

TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

May 30, 1984

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Adensam:

In the Matter of the Application of) Docket Nos. 50-390
Tennessee Valley Authority) 50-391

- References: 1. D. S. Kammer's letter to E. Adensam dated July 26, 1983.
2. My letter to E. Adensam dated January 30, 1984.
3. D. S. Kammer's letter to E. Adensam dated October 12, 1983.

In reference 1, TVA committed to provide NRC with the Underwriters Laboratories' (UL) test report for the one-hour, fire-rated barriers being used at WBN to separate redundant safe shutdown circuits. Reference 2 provided this test report to NRC but emphasized that additional information would be forthcoming regarding the fire barrier material used to enclose junction boxes. Enclosure 1 provides this information.

In the response to NRC concern No. 2 as identified in reference 3, TVA committed to inspect approximately 10 percent of the required safe shutdown circuits outside containment to verify proper correlation between as-designed and as-constructed configurations. Enclosure 2 provides information on the inspection.

If you have any questions concerning this matter, please get in touch with D. P. Ormsby at FTS 858-2682.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

8406050440 840530
PDR ADOCK 05000390
F PDR

L. M. Mills
L. M. Mills, Manager
Nuclear Licensing

Sworn to and subscribed before me
this 30th day of May 1984

Paulette W. White
Notary Public
My Commission Expires 9-5-84

Enclosures (2)

cc: U.S. Nuclear Regulatory Commission (Enclosures)
Region II
Attn: Mr. James P. O'Reilly Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

B3002
1/1

DOCKET NO. 50-390...WATTS BAR..TVA

FIRE BARRIERS FOR REDUNDANT
SAFE SHUTDOWN CIRCUITS

Rec'd w/ltr 5/30/84...8406050440

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WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
FIRE BARRIERS FOR REDUNDANT SAFE SHUTDOWN CIRCUITS

- References: 1. D. S. Kammer's letter to E. Adensam dated July 26, 1983
2. L. M. Mills' letter to E. Adensam dated January 30, 1984

In reference 1, TVA committed to provide NRC with the Underwriters Laboratories (UL) test report for the one-hour, fire-rated barriers being used at Watts Bar Nuclear Plant to separate redundant safe shutdown circuits. Reference 2 provided this test report to NRC and indicated that additional information was forthcoming regarding certification of fire barrier material used to enclose junction boxes.

To satisfy the need for a certified junction box fire barrier design, the vendor (3M) again went to UL for testing. This time 3M added an additional layer of fire barrier mat to the junction box configuration. This design successfully passed the test and received UL certification (refer to attachment A, UL Report R10125). However, due to the temperatures measured inside the box during the test, UL put a stipulation on the junction box certification. The stipulation was that the certification was good only if the user provided evidence that the cables being protected will perform their required design function when exposed to the temperatures measured by UL during the actual fire test conditions.

To accommodate the UL stipulation, TVA performed oven tests on cables at their Central Laboratory (Chattanooga Power Service Center). TVA tested all cable types which pass through a 3M fire barrier. All the cable types passed the test with a minimum margin of 70°F except for the cables insulated with polyethylene (refer to attachment B, Central Laboratory's Services Report E386-84-3037, and the accompanying calculations). TVA types PJ, PJJ, PN, and PNJ are all polyethylene cables which are used by TVA. However, type PJJ is the only type which passes through 3M fire barrier as part of safe shutdown circuits.

As a result of the polyethylene cable (PJJ) failure, nonconformance report (NCR) WBN EEB 8408 was initiated and reported to NRC-OIE, Region II, as a 10 CFR 50.55(e) item on April 5, 1984. This nonconformance identifies the fact that all types of polyethylene-insulated cables are unacceptable for use concurrently with the 3M fire barrier. The corrective action for this NCR includes replacing the PJJ cable in conduits with qualified cable. All PJJ cables in cable trays which are identified as safe shutdown circuits will be either replaced with qualified cable or rerouted out of the fire barrier area. No PJJ cables are routed through junction boxes. The corrective action will be completed by June 15, 1984, for unit 1 and by December 21, 1984, for unit 2.

ENCLOSURE 2
WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
COMPLIANCE WITH 10 CFR 50, APPENDIX R

Reference D. S. Kammer's letter to NRC dated October 12, 1983

The reference provided responses to five NRC concerns pertaining to compliance with 10 CFR 50, Appendix R, fire protection requirements at Watts Bar Nuclear Plant. The following information completes the requirements for TVA's response to NRC concern No. 2, "Potential discrepancy between "stated design" and "as built" configuration."

