthetic Rubber)
Okonite - Ethylene Propylene Rubber
Okolon - Hypalon
Okogard - Ethylene Propylene base thermosetting compound
Okotherm - Silicone Rubber

The instrument cable termination materials are a combination of the instrument cable material and the splicing material which follows:

(a) Chemelex adhesive Sealant RTVW (product data sheet attached).

(b) Raychem WCSF -115-6-N + Heat Shrink

(c) Burndy Connector YSV14

(d) Raychem WCSF-070-12-N Heat Shrinkable Tubing or WCSF-200-12-N

The power cable termination materials are a combination of the power cable materials and b, c, and d (above).

Please be advised that the present schedule for submitting this information is 8/13/81 to the Nuclear Safety and Licencing Section of AEPSC and 8/27/81 to the N.R.C. Your cooperation in realizing these schedules will be greatly appreciated.

Luis Caso
L.F. Caso

LFC:deh
Attachments

Approved: J.M. Intrabartola/TEK
J.M. Intrabartola

cc: S.H. Horowitz
T.E. King
C.A. Ramjohn
E. Welz

1 DEVICE	2 PG#	3 MATERIAL	REQUIRED OPERATING TIME	5 Required operating time REFERENCE	6 TEST DURATION	7 Environmental TEST PROFILE
INSTRUMENT CABLE U1	CI 1	XLPE/CSPE	4 MONTHS	FIG. 13.6-1,-2 FIG 13.13-1	7½ days	pg CI 1-2
" " none	CI 2	XLPE/HYPALON	4 MONTHS	AEW6504 Fig 1&2 FIG. 022.9-1,-2	30 days	pg CI 2-2
U2 CI5 " " U1	CI 3	EPDM/HYPALON	1 Year	AEW 6504 Fig 1&2 Fig 022.9-1,-2	30 days	pg CI 3-2, 3
U2 CI6 " " U1	CI 4	XLPE/CSPE	1 YEAR	FIG. 0.27	22 hrs	pg CI 4-2
U2 CI7 " " U1	CI 5	CSPE/CSPE	1 YEAR	AEW 6504 Fig 1&2 FIG 022.9-1,-2	119 hrs	pg CI 5-2, 3, 4,
" " U1,2	CI 8	XLPE/HYPALON	1 YEAR	AEW 6504 Fig 1&2 FIG 022.9-1,-2	30 days	pg CI 8-2
" " U1,2	CI 9	EPDM-HYPALON/ HYPALON	1 YEAR	AEW 6504 Fig 1&2 FIG 022.9-1,-2	30 days	pg CI 9-2
" " U1,2	CI 10	XLPE/CSPE	1 YEAR	FIG 0-27	22 hrs	pg CI 10-2
POWER CABLE none	CP1	OKONITE/OKOPRENE	1 YEAR	FIG 0-27	130 days	pg CP1-2
none	CP2	OKONITE/OKOPRENE	1 YEAR	AEW 6504 Fig 1&2 Fig. 13.13-1	130 days	pg CP2-2
U2 CP1 U1	CP3	EPR/NEOPRENE	1 YEAR	Fig. 0-27		
none	CP6	OKOGARD/OKOLON	1 YEAR	Fig 0-27	130 days	pg CP6-2
U2 CP13 U1 CP5 CP12 U1	CP10	EP/HYPALON	1 YEAR	Fig 0-27		

1	2	3	4	5	6	7
DEVICE	PG #	MATERIAL	REQUIRED OPERATING TIME	REQUIRED OPERATING TIME REFERENCE	TEST DURATION	ENVIRO[illegible]NTAL TEST PROFILE
POWER CABLE U1	CP 11	HTK/FR	1 YEAR	Fig 0-27	7 days 13 hrs	pg CP 11-2
U2-CP4 " U2-CP2 " U2-CP7 U1	CP 12	EPR/HYPALON	3 Months	AEW 6504 Fig 1&2 Fig 13.13-1	20 days	pg. CP 12-2
U2-CP5 " " U1	CP 13	EP/HYPALON	3 Months	AEW 6504 Fig 1&2 Fig 022.9-1,-2	13 days 6 hrs	pg CP 13-2
" " none	CP 4	OKOTHERM/ASBESTOS BRAID	3 Months	AEW 6504 Fig 1&2 Fig 022.9-1,-2	31 days	pg CP4-2, 3
INSTRUMENT CABLE TERMINATION U1,2	TI 1	same as TI-9 U1,2	1 YEAR	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TI1-2, 3, 4, 5, 6, 7, 8, 9
" " U1,2	TI 2		4 Months	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TI2-2, 3, 4, 5, 6, 7, 8, 9
" " U1,2	TI 3		4 Months	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TI 3-2
" " U1,2	TI 4		4 Months	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TI 4-2 THRU 11
" same as TI-10 " [illegible]	TI 5		1 YEAR	EAW 6504 Fig 1&2 Fig 13.13-1	6½ days	pg TI 5-2
POWER CABLE TERMINATION U1,2	TP1		1 YEAR	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TP1-2, 3
" " U1,2	TP2		1 YEAR	AEW 6504 Fig 1&2 Fig 022.9-1,-2	116 hrs	pg TP2-3, -3
" " U1,2	TP 3		1 YEAR	AEW 6504 Fig 1&2 FIG 022.9-1,-2	116 hrs	pg TP3-1, 2
" " U1,2	TP 4		1 YEAR		116 hrs	NA

1 DEVICE	2 PG #	3 MATERIAL	4 REQUIRED OPERATING TIME	5 REQUIRED OPERATING TIME REFERENCE	6 TEST DURATION	7 ENVIRONMENTAL TEST PROFILE
HYDROGEN SKIMMER UI, V	F1.	THERMALASTIC EPOXY INSULATION F	1 YEAR	AEW 6504 Fig 1 & 2 Fig 13.13-1.	192 hrs	pg F1-2.
HYDROGEN RECOMBINER. UI, V	H1	NA	3 MONTHS	AEW 6504 Fig 1 & 2 Fig 13.13-1.	25 hrs.	pg H1-2.
PUMP MOTOR UI, V	M1	CLASS F.	1 YEAR	NA		
PUMP MOTOR UI, V	M2	Class F	1 YEAR.	NA.		

CLASS F INSULATION MATERIAL

MAGNET WIRE INSULATION:	HEAVY FILM + SINGLE DACRON GLASS
COIL GROUND INSULATION	NOMEX MICA
TAPE WRAPPER	GLASS TAPE OUTER TYPE
RESIN	EPOXY - VACUUM PRESSURE IMPREGNATED.
LEADS.	HYPALON.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

DATE: AUGUST, 7, 1981.

Ref # 63
Attachment 7 b

SUBJECT:

FROM: L.F. CASO

TO: C.H. SHIH

PLEASE FIND ENCLOSED, ARRHENIUS PLOTS FOR CABLE MATERIALS IDENTIFIED BELOW. THESE PLOTS ARE TO SUPPLEMENT DATA TRANSMITTED TO YOU IN MY LETTER OF AUGUST 5, 1981 REQUESTING ARRHENIUS ANALYSIS. PAGE NUMBERS CORRESPOND TO COLUMN 2 OF THE DEVICE LIST WHICH WAS TRANSMITTED TO YOU PREVIOUSLY.

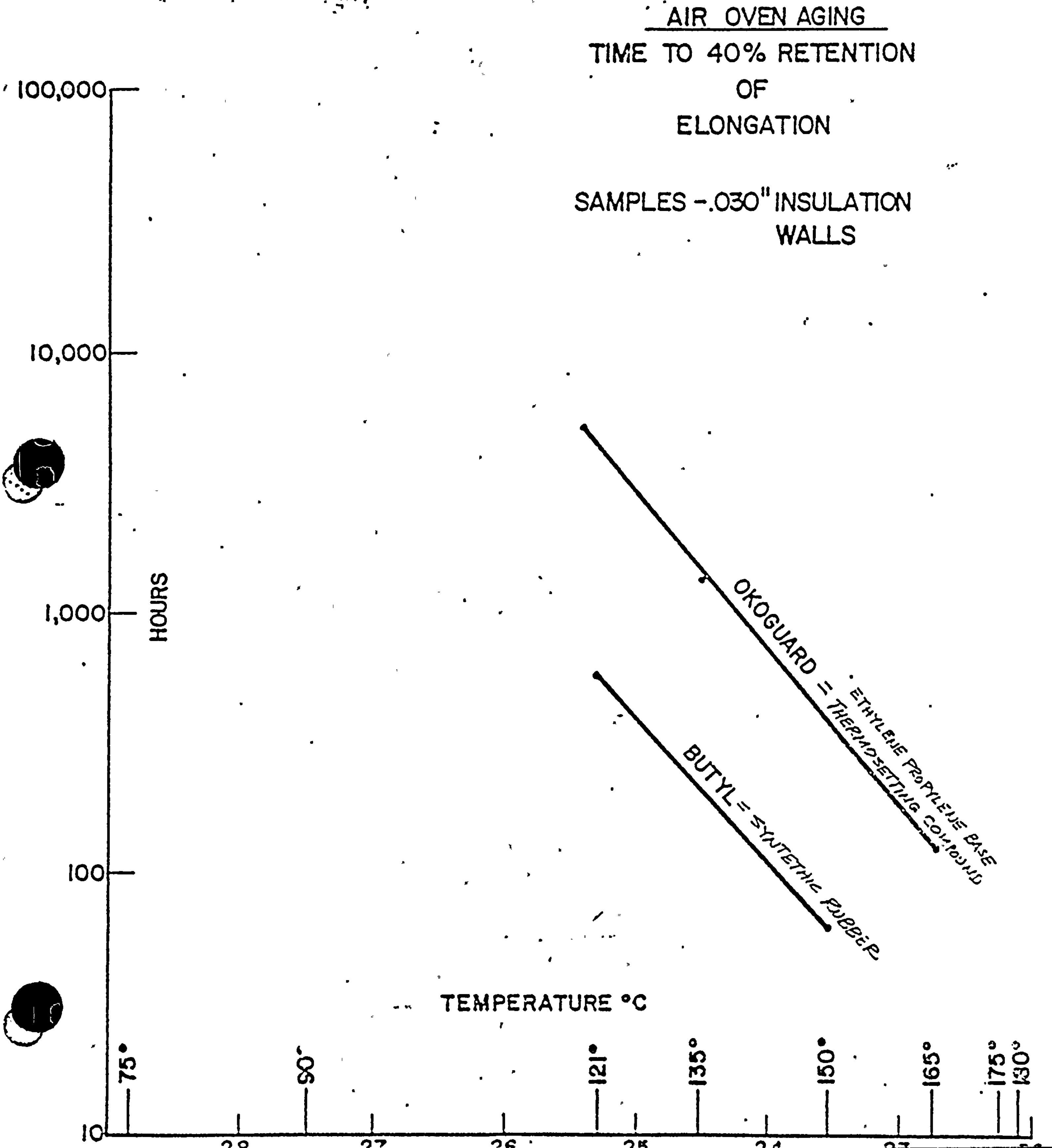
PG #	CABLE MATERIAL
CI2	XLPE (CROSSLINKED POLYETHYLENE).
CI8	FR-XLP
CP1 & 2	OKONITE (ETHYLENE PROPYLENE RUBBER.
CP6	OKOGARD (ETHYLENE PROPYLENE BASE THERMOSETTING COMPOUND)

