

		CALCULATION CONTINUATION SHEET				SHEET 4 OF 5			
CEI	CALC. NO. EQ-095		DCP NO.		ASSIGNMENT NO. E0382				
	SUBJECT Qualified Life of Brand Rex cable ID23R47A								
REVISION	0		1		2		3		4
PREPARED BY/DATE	J. M. Ginn 3-8-90								
CHECKED/VERIFIED BY/DATE	G. B. T. 3-8-90								

Part A cont. - Qualified Life of Cable ID23R47A using an Activation Energy of 2.1122

$$\text{Qualified Life}_{210} = 168 e^{-2.1122/k \left(\frac{1}{509} - \frac{1}{572} \right)} = 65179 \text{ hrs}$$

$$\text{Remaining life}_{210} = 65179 - 3650 = 61529 \text{ hrs}$$

$$\text{Qualified Life}_{221} = 61529 e^{-0/k \left(\frac{1}{572} - \frac{1}{578} \right)} = 21620 \text{ hrs}$$

The qualified life of Brand Rex cable ID23R47A using an activation energy of 2.1122 equals $21620 + 3650 = 25270 \text{ hrs}$
 $= \underline{2.8846 \text{ years}}$
 + accident

Assuming a maximum average ambient temp. of 221°F, the Brand Rex cable ID23R47A will require replacement at the Third Refuel Outage. Replace cable prior to Third RFO if average ambient cable temp. meets or exceeds 222°F.

9005310196 900521
 PDR ADOCK 05000440
 F PDC

CEI	CALCULATION CONTINUATION SHEET						SHEET <u>5</u> OF <u>5</u>	
	CALC. NO. <u>EQ-095</u>		DCP NO.		ASSIGNMENT NO. <u>80382</u>			
	SUBJECT <u>Qualified Life of Brand Rex Cable 1D23R47A</u>							
REVISION	0	1	2	3	4			
PREPARED BY/DATE	<u>J. McKinn</u> <u>3-8-90</u>							
CHECKED/VERIFIED BY/DATE	<u>C. B. T. H. H.</u> <u>3-8-90</u>							

Part B

Calculation using an activation energy referenced from the Rockbestos report QR-5804, the qualified life of Brand Rex cable 1D23R47A will be calculated. Franklin Report F-CS120-1 provides 2 sets of aging data applicable to this cable, 158°C/168 hrs and 136°C/168 hrs. Although previous calculations utilized the 136°C/168 hr aging for conservatism, ^{LLM 3-8-90} ~~aging of 158°C/168 hr aging for conservatism~~, aging of 158°C/168 hrs is also acceptable for use. The PNPP accident profile is enveloped by the LOCA test performed by Franklin Research Center. A 5 month operating temperature of 210°F (99°C) will be considered. The ambient temperature of 222°F (105°C) will be considered for the remainder of the cable qualified life.

Abnormal/Normal

$$\text{life}_{210} = 168 e^{-\frac{1.3464}{R} \left(\frac{1}{731} - \frac{1}{372} \right)} = 52771 \text{ hrs}$$

$$\text{remaining life}_{210} = 52771 - 3650 = 49121 \text{ hrs}$$

$$\text{life}_{222} = 49121 e^{-\frac{1.3464}{R} \left(\frac{1}{372} - \frac{1}{371} \right)} = 22613 \text{ hrs}$$

~~remaining~~

The qualified life of this cable using an activation energy of 1.3464 equals $22613 + 3650 = 26263 \text{ hrs}$
 $= \underline{\underline{2.998 \text{ years}}}$
 + accident



AH.1 Sh 1/4

SP. 568-4549-00

BRAND-REX CABLE SYSTEMS DIVISION
1800 West Main Street
Williamson, CT 06226-1128
203-486-0000

EXC-2

MULTICONDUCTOR

REPORT #QULT-7600

LONG TERM THERMAL AGING

ARRHENIUS PLOT

40 YEAR LIFE

GENERAL: The following information outlines our approach and technique in verifying the 40 year service life of our cross-linked polyethylene insulation. Brand-Rex designation T-162.

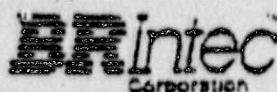
PURPOSE: To establish the aging temperatures, failure criterion and Arrhenius plot for our cross-linked polyethylene insulation such that a minimum 40 year life at 90°C (rated temperature) can be verified.