An onsite inspection was performed by TVA at Watts Bar. As indicated in the reference, this inspection included a randomly selected sample of approximately 10 percent of the required safe shutdown circuits routed in conduit outside the containment. The following circuits were inspected:

1. All four unit 1 channelized conduit systems used to route pressurizer level and pressure indications and steam generator instrumentation cables. These four conduit systems were inspected along their entire length between the Control Building and Reactor Building shield wall.
2. Redundant power feed circuits for the component cooling system pumps.
3. Station fire pump power circuit inside the Auxiliary Building from the essential raw cooling water (ERCW) conduit duct bank system to their respective 480V shutdown power boards.

As a result of this inspection, there were no new circuit interactions (two redundant required safe shutdown circuits less than 20 feet apart) identified which had not previously been identified on electrical conduit and grounding drawings. Therefore, TVA concludes that a sufficient confidence level has been demonstrated by the inspection to conclude the design drawings depict the as-installed configuration.

ATTACHMENT A

Electro-Products Division/3M

3M Center
St. Paul, Minnesota 55144
612/733 1110

CF
009



SUMMARY OF U. L. CLASSIFICATION DOCUMENTS

PROTECTIVE ENVELOPE FOR CLASS 1E CIRCUITS

REPORT #3410539909-18A

System: 3M Fire Barrier Mat M20A plus Fire Barrier Composite Sheet CS-195 on junction boxes.

Fire Rating: "The electrical protection system(s) are judged to achieve a 1-hour fire rating" (see Appendix 1).

Supplier: 3M (see Appendix 2).

Installer: As trained and certified by 3M (see Appendix 2).

Recognized Testing Laboratory: U. L. (see Appendix 2).

Date(s) of Test(s): July 14, 1983

Report File: R10125 - Project 82NK21937; dated January 19, 1984 (see Appendix 2).

Acceptance Criteria: The 1-hour fire rating of electrical circuit protective systems was established by evaluating the performance of the system with respect to maintaining the integrity of the electrical circuits under fire exposure conditions and during a hose stream test following the fire exposure.

Test 1 - Exposure Fire	
Fire Conforms to ASTM-E119:	Yes
Material Hazards Analysis:	Pass
Generic Cable or Other:	Generic
Cable Continuity Test	Hose Stream
Test	Pass

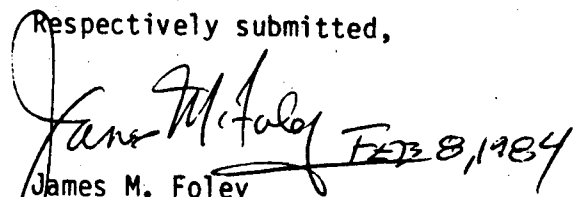
Result - Pass requirements of an electrical circuit protective system for a 1-hour rating.

Material: 3M Fire Barrier Mat M20A, Scotch Brand Electrical Tape #49, 3M Aluminum Tape #49 (alternate #425 tape), and/or 5/8" steel strapping, 1/2" hardward cloth, Fire Barrier Caulk CP-25 and/or Putty 303, Fire Barrier Composite Sheet CS-195, and Unistrut Framing System.

Attachments:

- (1) Appendix 1 - Summary of information in U. L. Reports.
- (2) Appendix 2 - Information on supplier, installers and recognized testing laboratory.
- (3) Appendix 3 - Test reports from recognized laboratory.
- (4) Appendix 4 - Cable continuity test and installation drawings.

Respectively submitted,


James M. Foley
Technical Manager
Electro-Products Division Laboratory

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, expressed or implied:

Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his intended use, and user assumes all risks and liability whatsoever in connection therewith.

Statements or recommendations not contained herein shall have no force or effect unless in an agreement signed by officers of seller and manufacturer.

APPENDIX 1

PROTECTIVE ENVELOPE FOR CLASS 1E CIRCUITS

REPORT #3410539909-18A

Based upon U. L. Test Report File R10125-1, 2 - Project 82NK21937, dated January 19, 1984 (see Appendix 3B for complete U. L. Report).

Fire Barrier System CS-195/M

	<u>Result</u>	<u>Page In Report</u>	<u>Reference Pages</u>
1.0 Fire Prot. Rating	One hour	6	5
1.1 ASTM-E119	Conforms	6	5
1.2 ASTM-E84	Acceptable	Appendix 3B	of this report
1.3 Temperatures on Conductors	*	5	Illus. 7
1.4 Cables Generic 1	Bare Copper	1	2
1.5 Cable Continuity	Functional**	Appendix 4A	5
1.6 Hose Stream Test	Pass	6	5
1.7 Furnace Size	22' 10" x 14' 2" x 7' Approx.		Illus. 1

See Appendix 3B for data.

*Temperatures on bare conductor through 60 minutes thermocouple 246 - 454.6 °F, Illus. 7.