L F Caso

APPROVED: J.M. Intrabartola / TK
J.M INTRABARTOLA

CC: H. N. Scherer, Jr. - Columbus
SH Horowitz
TE King

REF pg cP6


AIR OVEN AGING
TIME TO 40% RETENTION
OF
ELONGATION
SAMPLES -.030" INSULATION
WALLS
100,000
10,000
1,000
100
10
HOURS
OKOGUARD = ETHYLENE PROPYLENE BASE THERMOSETTING COMPOUND
BUTYL = SYNTETHIC RUBBER
TEMPERATURE °C
75°
90°
121°
135°
150°
165°
175°

Ref. pg CP 1 & 2

FIGURE I

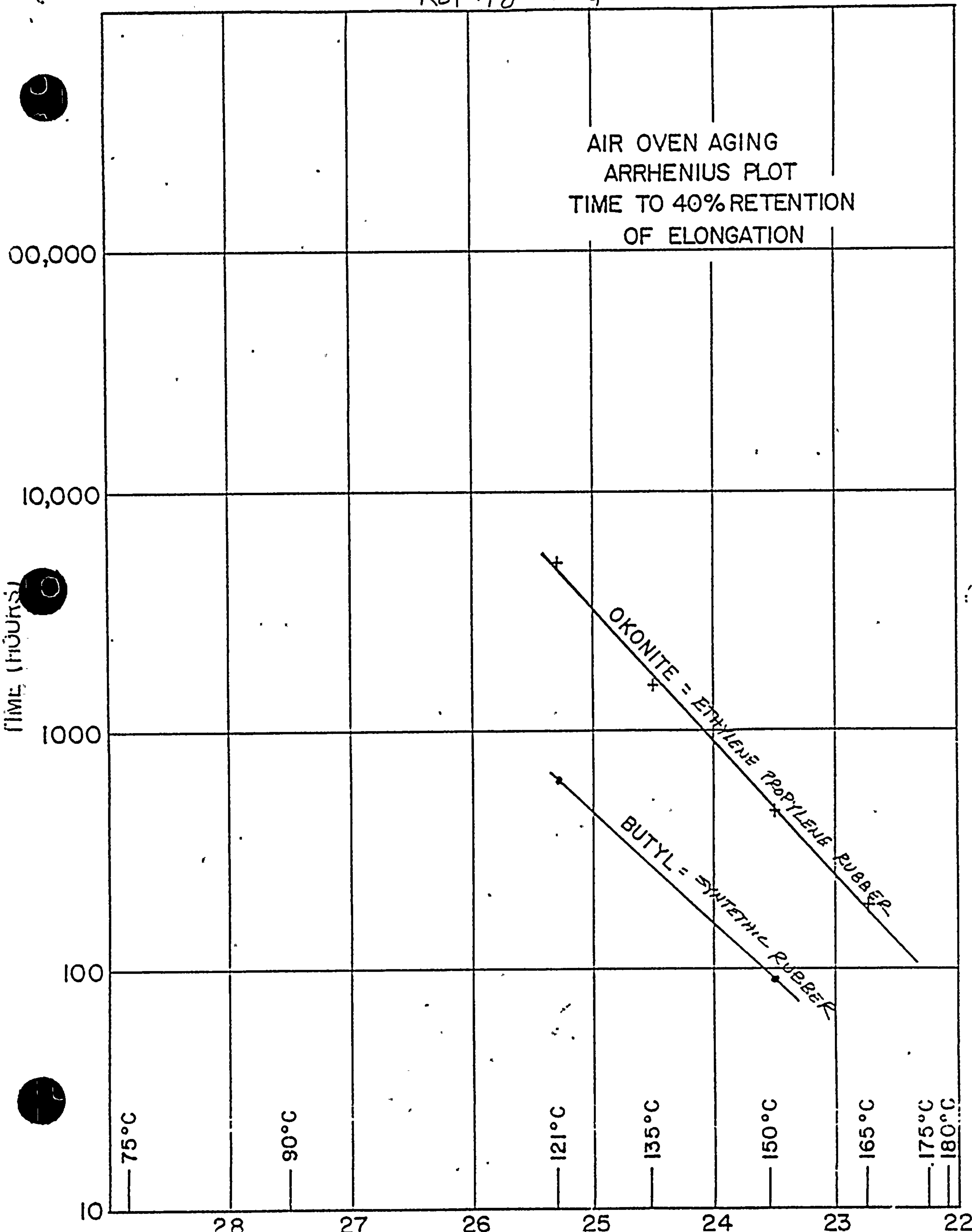
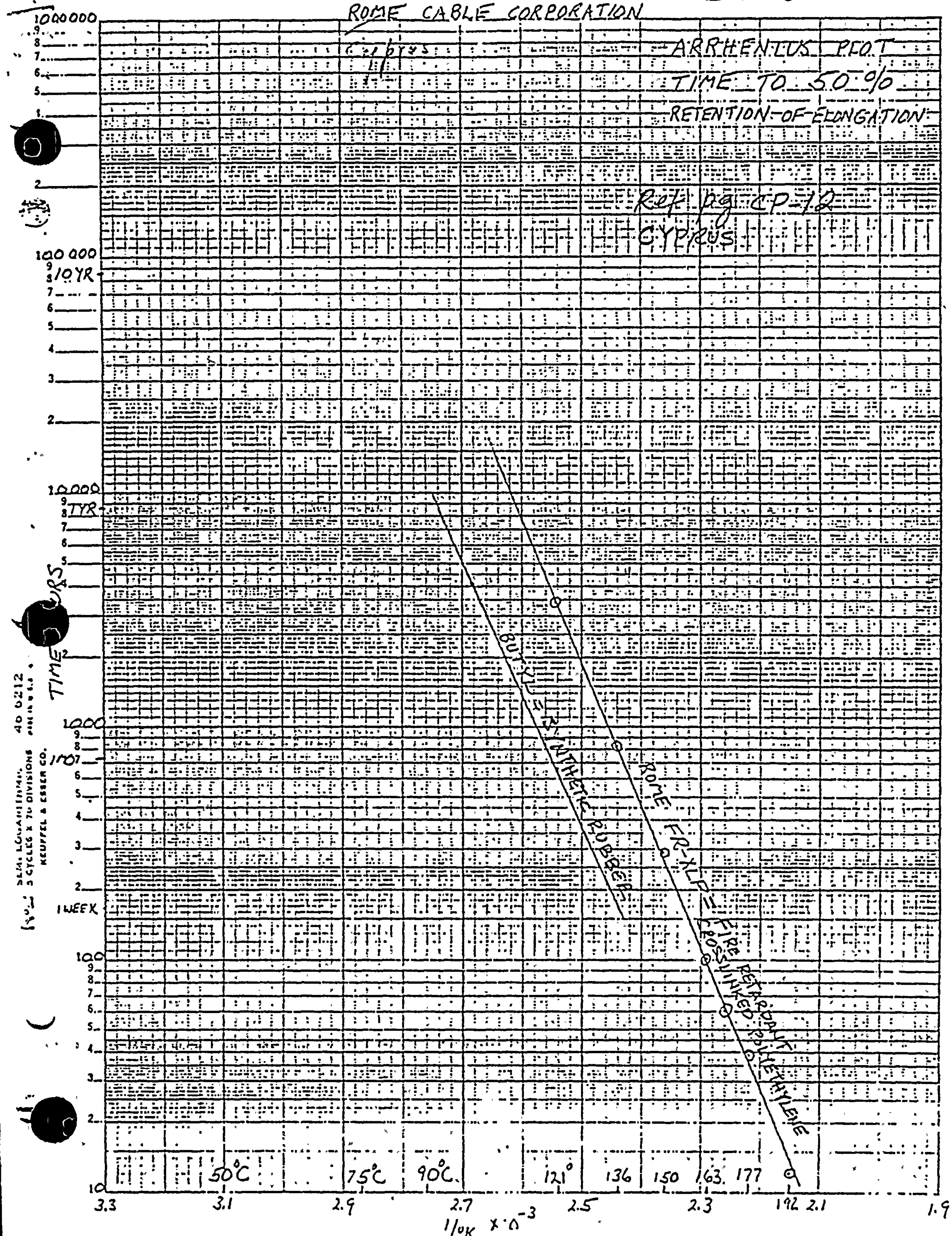