ARRHENIUS TECHNIQUE: The arrhenius equation is generally considered to be the best method of approximating the relationship between insulation life and temperature applicable to the service life of an insulated conductor. By selecting aging temperatures well above the expected normal operating temperature and establishing a failure criteria, a set of data points can be plotted. From this point, an indication of insulation performance can be extrapolated by shorter term agings.

BRAND-REX APPROACH: Samples were prepared in two ways. Ten groups of three samples were prepared by stripping the insulation from the conductor to make standard specimens for tensile and elongation measurement. Secondly, four samples 8 feet long were made into 6 inch coils for dielectric strength measurements.

Aging - Aging was accomplished by placing samples of the insulation in ovens at four different temperatures and aging until failure occurred.

Three Blue 'M' forced draft ovens were used in this test. All three ovens satisfied the requirements of ASTM-D-2436. The air flow was adjusted to give approximately 160 air changes per hour. The four test temperatures were 113°C, 121°C, 136°C and 150°C.



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AH. 1 Sn 2/4

BRAND-REX APPROACH - cont'd.

Failure Criterion - Testing for failure was accomplished by two methods. At specific intervals one group of three tensile samples was removed from the oven, cooled for 24 hours at room temperature and tested for tensile and elongation according to standard industry practices. Secondly, approximately 18 inches were cut from each of two coils and cooled for 24 hours at room temperature. Each coil was then attached to a mandrel whose diameter was eight times the diameter of the insulation while a 1.5 pound weight was attached to the other end. The sample was then wound on the mandrel both clockwise and counter-clockwise, twice in each direction. Upon removal from weight and mandrel, the sample was examined for cracking; if none were observed, it underwent a dielectric test.

The dielectric test consisted of a one hour soak in a 1% NaCl-Water solution. While the sample was still immersed, 4 KV AC was applied for 5 minutes. The voltage was applied at a rate of 150 volts/second. If no failure was observed, the voltage was increased at 500 volts/second until the sample broke down. The wall thickness was then measured at point of failure.

Failure was considered to be the failure of the insulation to withstand the 4 KV-AC for 5 minutes or if cracking was observed in the mandrel test. The tensile and elongation measurements were made only to correlate with the dielectric test.

The failure times for this compound are as follows:

<u>Test Temperature</u>	<u>Voltage Failure Time</u>
150°C	394 Hr.
136°C	1068 Hr.
121°C	4320 Hr.
113°C	15684 Hr.




AH. 1 Sh 4/ 4.

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ARRHENIUS PLOT: The above temperature and failure times were used on an Arrhenius plot in which the log of time to failure is plotted against the reciprocal absolute temperature. The point at which this plot crosses the rated temperature line is considered the thermal life of the material.

It should be noted here that the Arrhenius technique is valid if only one chemical reaction is controlling the insulation aging process. Our cross-linked polyethylene is formulated with many ingredients, each reacting differently with respect to time and temperature. On this basis, the aging points are the closest representation of 90°C and consequently our plot is a point to point and not a best fit straight line.

