SHOREHAM NUCLEAR POWER STATION

QUALIFICATION REPORT

GENERAL ELECTRIC 200 SERIES ELECTRIC PENETRATIONS

December, 1982

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TABLE OF CONTENTS

1.0 INTRODUCTION

The discussions, calculations, and conclusions contained in this report establish the environmental qualification of the General Electric 200 Series low voltage containment electrical penetrations.

The qualification of these penetrations is based on testing described in Sensor Products Engineering Memo No. 994-76-018, Rev. 1 (Appendix A), hereinafter called "the test report." In particular, under the LOCA test, only Tests #1 and #2 are used to demonstrate qualification levels.

All GE drawings, specifications, and part numbers referred to (in parentheses) herein are in Appendix B, with the exception of two which are proprietary to GE. These two drawings are cited to demonstrate traceability and do not contain information essential to this discussion. The applicability of these drawings to the Shoreham penetrations has been established through the GE Installation Manual supplied to Shoreham and the GE EIS File printout, which lists the subassembly drawings related to these penetrations. Excerpts from the manual and the EIS File printout are also included in Appendix B.

2.0 PRODUCT DESCRIPTION

The GE 200 Series low voltage penetrations are required to maintain primary containment pressure integrity and supply voltage and current through their conductors.

The construction and configurations of the 200 Series electric penetration modules are discussed below and depicted in Figure 1.

All modules utilize the identical stainless steel housing (195B9702). Within the steel housing are solid conductor wire (or rods), wire or rod coating (insulation), spacer or potting boards, and epoxy sealant. Each are discussed as follows:

The solid conductors are either copper or thermocouple extension wire, with diameters consistent with AWG application (262A6849, 262A6853, 262A6854). The conductors are coated with Scotchkote (262A6669).

The epoxy sealant is identical for all modules and denoted as EMR-300 and EMR-301, where the EMR-300 (262A7075) is the primary sealant in the basic module and EMR-301 (272A8189) is used to secure the stranded wires to the primary module. Chopped fiberglass is introduced into the EMR-300 as a reinforcement.

All spacer boards are made from GE Textolite (167A2534), which is a glass cloth base epoxy sheet.

The stranded wires (262A7898), which are insulated with cross-linked polyethylene, are connected to the solid conductors via copper connectors on both ends of the modules, either pin type (234A9806) for #12 and #8 AWG and thermocouple extension wires, or threaded type (225A5146) for #2 through #4/0 AWG wires. All connections are protected by Raychem Shrink Tubing (175A8230).

In addition, there is an XR5237 (262A7076) (3M Company) rigid epoxy cosmetic cover at the ends of all modules, which serves no functional purpose. Failure of this epoxy will not adversely effect operation of the penetration.

Therefore, all 200 Series penetrations employ the same materials and same basic configuration and can be considered similar for the purpose of equipment qualification.

3.0 INSTALLED VS. TESTED CONFIGURATION

The electric penetration header plates are welded to the containment nozzles in a horizontal attitude. All but five (5) penetration header plates are mounted on the outside wall of the primary containment (Attachment 1). Junction boxes are installed on both ends of all penetrations and enclose the penetration modules.

In the test configuration, the module is installed in a vertical attitude as shown in Figure 2. No junction box protection is provided. In the test configurations, the modules, wire, and connections are directly exposed to the saturated steam environment.

The test configuration is, therefore, more severe than the installed configuration since it has no protection by the junction box and is exposed to direct saturated steam conditions (see Section 4.1). In addition, the autoclave is not a heat sink like the containment wall, therefore allowing the penetration to be heated up somewhat more rapidly than in the actual installation.

4.0 ENVIRONMENTAL QUALIFICATION

4.1 Design Basis Event

The postulated profile of environmental conditions for the LOCA event for Shoreham is as follows for inside the drywell:

Duration (hours)	3	3	18	72	4224
Temperature (°F)	340	320	250	200	150
Pressure (psig)	48	48	15	15	10
Humidity	100%	100%	100%	100%	100%

This information is taken from Figure D-1 in Reference 1.

The test profile (Tests #1 and #2 on page 32 of the test report) was as follows for the first 24 hours of testing:

Duration (hours)	3.5	3.5	17
Temperature (°F)	340	328	275
Pressure (psig)	103	80	26
Humidity	100%	100%	100%

The postulated and test temperature profiles are shown together for comparison on Figure 3.

For the first 24 hours of the test, the test profile envelopes the Shoreham postulated profile in pressure, duration, and temperature.

During the first 24 hours of the test, simultaneous voltage (250 VAC) and current (2.5 amps) were continuously applied to both the #12 AWG and thermocouple modules (Test Report, pages 32 and 33, Tests #1 and #2) which represent all low voltage modules (see Section 2.0).

The test setup is as shown in Figure 2. The penetration modules remained helium leak tight to less than 1×10^{-6} cc He/sec. (Test Report, page 34) which satisfies the IEEE Standard 317-1976 guideline of 1×10^{-2} cc N_2/sec.

The over-testing described above is adequate to extend the qualification for both pressure integrity and operability over the remaining period to cover 180 days (see Sections 4.2 and 4.3 below).

In addition, the dielectric strength test of the #12 and thermocouple modules is adequate to qualify the remaining modules as discussed in Section 4.6, and the heating effects of the thermocouple module (I^2R) are in excess of plant applications as discussed in Section 4.5.

4.2 Pressure Integrity

The 200 Series low voltage containment penetration is designed and constructed to maintain containment pressure boundary integrity during all plant postulated normal and accident environmental conditions.

The 200 Series penetration is mechanically structured to prevent "blow out" of the modules and a subsequent loss of containment integrity. As shown in Figure 1, the internal components rest against a lip on each side of the steel penetration housing to prevent "blow out" initiated from either direction.

Environmental qualification testing (Test Report, page 32, Tests #1 and #2) has demonstrated the ability of the penetration modules to withstand extreme external pressure (103 psig) at elevated temperatures (340°F peak) without loss of any structural integrity.

The modules were satisfactorily tested to demonstrate pressure integrity during postulated post-LOCA pressure and temperature conditions subsequent to sequential testing for thermal cycle stress aging and radiation. External test pressures ranged from 20 to 103 psig with corresponding temperatures of 210°F to 340°F. The ability of the penetrations to maintain containment integrity given a postulated peak accident pressure of 48 psig is demonstrated with a tested leak rate less than 1×10^{-6} cc/sec. (Test Report, p. 34) at a tested pressure of 103 psig, which is more than twice the 48 psig peak postulated pressure.

Subsequent to attaining the 48 psig peak accident pressure, postulated containment pressure decreases to 15 psig in 6 hours and to less than 10 psig within 4 days (FSAR Figure 6.2.1-12), which will not be exceeded for 180 days (Section 4.1). Internally, the Series 200 penetrations are normally pressurized with nitrogen to 15 psig. Therefore, within 6 hours of accident initiation, and for 180 days thereafter, the internal N_2 penetration pressure is likely to be equal to or greater than the postulated containment pressure.

Pressure integrity was demonstrated for the Series 200 penetrations during the above testing for 1.25 hours (test #1) plus 13 days (Test #2). The first 24 hours of this testing, during which the device was energized, was extrapolated to 4.7 years beyond the 180-day accident profile (see Sections 4.3 and 5.0). The remaining 289.25 hours of testing provides an additional 1.76 years, when extrapolated at the normal maximum temperature of 150°F.

Therefore, the Series 200 penetrations have been demonstrated to retain their structural integrity and perform their pressure boundary function during postulated accident conditions.

4.3 Operating Time

These penetrations are required to withstand the postulated accident conditons discussed in Section 4.1 above and still maintain their required safety functions of electrical capability and containment (pressure) integrity for at least the duration of the accident (180 days). In order to meet these requirements, the first 24 hours of the test profile (see Section 4.1 above), during which this device demonstrated both electrical capability and pressure integrity, was extrapolated utilizing Arrhenius methodology.

4.3.1 Determination of Activation Energy

It is assumed that only non-metallic materials of construction are sensitive to thermal aging. The rigid structure and relatively high melting points of metals indicate that they will be unaffected by the range of temperatures with which we are concerned in this study. An evaluation of the construction of these penetrations (see Section 2.0) resulted in the following conclusions regarding the non-metallic components contained within this device.

a. Ethylene Propylene Rubber (EPR) 'O' - Rings

This component establishes the seal between the individual modules and the header plate and is required for maintaining pressure integrity only.

A survey of available literature indicates that this material has an activation energy of 1.28 eV (Ref. 2, p. B-4).

b. EMR-301 Epoxy

This material is used to pot the stranded connection wires into the penetration assembly. Electrical insulation is not required to be maintained by the epoxy but rather by the Raychem Shrink Tubing and stranded wire insulation. In addition, it is the EMR-300 (see below) which is required to maintain pressure integrity. Degradation of this material will not effect the ability of this device to perform its safety functions. Therefore, this epoxy will not be considered in this analysis.

c. Textolite Spacer Boards

This component is used to aid in manufacturing by maintaining the spacing of the conductors during the potting process (163C1790). Degradation of this material would not affect the ability of this device to perform its safety function. Therefore, this material will not be considered in this analysis.

d. XR5237 Epoxy

This material is applied as a cosmetic finish to the assembly and serves no safety function. Therefore, this material will not be considered in this analysis.

e. Flamtrol or Vulkene Stranded Wire

The cable supplied for customer connections utilizes a cross-linked polyethylene (XLPE) insulation (Attachment 2). A survey of available literature indicates that this material has an activation energy of 1.23 eV (Ref. 2, p.B-8).

f. Raychem Shrink Tubing

The shrink tubing provides electrical insulation for the connection between the conductor and the stranded wire, and for that part of the conductor on the EMR-301 side of the spacer board. Raychem specification RT-1136 (Attachment 3) for polyolefin, flexible tubing shows that this tubing must maintain 50% of its dielectric strength and 70% of its tensile strength after exposure to 7 days at 158°C and 60 days at 134°C. Using this data in the Arrhenius equation (Ref. 2, Eq. 4-16) yields an activation energy of 1.35 eV.

g. Scotchkote Coating

This coating is applied to the conductors to maintain electrical resistance between them. While this coating is no longer manufactured, its properties are considered similiar to Scotchcast 5230 (Attachment 4). This substance maintained 50% of its dielectric stength after exposure to 400 hours at 200°C, 2000 hours at 180°C, and 7500 hours at 162°C. Using this data in the Arrhenius equation results in an activation energy of 1.49eV.

h. EMR-300 Epoxy

This epoxy forms the primary seal for these penetration modules. While its activation energy is not currently known, a review of the activation energies typical of epoxies which exhibit similar properties (e.g., 2.04eV for GE's N229) indicates that the limiting activation energy for the other materials contained within this assembly should be much lower, and therefore bounding for this epoxy.

Therefore, the limiting activation energy for the critical materials contained within this device, specifically EPR, XLPE, Raychem shrink tubing, Scotchkote and EMR 300, is considered to be the 1.23 eV for XLPE.

It should be noted that the activation energies listed above are for materials exposed directly to air. Due to the nature of the construction of these penetrations, the EMR 300 epoxy, Scotchkote, and Raychem shrink tubing are either sealed from any gaseous environment or will normally be exposed to nitrogen only. Since it is generally considered that oxidation is one of the dominant mechanisms for thermal degradation (Reference 4), the activation energies presented here are considered conservative due to the lack of an oxidizing atmosphere.