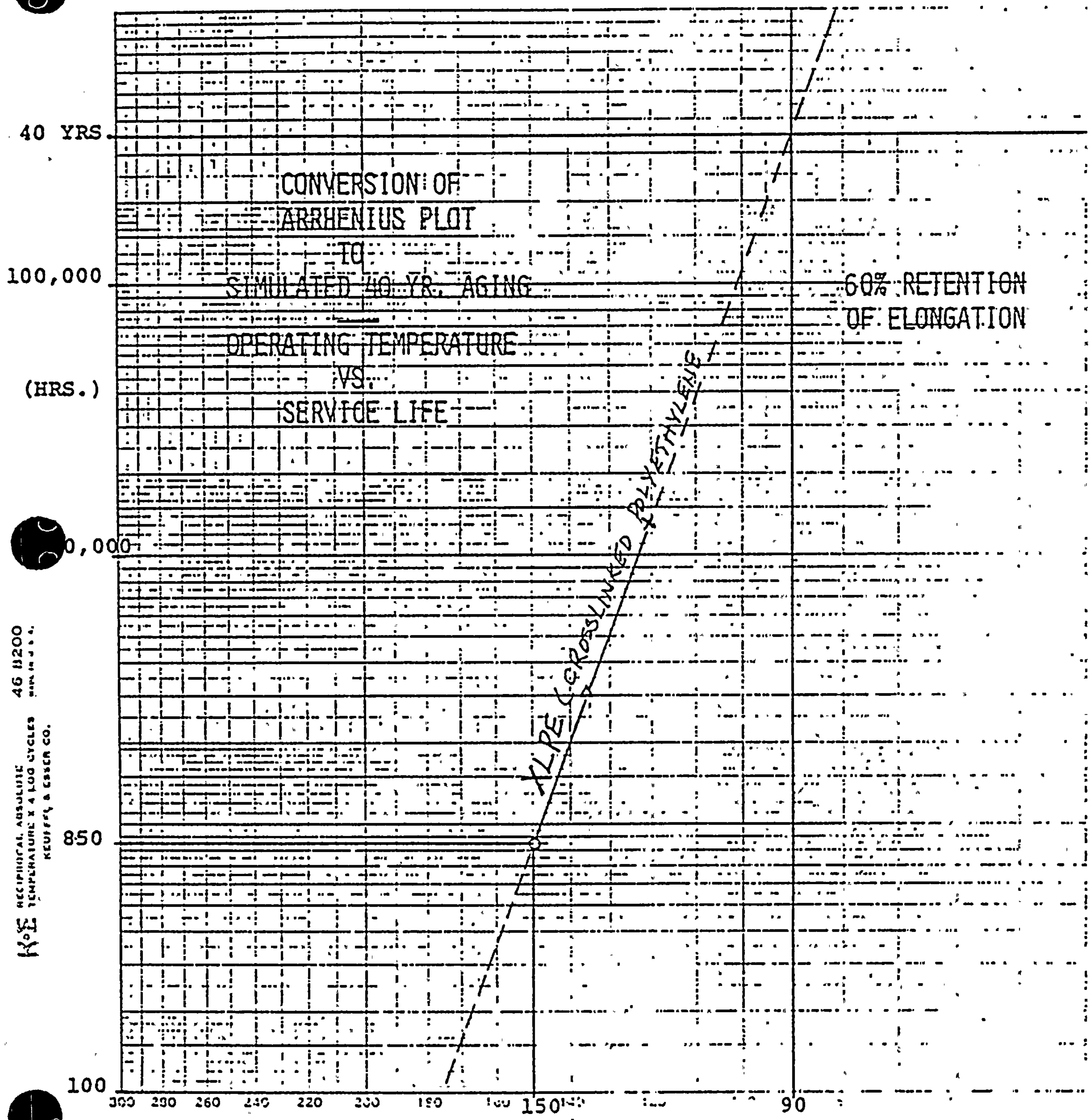
EXHIBIT - 13



ROME CABLE CORPORATION
Cyprus
ARRHENIUS PLOT
TIME TO 50 %
RETENTION OF ELONGATION
Ref pg CP-12
CYPRUS
100 000
10 YR
10 000
1 YR
1000
1 MO
1 WEEK
100
10
TIME HOURS
BUTYL = SYNTHETIC RUBBER
ROME FR-XLP = FIRE RETARDANT CROSSLINKED POLYETHYLENE
50°C
75°C
90°C
121°
136
150
163
177
192
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1/°K x 10^-3
SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
46 6212

ROCKBESTOS FIREWALL III

Ref. pg CI 2



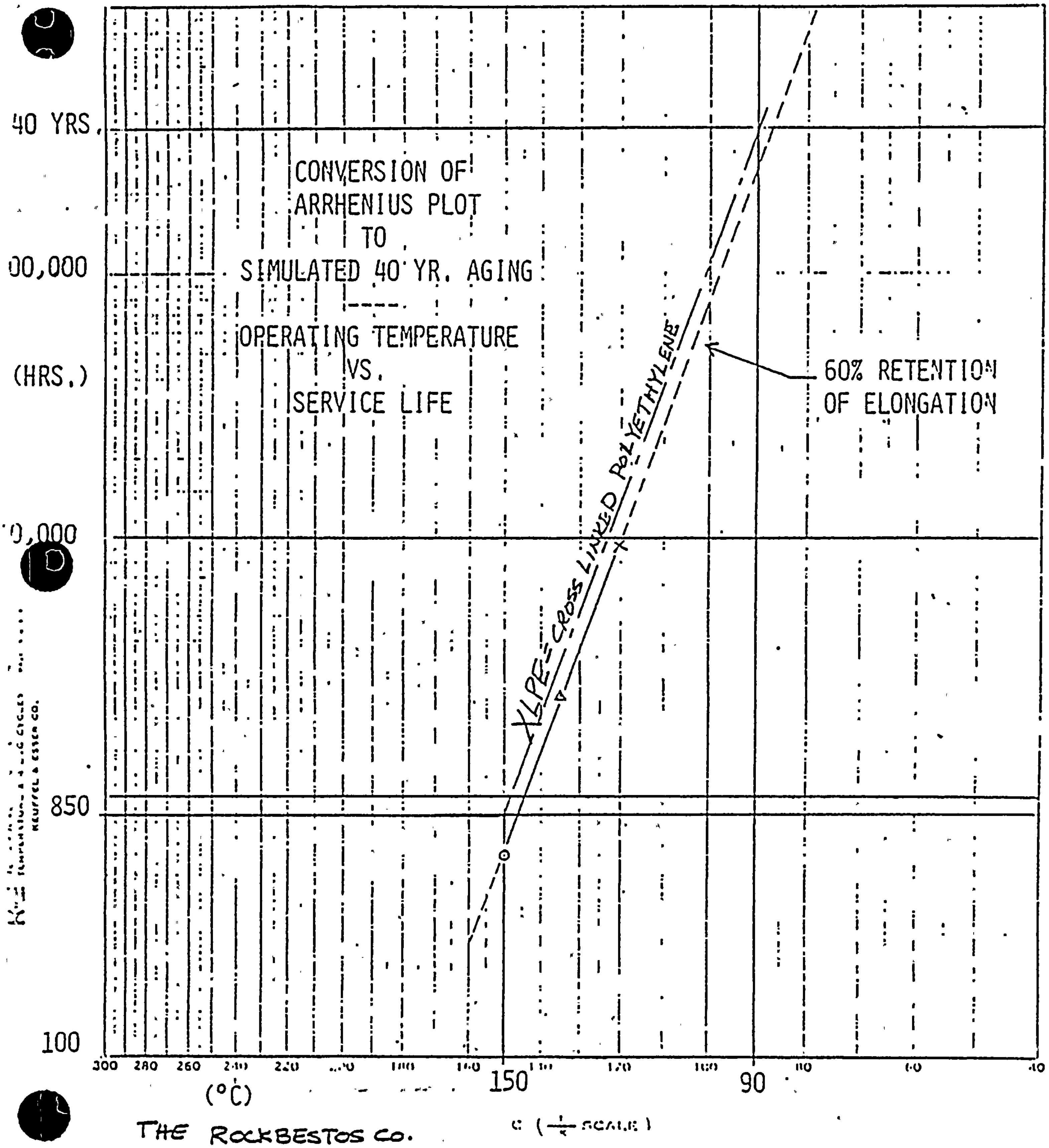
(°C)

°C (1/°K Scale)

THE ROCKBESTOS CO
JULY, 1977.
REVISED NOV. 26 1979.