QUALITY ASSURANCE ENGINEER
TITLE


SIGNATURE

10/7/85
DATE

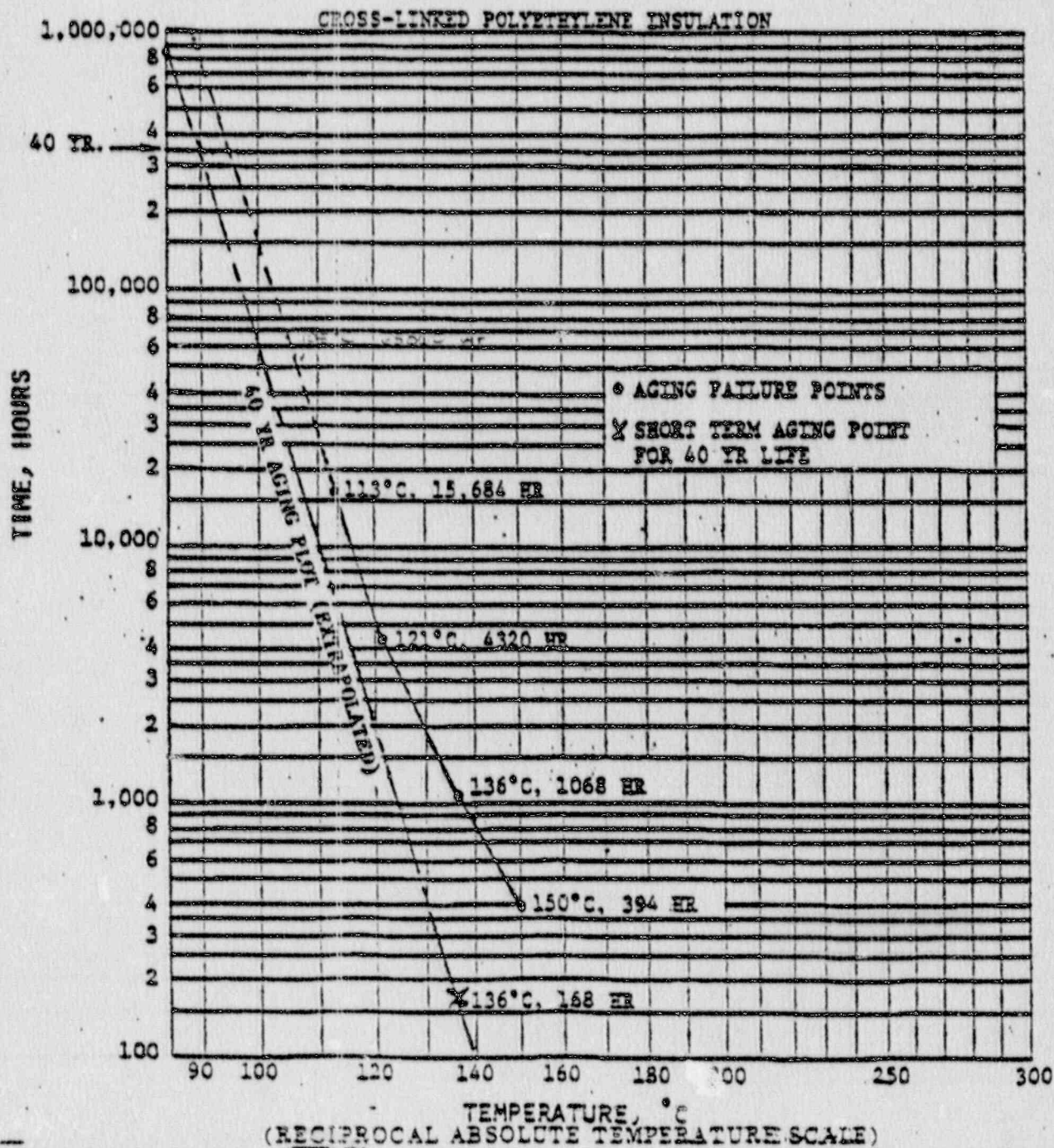
UTILITY ENGINEERING MANAGER
TITLE


SIGNATURE

10/5/85
DATE

BRAND-REX CABLE SYSTEMS DIVISION
1500 West Main Street
Wilmington, CT 06226-1128
203/456-8000

LONG TERM THERMAL AGING
ARRHENIUS PLOT
40 YEAR LIFE



An Affiliate of Cables Corporation

203/456-E/000

FAX 203-456-1305

FAX# (216) 259-5915

ATTENTION: LORI MacGUIRE

FROM: STEVE SANDBERG

DATE: 1/9/90

CC: _____

MESSAGE:

REF. YOUR FAX OF 1/3/90

ACTIVATION ENERGY FOR OUR

QUALIFIED XLPE is 2.13 EV

BASED ON TEMPERATURES AT

113, 121 AND 136°C



141
AH. 4

BRAND-REX CABLE SYSTEMS DIVISION
1600 West Main Street
Willimantic, CT 06226-1128
203 456-8000

June 25, 1987

American Electric Power Service Corp.
P.O. Box 16631
Columbus, OH 43216-6631

Attention: Mr. Robert Neurich

Reference: Indiana & Michigan Electric Co.
Donald C. Cook Generating Plant
P.O. #02655-041-5X
Control Cables

Subject: Brand-Rex Nuclear Qualified Crosslinked Polyethylene Insulation
Arrhenius Plot/Activation Energy


Dear Sirs:

As a follow-up to your telephone request of June 25th, Brand-Rex states that the Arrhenius Activation Energy for cables on the above referenced Purchase Order is 2.13 electron volts.

Trusting this information is satisfactory, we remain,

Very truly yours,

BRAND-REX CABLE SYSTEMS DIVISION


Stephen J. Sandberg
Utility Industry Manager

kmw

cc: Rich DeHay