4.3.2 Extrapolation of the Test Profile

Since thermal degradation is a cumulative process, the test profile discussed in Section 4.1 above can be regrouped for convenience as follows:

Duration, Hours	Temperature, °F (°K)
3.5	340 (444)
0.25	334 (441) (Avg.)
3.25	328 (437)
0.5	301.5 (423) (Avg.)

Duration, Hours	Temperature, °F (°K)
0.75	300 (422) (Avg.)
1.5	287.5 (415) (Avg.)
14.25	275 (408)

Total = 24 Hours

The Arrhenius equation is as follows:

$$t_s = t_a \exp \frac{\beta}{k} \left(\frac{1}{T_s} - \frac{1}{T_a} \right)$$ Reference 2, Equation 4-16

Where:

t_s = Service Time

t_a = Test Time

T_s = Service Temperature (°K)

T_a = Test Temperature (°K)

β = Activation Energy = 1.23 eV

k = Boltzman's Constant = 8.617×10^{-5}

The above equation is used to extrapolate the test profile to envelope the postulated accident temperature profile by determining conditions of equivalent degradation as shown in the table below.

T_s, °F(°K)	T_a, °F(°K)	t_a	Calculated t_s	Required Time
340 (444)	340 (444)	3 hours	3 hours	3 hours
320 (433)	340 (444) 334 (441) 328 (437)	0.5 hours 0.25 hours 1.05 hours	1.13 hours 0.45 hours 1.42 hours Subtotal=3 hrs	3 hours
240 (394)	328 (437)	0.51 hours	18 hours	18 hours
200 (366)	328 (437)	0.13 hours	73.42 hours	72 hours
150 (339)	328 (437)	0.34 hours	178.71 days	176 days
		Total =	183 days	

The results are graphed in Figure 4, which shows that the extrapolated test profile envelopes the postulated accident conditions for at least 183 days with 18.22 hours of electrical operability test time and 12 days of pressure integrity test time not used. This margin will be used in Section 5.0 to justify an appropriate surveillance interval for this equipment.

4.4 Radiation

The postulated radiation inside the containment in the vicinity of the electric penetrations is:

Period	Dose (rads)	Reference
40-year Normal	1.8×10^7	FSAR Table 3.11.2-1 and Reference 1, Figure D-1
180-day Accident	3.87×10^7	SWEC Calculation SNPS-1-URB-25-A, Revision 1
Total =	5.67×10^7	

Prior to LOCA Tests #1 and #2, the 200 Series penetration modules were successfully tested to (Test Report, p. 13):

Module	Serial No.	Dose
4/0 AWG	TG-8	5.3×10^7 rads
2 AWG	TG-7	9.8×10^7 rads
8 AWG	TG-6	6.7×10^7 rads
12 AWG	TG-5	6.0×10^7 rads
T/C	TG-3	5.0×10^7 rads
SRM/IRM	TG-1	6.1×10^7 rads

The only test exposures less than the maximum postulated dose are for the T/C and 4/0 modules. Due to the similarity established in Section 2.0, the other modules are representative of these for the purpose of type testing. The "Shield Building Seal" referred to in the test report is a module separate from and independent of the Series 200 module, as described on page 3 of the test report and is not applicable to the penetrations installed at Shoreham.

4.5 Conductor Heating

The current-carrying penetration conductors have been investigated for I^2R heating. The actual I^2R heating was determined to be less that the I^2R heating in the qualification tests (see Attachment 5).

4.6 Dielectric Strength

The power assemblies (#2 AWG, #8 AWG, #4/0 AWG) utilizing 125 VDC or 120 VAC are qualified by similarity to the #12 AWG and thermocouple assemblies which were energized at 250 VAC and carrying current throughout the LOCA qualification (see Section 2.0).

Power assemblies utilizing 480 VAC and requiring operability for 70 minutes are qualified by the power assembly LOCA Test #1 (Test Report, pages 32 and 33), wherein the conductors were energized at 500 VAC and carrying current for 75 minutes.

Power assemblies utilizing 480 VAC and requiring operability for 180 days require special consideration. The test conducted on the thermocouple module provided a voltage stress of 250 VDC across a minimum dielectric thickness of .0555" (163C1790) or 4.5 volts/mil. The #2 AWG modules which carry the load for the 480V circuits require a dielectric strength of 480V across 0.077" (163C1790) or 6.2 volts/mil. Although the test value did not exceed the required value, these are exceedingly low dielectric stresses. Typical dielectric strength for epoxy resins varies from 425 to 2000 volts per mil (Reference 3) depending upon dielectric thickness. At LOCA temperatures, dielectric strength will be approximately 200 volts/mil (Reference 5), well above the required 6.2 volts/mil. Because the required dielectric strength is very small compared to the above epoxy resin dielectric strength, the assemblies using 480 VAC will function as required.

5.0 SURVEILLANCE PROGRAM

A maintenance and surveillance program will be performed to monitor penetration integrity. Periodicity will coincide with required leakage tests per Appendix J to 10 CFR 50 (Type B tests).

A maintenance and surveillance program will also be performed to monitor the electrical characteristics of these penetrations. The periodicity of this surveillance is justified by extrapolation of the 18.22 hours of test time remaining from the calculations in Section 4.3.2 to an equivalent time at the maximum normal ambient temperature of 150°F.

Test Duration	Test Temperature, °F (°K)	Time To Equivalent Damage
1.22 hours	328 (437)	641 days
.5 hours	301.5 (423)	89 days
.75 hours	300 (422)	123 days
1.5 hours	287.5 (415)	140 days
14.25 hours	275 (408)	735 days

Total = 1,728 days
= 4.7 years

Therefore, a surveillance interval of less than approximately 4.7 years is justified. The electrical surveillance testing will be performed during each refueling outage. Measurements will be made on a sample of installed spare modules.

The surveillance program will consist of a leakage resistance measurement made at not more than 500 volts to preclude damage consequent to the test. Leakage resistance and ambient temperature will be recorded.

The rejection criterion will be a marked decrease in resistance with time, which cannot be accounted for by temperature variations. Note that any specific resistance measurement is essentially meaningless, but a rapidly decreasing series of resistance measurements implies that degradation may have taken place.

6.0 ANOMALIES

Sensor Products Engineering Memo No. 994-76-018, Rev. 1 (Appendix A), is the basis for qualification. In that report, anomalies observed during the testing were recorded.

An arbitrary 30% of module connectors to be energized was established at the onset of the test program. The actual numbers were as follows:

Size (Module)	Available Conductors	# Tested	Percent
4/0	4	3	75
2	10	6	60
8	30	15	50
12	85	28	33

The following two anomalies occurred:

1. In test #1, a dummy module blew out of the autoclave and caused a severe energy release which bent the uninsulated wire connections of the power modules to short to the wall of the autoclave when high voltage was applied.

2. In test #3, 2 of the 10 cables of the #2 AWG modules shorted to the autoclave wall due to steam buildup within the autoclave. Removal of those 2 cables reduced the sample size to 40%.

In test #1, the module which blew out was an old one (not 200 Series) which was used as a plug to fill the 7th hole in the headplate. Therefore, the blowout has no significance for the qualification of the 200 Series test specimens.

It should be noted that in anomalies 1 and 2 above, the autoclave inside diameter had only a matter of 1 or 2 inches clearance from uninsulated cable connections external to the test specimen modules, and that any movement of the cables would likely cause a short. This condition had always been known by the test engineers, and the associated risks were taken. The close clearance and uninsulated connections are not representative of the actual installation. Therefore, the shorting has no significance for the qualification of the test specimens.

7.0 REFERENCES

1. Environmental Qualification Report for Class 1E Equipment for Shoreham Nuclear Power Station - Unit 1, Revision 4, October, 1982.

2. Carfagno, S. P., and R. J. Gibson, A Review of Equipment Aging Theory and Technology, EPRI NP-1558, September 1980.

3. Handbook of Epoxy Resins, Lee and Neville, McGraw Hill, 1966, pp. 6-53.

4. General Principles for Temperature Limits in the Rating of Electric Equipment, IEEE Std. 1-1969.

5. General Electric Report No. DF-59SL110, Improvement in Proof Test Method for Searching Out Weaknesses in Generator Stator Bars, September 1959.