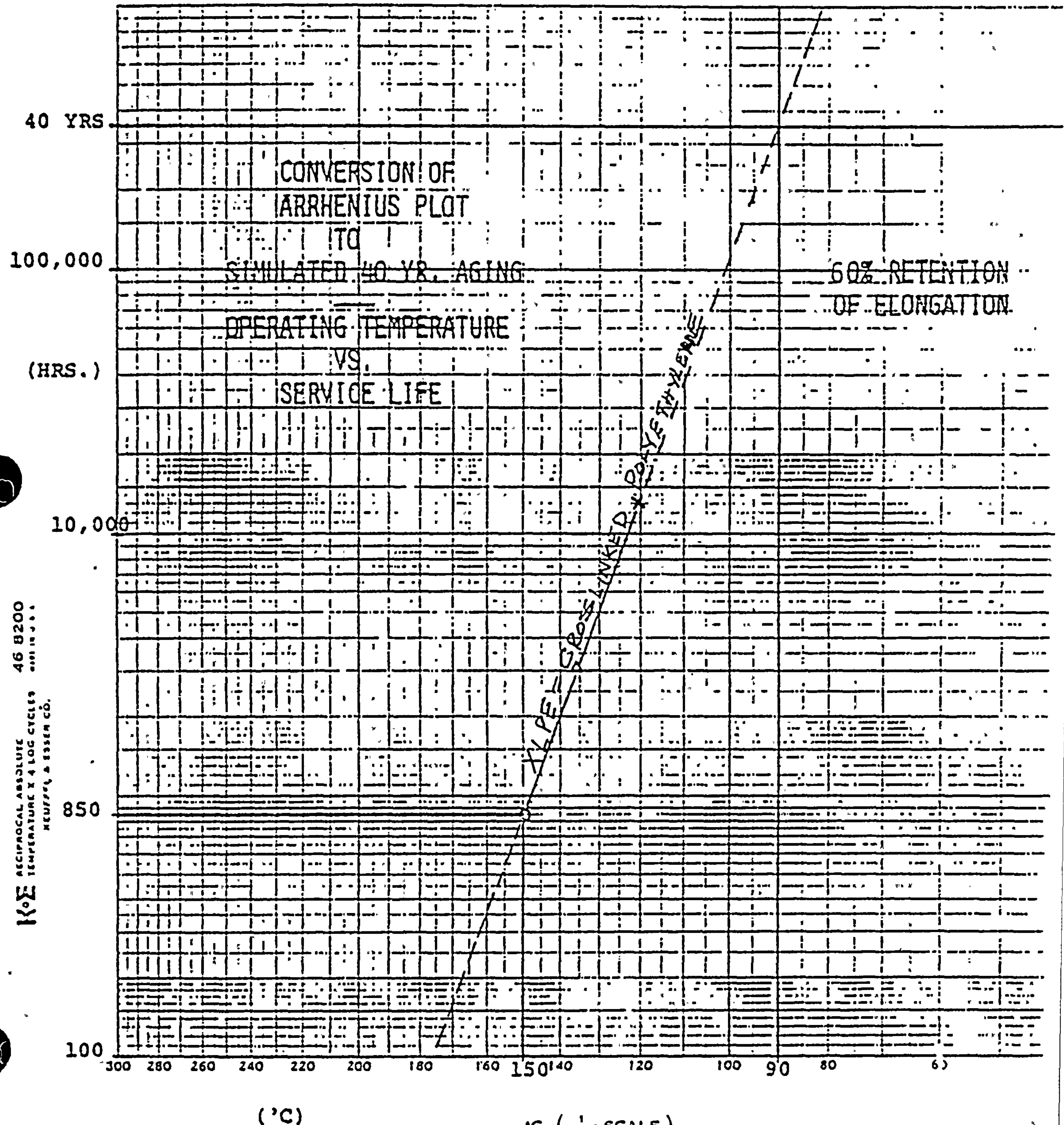
ROCKBESTOS FIREWALL III
(IRRADIATION CURED)

REF. pg. CI2



THE ROCKBESTOS CO.
JUNE 7, 1978

ROCKBESTOS FIREWALL III REF pg CI 2



THE ROCKBESTOS CO.
JULY 7, 1977.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

August 27, 1981

Ref #63

SUBJECT: Arrhenius Analysis

Attachment 7C

FROM: L. F. Caso

TO: R. M. Hayes

Please find enclosed the additional information you requested to complete the Arrhenius Analysis for the devices listed in my letter to C. H. Shih, dated 8/5/81. Table 1 lists the device locations (in or out of containment), ΔTA, TSET and TA. LOCA profile is the same for all devices in the containment (022.9-1, 2). Test profile for CP10 is enclosed. Test profiles for CP3, TP4, M1 and M2 are not available. Note however, that these devices are all outside the containment.

see Ref 65 CNAPD 3?2 westinghouse WCAP 7829

Table #2 lists the manufacturer, insulation and jacket materials for the instrument and power cables. This table would help in identifying the Arrhenius plots with their associated cables. Please note that the Arrhenius plot previously identified with CI8 is incorrect. The plot for this cable (Cerro Wire & Cable Company) is also enclosed.

L.F. Caso / BR

L. F. Caso

LFC/jal

APPROVED J. M. Intrabartola / FLC

J. M. INTRABARTOLA

cc: T. E. King
S. H. Horowitz
H. N. Scherer, Jr. - Columbus
C. H. Shih
E. Welz
C. Ramjohn

INTRA-SYSTEM

TABLE I

PG #		LOCATION	Δt_A	T_{SET}	T_A
CI	1	IN CONTAINMENT	40 YRS	106.5°F	110°F
	2	↓	↓	↓	↓
	3	↓	↓	↓	↓
	4	OUT-SIDE CONT. ↓	↓	↓	↓
	5	↓	↓	↓	↓
	8	↓	↓	↓	↓
	9	↓	↓	↓	↓
	10	OUT-SIDE CONT.	↓		
CP	1	OUT-SIDE CONT.	↓		
	2	OUT-SIDE CONT	↓		
	3	OUT-SIDE CONT	↓		
	4	IN CONTAINMENT	↓	106.5°F	110°F
	6	↓	↓	↓	↓
	10	↓	↓	↓	↓
	11	↓	↓	↓	↓
	12	OUT-SIDE CONT.	↓		
	13	OUT-SIDE CONT.	↓		
TI	1	IN-CONTAINMENT	↓	106.5°F	110°F
	2	↓	↓	↓	↓
	3	↓	↓	↓	↓
	4	↓	↓	↓	↓
	5	↓	↓	↓	↓
TP	1	↓	↓	↓	↓
	2	↓	↓	↓	↓
	3	↓	↓	↓	↓
	4	OUT-SIDE CONT.	↓		
F	1	IN-CONTAINMENT	↓	106.5°F	110°F
H	1	IN-CONTAINMENT	↓	106.5°F	110°F
M	1	OUT-SIDE CONT.	↓		
M	2	OUT-SIDE CONT.	↓		

USE T_{SET} = 106.5 & T_A = 110 FOR DEVICES OUTSIDE CONTAINMENT.

TABLE #2

	Pg #	MANUFACTURER	INSULATION/ JACKET
X	CI 1	Boston Insulated Wire Co.	XLPE/CSPE
✓	CI 2	Rockbestos	XLPE/Hypalon
X	CI.3	Samuel Moore & Co	EPDM-Hypalon/Hypalon
X	CI 4	Continental	XLPE/CSPE
X	CI.5	Boston Insulated Wire Co.	CSPE/CSPE
✓	CI 8	Cerro Wire and Cable Co.	XLPE/Hypalon
✓X	CI 9	Samuel Moore & Co.	EPDM-Hypalon/Hypalon
X	CI 10	Continental	XLPE/CSPE
✓	CP 1	Okonite	Okonite/Okoprene
✓	CP 2	Okonite	Okonite/Okoprene
✓	CP 3	Essex	EPR/Neoprene
	CP 4	Okonite	Okotherm/Asbestos braid/Aluminium
✓	CP 6	Okonite	Okoguard/Okolon
✓	CP 10	Anaconda	EP/Hypalon
X	CP 11	Kerite	HTK/FR
X	CP 12	Cyprus	EPR/Hypalon
✓	CP 13	Anaconda	EP/Hypalon

✓ - ARRHENIUS PLOT WAS TRANSMITTED

TEST PROFILE FOR CP-10

From Ref. 25. Qualified by Isomedix Corp. Test Report of November 1975

Type of Test: Simultaneous, gamma radiation
steam
chemical spray

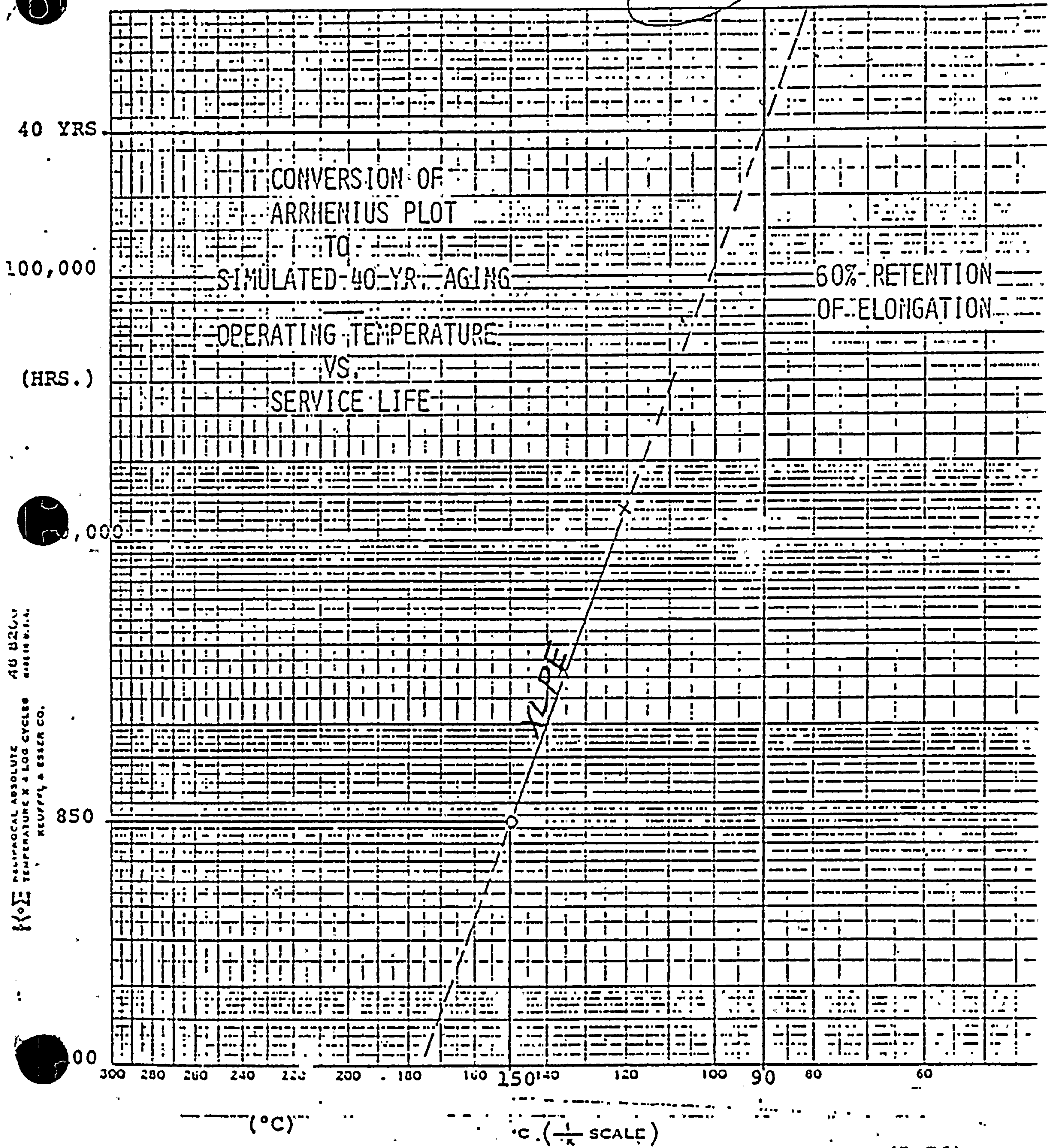
Test Profile:

.2 - .3 Mrads/hr, 200 Mrads
346°F, 113 psig for 5 hrs
265°F, 28 psig for 4 days
215°F, 2 psig for 26 days

Chemical Spray: 3000 ppm boron as boric acid in solution with .064 molar sodium thiosulfate buffered with sodium hydroxide to a PH of 9 to 11.