**The minimum temperature at which the Detroit Edison cables will fail is 610 °F (320 °C).

APPENDIX 2

INFORMATION ON SUPPLIER, INSTALLER AND RECOGNIZED TESTING LAB

REPORT #3410539909-18A

Supplier: 3M
Electro-Products Division
3M Center - Building 260-5
St. Paul, MN 55144
Attention: W. J. McDonough
Division Administration Manager

Installer: As trained and certified by 3M (2)

Recognized Testing Laboratory: Underwriters Laboratory Inc.
333 Pfingsten Road
Northbrook, IL 60062
Attention: C. J. Johnson
Engineering Associate
Fire Protection Dept.

APPENDIX 3 SUMMARY

INDEPENDANT LABORATORY TEST REPORTS

REPORT #3410539909-18A

CONTENTS:

3A-EXPOSURE FIRE TEST REPORT

JANUARY 19, 1984

3B-ASTM-E84 TEST REPORT



UNDERWRITERS LABORATORIES INC.
333 PFINGSTEN ROAD · NORTHBROOK, ILLINOIS 60062

an independent, not-for-profit organization testing for public safety

January 19, 1984

Minnesota Mining & Manufacturing Co.
Mr. Jack Tuzinski
260-5A 3M Center
St. Paul, MN 55144

Our Ref: R10125, 82NK21937

Subject: Type M20-A Intumescent Mat and Type CS-195 Intumescent Sheet Used as an Electrical Circuit Protective System for Steel Junction Boxes

Dear Mr. Tuzinski:

This is to confirm that on July 14, 1983, a fire endurance and hose stream test was conducted on a full-scale floor assembly containing eight electrical circuit protective systems. The following is an interim Letter Report summarizing the details and results of one of the electrical circuit protective systems which was included in the full-scale floor test assembly. The subject of this interim Letter Report is a nominal 12 by 12 by 6 in. deep steel junction box containing a bare copper conductor and protected with a wrap of Type M-20A intumescent mat surrounded by a Type CS-195 intumescent sheet enclosure secured to a steel framework.

MATERIALS:

The following is a description of the materials used in the subject electrical circuit protective system.

Floor Assembly - The floor assembly consisted of nominal 8 in. thick steel-reinforced vermiculite concrete slabs.

Steel Junction Box - The UL Listed junction box used in the electrical circuit protective system consisted of a five-sided box and a cover. The five-sided box measured 12 by 12 by 6 high and was formed of 0.060 in. thick (No. 16 gauge) painted steel. The open top of the box was provided with a 3/8 in. wide hemmed edge around its perimeter. The junction box cover was 12-1/4 by 12-1/4 by 5/16 in. high and was formed of 0.060 in. thick (No. 16 gauge) painted steel. The interior of the cover was provided with a 3/4 in. wide by 3/16 in. thick neoprene rubber gasket around the entire perimeter. The cover was provided with a nominal 1/4 in. diameter hole at each corner for screw-attachment to the junction box.

Look For The  Listing or Classification Mark On The Product

Steel Conduit - The nominal 2 in. diameter Trade Size rigid steel conduit penetrating the steel junction box had an outside diameter of 2.375 in. and a wall thickness of 0.142 in.

Bare Copper Conductor - The No. 8 AWG stranded bare copper conductor was 0.146 in. diameter and consisted of seven 0.049 in. diameter strands.

Steel Framing - The steel framing for the junction box enclosure consisted of No. 14 gauge Types A1000 and A3300 Unistrut channels and Types A1065, A2223 and modified A2227 Unistrut fittings. The steel framing was assembled using 3/8 in. diameter by 3/4 in. long hex-head cap screws in conjunction with Type A3008 Unistrut nuts.

Threaded Rod - The threaded rods used to support the steel junction box and the steel framing were nominal 3/8 in. diameter by 12 in. long zinc-plated threaded steel rods.

Intumescent Mat - The flexible foil-faced intumescent mat material was nominal 1/4 in. thick and was supplied in nominal 48 in. wide rolls. The intumescent mat material was also supplied in 4 in. wide rolls for use as a joint cover for the protective enclosure around the steel junction box. The intumescent mat, manufactured by Minnesota Mining and Mfg. Co. and designated "Type M20A", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Intumescent Sheets - The foil-faced sheet-metal backed intumescent elastomeric material sheets used to protect the junction box were supplied in nominal 36 by 36 by 1/4 in. thick sheets. The sheets, manufactured by Minnesota Mining & Mfg. Co. and designated "Type CS-195" will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Hardware Cloth - The hardware cloth consisted of 0.041 in. diameter (No. 19 AWG) galvanized steel wires welded to form a 1/2 in. square grid. The hardware cloth was supplied in a nominal 12 in. and 24 in. wide by 100 ft long rolls.