FIGURES

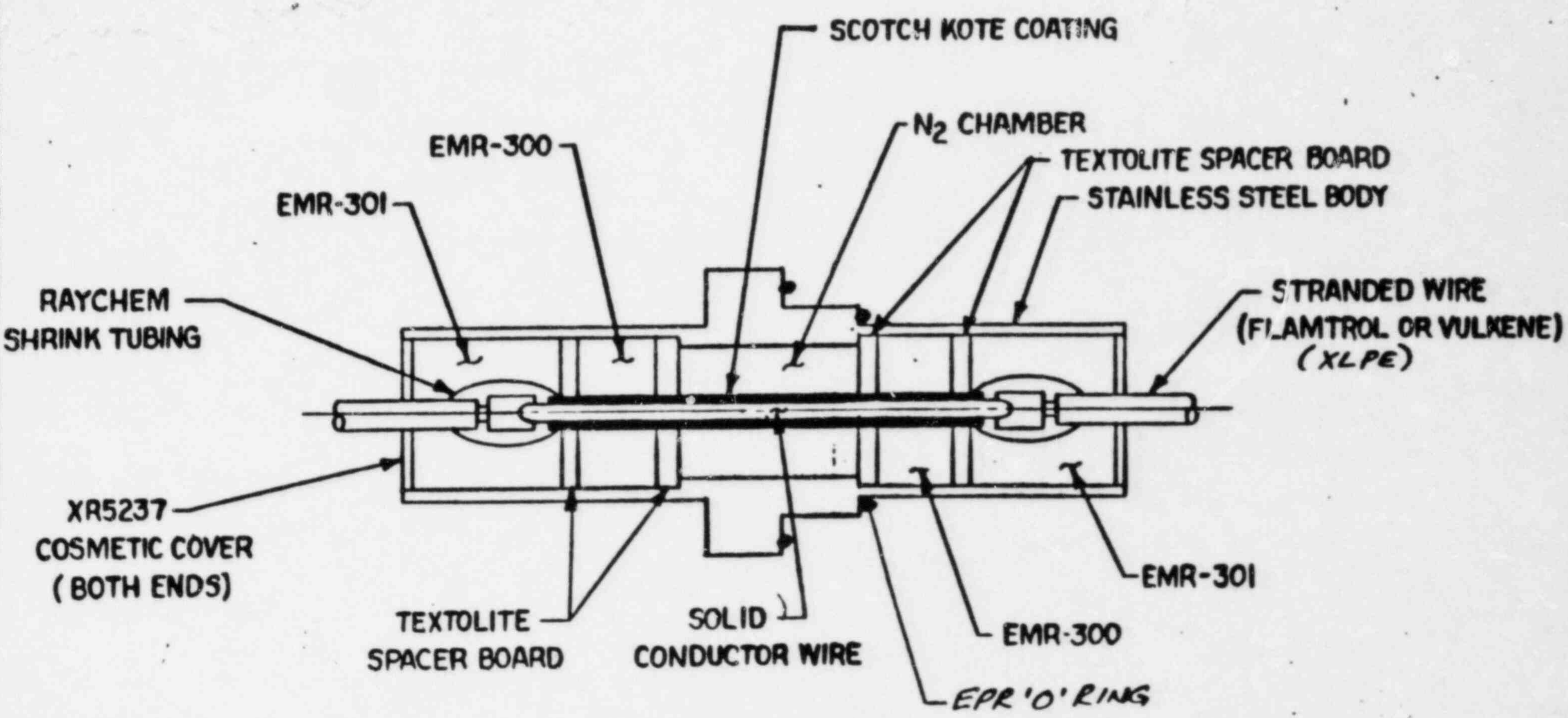


FIGURE 1 - TYPICAL PENETRATION ASSEMBLY

TEST SETUP · LOCA TEST

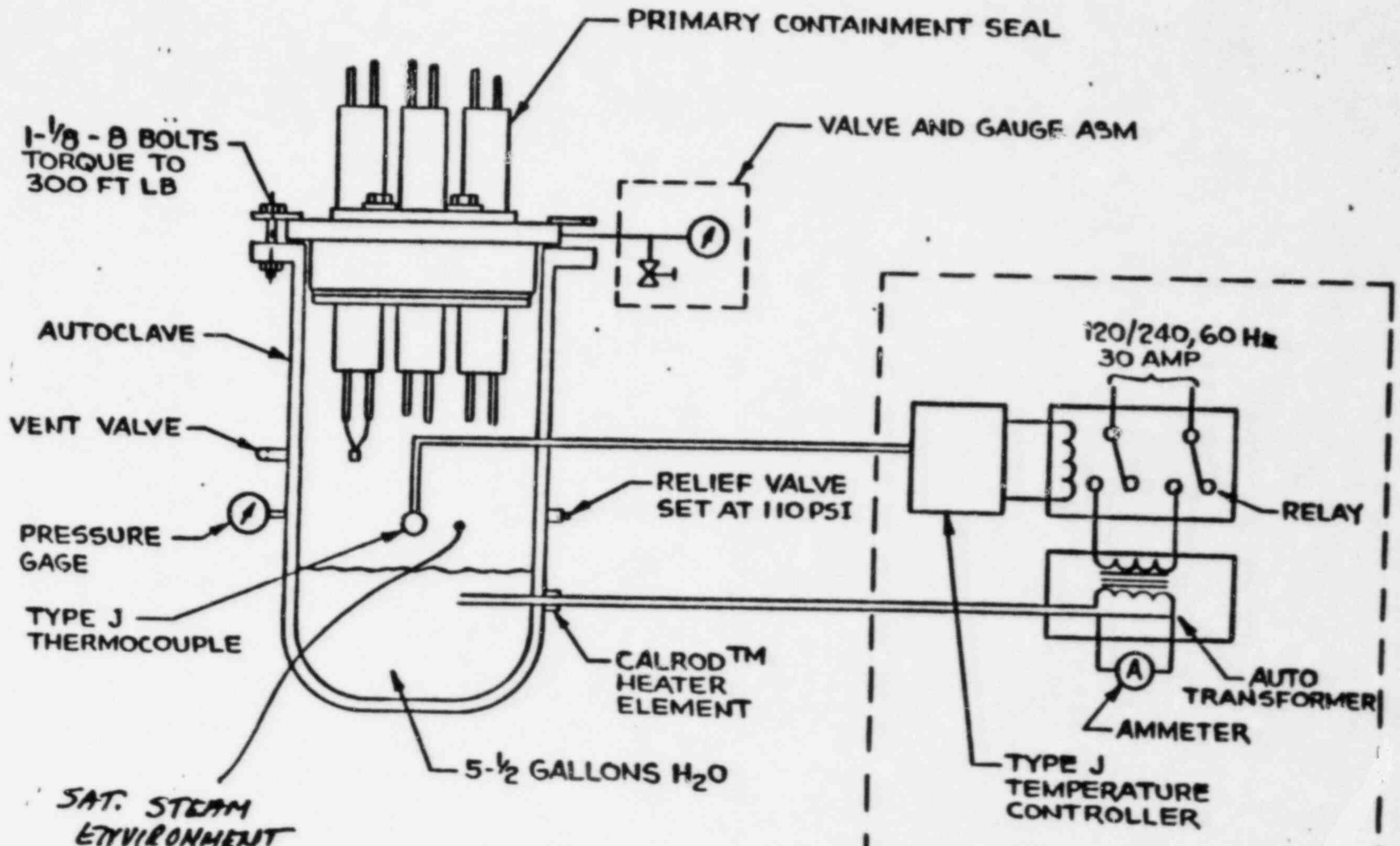


FIGURE 2 - TEST SETUP

FIGURE 3
ACCIDENT VS TEST PROFILE
(DURATION OF ENERGIZATION)

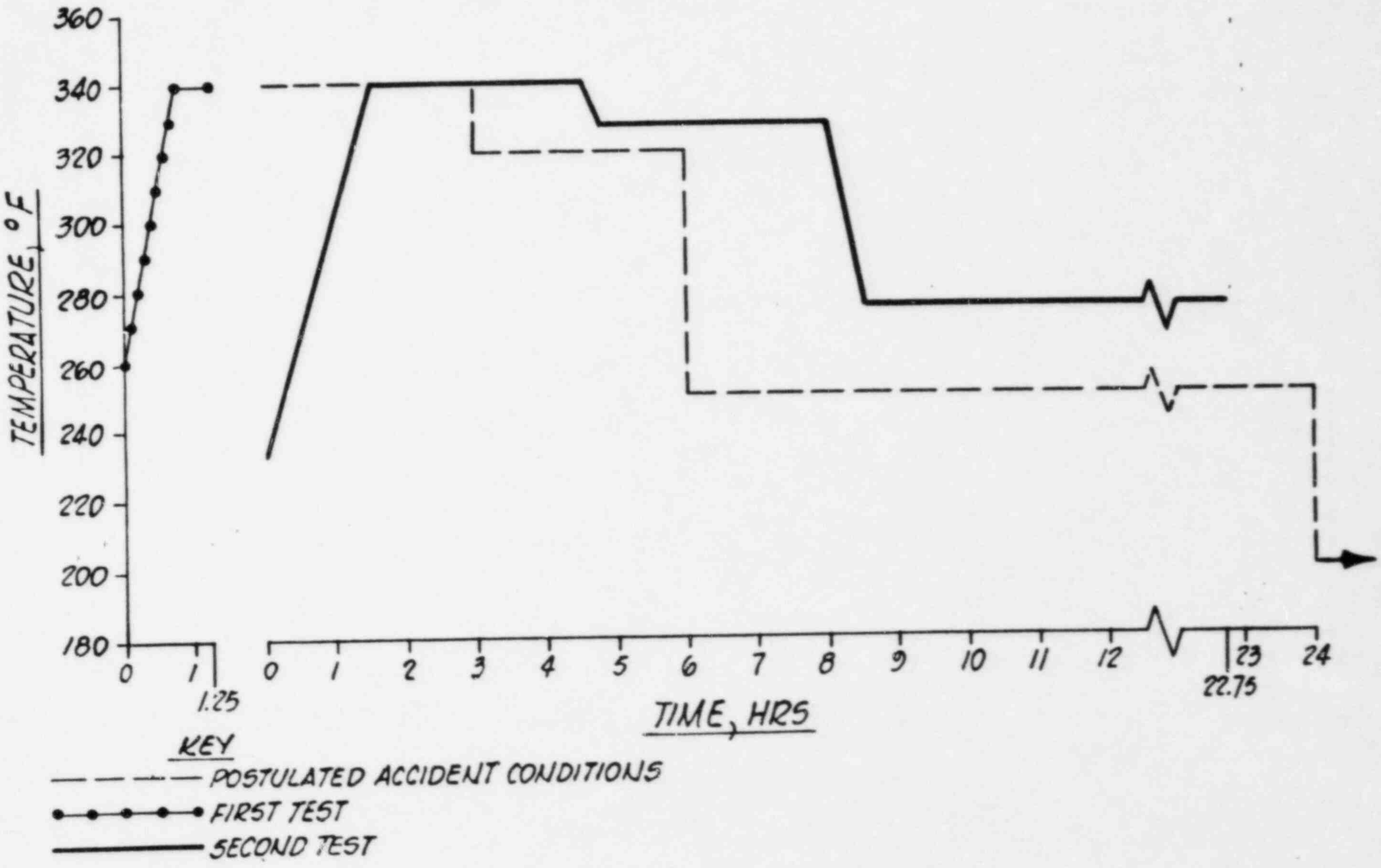
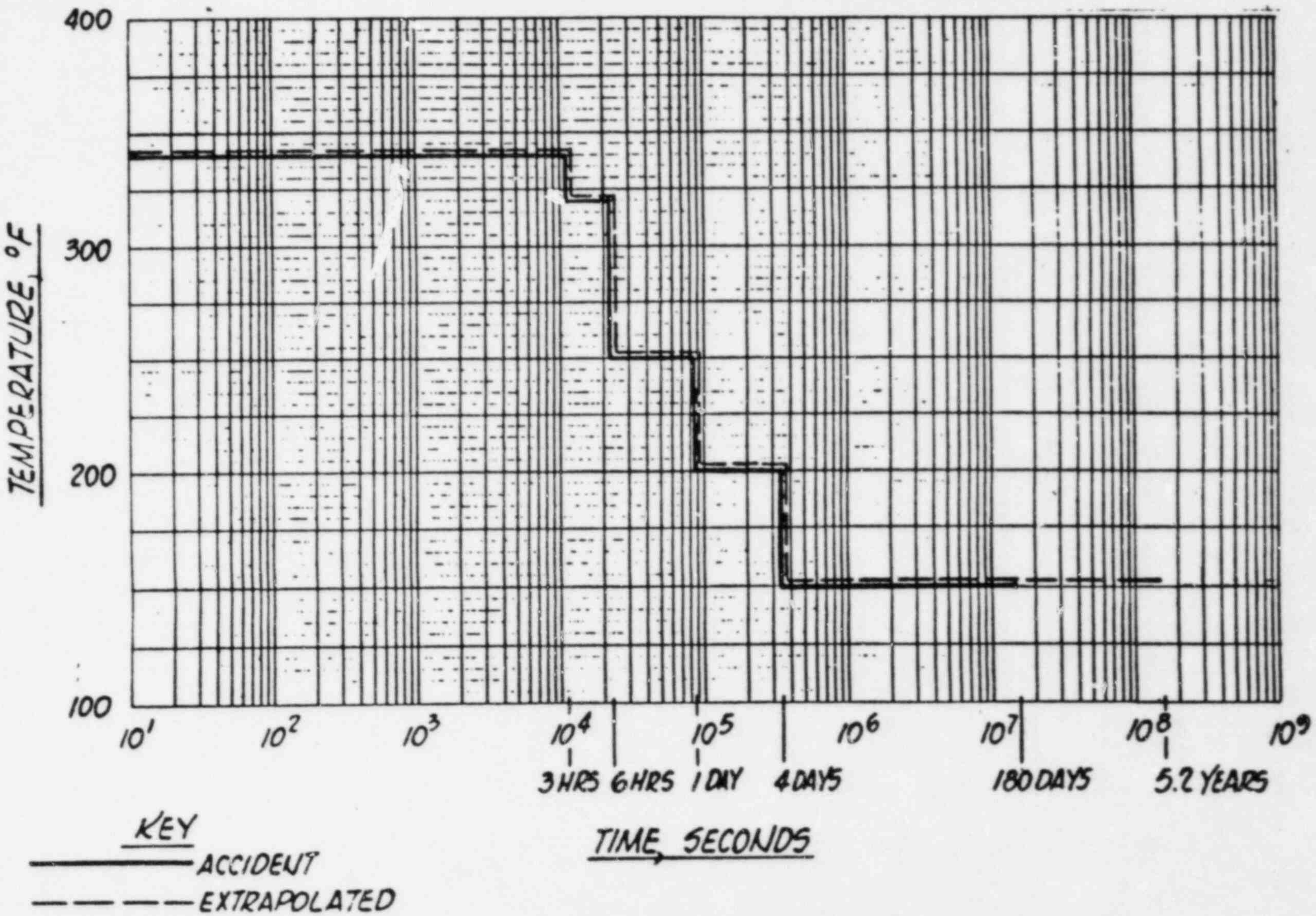


FIGURE 4
TEMPERATURE PROFILE COMPARISON



ATTACHMENTS

ATTACHMENT 1

PENETRATIONS MOUNTED FROM INSIDE PRIMARY CONTAINMENT

Only five 200 series low voltage electrical penetrations were installed with the header plate for the penetration modules on the inside of the primary containment wall. These are identified below:

1. 1T23*Z-WC4, Class 1E, control circuits - No. 12 AWG.
2. 1T23*Z-WD1, Non-Class 1E, instrumentation, SRM, IRM, and LPRM, No. 12 AWG.
3. 1T23-Z-WB1, Non-Class 1E, low voltage power - No. 2 and No. 4/0 AWG.
4. 1T23-Z-WB6, RPI, instrumentation - No. 12 AWG.
5. 1T23-Z-WC6, RPI, instrumentation - No. 12 AWG.