(ROCKBESTOS FIREWALL III)

CERRO WIRE & CABLE CO. (CI-8)



Raychem
Energy Division

Report*

Ref 63
Attachment # 8

DONALD C. COOK NUCLEAR PLANT;
ACCEPTED FOR Q/A BY [signature]
OF [illegible].GEN.SECT.AEPSC,N.Y.
[illegible] TO DOCUMENTATION FILE REQUIRED: YES X | NO
N-LIST UPDATE REQUIRED: YES | NO X
DATE: 10/22/82
E. G. SECT. FILE: ______

Title:	Pages:
HEAT AGING STUDY OF WCSF COMPOUND	7
	Enclosures:

Report Number:	Date:
EDR 2001	10 August 1978

Tested by:	Prepared by:	Approved by:
	David D. Nyberg	Dan Magay
Signature:	Signature: David D. Nyberg	Signature: Dan Magay

Raychem Corporation
Energy Division

*Report may only be used unchanged.

ABSTRACT

Radiation crosslinked slabs of WCSF compound and WCSF 070/250 tubing were subjected to oven aging in air at 136°C, 150°C, 162°C and 175°C. Based on an Arrhenius analysis of the oven aging data, the time to 50% retention of original elongation plotted on semilog paper against the reciprocal of absolute temperature in degrees Kelvin yields a predicted service life for WCSF compound of 40 years at a continuous operating temperature of 91°C.

CONTENTS

1. OBJECTIVE

To assess the thermal oxidative resistance of radiation cross-linked slabs of WCSF compound by oven aging of specimens in air at 136°C, 150°C, 162°C and 175°C.

2. TEST PROCEDURE

2.1 Specimen Preparation

Standard, pelletized, virgin WCSF compound was used. Slabs (6" x 6") were compression molded. Thickness was 75 ± 12 mils. The slabs were crosslinked by radiation to the same crosslink density as WCSF tubing. Two Die D specimens from each slab were tested for tensile strength, ultimate elongation and tensile stress at 50% and 100% elongation (crosshead speed 2 inches per minute). The stress-strain values from this were averaged and used as the original values to which the heat aged samples were compared.

Forty three (43) slabs were prepared. Standard deviations for tensile strength, ultimate elongation and tensile stress at 50% and 100% elongation were calculated based on the original data from the two Die D specimens from each slab. Slabs were discarded if the above original stress-strain values were outside the mean value ± twice the standard deviation for that value.

From the acceptable slabs (41), Die D specimens were cut and all combined. Five Die D specimens were chosen at random from the combined lot to provide one data point for the heat aging study. The original cross-sectional area of the specimens (pre-measured) were used to calculate the stress-strain properties after heat aging.

A few specimens of WCSF 070/250 plant production tubing were included in this oven aging study to allow some comparison to the slab data. The tubing was recovered prior to heat aging. Three specimens of recovered tubing were used to calculate an average original value for the stress-strain properties of interest. As with WCSF compound, five specimens were used for each data point.

2.2 Oven Aging

Forced air type Blue M ovens were used for heat aging at 136°C, 150°C, 162°C and 175°C. The ovens were calibrated with a 12 point recording thermocouple set-up at 12 different zones in the oven chamber. The temperature was monitored regularly with a single thermocouple permanently assigned to each oven. The temperature variation was less than ±2% of the specified exposure temperature in degrees centigrade.

The specimens in groups of five were hung vertically from the oven tray utilizing metal clips and hooks in the conventional Raychem manner.

3. TEST RESULTS

3.1 Retention of Elongation

The property of prime interest in this study was retention of original elongation which is a measurement of flexibility (or lack of brittleness). Both slabs and tubing oven aged at essentially equivalent rates with a reduction of tensile strength and with a slow increase in tensile stress (modulus) or stiffness.

The retention of original elongation versus time was plotted during the oven aging periods at the four different temperatures. In Table 5.1 the time (hours) to various percent retentions of original elongation are tabulated and this data is presented in graphical form in Figure 6.1.

3.2 Arrhenius Thermal Plot

In order to construct the Arrhenius thermal plot in Figure 6.2, we chose an end-point for retention of original elongation of 50%. The four experimental points for 136°C, 150°C, 162°C and 175°C yield a reasonably straight line predicting a service life of 40 years at a continuous operating temperature of 91° based on a conventional Arrhenius analysis of the time to 50% retention of elongation plotted on semilog paper against the reciprocal of absolute temperature in degrees Kelvin.

3.3 Calculation of Heat of Activation

From the slope of the Arrhenius thermal plot, the heat of activation for the thermal oxidation of WCSF compound was calculated to be 29 kcal/mole for the end-point of 50% retention of original elongation. This was calculated using the following equations:

$$b = \frac{2.303\,(\log_{10} t_2 - \log_{10} t_1)}{\frac{1}{T_2} - \frac{1}{T_1}}$$

Heat of Activation = Δ H act = R x b

where t_2 = time to endpoint (100,000 hours)

t_1 = time to endpoint (1000 hours)

T_2 = $^oC + 273$ corresponding to t_2

T_1 = $^oC + 273$ corresponding to t_1

b = ΔH act/R

R = 1.98 cal mole $^{-1}$ $^oC^{-1}$

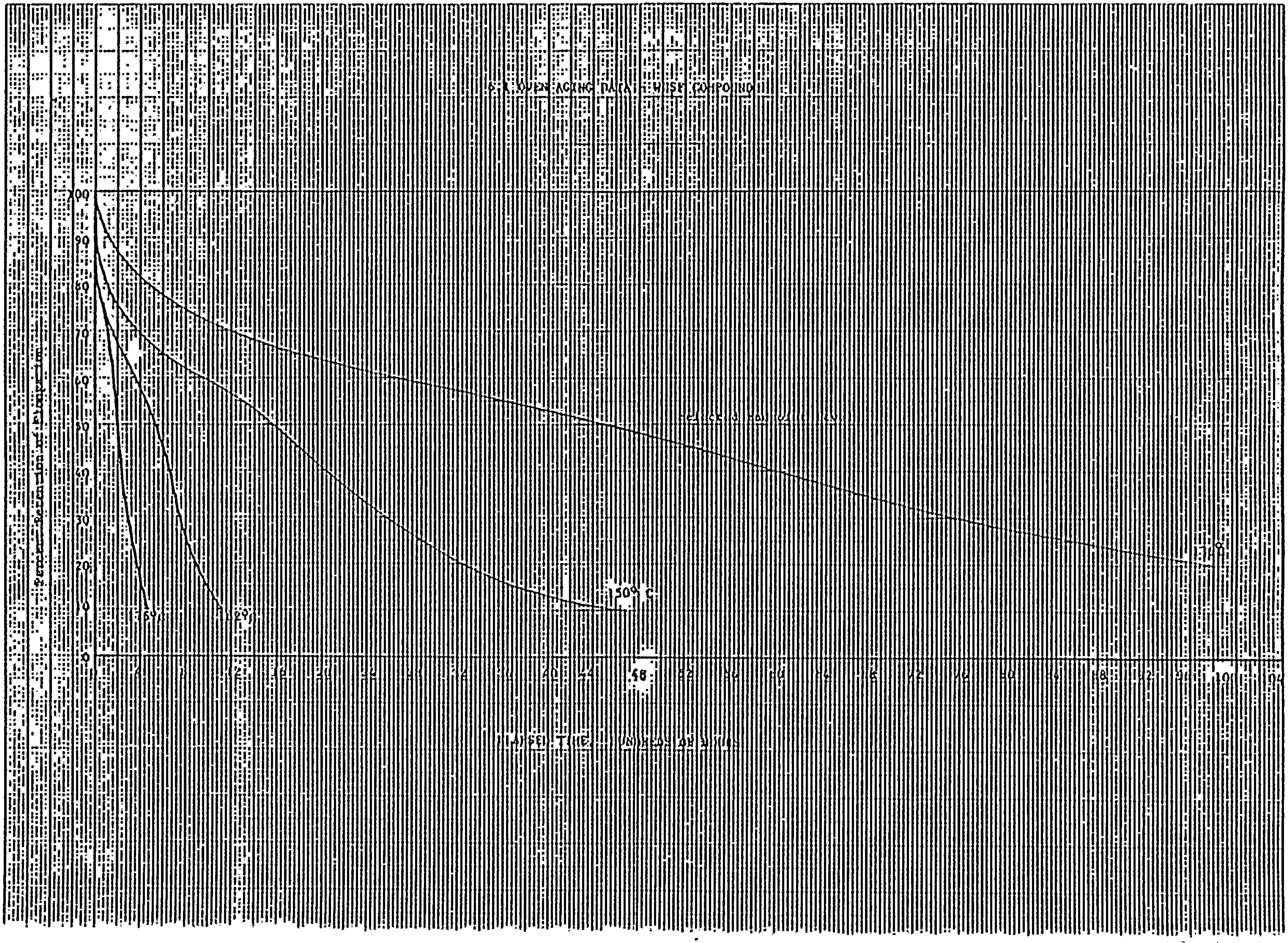
4. CONCLUSIONS

On the basis of the oven aging study described in this report and the use of a conventional Arrhenius analysis of the data, it is concluded that the useful service life of radiation crosslinked WCSF compound is predicted to be 40 years at a continuous operating temperature in excess of 90^{o}C. The heat of activation for the thermal oxidation of WCSF compound was calculated to be 29 kcal/mole.