Fasteners - The fasteners used to secure the intumescent sheet to the steel framing were No. 10-16 by 3/4 in. long self-drilling, self-tapping hex washer head steel screws in conjunction with 5/8 in. diameter steel washers.

Banding Strap - The carbon steel banding straps used to secure the intumescent mat to the steel junction box and to secure the joint covers to the intumescent sheet enclosure were 5/8 in. wide by 0.020 in. thick. The 1 in. long channel-shaped crimp clips used in conjunction with the banding straps were 11/16 in. deep with 1/4 in. flanges. The clips were formed of 0.021 in. thick electro-galvanized steel.

Caulk - The caulk used to seal the joints of the intumescent sheets and as part of the floor firestop system was supplied in 10-1/2 oz cartridges. The caulk, manufactured by Minnesota Mining and Mfg. Co. and designated "Type CP-25", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

Foil Tape - The 3 in. wide pressure-sensitive aluminum foil tape was supplied in rolls. The tape, manufactured by Minnesota Mining & Mfg. Co. and designated "Type 425", will be Classified as "Electrical Circuit Protective Material" in the Building Materials Directory under the Follow-Up Service of Underwriters Laboratories Inc.

CONSTRUCTION OF TEST ASSEMBLY:

Prior to installation of the steel junction box, a nominal 2-3/8 in. diameter hole for the nominal 2 in. diameter Trade Size steel conduit was die-cut in the side of the junction box to accommodate the steel conduit. A nominal 1 in. diameter hole was drilled in the bottom of the junction box (top, as installed) for passage of the thermocouple wires. The steel junction box was secured to the underside of the floor using four nominal 3/8 in. diameter threaded steel rods in conjunction with steel nuts and 1-1/4 in. diameter steel washers as shown in ILL. 1. In order to effect a good seal with the underside of the floor, a wide band of Type CP-25 caulk was applied around the entire perimeter of the junction box at its interface with the underside of the floor.

The nominal 2 in. diameter Trade Size rigid steel conduit was installed as shown in ILL. 1. The conduit was secured to the steel junction box using a set-screw connector with a lock nut and bushing. The conduit was nominally 5 ft long and was supported near its opposite end using a 3/8 in. diameter threaded steel rod in conjunction with a "U" shaped conduit hanger bracket. The individual No. 8 AWG bare copper conductor was installed in the steel junction box and conduit as shown in ILL. 1.

A nominal 6 in. wide strip of Type M20A intumescent mat was wrapped around the four sides of the steel junction box and secured in place with foil tape, as shown in ILL. 2. A nominal 2-3/8 in. diameter cutout was made in the intumescent mat strip to accommodate the conduit. A nominal 16 in. square section of intumescent mat was secured to the underside of the steel junction box with foil tape, as shown in ILL. 2.

The steel framing for the protective enclosure around the steel junction box was installed as shown in ILL. 3. The steel framing was installed such no contact was made between the framing and the junction box. The steel framing was secured to the underside of the floor using nominal 3/8 in. diameter threaded steel rods in conjunction with steel nuts and 1-1/4 in. diameter steel washers, as shown in ILLS. 1 and 3.

After installation of the steel framing about the steel junction box, the nominal 2 in. diameter rigid steel conduit was wrapped with four layers of Type E-50 nonintumescent mat secured in place with aluminum foil tape and Type 34 ceramic cord.

Intumescent sheet was cut-to-size and screw-attached to the steel framing (aluminum foil face on exterior) with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter steel washers. The screws were located at each corner of the sheet to hold each sheet in position. The overall dimensions of the intumescent sheet enclosure were 18-1/2 in. by 19 in. by 9 in. deep. A bead of caulk was applied over the butted joints of the intumescent sheets and each joint was covered with a layer of 4 in. wide intumescent mat (aluminum foil face on exterior) and a 4 in. wide strip of steel hardware cloth. The intumescent mat and steel hardware cloth were secured to the intumescent sheet with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws with 5/8 in. diameter washers spaced approximately 3 in. on center. The intumescent sheets and joint covers were additionally secured in place with a steel banding strap wrapped around the top and bottom of the enclosure and secured with crimp clips.

As a final step, an 8 in. wide strip of intumescent mat (aluminum foil face on exterior) and an 8 in. wide strip of steel hardware cloth were formed into an angle with 2 in. and 6 in. legs and was installed at the interface of the protective enclosure and the underside of the floor around the entire perimeter of the enclosure, as shown in ILLS. 2 and 3. The 2 in. legs of the intumescent mat and steel hardware cloth angles were secured to

the intumescent sheet of the protective enclosure with No. 10-16 by 3/4 in. long self-drilling, self-tapping hex-washer head steel screws and a steel banding strap. The 6 in. legs of the intumescent mat and steel hardware cloth angles were secured to the underside of the floor with Type 8D coated sinker nails in conjunction with 5/8 in. diameter steel washers.