Of these, only one serves Class 1E equipment control circuits whose operability is safety-related. These circuits are energized at 120V and carry low current.

ATTACHMENT 2

Index Item 32

WIRE AND CABLE PRODUCT DATA

VY 10/8/80

September 28, 1973

Supersedes issue dated September 1, 1966

PRODUCT DESCRIPTION

General Electric Vulkene Type SIS switchboard wire, originally introduced in December 1961, is now accepted and is used by all major electric switchboard and control apparatus manufacturers. The Vulkene insulation, which requires no braid or other fibrous covering, allows smaller diameters and lighter weight than formerly possible in such wire.

PRODUCT DATA

Vulkene Type SIS switchboard wire consists of a tinned solid or stranded copper conductor, a paper separator for easy stripping and Vulkene insulation—a single extruded wall of chemically cross-linked, filled polyethylene. Vulkene, invented in the General Electric Company's Research and Development Center and developed as an insulation in the Wire and Cable Department's laboratories, is the result of years of testing many methods of compounding, processing and extruding to provide the proper balance of properties needed in a superior wire insulation. Vulkene is a thermosetting insulation with excellent thermal and electrical properties, chemical and moisture resistance, and mechanical toughness that make it superior to any other general-purpose insulation. The fact that the insulation is thermosetting and not thermoplastic means that temporary overloads will not melt the insulation as the case may be with polyvinyl chloride. The elimination of the fibrous coverings simplifies termination, saves space and improves the appearance of the wire with no sacrifice in technical properties.

APPROVED WIRING FOR SWITCHGEAR

The Power Switchgear Assemblies Group of the Switchgear Section of NEMA has revised its Standard Publication for Power Switchgear Assemblies, SG5, to read as follows:

"SG5-5.08 Small Wiring

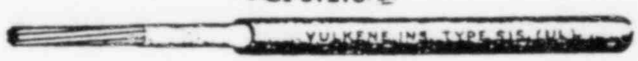
Insulated wire, not less than No. 14 AWG stranded, with insulation complying with Section 384-9 of the National Electrical Code 1962 or latest revision thereof, shall be used on small wiring. Where solid wire is used, the minimum size shall be No. 12 AWG. The internal wiring of component devices or parts shall be in accordance with the applicable industry standards.

For wiring of supervisory and annunciator circuits, small wiring may be used provided it is adequately supported and will meet the voltage and current requirements of the circuit."

G-E Vulkene switchboard wire is listed by Underwriters' Laboratories, Inc., as Type SIS for wiring switchboards and other industrial control panels in accordance with Article 384 of the National Electrical Code. This switchboard wire is recognized by NEMA as approved wiring for switchgear.

VULKENE TYPE SIS SWITCHBOARD WIRE

SI-57275



Single Conductor **600 Volts** **90 °C Conductor Temperature**

CONSTRUCTION:

Two-cycle tinned copper conductors, paper separator, Vulkene insulation. Standard color is dark gray. Black, white, green, red, yellow or blue available on special order. Listed by Underwriters' Laboratories, Inc. as Type SIS in Sizes No. 14 AWG and larger.

Size AWG	No. of Strands	Insulation Thickness in Mils	Approx O D in Inches	Net Wt Lb/M Ft
18	1	30	.11	10
18	7	30	.11	11
18	16	30	.11	11
18	41	30	.11	11
16	1	30	.12	14
16	7	30	.13	15
16	26	30	.13	15
14	1	30	.13	19
14	7	30	.14	20
14	41	30	.14	20
12	1	30	.15	28
12	7	30	.16	28
12	65	30	.16	28
10	1	30	.17	41
10	7	30	.18	42
10	105	30	.19	43
8	1	45	.23	69
8	7	45	.25	70
8	133	45	.27	75
6	1	60	.30	110
6	7	60	.32	113
6	133	60	.33	119
4	1	60	.34	162
4	7	60	.37	166
4	133	60	.40	175

* *Registered trade-mark of General Electric Company.*

PRODUCT DATA

TABLE I
COMPARATIVE DATA—SWITCHBOARD WIRE
TYPICAL VALUES

Test	Type TA	Type TBS	Vulkene Type SIS
EMPERATURE RATING			
Maximum operating temperature	90 °C	90 °C	90 °C
Emergency rating	110 °C	110 °C	125 °C
Short circuit rating—30 sec	150 °C	150 °C	200 °C
CTRICAL PROPERTIES			
sulation resistance			
Dry at rated temperature Megohms—M ft	1.4	0.6	33.2
ICAL PROPERTIES			
ginal			
nsile strength, psi	2300	2300	2000
ngation—%	280	275	200
—air bomb, 42 hr, 80 psi, 127 °C			
sile strength—% of original	100	100	98
gation—% of original	100	100	100
air oven, 60 days, 90 °C			
le strength—% of original	109	100	100
ation—% of original	50	83	76
flow—wound around .128" mandrel			
eight			
n—Kilovolts			
l	27+	27+	27+
hr at 135% rated current	20	20	19.8
flame test	Passes	Passes	Passes
rosion	None	None	None
nce	Good (slight trace)	Good (slight trace)	Excellent (no trace)

TABLE II
COMPARISON OF VULKENE WITH PVC

Test	Vulkene Type SIS 1/32" Wall †	PVC 1/32" Wall
Single impact		
Pounds to failure		
5/16" rod	2.0	1.0
1/2" rod	2.0	0.5
Slow compression		
Pounds to failure	190	152
Penetration test—90 degree sharp edge		
Load in grams to penetrate insulation in 10 minutes after 10 minutes preheat at 90 °C	6800	1300
Insulation resistence		
Megohms—M ft		
Original	3975	320
1 day @ 97 °C	24	0.41
7 days @ 97 °C	23	0.84
Insulation flow—wound around .128" mandrel with 6 lb weight		
Breakdown—volts		
Original	27+	27+
After 1 hr. at 135% rated current	19.8	0.8
Abrasion resistance—Sandpaper 150 grit B with 3 lb weight		
Inches to failure	40	34
† Cut-through—.025" steel strap wound around insulation with 10.5 lb weight		
% deformation of insulation		
Start @ 25 °C	9.5	16
1 hr @ 25 °C	13	32
10 hr @ 25 °C	14	34.5
50 hr @ 25 °C	14	34.5
100 hr @ 25 °C	15	35
† Cut-through—.025" steel strap wound around insulation with 3.5 lb weight		
% deformation of insulation		
Start @ 90 °C	27	38
1 hr @ 90 °C	27	50
10 hr @ 90 °C	29	57
50 hr @ 90 °C	30	59
100 hr @ 90 °C	30	60

† New Information.

COMPARISON DATA

Examination of the data in Table I comparing Vulkene Type SIS switchboard wire with the conventional thermoplastic-asbestos (Type TA) and the thermoplastic-cotton braid (Type TBS) shows that Vulkene Type SIS switchboard wire equals or exceeds these excellent wires in every important property. The improved insulation resistance helps insure that in heavily wired switchgear leakage to ground will be minimized. The high tensile strength and elongation of Vulkene Type SIS switchboard wire are an indication of the physical toughness so essential to successful factory and repair shop usage of switchboard wire. Another significant property is the excellent flame resistance of this Vulkene compound. This Vulkene insulation was specially developed to obtain the flame resistance so necessary for switchboard wire. Up to now no thermosetting insulation without an outer covering could be used for this application.

For greater economy some users are tempted to use straight PVC (polyvinyl chloride) as the insulation for switchboard wire. Examination of Table II shows Vulkene Type SIS switchboard wire to be superior to PVC in every important respect. The cut-through resistance of Vulkene Type SIS switchboard wire is superior to PVC both at room temperature and at high ambient temperatures. Even under the most adverse wiring conditions adequate insulation wall will be maintained.

This excellent balance of physical, electrical, and thermal properties make Vulkene Type SIS switchboard wire an outstanding choice for this application.

PRODUCT DATA

GUIDE SPECIFICATION
VULKENE SWITCHBOARD WIRE AND CABLE

1. SCOPE

1.1 This specification covers single conductor switchboard wire and cable insulated with filled chemically cross-linked polyethylene in sizes No. 18 through No. 4 AWG copper conductors. The wire or cable shall be suitable for operation at conductor temperatures of 90°C or less in dry locations at a maximum voltage rating of 600 volts. Sizes No. 14 AWG and larger shall be listed by the Underwriters' Laboratories, Inc., as suitable for switchboard wire use.

2. CONDUCTORS

2.1 Conductors shall be coated copper meeting the applicable requirements of the IPCEA-NEMA Standards Publication (IPCEA Publication No. S-66-524, NEMA Publication No. WC-7-1971 or latest edition). Conductors shall be solid or stranded. Class of stranding shall be specified by the user.

3. SEPARATOR

3.1 A separator, when used, shall consist of a helical or longitudinal wrap of paper or other suitable material directly over the conductor.

4. INSULATION

4.1 The insulation shall consist of an extruded wall of chemically cross-linked, filled polyethylene, dark gray in color unless otherwise specified. When tested in accordance with Part 6 of IPCEA S-66-524, the insulation shall meet the following requirements:

PHYSICAL REQUIREMENTS

Tensile Strength, minimum psi 1800
Elongation, minimum percent 150

AGING REQUIREMENTS—After Air Oven Test at 121±C for 168 Hours

Tensile Strength, minimum percentage of unaged value 70
Elongation at rupture, minimum percent of unaged value 70

Insulation Thickness. The average thickness of insulation shall not be less than that given in the following table. The minimum thickness shall not be less than 90 percent of those values.

INSULATION THICKNESS

CONDUCTOR SIZE-AWG	INSULATION THICKNESS-Mils
18-10	30
8	45
6-4	60

5. TESTS

5.1 The completed wire shall meet the following requirements:

5.1.1 Flame Test. A 22-inch specimen of the wire shall meet the vertical flame test requirement described in 6.19.5 of IPCEA S-19-81.

5.2 Voltage Test. The insulation on a 12-inch specimen of the wire shall withstand for one minute the alternating voltage indicated in the following table. The central 6-inch portion of the specimen shall be wrapped in metal foil and the voltage shall be applied between the conductor and the foil.