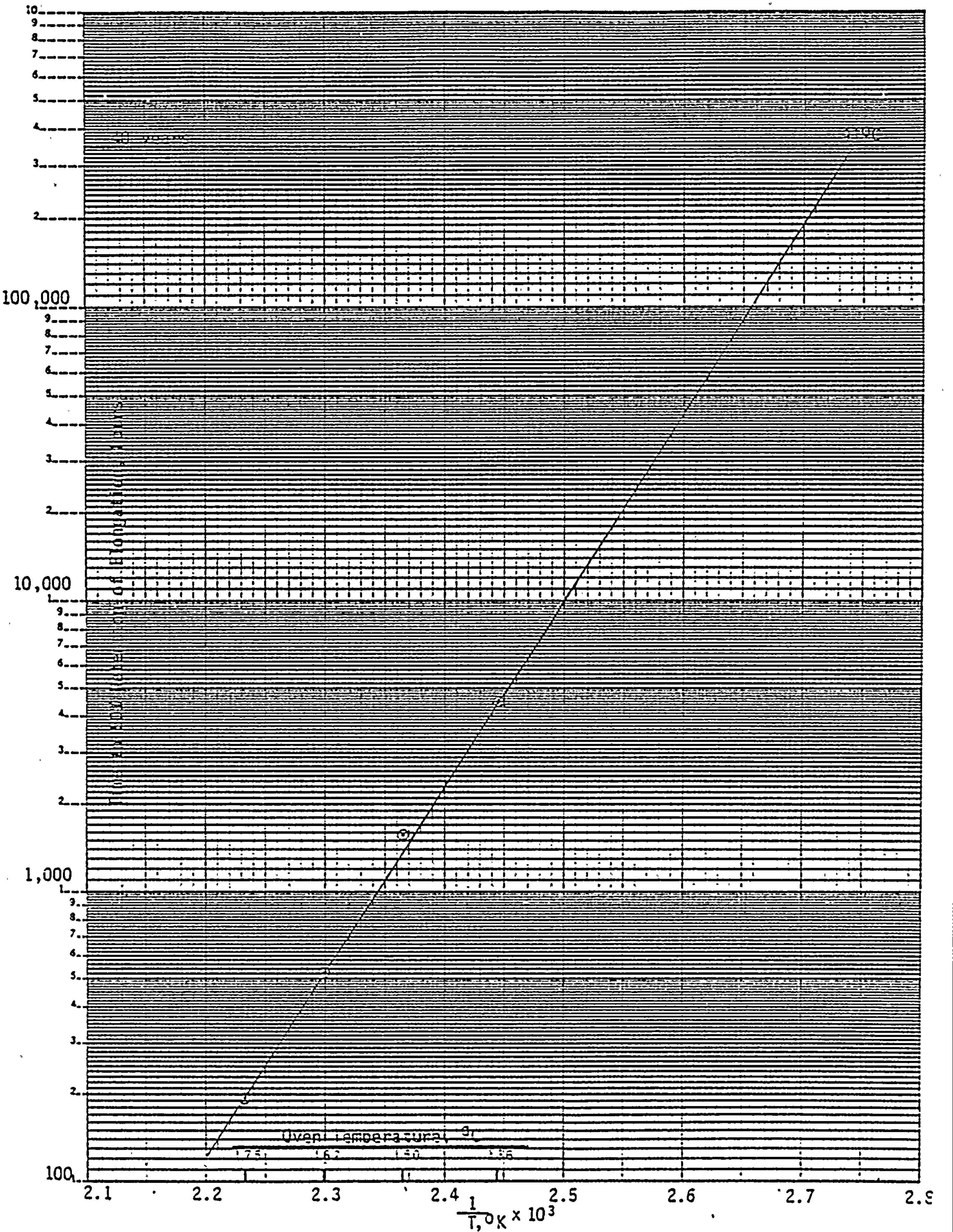
5. TABLE

5.1 OVEN AGING DATA - WCSF COMPOUND

Oven Temperature, °C	TIME (hours) to Various Levels of Retained Elongation								
	90%	80%	70%	60%	50%	40%	30%	20%	10%
136	71	470	1230	2700	4500	6020	7510	9810	--
150	35	107	331	960	1570	2030	2600	3230	4720
162	12	30	130	350	521	637	744	876	1100
175	4	20	112	154	194	228	279	361	450


150° C
100
90
80
70
60
50
40
30
20
10
0
48

6.2 Arrhenius Thermal Plot - WCSF Compound



AMERICAN ELECTRIC POWER SERVICE CORPORATION

AMERICAN ELECTRIC AEP POWER SYSTEM

DATE: September 28, 1982

SUBJECT: The Kerite Company Cable Environmental Qualification

FROM: L. F. Caso

TO: 79-01B Central File

The attached letter from the Kerite Company dated 9/21/82 should be made part of our equipment qualification document reference numbers (63) 68,70 and 72.

L F Caso

L. F. Caso

2.4/LFC:jal

APPROVED [signature]

J.M. ~~INTRABARTOLA~~

49 Day Street
Seymour, Connecticut 06483
(203) 888-2591

Mail All Correspondence To:
P.O. Box 452
Seymour, Connecticut 06483

the kerite company

9/24
TJM

September 21, 1982

American Electric Power Service Corporation
2 Broadway
New York, NY 10004

ATTENTION: T.J. MASSAR -
ELECTRICAL ENGINEERING DIVISION

Dear Sir:

SUBJECT: DONALD C. COOK NUCLEAR PLANT

REFERENCE: QUALIFICATION UPDATE

1975 per N. Duke 9/27/8

We have enclosed LOCA profile (excerpted from "Tests of Electrical Cables Under Simultaneous Exposure to Gamma Radiation, Steam and Chemical Spray While Electrically Energized" - March, 1985, Final Report #F-C4020-2, Figure 1) which describes a 100-day test conducted by the Franklin Institute Research Laboratories. This test provided a sodium borate chemical spray with a pH of 10.5 for 100 days continuously. The attached profile and the following results are offered as documentation of Kerite insulation and jacket materials' "Long-Term" (three months) immersion performance in a sodium borate solution.

The two cable samples (tested in referenced report) are representative of each 1/C which form the 3/C cable. Both samples (aged and unaged) are described as follows:

> 1/C, #6 AWG, 65 mil HTK (N-98) insulation and 65 mil FR (HC-711) jacket.

Each sample was irradiated to 200 megarads while installed in the autoclave. In summary, both cables maintained their electrical loading (1000v ac, 50 amps) throughout the test. Each cable passed the 5 minute voltage withstand test of 80 volts ac per mil of conductor insulation. This test was performed after completion of the LOCA exposure and prior to disassembly of the test vessel while the cables were still on the mandrel.

We trust that this is sufficient information to enable you to answer the inquiry of the NRC.

Very truly yours,

THE KERITE COMPANY

From the office of: C.A. Lundy
Metropolitan Sales Manager

Signee: Norma H. Dube
Administrative Sales Assistant

CAL/NHD/ss
Enclosure

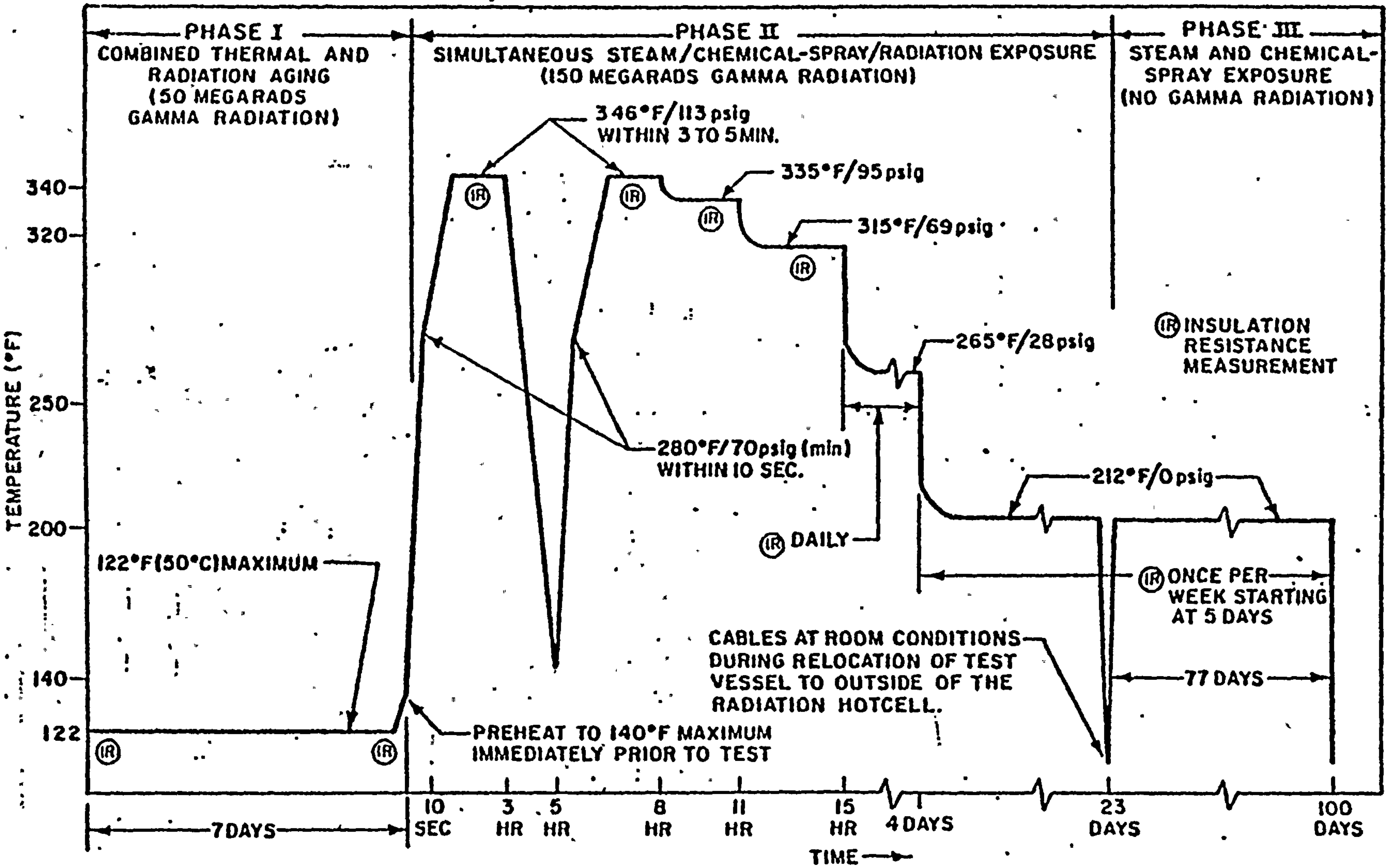


Figure 1. Specified Temperature, Pressure and Radiation Test Profile

F-C4020-2

Attachment C to AEP:NRC:0578H
Donald C. Cook Plant Unit Nos. 1 and 2
Update to AEP:NRC:0578B
Reference Lists