FIRE ENDURANCE AND HOSE STREAM TESTS:

METHOD

The fire endurance test was conducted with the furnace temperatures controlled in accordance with the Standard, Fire Tests of Building Construction and Materials, UL 263 (ASTM E119).

The temperatures on the bare copper conductor, the steel junction box, the steel conduit, the air space within the steel junction box and at various point within the protective enclosure were measured by 20 thermocouples, located as shown in ILLS. 4 and 5.

The test assembly was subjected to a 60 min fire exposure. Immediately following the fire exposure, the test assembly was removed from the furnace and was subjected to a 30 psi hose stream applied for a duration of 2 min, 30 s.

RESULTS

The temperatures measured by the various thermocouples were recorded at 2-1/2 min intervals during the initial 15 min of the fire exposure. Thereafter, the temperatures were measured at 5 min intervals. These temperatures are shown in the tables on ILLS. 6 through 11.

The temperature of the bare copper conductor within the junction box protective system was 89°F at the start of the fire exposure test. The temperature of the bare copper conductor within the junction box at 60 min was 455°F (Thermocouple No. 246). The maximum steel junction box temperature and the maximum steel conduit temperature at 60 min were 583°F (Thermocouple No. 242) and 597°F (Thermocouple No. 245), respectively.

Following the fire exposure and hose stream test, the protective enclosure about the steel junction box was intact.

R10125, 82NK21937
January 19, 1984
Page 6

C O N C L U S I O N S

Based on our review of the test data from the full-scale floor fire test, Classification will be established for the electrical circuit protective system described herein. The Classified system will specify that electrical cables used in the protective system must be tested individually to demonstrate their electrical functionability at short-term exposures to elevated temperatures equal to their rated conductor temperatures plus the maximum individual cable or junction box temperature rise measured at the one hour rating period time.

A detailed Report is being prepared describing the electrical circuit protective system described herein and the remainder of the electrical circuit protective systems incorporated in the July 14, 1983 fire test.

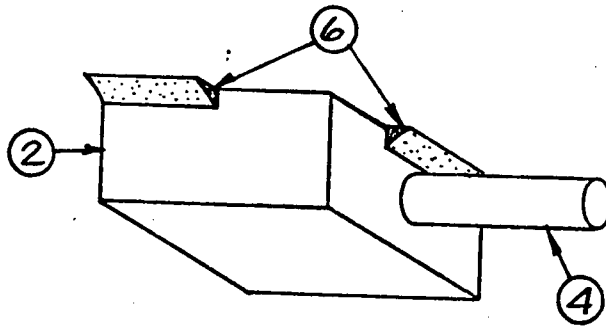
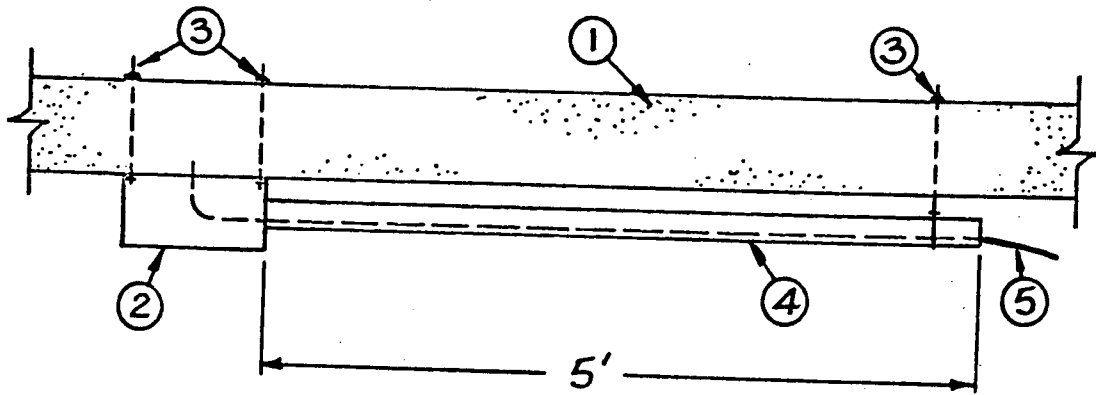
The work being conducted under Project 82NK21937, File R10125 was not completed in time for publication of the new Electrical Circuit Protective Systems in the 1984 Building Materials Directory. However, the new Electrical Circuit Protective Systems from the July 14, 1983 fire tests will appear in the July supplement to the 1984 Building Materials Directory.