CONDUCTOR SIZE-AWG	AC TEST VOLTS
18-10	1500
8-4	2000

ATTACHMENT 3

Raychem	SPECIFICATION RT-1136
Raychem Corporation, 300 Constitution Drive, Menlo Park, California 94025	THIS ISSUE: ISSUE 1
	DATE: 1 OCTOBER 1980
	REPLACES: NONE

VERSAFIT™ TUBING

POLYOLEFIN, FLEXIBLE, HEAT-SHRINKABLE, FLAME RETARDANT

1. SCOPE

This specification covers the requirements for one type of flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 115°C *(239°F)*. VersaFit is UL recognized, meeting all the requirements of UL 224 for 125°C *(257°F)* flexible, heat-shrinkable, polyolefin tubing with VW-1 rating and is CSA certified in accordance with Bulletin 985.

2. APPLICABLE DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

2.1 UNDERWRITERS LABORATORIES, INCORPORATED

UL Subject 224 - Extruded Insulating Tubing

(Copies of UL publications may be obtained from Underwriters Laboratories, Inc., 1285 Walt Whitman Road, Melville, Long Island, New York 11746.)

2.2 CANADIAN STANDARDS ASSOCIATION

Bulletin 985 CSA Certification Requirements for Heat-Shrinkable Irradiated Crosslinked Polyethylene Insulating Tubing Rated at 125°C and 600 Volts

(Copies of CSA publications may be obtained from Canadian Standards Association, 187 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1R3.)

2.3 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

D 2671 Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

3. REQUIREMENTS

3.1 MATERIAL

The tubing shall be fabricated from thermally stabilized, flame-retardant, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

3.2 PROPERTIES

The tubing shall meet the requirements of Table 3.

3.3 COLOR

The tubing shall be available in black and white.

4. QUALITY ASSURANCE PROVISIONS

4.1 CLASSIFICATION OF TESTS

4.1.1 Qualification Tests

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests listed in this specification.

4.1.2 Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of the following: dimensions, longitudinal change (4.3.1), tensile strength, ultimate elongation, flammability, and heat shock.

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

Qualification test samples shall consist of 50 feet *(15m)* of tubing of the size and color specified. Qualification of one size or color shall qualify all sizes and colors.

4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of not less than 16 feet *(5 m)* of tubing selected at random from each lot. A lot shall consist of all tubing of the same size from the same production run and offered for inspection at the same time.

4.3 TEST PROCEDURES

Unless otherwise specified, tests shall be performed on specimens which have been fully recovered by conditioning in accordance with 4.3.1. Prior to all testing, the test specimen (and measurement gauges, when applicable) shall be conditioned for 3 hours at 23 ± 3°C *(73 ± 5°F)* and 50 ± 5 percent relative humidity. All ovens shall be of the mechanical convection type in which air passes the specimens at a velocity of 100 to 200 feet *(30 - 60 m)* per minute.

4.3.1 Dimensions and Longitudinal Change

Three 6-inch *(150 mm)* specimens of tubing, as supplied, shall be measured for length, to an accuracy of ± 1/32 inch *(± 1 mm)*, and inside diameter in accordance with ASTM D 2671. The specimens then shall be conditioned for 3 minutes in 200 ± 3°C *(392 ± 5°F)* oven, removed from the oven, cooled to 23 ± 3°C *(73 ± 5°F)*, remeasured for length, inside diameter, and wall thickness in accordance with ASTM D 2671. The longitudinal change shall be calculated as follows:

$$C = \frac{L_1 - L_0}{L_0} \times 100$$

Where: C = Longitudinal Change [percent]

L_0 = Length Before Conditioning [inches *(mm)*]

L_1 = Length After Conditioning [inches *(mm)*]

4.3.2 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with ASTM D 2671 using 1 inch *(25 mm)* bench marks and a 1 inch *(25 mm)* initial jaw separation. The speed of jaw separation shall be 20 ± 2 inches *(500 ± 50 mm)* per minute.

4.3.3 Copper Stability

Six 6-inch *(150 mm)* specimens of tubing shall be slipped over a snug fitting, straight, clean, bare copper conductor. For tubing sizes 1/4 and smaller a solid conductor shall be used; for tubing sizes 3/8 and larger a solid or tubular conductor shall be used. The specimens on the conductors shall be conditioned for 24 hours in a desiccator or similar humidity chamber at 90 to 95 percent relative humidity and 25 ± 3°C *(77 ± 5°F)*. Three specimens shall be conditioned for 7 days at 158.0 ± 1.0°C *(316.4 ± 1.8°F)* oven and three specimens shall be conditioned for 60 days in a 134.0 ± 1.0°C *(273.2 ± 1.8°F)* oven. After conditioning, the specimens shall be removed from the oven and cooled to 23 ± 3°C *(73 ± 5°F)*. The copper conductor then shall be removed from the tubing, and the tubing and conductor shall then be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing then shall be conditioned at room temperature for 16 to 96 hours and tested for ultimate elongation in accordance with 4.3.2.

4.3.4 Dielectric Withstand, Breakdown, and Strength

The dielectric strength of the tubing shall be measured under oil in accordance with ASTM D 2671. Five 6-inch *(150 mm)* specimens of tubing shall be recovered over a metal mandrel by conditioning for 3 minutes in a 200 ± 3°C *(392 ± 5°F)* oven. The mandrel diameter shall be slightly larger than the fully recovered inside diameter of the tubing being tested. The metal mandrel shall serve as one electrode and a 1-inch *(25 mm)* wide strip of lead foil wrapped around the outside of the tubing as the other electrode. The test voltage shall be applied at a rate of rise of 500 volts per second. Thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown. Specimens for dielectric withstand shall be held for 60 seconds at 2500 volts.

4.3.5 Corrosive Effect

Six specimens of tubing shall be tested for copper contact corrosion in accordance with ASTM D 2671, Method B. Three specimens shall be conditioned for 7 days in a 158.0 ± 1.0°C *(316.4 ± 1.8°F)* oven and three specimens shall be conditioned for 60 days in a 134.0 ± 1.0°C *(273.2 ± 1.18°F)* oven. After conditioning, the specimens shall be visually examined for evidence of corrosion.

3/6

4.4 REJECTION AND RETEST

Failure of any sample of tubing to conform to any one of the requirements of this specification shall be cause for rejection of the lot represented. Tubing which has been rejected may be replaced or reworked to correct the defect and then resubmitted for acceptance. Before resubmitting, full particulars concerning the rejection and the action taken to correct the defect shall be furnished to the inspector.

5. PREPARATION FOR DELIVERY

5.1 FORM

The tubing shall be supplied on spools, unless otherwise specified.

5.2 PACKAGING

Packaging shall be in accordance with good commercial practice.

5.3 MARKING

Each container of tubing shall be permanently and legibly marked with the size, quantity, manufacturer's identification, specification number, and lot number.

4/6

TABLE 1

TUBING DIMENSIONS

Size	AS SUPPLIED		RECOVERED							
	Inside Diameter Minimum		Inside Diameter Maximum		Wall Thickness (Inches, Millimetres)					
					Minimum		Maximum		Nominal	
	Inches	Millimetres	Inches	Millimetres						
3/32	.093	2.36	.046	1.17	.017	0.43	.023	0.58	.020	0.51
1/8	.125	3.18	.062	1.58	.017	0.43	.023	0.58	.020	0.51
3/16	.187	4.75	.093	2.36	.017	0.43	.023	0.58	.020	0.51
1/4	.250	6.35	.125	3.18	.022	0.56	.028	0.71	.025	0.64
3/8	.375	9.53	.187	4.75	.022	0.56	.028	0.71	.025	0.64
1/2	.500	12.70	.250	6.35	.022	0.56	.028	0.71	.025	0.64
3/4	.750	19.05	.375	9.53	.027	0.69	.033	0.84	.030	0.76

TABLE 2

MANDREL DIMENSIONS FOR BEND TESTING

Tubing Size	Diameter of Mandrel (Inches Millimetres)	
3/32 to 1/4 inclusive	5/16	7.9
3/8 to 3/4 inclusive	3/8	9.5

5/6

TABLE 3

REQUIREMENTS

PROPERTY	UNIT	REQUIREMENT	METHOD OF TEST
PHYSICAL Dimensions	Inches *(mm)*	In accordance with Table 1	Section 4.3.1 ASTM D 2671
Dimensional Recovery	Inches *(mm)*	In accordance with Table 1	Section 4.3.1 ASTM D 2671
Longitudinal Change ASTM D 2671 UL 224	 Percent Percent	 +1, −10 +3, −3	Section 4.3.1 ASTM D 2671 UL 224
Tensile Strength	psi *(MPa)*	1500 minimum *(10.3)*	Section 4.3.2 ASTM D 2671
Ultimate Elongation	Percent	200 minimum	Section 4.3.2 ASTM D 2671
Secant Modulus	psi *(MPa)*	1.5 × 10⁴ maximum *(103)*	ASTM D 2671
Deformation at 125 °C *(257 °F)*	Percent	50 maximum	UL 224
Low Temperature Flexibility 1 hour at −30 °C *(−22 °F)*		No cracking	UL 224
Heat Shock 1 hour at 136 °C *(277 °F)*		No cracking	UL 224
Heat Aging 7 days at 158 °C *(316 °F)* 60 days at 134 °C *(273 °F)* Followed by tests for:			UL 224
Tensile Strength Ultimate Elongation Flexibility Dielectric Withstand Dielectric Breakdown Dielectric Strength	psi *(MPa)* Percent Seconds Volts Volts/Mil *(Volts/mm)*	70% minimum of original 100 minimum No cracking 60 minimum 50% minimum of unaged specimens 500 minimum *(19,680)*	Section 4.3.2 Section 4.3.2 UL 224 Section 4.3.4 Section 4.3.4 ASTM D 2671
Copper Stability 7 Days at 158 °C *(316 °F)* 60 Days at 134 °C *(273 °F)* Followed by test for:		No brittleness, glazing, cracking or severe discoloration of tubing. No pitting or blackening of copper.	Section 4.3.3 ASTM D 2671
Ultimate Elongation	Percent	100 minimum	Section 4.3.2
Restricted Shrinkage		Pass	UL 224
ELECTRICAL Dielectric Withstand at 2500 V	Seconds	60 minimum	Section 4.3.4 UL 224
Dielectric Strength	Volts/Mil *(Volts/mm)*	500 minimum *(19,680)*	Section 4.3.4
Volume Resistivity	Ohm-cm	10¹⁴ minimum	ASTM D 2671
CHEMICAL Corrosive Effect 7 days at 158 °C *(316 °F)* 60 days at 134 °C *(273 °F)*		Noncorrosive	Section 4.3.5
Flammability		Pass	UL 224, VW-1
Water Absorption 24 hours at 23 °C *(73 °F)*	Percent	0.5 maximum	ASTM D 2671

ACTIVATION ENERGY $\phi = \frac{\ln\left(\frac{t_s}{t_a}\right)k}{\frac{1}{T_s} - \frac{1}{T_a}} = \frac{\ln\left(\frac{60}{7}\right) 8.617 \times 10^{-5}}{\frac{1}{407} - \frac{1}{431}} = 1.35 eV$

Printed by Raychem Printing Services

6/6

ATTACHMENT 4

eds nuclear
An Impell Corporation Company

FILE: 0630-001-671

RECORD OF CONVERSATION

COPY: NK Woodward
SR Pauly
C Meyer (3-M)