Document References Cited in IE Bulletin 79-01B

1. Conax Corp. Test Report IPS-234
2. Conax Corp. Test Report IPS-62
3. Conax Corp. Test Report IPS-137
4. Conax Corp. Analysis Report IPS-324
5. FIRL Test Report F-C3341
6. FIRL Test Report F-C3694
7. Kerite Co. Report on the effects of Gamma Rad. and Autoclaving on Kerite power and control cables
8. Conax Corp. Test Report IPS-348
9. FIRL Test Report F-C4033-1
10. FIRL Test Report F-C3683
11. Isomedix Corp. Test Report of May, 1976
12. Cerro Wire and Cable Test Report of May, 1976
13. Westinghouse-Canada Test Report CWAPD-332
14. FIRL Test Report F-C4033-3
15. Westinghouse-Canada Test Report CWAPD-326
16. Limitorque Corp. Test Lab. Project #600456
17. Conax Corp. Test Report IPS-326
18. Conax Corp. Test Report IPS-327
19. Conax Corp. Test Report IPS-329
20. Westinghouse Corp. Test Report WCAP-7709-L, Suppl. 2
21. Westinghouse Corp. Test Report WCAP-7829
22. Limitorque Corp. Test Report #600198
23. Limitorque Corp. Test Report #600376A
24. Limitorque Corp. Test Report #600461
25. Isomedix Corp. Test Report of November, 1975

26. Foxboro Test Report TE-1013

27. Westinghouse Electric Corp. Communication NS-PLC 5023 dated 4/26/78 from T. M. Anderson - Westinghouse to E. G. Case - NRC

28. Westinghouse Electric Corp. Test Report WCAP-9157

29. Automatic Switch Co. Report AOS 21678/TR

30. Westinghouse Electric Corp. Communication NS-TMA-1959

31. Boston Insulated Wire Test No. 730212

32. Boston Insulated Wire Test No. 75C008

33. FIRL Test Report F-C-2935, Excerpt from

34. Rockbestos Products: Qual. of Firewall III Class IE Electric Cables

35. FIRL Test Report F-C 3016

36. FIRL Test Report F-C 4350-3

37. Okonite Co. Qual. of Okoguard Ethylene-Propylene Rubber Insulation for Nuclear Plant Service (5-2-77)

38. Cyprus Statement of 6-16-76

39. Cyprus Statement of 9-14-76

40. Cyprus Report No. 3525

41. Cyprus Report No. 3658

42. Cyprus Statement of 6-16-76

43. Qual. of Namco Controls Limit Switch

44. FIRL Test Report F-C 3271

45. Conax Test Report IPS-339

46. Conax Test Report IPS-349

47. Letter of 6-21-71 from W. P. Hergrueter, Customer Service Lab. Bklyn., N. Y. to A. H. Statton, Boston Edison Co.

48. Letter of 4-17-80 from J. M. Allen (Mobil Oil Corp.) to Allen Feibleman (MEP)

49. Okonite Co. Qual. of Okonite Ethylene-Propylene Rubber Insulation for Nuclear Plant Service 7-3-78

50. Westinghouse Corp.WCAP 8541 Topical Report, Environmental Testing of Foxboro Transmitters

51. ITT/Barton Product Bulletin 288A/289-2 and Technical Manual 505-4 (A)

52. ITT/Barton Product/Bulletin GI-23-3

53. ITT/Barton Product/Bulletin GS-2A-ICIE

54. Foxboro Product Spec. PSS-2A-1B3A

55. Westinghouse Corp. Spec. 677271

56. Fisher Control Co. Oper. Test of Fisher Type 546 Electro Pneumatic Transducer

57. Auto Switch Co. Catalog No. 30 Bulletin 8300, 8302, 8315

58. Auto Switch Co. Catalog No. 30 Bulletin 8316

59. AEPSC NS&L Calculation DC-N-6420-2

60. Elect. Penetration Analysis

61. Flood-up Tube Qualification Packet

62. Instr. Cable Term Qual.

63. Required Time Qual. Analysis

64. Containment Spray Pump Motor

65. Environmental Qual. Class IE cable for outside containment service.

66. Westinghouse Electric Corp. Communications NS-TMA-2120

67. Westinghouse Electric Corp. Communications NS_TMA-2441 WCAP 9885.

68. Electrical Cable Submergence Qualification

69. Acton Test Report 16013-2 of July 6, 1981

70. Letter of 4/18/80 From Robert Henry of Kerite to L. F. Caso-AEP

71. Conax Corp. IPS-325

72. Chemical Spray pH Qualification

73. EC P1-2-00-04 Arrhenius Calc. on Barton Transmitters

Specified Environment Document References

EE Division

Ref. No.	Parameter	Reference	Device Designation
102	Temperature	FSAR App. N Fig. N13.13-1 N13.13-2 FSAR Figs 14.3.4-11,-12 (U1)	Elect. penetr- ations Hydrogen Recomb. IMO-315 316, 325, 326 VMO-101,102 QCM-250
102	Temperature	FSAR Figs. 022.0-1,-2 FSAR Figs. 14.2.5-9,-10	Air Recirc. Fan NRV valve L. Sw's. IMO-51, 52, 53, 54 IMO-128 ICM-111, 129 NMO-151, 152, 153
103	Pressure	Westinghouse Letter AEW 6504, Fig. 1&2	Elec. Pen. Hydr. Recomb. Air Recirc. Fan IMO-51, 52, 53, 54 IMO-128 ICM-111, 129
103	Pressure	W Letter AEW 6504 Figs 1&2	IMO-315, 316, 325 326 VMO-101, 102 QCM-250 NMO-151, 152, 153
103	Pressure	FSAR 14.3.4 (U1)	NRV L. SW's
104	Chemical Spray	FSAR Fig. 14.3. 4-6 (U1)	NRV L. SW's
105	Radiation	NS&L Review calculation SF Merger AEP-NRC-0578 Dated 10/6/81	All inside containment equipment
106	Radiation	Letter of 12/16/81 from: C. Ramjohn to: S. M. Toth	All outside containment equipment

Ref. No.	Parameter	Documentation Reference	Device Designation
107	Temperature Pressure	FSAR Fig. 14.4-6-8 (U1)	All outside containment equipment
108	Required Operating Time	Letter of 1/20/82 From: K. Vehstedt To: L. F. Caso	VMO-101, 102 QCM-250
109	Required Operating Time	FSAR Table 7.5-2	Electrical Penetrations Hydrogen Recomb. Air Recirc. Fan motors IMO-51, 52, 53, 54 IMO-128 ICM-111, 129
110	Required Operating Time	Letter of 4/14/75 9/29/75 From: J. Tillinghast AEP To: K. Kniel-NRC	IMO-315. 316. 325 326 Outside contain-MOV valves
111			
112			
113			
114	Chemical Spray	Tech. Spec 3/4-5, 3/4-5.6	Elec. Penetration Hydr. Recomb. Inside cont. valve (except VMO's & NMO's)
115 118	Chemical Spray	Letter of 1/10/78 From: S.J. Milioti To: J. Feinstein	Air Recirculation fan motor VMO-101,102
116	Chemical Spray	Letter of 4/23/82 From: T. Durando To: L. F. Caso	NMO-151, 152, 153
117			
118	Required	Letter of 4/14/82 From: K. Vehstedt To: L. F. Caso	Outside containment Pump Motors NRV Lim. Sw's NMO-151, 152, 153 ICM-305, 306

Attachment D to AEP:NRC:0578H
Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Update to AEP:NRC:0578B
Upper Compartment Temperature

[illegible]

Contrary to what is stated in Section 3.3 of the NRC Equipment Qualification Safety Evaluation Report, the maximum upper compartment temperature is not 130°F.

The worst-case temperature transients for a MSLB are given in Section 14.3.4 (Unit II) in the updated FSAR. The peak upper compartment temperature is approximately 150°F.

The worst-case temperature transients for a LOCA are given in Section 14.3.4 (Unit I), Figures 14.3.4-11 and 14.3.4-12. The peak upper compartment temperature from Figure 14.3.4-12 is approximately 150°F. This value is higher than the 130°F given in the NRC SER as the maximum temperature.

In response to an NRC question during a telephone conversation on this topic, the analyses of the containment response to LOCAs and MSLBs did account for operation of the air return fans.

[illegible]

Attachment E to AEP:NRC:0578H
Donald C. Cook Plant Unit Nos. 1 and 2
Update to AEP:NRC:0578B
General Notes

GENERAL NOTES

1. Any one piece of equipment may be qualified by more than one test report. For instance, it may be qualified for steam environment by one report, for chemical spray environment by another, and for radiation environment by still another report. In a case like this, the quaiification chart will list the different test reports and will specify, for each report, the qualification method used for that test (simultaneous, or sequential testing).