Very truly yours,



C. J. JOHNSON
Engineering Associate
Fire Protection Department

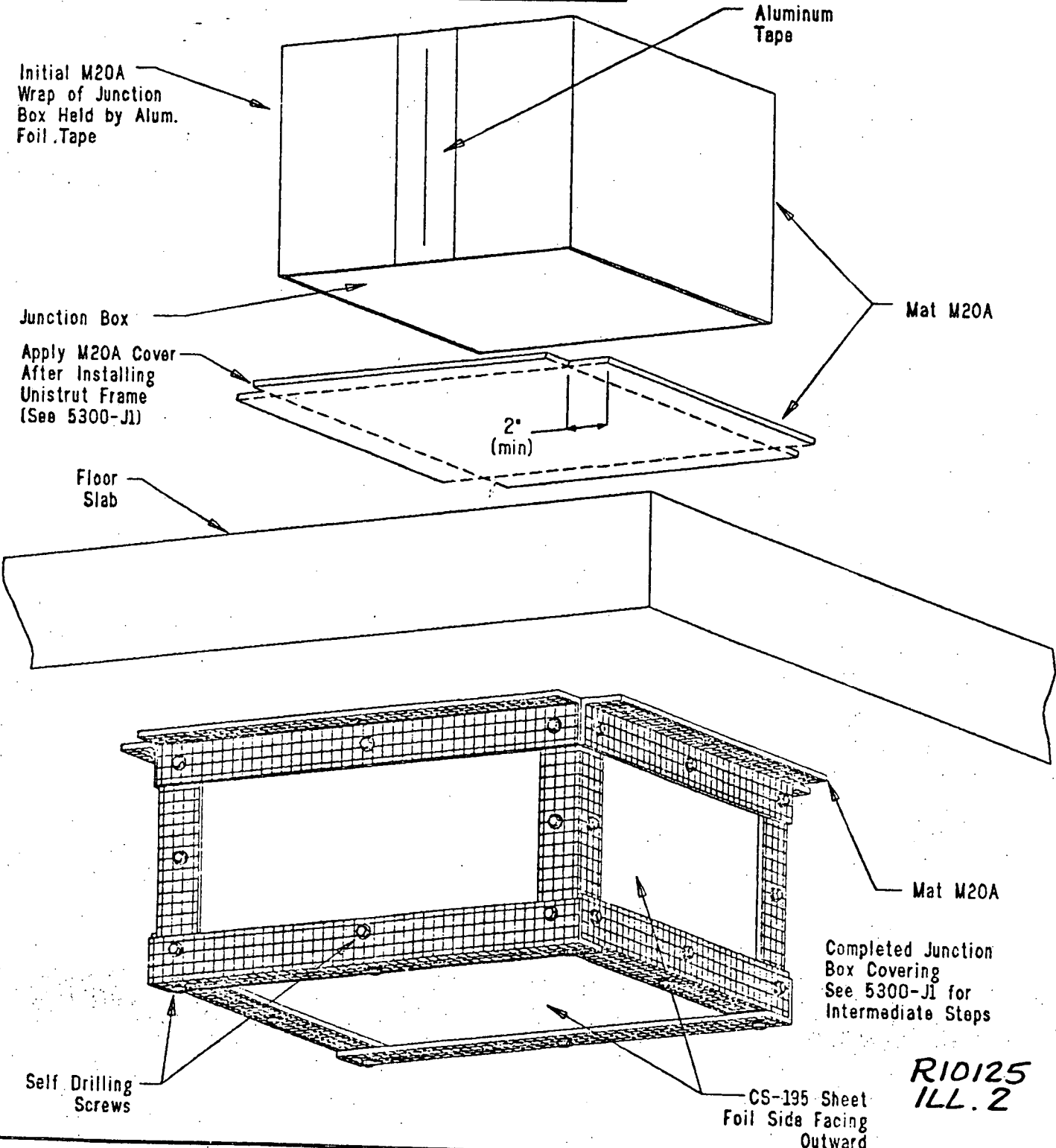
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1. NOM. 8" THK. VERMICULITE CONCRETE FLOOR.
2. NOM. 12"x12"x6" DP. 16 GA. STL. JUNCTION BOX.
3. NOM. $\frac{3}{8}$ " ϕ THREADED STL. ROD w/NUTS & WASHERS.
4. NOM. 2" ϕ TRADE SIZE RIGID STL. CONDUIT.
5. NO. 8 AWG BARE CU CNDR.
6. TYPE CP-25 CAULK MATERIAL APPLIED AROUND ENTIRE PERIMETER OF JUNCTION BOX @ INTER-FACE w/ FLOOR.

R10125
ILL. 1

REFERENCE PRINT	REFERENCE DESCRIPTION
5300-J1-1	INSTALLATION INSTRUCTIONS
5300-J1-ML	MATERIAL LIST



R10125
ILL. 2

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable; however, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.