[x] Telephone [ ] Meeting [ ] Other

TO: Curt Meyer FROM: Steve Pauly DATE 11/29/82

COMPANY: 3-M Product Information Center PHONE NO.: 612-733-6739

SUBJECT: Scotchkote Resin 2006

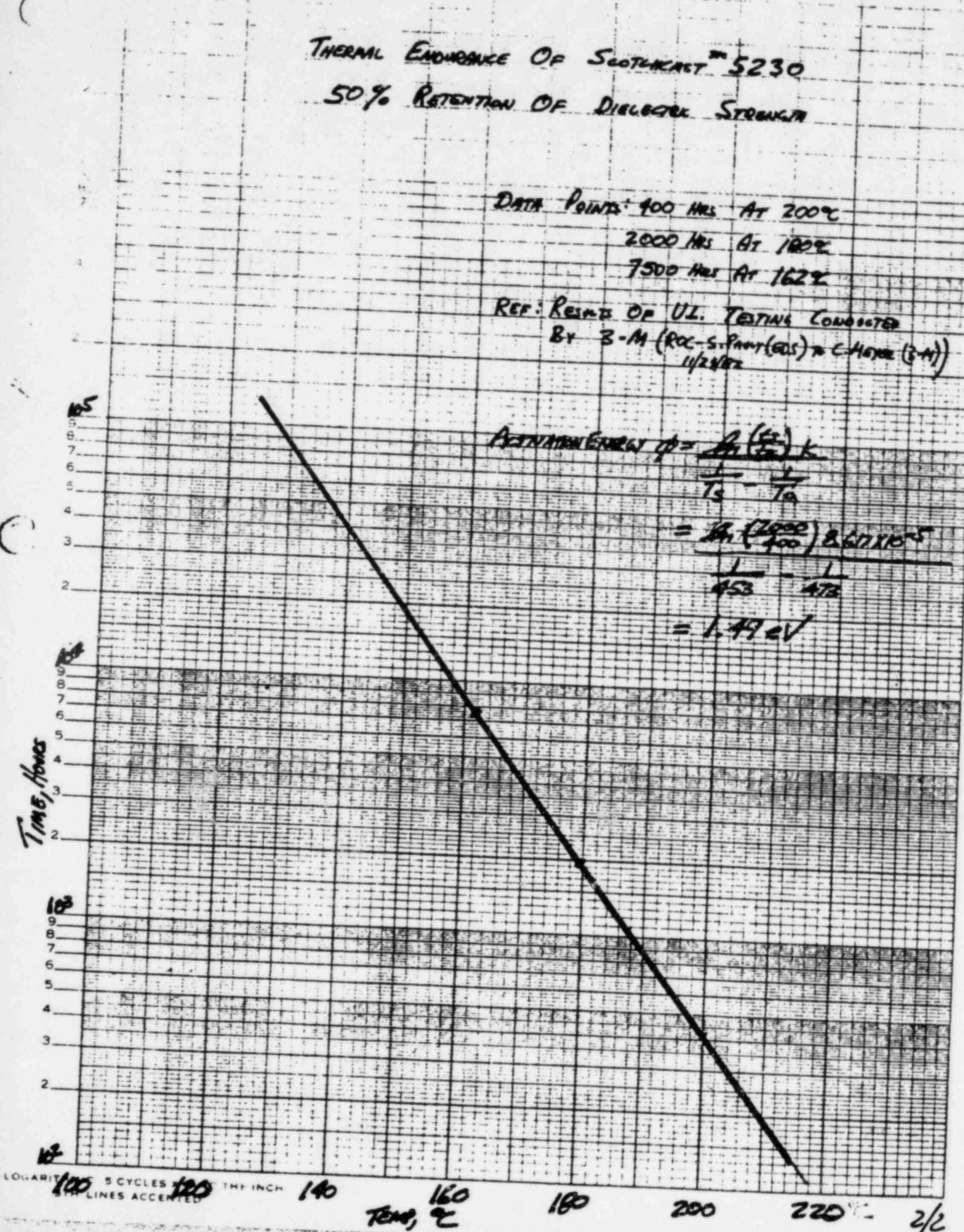
Summary of Conversation:

Mr. Meyer stated that 3-M no longer produces this coating. However, from the description of the properties listed on G.E. Drawing No. 262A6669, this resin is probably most similar to Scotchcast 5230. In particular, the specific gravity for Scotchcast 5230 of 1.5 is close to the specific gravity of 1.62 for Scotchkote 2006. The lower specific gravity of the Scotchcast 5230 would probably make heat aging data for Scotchkote 2006 conservative. The Scotchcast 5230 was exposed to the following condition to achieve 50% breakdown in dielectric strength:

2000 hrs at 180°C
7500 hrs at 162°C
400 hrs at 200°C

(see attached Arrhenius plot)

1/2



THERMAL ENDURANCE OF SCOTCHCAST™ 5230
50% RETENTION OF DIELECTRIC STRENGTH
DATA POINTS: 400 HRS AT 200°C
2000 HRS AT 180°C
7500 HRS AT 162°C
REF: RESULTS OF UL TESTING CONDUCTED BY 3-M (ROC-S. PAINT (GDS) to C. HEYER (3-M)) 11/28/82
ACTIVATION ENERGY $\phi = \frac{\ln\left(\frac{t_1}{t_2}\right) k}{\frac{1}{T_S} - \frac{1}{T_R}}$
$= \frac{\ln\left(\frac{2000}{400}\right) 8.617 \times 10^{-5}}{\frac{1}{453} - \frac{1}{473}}$
$= 1.49\ eV$
TIME, HOURS
10^5
10^4
10^3
10^2
TEMP, °C
100
120
140
160
180
200
220
LOGARITHMIC 5 CYCLES X ... THE INCH
... LINES ACCENTED

ATTACHMENT 5

I^2R HEATING CONSIDERATIONS

JUSTIFICATION FOR SELECTING A "CONTINUOUSLY ENERGIZED" ELECTRICAL PENETRATION (TYPE 200 SERIES) FOR I^2R (HEAT LOSS) CALCULATIONS

Penetrations are ampacity rated based on carrying current continuously. The time constant (time to achieve a stable temperature rise) of electrical apparatus, including penetrations, is typically about 1/2 hour, thus loads which are intermittently energized for periods less than one minute do not contribute significantly to the bulk temperature rise of the penetration. Further, intermittent loads (MOV's, etc) are applied using continuous ampacity ratings, giving very modest heating contributions.

All type 200 series penetrations are designed and tested the same way whether the loads are class IE or non-class IE. Thus, it makes no difference which penetration is selected for heating calculations provided the criterion is met; it must contain similarly loaded continuously energized conductors. The penetration selected for I^2R calculations represents the worst case as selected from formal FE-36 series drawings and the electrical motor load list.

See the attached SWEC Calculation No. E-56.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

*SEE INSTRUCTIONS ON REVERSE SIDE

5010.64 (FRONT)

CLIENT & PROJECT: LONG ISLAND LIGHTING COMPANY SHOREHAM NUCLEAR POWER STATION

PAGE 1 OF 13

CALCULATION TITLE (Indicative of the Objective): DETERMINE ACTUAL I^2R LOSSES IN GE 200 SERIES REACTOR CONTAINMENT PENETRATIONS

QA CATEGORY (✓): ☒ I - NUCLEAR SAFETY RELATED ☐ II ☐ III ☐ OTHER

CALCULATION IDENTIFICATION NUMBER

J. O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
11600.02	ELECTRICAL	E-56	- NA -	33A

* APPROVALS - SIGNATURE & DATE			REV. NO. OR NEW CALC NO.	SUPERSEDES * CALC. NO. OR REV. NO.	CONFIRMATION * REQUIRED (✓)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)			YES	NO
JOHN M. ZICKO John M Zicko 11/10/82	William K Shosho William K Shosho 11/18/82	Yilmaz Can Yilmaz Can 11/18/82	E-56	0		✓

DISTRIBUTION*

GROUP	NAME & LOCATION	COPY SENT (✓)	GROUP	NAME & LOCATION	COPY SENT (✓)
RECORDS MGT. FILES (OR FIRE FILE IF NONE)	FIRE FILE 401 SUMMER	✓			
ELECTRICAL	JOB BOOK 19.4 (ORIGINAL)	✓			
ELECTRICAL	JOB BOOK 241.21.1	✓			

TABLE OF CONTENTS

ATTACHMENTS

DWG 11600-02-FE-36F-5 TITLE: WIRING DIAG ELECTRICAL PENETRATION EAST B3
DWG 11600-02-FE-36W-5 TITLE: WIRING DIAG ELECTRICAL PENETRATIN WEST B1

CALCULATION SHEET

A5010 61

STONE & WEBSTER ENGINEERING CORPORATION

PREPARER/DATE	REVIEWER/CHECKER/DATE	J.O./W.O./CALCULATION NO.	REVISION	PAGE
John M Zielar 11/10/82	W Shelor 11/18/82	11600.02 E-56	0	4 of 13

SUBJECT/TITLE: I^2R LOSSES IN GE 200 SERIES PENETRATIONS

INDEPENDENT REVIEWER/DATE: Y Can 11-18-82

QA CATEGORY/CODE CLASS: I

SOURCES OF DATA ✓

(1) ENVIRONMENTAL QUALIFICATION REPORT APPENDIX D REV 4 DATED 9/8/82 (FOR SERVICE CONDITIONS)

(2) GE SPE MEMO 994-76-018 REVISION 2 DATED 1/20/77 PAGE 32 (FOR TEST VALUES)

(3) OKONITE CABLE COMPANY BULLETIN EHB-78 DATED 1978 PAGES 3 & 4 (FOR COPPER CONDUCTOR RESISTANCE AND TEMPERATURE CORRECTION FACTORS)

(4) GE DESIGN SPEC 262A7173 REV 6 DATED 10/25/77 PAGE 12 (FOR MAXIMUM PERMISSIBLE HEAT LOSS)

(5) GE PROJECT QUALITY PLAN QP 10.038 REV 1 DATED 10/7/77 (FOR RESISTANCE OF #12AWG ALUMEL-CONSTANTAN WIRE)

(6) MOTOR & ELECTRIC LOAD LIST PES-300 DATED 11/1/82 (FOR ELECTRICAL LOAD CURRENTS)

(7) STONE & WEBSTER 11600.02-FE-36 SERIES WIRING DRAWINGS (FOR DETERMINING LOADS FED VIA THE PENETRATIONS)

CALCULATION SHEET

A5010.61

STONE & WEBSTER ENGINEERING CORPORATION

PREPARER/DATE	J.O./W.O./CALCULATION NO.		REVISION	PAGE
John M Zeder 11/10/82	11600.02	E-56	0	5 of 13
	REVIEWER/CHECKER/DATE		INDEPENDENT REVIEWER/DATE	
	[signature] 11/18/82		[signature] 11-18-82	

SUBJECT/TITLE: I^2R LOSSES IN GE 200 SERIES PENETRATIONS

QA CATEGORY/CODE CLASS: I

APPROACH - AFTER REVIEWING STONE & WEBSTER 11600.02-FE-36 SERIES WIRING DRAWINGS (CONNECTION DRAWINGS) IT WAS DETERMINED THAT THE ONLY SERIES 200 PENETRATIONS WITH CONTINUOUSLY ENERGIZED POWER LOADS ARE EAST B3 & WEST B1 (1T23-Z-EB3 & WB1 RESPECTIVELY).