   For the case where a parameter has been qualified by test but the range attained during testing fell short of the required levels in the specified D. C. Cook plant environment, engineering analysis may have been used to explain why the environmental quantities achieved during testing are adequate for the application at hand. In these instances we call the equipment qualified by "Combination Method". This device has been used mainly to explain "Operating Time" and "Chemical Spray" qualifications.

   In some instances our devices have not been tested at all, however because they are required to operate in a relatively mild post-accident environment (e.g. outside containment) and because we know of devices qualified for a much harsher environment using similar or some generic type material; we have called these devices qualified by "Engineering Review Methods".

   According to this logic, electrical devices that will be submerged following an accident inside containment, have been qualified as follows:

   a. Equipment is protected against submergence by floodup tubes: cable and cable terminations at the containment penetrations (Engineering Review Method).

   b. Equipment has been qualified for submergence but the submergence test did not include a radiation test (Combination Method).

   c. Equipment has been qualified for LOCA and MSLB and has been immersed after these tests as required by IEEE 383-1974 (Engineering Review Method).

2. The limit switches, along with their cable and their cable terminations, for the valves listed below have been deleted from Attachments 2 and 3 to our submittal AEP:NRC:00356 ("Master List No. 2"). These limit switches are used for valve position indication only; that is, they are not used in the valve control circuit and are, therefore, not needed for the operation of the valve.

Valve	Inside Containment	Location Outside Containment
MRV-211		X
212		X
221		X
222		X
231		X
232		X
241		X
242		X
213		X
223		X
233		X
FRV-210		X
220		X
230		X
240		X
VCR-11	X	
21	X	
101	X	
102	X	
103	X	
104	X	
105	X	
106	X	
107	X	

For the valves outside containment, valve position can be readily verified. Those inside containment (VCR's) are containment isolation valves; a redundant containment isolation valve located outside the containment, in series with the one inside the containment, will serve as a backup device. The position of the valve outside containment can be verified.

3. Inside the containment, the LOCA pressure profile consists of an initial peak and a long-term peak after the ice melts out. The maximum calculated initial peak is 14.4 psig across the operating deck, as stated in Unit 2 FSAR Section 14.3.4. The long-term peak is shown in Figures 1 and 2 of Westinghouse letter AEW-6504 to AEPSC (Ref. 103). For the Cook Plant, the calculated minimum ice mass is 2.13×10^6 lbs. or 1098 lbs/basket. The value is intermediate to the cases pictured and gives a long term peak of 12 psig.

4. In the equipment qualification charts, the symbol "NA" means "not applicable."

5. The bounding values given in the specified environment column give a very conservative description of the adverse environment for two reasons. First, each bounding value may come from a different analyzed accident case, so that typically all the worst values are not calculated to occur during the same postulated scenario. Also, some of the equipment referenced to a specific chart may be subject

to only some of the adverse environment parameters or to much less severe calculated values of some parameters.

6. Equipment required due to changes in emergency operating procedures after January 14, 1980 (the issue date of IE Bulletin 79-01B) is not always included in this submittal. The cut-off date was agreed to by members of your staff at the February 7, 1980 clarification meeting in Glen Ellyn, Illinois.

NOTE ON VALVE MOTOR OPERATORS

The valve operators previously listed below were qualified for operation in a radiation environment. See letter of 7/17/80 from J. J. Oliver - Limitorque, to L. F. Caso - AEP (Ref. 74). These valves however, are equipped with brakes and the brakes were not part of the assembly when the valves were qualified for radiation. However, postulated failure of the brakes due to high radiation levels will not prevent the valves from opening. See letter of 11/2/81 from T. Durando of the Piping and Valves Section to L. F. Caso of the Electrical Generation Section (Ref. 74).

VALVE	COMMENT
ICM-311 321	These valves would only be operated if the RHR spray system was employed. The RHR spray system is back up containment pressure suppression system and the Cook safety analysis as reported in the FSAR demonstrates that is not needed for LOCA or HELB mitigation.
IMO-340 350 360 361 362	These valves are used during the switchover from the ECC injection phase to EEC recirculation. However, the sequence of their operation as defined in emergency operating procedures limits the time of their exposure prior to their operation to only a very short time.
IMO-910 911	These valves are used to terminate the suction of the charging pumps from the RWST once ECC switchover to to recirculation has been accomplished. They are protected against exposure to post-LOCA recirculation flow by a check valve.

NOTES ON CABLE TERMINATIONS

1. Calculated containment temperature 2.78 hours after a LOCA is 185^{O}F and decreasing (Figure 14.3.4-17, Unit I). This long term environment does not pose a challenge to the mechanical or electrical quality of the termination.

2. 230^{O}F for ten seconds and 11.5 psig for 0.1 seconds will not challenge the mechanical or electrical quality of the termination.

3. Environmental qualification for the control cable termination at the solenoid operated valves which serve the air-operated containment isolation valves (the VCRs) is not needed for the following reason. Energization of the solenoid is necessary to keep the containment isolation valves open. If the valves were open at the time of the accident, a containment isolation signal would de-energize the solenoid, closing the valves. If the valves were closed, they would remian closed. No matter what the initial valves' position is at the time of the accident, no failure of the cable termination will succeed in energizing the solenoid and opening the valves, when the containment isolation signal and/or the control switch in the control room has been actuated to close the valves.

4. Note 1 on valve motor operators pertains also to the termination at the motors serving the valves listed.

NOTES ON CABLES

1. Instrument cable for the following instruments inside containment is not in floodup tubes in either Unit I or Unit 2.

   a. Main steam flow transmitters:

      MFC-110, 111, 120, 121, 130, 132, 140, 141 & 142

   b. Pressurizer pressure transmitter:

      NPS-153

   c. Reactor Coolant System narrow range temperature transmitters:

      NTP-110, 111, 120, 121, 130, 131, 140, 141, 210, 211, 220 230, 231, 240, 241.

Placing these instrument cables in floodup tubes is not necessary for the following reasons. The MFC's and the NTP's will only be used for actuation of protective systems immediately after the accident, long before their cable becomes submerged. NPS-153 provides an additional monitoring function to that already provided by NPP-151, 152, and 153 which have their cables protected by floodup tubes.

2. Control cables for the following equipment inside containment is not in floodup tubes in Unit 1 only.

   Containment isolation valves (VCR's) listed in General Note 2. Operation of these valves (closing them) will take place immediately after the accident, long before the cable will be submerged. Postulated cable damage (because of submergence or otherwise) is not capable of re-opening these valves.

3. Calculated containment temperature 2.78 hours (10,000 seconds) after a LOCA is 185°F and decreasing (Figure 14.3.4-17, Unit 1). The electrical cable is rated for continuous operation at 194°F (90°C). Therefore the containment environmental temperature after 2.78 hours does not represent a challenge to the mechanical electrical quality of the cable.

NOTE ON INSTRUMENTS

Lists A-J, which are referenced on the equipment qualification charts, are attached.

(ATTACHMENT TO "NOTES ON INSTRUMENTS")

LIST A

Engineered Safeguards Actuation	Unit 1 Only
Containment Phase A isolation Actuation	Unit 1 Only
Main Steam Isolation Actuation	Both Unit 1 & 2
Reactor Trip Actuation	Both Unit 1 & 2
Main Steam - Normal System Monitoring	Both Unit 1 & 2

LIST B

Engineered Safeguards Actuation	Both Unit 1 & 2
Containment Phase A Isolation	Both Unit 1 & 2
Post Accident Monitoring	Unit 2 Only
Reactor Trip Actuation	Both Unit 1 & 2
Main Steam Normal System Monitoring	Both Unit 1 & 2
Remote Shut-down Monitoring	Both Unit 1 & 2

LIST C

Engineered Safeguards Actuation	Both Unit 1 & 2
Containment Phase A Isolation Actuation	Both Unit 1 & 2
Post Accident Monitoring	Unit 2 Only
Main Steam Isolation Actuation	Both Unit 1 & 2
Main Steam Normal System Monitoring	Both Unit 1 & 2
Remote Shut-down Monitoring	Both Unit 1 & 2

LIST D

Engineered Safeguards Actuation	Unit 1 Only
Containment Phase A Isolation Actuation	Unit 1 Only
Main Steam Isolation Actuation	Both Unit 1 & 2
Main Feedwater Isolation Actuation	Both Unit 1 & 2
Reactor Trip Actuation	Both Unit 1 & 2
Reactor Coolant Normal System Monitoring	Both Unit 1 & 2

LIST E

Engineered Safeguards Actuation	Both Unit 1 & 2
Containment Phase A Isolation Actuation	Both Unit 1 & 2
Remote Shut-down Monitoring	Both Unit 1 & 2
Reactor Coolant Normal System Monitoring	Both Unit 1 & 2

LIST F

Engineered Safeguards Actuation	Both Units 1 & 2
Containment Phase A Isolation Actuation	Both Units 1 & 2
Post Acccident Monitoring	Unit 2 Only
Containment Phase B Isolation Actuation	Both Units 1 & 2
Containment Spray Actuation	Both Units 1 & 2
Main Steam Isolation Actuation	Both Units 1 & 2

LIST G

Post Accident Monitoring	Unit 2 Only
Containment Phase B Isolation Actuation	Both Unit 1 & 2
Containment Spray Actuation	Both Unit 1 & 2
Main Steam Isolation Actuation	Both Unit 1 & 2

LIST H

Post Accident Monitoring	Unit 2.Only
Main Feedwater Isolation Actuation	Both Unit 1 & 2
Reactor Trip Actuation	Both Unit 1 & 2
Main Feedwater Normal System Monitoring	Both Unit 1 & 2

LIST J

Reactor Trip Actuation	Both Unit 1 & 2
Post Accident Monitoring	Unit 2 Only
Remote Shut-down Monitoring	Both Unit 1 & 2
Reactor Coolant Normal System Monitoring	Both Unit 1 & 2