Electro-Products Division/3M

ISSUE	DATE	REV	CH.
2	12-07-83		
NOT TO SCALE		CH.	J.R. TUZINSKI
DR. P.A. LeTOURNEAU		APP.	D.N. HUNTER
5300-J2			

3M

**FIRE BARRIER
Junction Box
Protection System
M20A - CS-195**

REFERENCE PRINT

- 5300-JI-1
- 5300-JI-ML
- 5300-J2

REFERENCE DESCRIPTION

- INSTALLATION INSTRUCTIONS
- MATERIAL LIST
- COMPLETED ASSEMBLY

3/8" Wedge Anchor Bolts with Washers or Alternate (2 on Each Upper Unistrut) (See 5300-T12-1)

7" Max. Spacing

Power Actuated D.N. Pins, 8D Concrete Nails or Alternate

1/4" CS-195 Sheet Foil Side Facing Outward

4" Strip Mat M20A Foil Side Facing Outward

4" Strip of 1/2" Welded Hardware Cloth

3/4" Bit Tip Self Drilling Screw with 5/8" by 1/4" Washer or Alternate

R10125
ILL. 3

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable. However, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.

ISSUE	DATE	REV	CH.
2	12-05-83		

NOT TO SCALE

DR. P.A. LeTOURNEAU

CH. J.R. TUJINSKI

APP. D.N. HUNDER

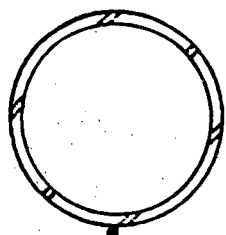
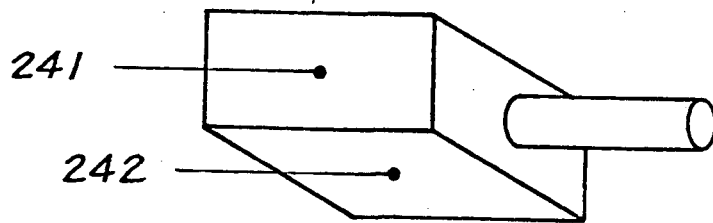
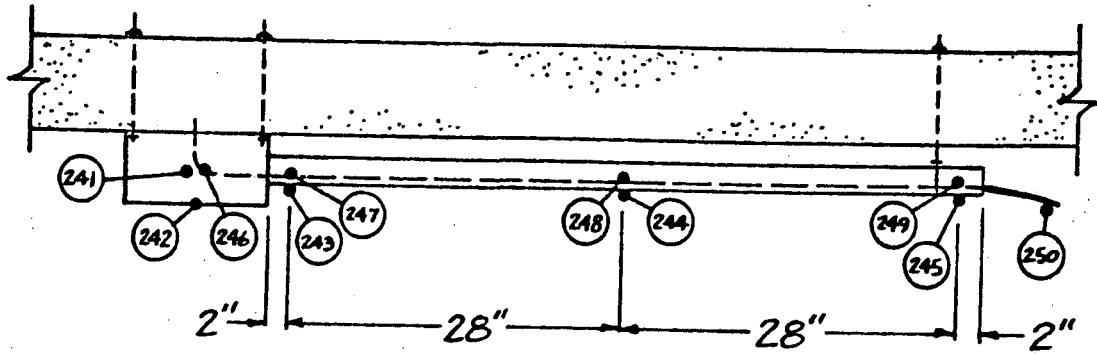
3M