FROM DRAWINGS 11600.02-FE-36F-5 AND 11600.02-FE-36W-5 THE CONTINUOUSLY ENERGIZED LOADS ARE THE DRYWELL COOLING SYSTEM FANS AND THE REACTOR RECIRCULATION PUMP MOTOR SPACE HEATER. ALL OTHER LOADS IN THESE TWO PENETRATIONS ARE EITHER INTERMITTENT IN NATURE (MOTOR OPERATED VALVES) OR ARE USED DURING REFUELING (LIGHTING PANELS, WELDING RECEPT)

I^2R LOSSES FOR BOTH OF THESE PENETRATIONS (WHICH CONTAIN THE POWER FEEDS FOR FOUR DRYWELL COOLING FANS AND ONE REACTOR RECIRC. PUMP MOTOR SPACE HEATER) WILL BE IDENTICAL SINCE THE NUMBER OF LOADED CONDUCTORS AND THE CURRENT THROUGH THESE LOADED CONDUCTORS IS THE SAME. THE RESULTS CAN BE APPLIED TO EITHER OF THE TWO PENETRATIONS

CALCULATION SHEET

A5010 81

STONE & WEBSTER ENGINEERING CORPORATION

PREPARER/DATE	J.O./W.O./CALCULATION NO.		REVISION	PAGE
John M. Zidco 11/10/82	11600·02	E-56	0	6 of 13
	REVIEWER/CHECKER/DATE	11/18/82	INDEPENDENT REVIEWER/DATE	11-18-82
SUBJECT/TITLE: I^2R LOSSES IN GE 200 SERIES PENETRATIONS			QA CATEGORY/CODE CLASS	I

CONCLUSION:

THE ACTUAL VALUES OF I^2R LOSS IN THE PENETRATIONS WITH THE CONTINUOUSLY ENERGIZED POWER CABLES IS 2.5 WATTS/FOOT WHICH IS BELOW THE MAXIMUM PERMISSIBLE LOSS OF 15 WATTS/FOOT (SEE APPENDIX A AND FIGURE 1) AT THE ASSUMED AMBIENT OF 150°F (65°C), AND IS ALSO BELOW THE LOSSES FROM THE TEST CURRENT OF 5.7 WATTS/FOOT FOR #2 AWG COPPER CONDUCTORS.

ACTUAL CALCULATED I^2R LOSSES FOR ASSEMBLY (SEE PG 9)

2.5 WATTS/FOOT

MAX PERMISSIBLE I^2R LOSSES FOR ASSEMBLY AT 150°F (65°C)
(SEE APPENDIX A & FIG 1)

15 WATTS/FOOT

I^2R LOSSES CALCULATED FROM TEST DATA FOR MODULE (SEE APPENDIX B)

5.7 WATTS/FOOT

CALCULATION OF I^2R LOSSES :-

CONTINUOUSLY ENERGIZED LOADS ARE :

EAST B3 PENETRATION

ASSUME ALL 4 FANS AND MOTOR SPACE HEATER RUNNING (WORST CASE)

1T47-FN-011B, 012B, 011D, 012D	DRYWELL COOLING FAN	FULL LOAD CURRENT* 30.0 AMPERES
1B31-MSH-02B	RECIRC P.P. MOTOR SPACE HEATER	3.0 AMPERES

WEST B1 PENETRATION

ASSUME ALL 4 FANS AND MOTOR SPACE HEATER ARE RUNNING (WORST CASE)

1T47-FN-011A, 012A, 011C, 012C	DRYWELL COOLING FAN	30.0 AMPERES
1B31-MSH-02A	RECIRC P.P. MOTOR SPACE HEATER	3.0 AMPERES

* SEE REF 6

THE CALCULATION OF I^2R LOSSES ARE BASED ON THE FOLLOWING FORMULA:

$$HL = I^2 \times R \times N.C. \times L \times T.C.F.$$

WHERE :

HL = HEAT DISSIPATED IN WATTS "I^2R LOSSES" (DESIRED RESULT)

I = FULL LOAD CURRENT OF LOAD (REF 6)

R = RESISTANCE IN Ω/FOOT @ 25°C (REF 3)

N.C. = NUMBER OF CONDUCTOR CARRYING CURRENT I (REF 7)

L = LENGTH IN FEET OF CONDUCTORS (ASSUMED)

T.C.F. = TEMPERATURE CORRECTION FACTOR (REF 3)

I^2R LOSSES FOR DRYWELL FAN CABLES:

CABLE FOR EACH OF THE 4 FANS ARE

3-#2 AWG Cu (FROM 11600.02-FE-36W-5 & 36F-5)

$$HL = 30^2 \times \left(\frac{0.17}{1000}\right) \times 12 \times 3 \times 1.25 = 6.885 \text{ WATTS}$$

OR BASED ON A 12 FOOT CABLE LENGTH

$HL = 0.57$ WATTS/FOOT

I^2R LOSSES FOR RECIRC PUMP MOTOR HEATER CABLES ARE:

CABLE FOR EACH HEATER IS
3-#2 AWG Cu (FROM 11600.02-FE-36W-5 & 36F-5)

$$HL = 3^2 \times \left(\frac{0.17}{1000}\right) \times 12 \times 3 \times 1.25 = 0.07 \text{ WATTS}$$

OR BASED ON A 12 FOOT CABLE LENGTH

$I^2R \doteq 0.01$ WATTS/FOOT

CALCULATION SHEET A5010.61

STONE & WEBSTER ENGINEERING CORPORATION

J.O./W.O./CALCULATION NO.		REVISION	PAGE
11600.02	E-56	0	9 of 13

PREPARER/DATE: John M. Zeller 11/10/82

REVIEWER/CHECKER/DATE: [signature] 11/12/82

INDEPENDENT REVIEWER/DATE: Y. Can 11-18-82

SUBJECT/TITLE: I^2R LOSSES IN GE 200 SERIES PENETRATIONS

QA CATEGORY/CODE CLASS: I

TOTAL I^2R LOSSES FOR EITHER OF THE PENETRATIONS

CONTRIBUTION FROM DRYWELL FAN CABLES (4 CKTS) $6.885 \times 4 = 27.54$ W

CONTRIBUTION FROM REACTOR RECIRC PP MOTOR HEATER CABLES $0.07 \times 1 = 0.07$ W

TOTAL 27.61 W

APPROXIMATE 27.61 WATTS TO 30 WATTS

AND BASED ON A 12 FOOT LENGTH OF CABLE

TOTAL I^2R IN WATTS PER FOOT IS

$$\frac{30}{12} = 2.5 \text{ WATTS/FOOT}$$

REFERRING TO FIGURE 1

AT THE ASSUMED AMBIENT TEMP OF 150°F (65°C) THE MAXIMUM ALLOWABLE I^2R LOSS IS 15 WATTS/FOOT WHICH IS GREATER THAN THE CALCULATED VALUE OF 2.5 WATTS/FOOT

NOTE: THE ABOVE LOADS DO NOT OPERATE DURING A DESIGN BASIS EVENT

PREPARER/DATE	J.O./W.O./CALCULATION NO.	REVISION	PAGE
John M. Zuter 11/10/82	11600-02 E-56	0	10 of 13
REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE		
VRShaler 11/18/82	Cam 11-18-82		
SUBJECT/TITLE	QA CATEGORY/CODE CLASS		
I^2R LOSSES IN GE 200 SERIES PENETRATIONS	I		

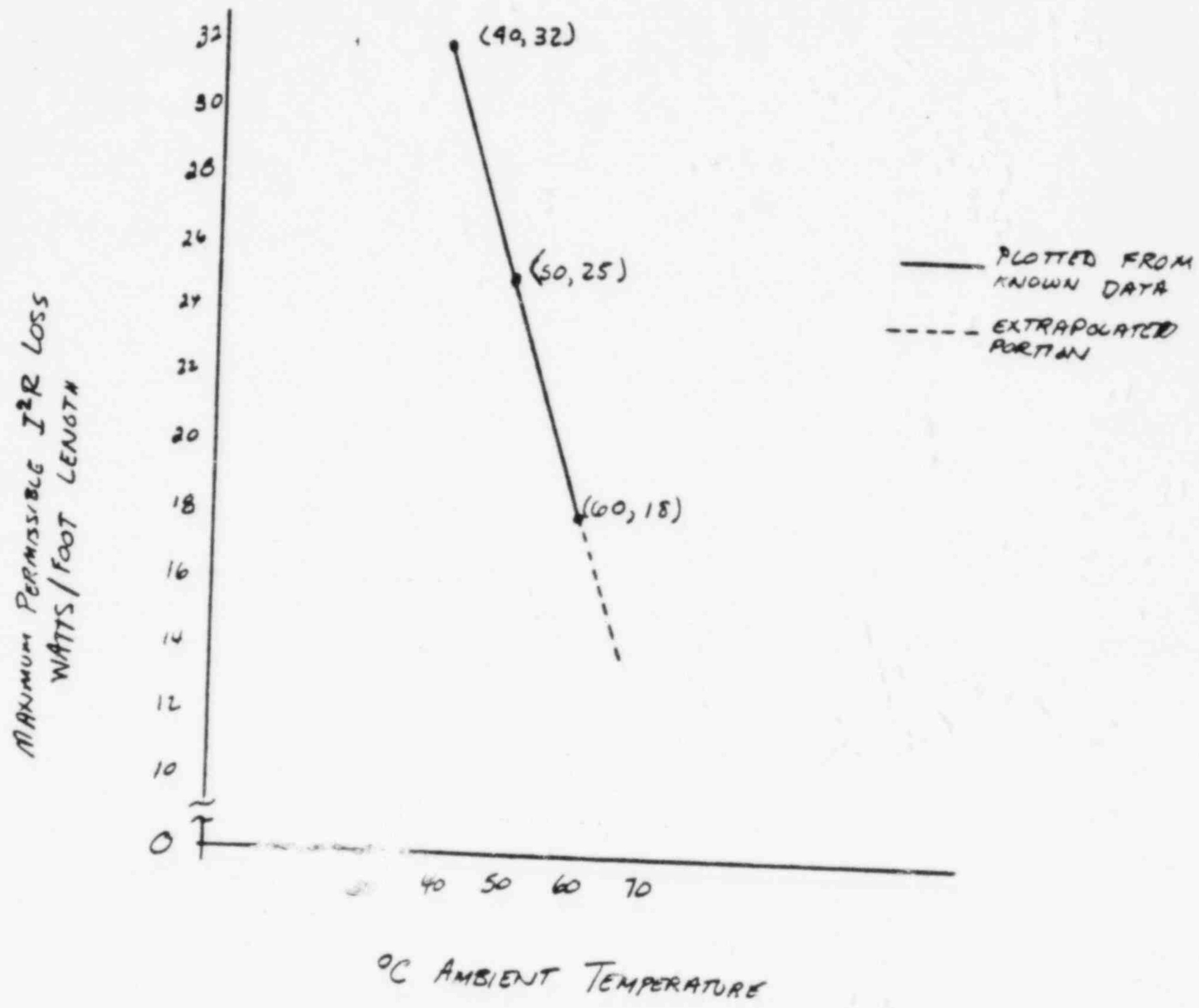


FIGURE 1 - AMBIENT TEMP VERSUS MAXIMUM ALLOWABLE I^2R HEAT LOSS PER FOOT LENGTH.

(DATA TAKEN FROM REF 4)

CALCULATION SHEET

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A5010 61

J.O./W.O./CALCULATION NO.	REVISION	PAGE
11600.02 E-56	0	11 of 13

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
John M Zecter 11/10/82	[signature] 11/18/82	Y Can 11-18-82

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
I^2R Losses in GE 200 Series Penetrations	I

Appendix "A"

GE DESIGN SPECIFICATION DATA
MAXIMUM PERMISSIBLE I^2R LOSSES
(SEE REF 4)

AMBIENT TEMPERATURE °C	°F	MAXIMUM PERMISSIBLE I^2R LOSSES WATTS/FT WITH BOTH ENDS OF PENETRATION SEALED
40	105	32
50	122	25
60	140	18

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A5010.61

J.O./W.O./CALCULATION NO.		REVISION	PAGE
11600.02	E-56	0	12 OF 13

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
John M. Zack 11/10/82	W. Shaw 11/18/82	Y Can 11-18-82

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
I^2R LOSSES IN GE 200 SERIES PENETRATIONS	I

APPENDIX "B"

TEST DATA FOR PENETRATIONS

CONDUCTOR SIZE (AWG)	TEST CURRENT	NUMBER OF CONDUCTORS	RESISTANCE Ω/1000' @ 25°C	CALCULATED I^2R LOSSES WATTS/FOOT	WATTS FOR 12' SECT
4/0	150	3	0.051	3.4	41.31
2	75	6	0.170	5.7	68.85
8	25	15	0.670	6.3	75.38
12	2.5	28	4.11	0.19	2.33

CALCULATION OF I^2R LOSSES FROM TEST VALUES (FORMULA FROM PAGE 7)

4/0 AWG

$$I^2R = 150^2 \times \left(\frac{0.051}{1000}\right) \times 3 \times 12 = 41.31 \text{ WATTS}$$

ASSUMING 12' SECTION

$$I^2R = \frac{41.31}{12} = 3.4 \text{ WATTS/FOOT}$$

2 AWG

$$I^2R = 75^2 \times \left(\frac{0.170}{1000}\right) \times 6 \times 12 = 68.85 \text{ WATTS}$$

ASSUMING 12 FOOT SECTION

$$I^2R = \frac{68.85}{12} = 5.7 \text{ WATTS/FOOT}$$

CALCULATION SHEET

A5010 61

STONE & WEBSTER ENGINEERING CORPORATION

PREPARER/DATE	J.O./W.O./CALCULATION NO.		REVISION	PAGE
John M. Zulco 11/10/82	11600-02	E-56	0	13 of 13
SUBJECT/TITLE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE		
I^2R Losses in GE 200 Series Penetrations	11/18/82	Y Can 11-18-82		
		QA CATEGORY/CODE CLASS		
		I		

<u>8 AWG</u>

$$I^2R = 25^2 \times \left(\frac{0.670}{100}\right) \times 15 \times 12 = 75.38 \text{ WATTS}$$

Assuming 12 foot Section

$$I^2R = \frac{75.38}{12} = 6.3 \text{ WATTS/FOOT}$$

<u>12 AWG</u>

$$I^2R = 2.5^2 \times \frac{1.11}{100} \times 28 \times 12 = 2.33 \text{ WATTS}$$

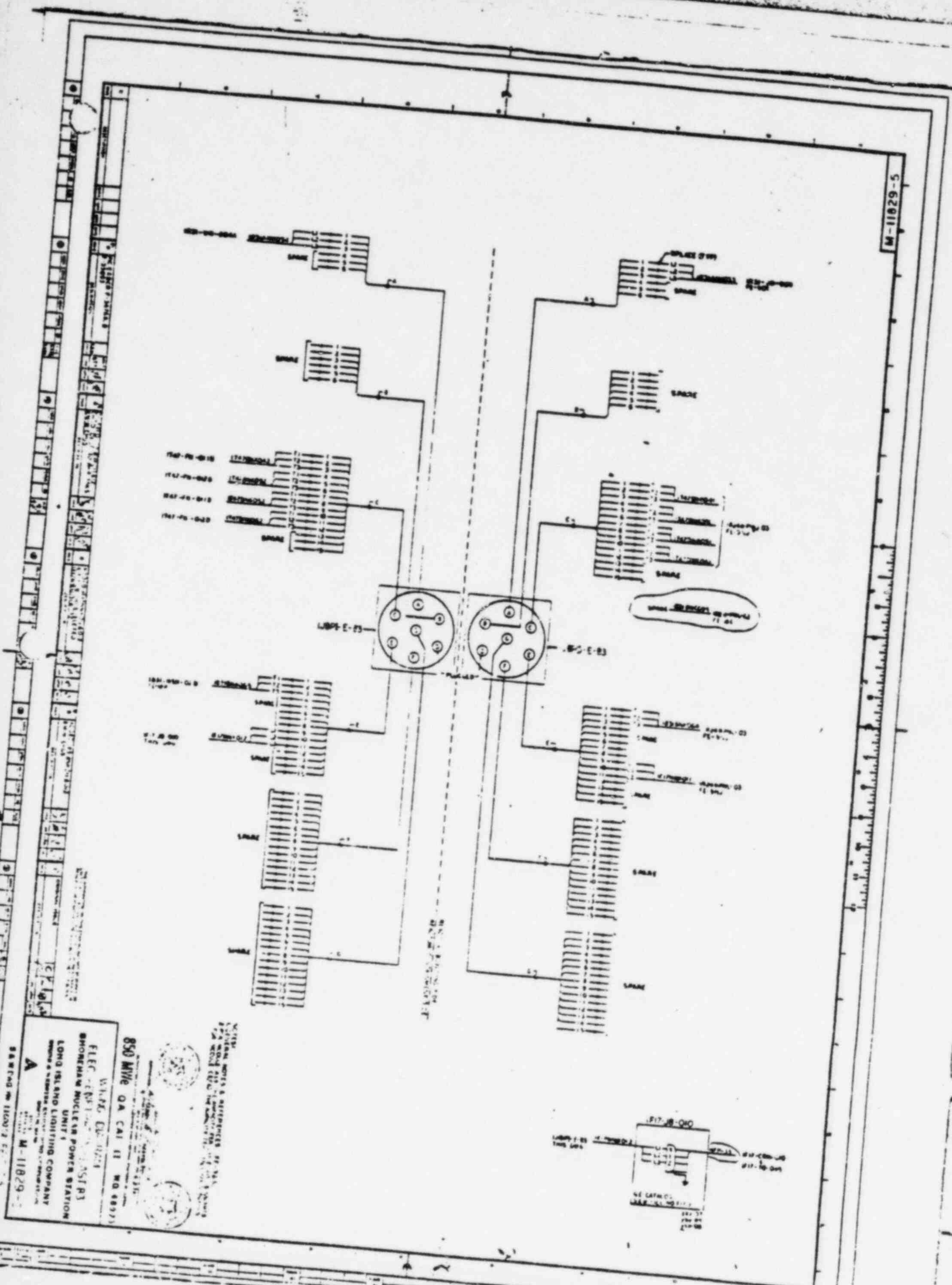
Assuming 12 ft Section

$$I^2R \ \frac{2.331}{12} = 0.19 \text{ WATTS/FOOT}$$

(1) Conductor Size, Test Current & Number of Conductors See Ref 2

(2) Resistance of #4/0, 2, & 8 Cables See Ref 3

(3) Resistance of #12 Cable which is Alumel-Constantan See Ref 5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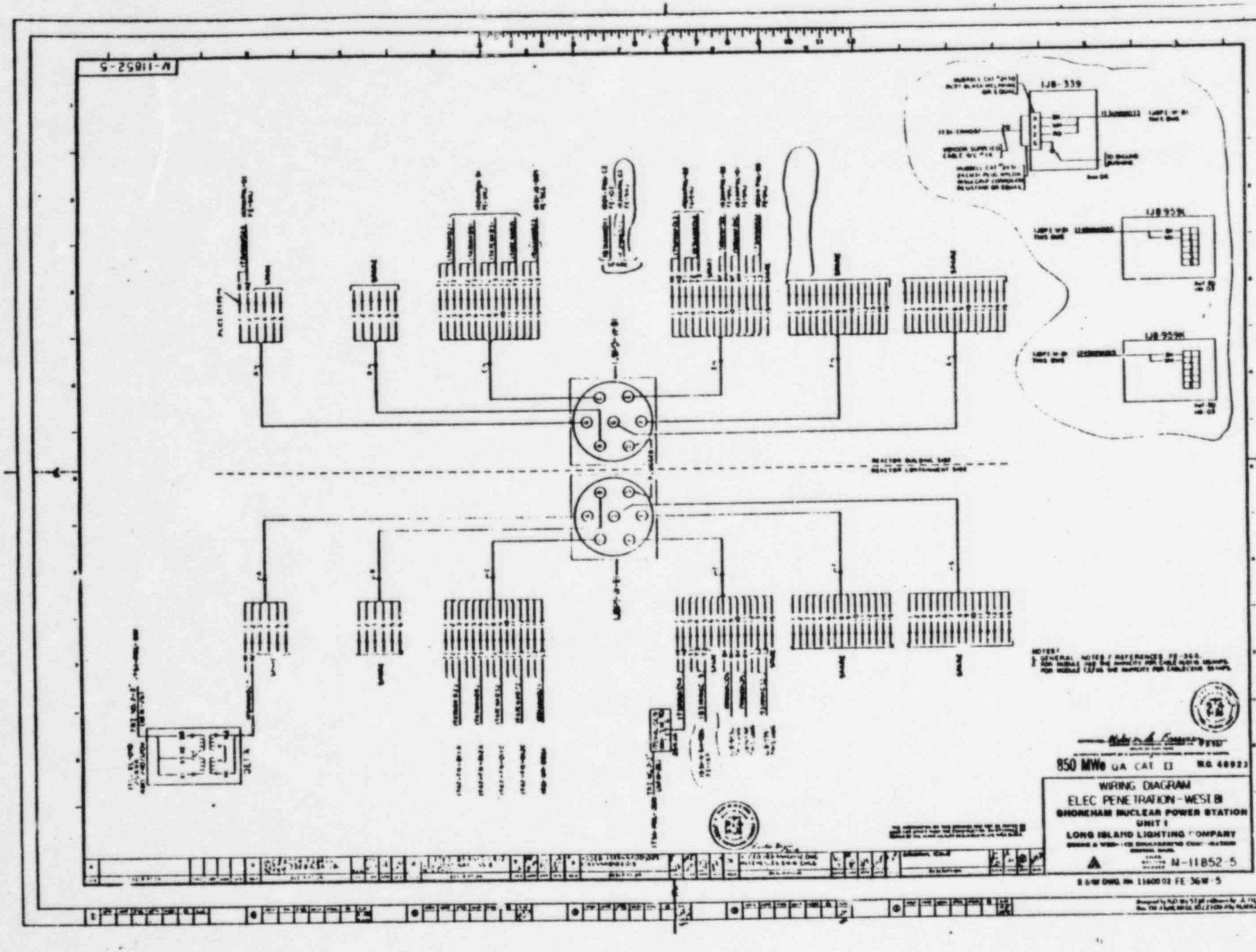
SPARE
850 MWe
SHOREHAM NUCLEAR POWER STATION
UNIT 1
LONG ISLAND LIGHTING COMPANY


IJB-339
IJB-959K
REACTOR BUILDING SIDE
REACTOR CONTAINMENT SIDE
850 MWe QA CAT II
WIRING DIAGRAM
ELEC PENETRATION - WEST BI
SHOREHAM NUCLEAR POWER STATION
UNIT I
LONG ISLAND LIGHTING COMPANY
N-11852-5
B&W DWG. No 1160002 FE 36W-5

APPENDIX A