FIRE BARRIER
Junction Box
Protection System
M20A - CS-195

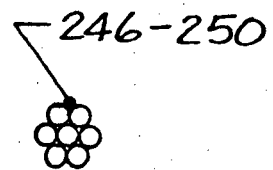
Fire-Products Division/3M



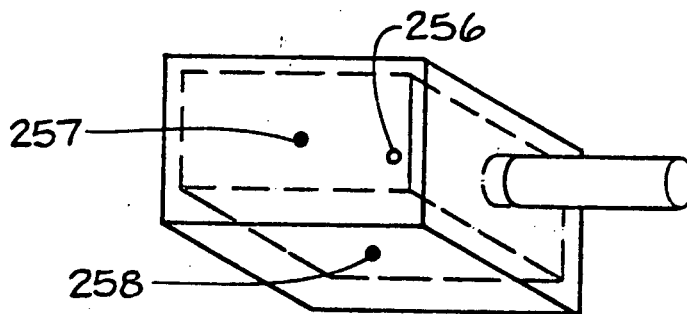
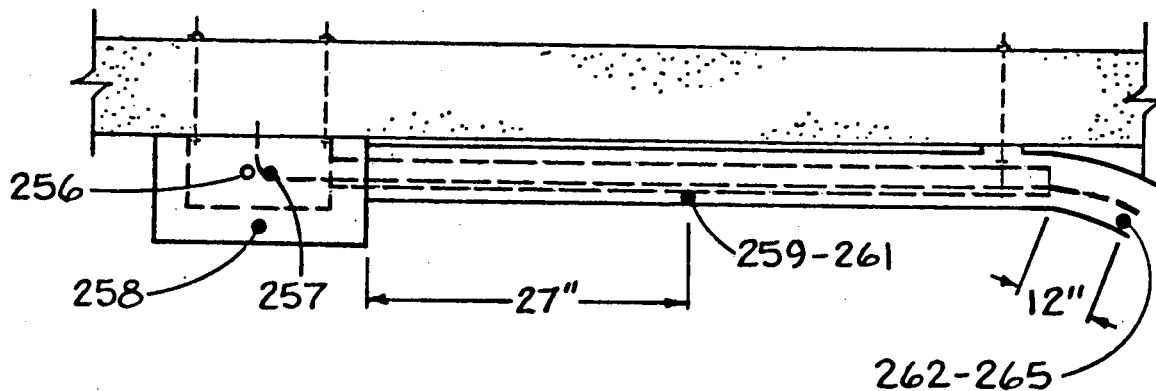
5300-J1



243, 244, 245



R10125
ILL. 4



T.C.	LOCATION
256	IN AIR WITHIN JUNCTION BOX @ CENTER
257, 258	BETWEEN INTUMESCENT SHEET & MAT WRAP
259	BETWEEN 2 ND & 3 RD LAYERS OF MAT WRAP
260	BETWEEN 1 ST & 2 ND LAYERS OF MAT WRAP
261	BETWEEN 3 RD & 4 TH LAYERS OF MAT WRAP
262	BETWEEN 1 ST & 2 ND LAYERS OF MAT WRAP
263	BETWEEN 2 ND & 3 RD LAYERS OF MAT WRAP
264	BETWEEN 3 RD & 4 TH LAYERS OF MAT WRAP
265	BETWEEN 4 TH & 5 TH LAYERS OF MAT WRAP

R10125
ILL. 5

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	241	242	243
TIME(MIN.)			
0	88.2	88.5	88.1
2.5	86.1	86.4	85.9
5	84.7	85.1	84.4
7.5	88.2	89.1	138.6
10	94.2	94.9	155
12.82	103.7	103.9	165
15.32	116.2	116	171.8
17.82	133.6	131.5	177.4
20.32	152.4	146	186.4
22.82	170.4	159.9	189.6
25.32	195.3	181.9	203.5
27.82	205.8	198.5	209.5
30.32	209.2	210	210.1
32.82	210.3	211.8	210.4
35.32	223.9	225.4	210.1
37.82	243.1	251	214.3
40.32	273.1	290.4	232.5
42.82	313.2	334.7	251.9
45.32	356.5	377	272.5
47.82	392.9	414.7	295.3
50.32	425	446.7	326.1
52.82	454.5	477.5	359.3
55.32	481.6	510.8	386.7
57.82	508.7	546.3	410
60.32	537.9	582.7	430.9

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	244	245	246	247
TIME(MIN.)				
0	88	88.6	89	88.6
2.5	85.9	86.2	88.8	88.5
5	84.3	86	88.7	88.5
7.5	87.3	146.2	89.7	89.8
10	91.9	157.7	94.6	100
12.82	100	165.9	104.6	115.1
15.32	112.6	173.5	117.3	130.6
17.82	129	182.6	135.5	146
20.32	145.8	192.8	154.3	160.9
22.82	159.4	207.7	168.1	173.8
25.32	188	238.9	189	192.8
27.82	212.6	246.8	207	209.9
30.32	215.4	258.9	209.8	209.5
32.82	220.2	286.4	209.7	210.3
35.32	232.5	307.3	209.7	213.2
37.82	248.8	327.7	216.9	221.6
40.32	271	357.3	236.6	240.2
42.82	297.6	390.7	265.1	264.2
45.32	322.8	421.5	294.4	287.9
47.82	346	450.3	324.9	311.5
50.32	368	478.4	355.8	335.2
52.82	390.6	510.3	386.9	360.9
55.32	411.9	538.8	415.9	384.8
57.82	433.7	568.6	440.2	407.3
60.32	456.6	597.1	454.6	428.7

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	248	249	250
TIME(MIN.)			
0	88.2	88.1	88.3
2.5	88.3	88.3	88.5
5	89.3	88.6	88.6
7.5	89	89.9	88.6
10	91.7	100.7	89.5
12.82	97.3	113.9	92.5
15.32	107.5	127.5	99.5
17.82	121.5	142.2	114.9
20.32	137.1	157.3	137.8
22.82	152.4	176.2	161
25.32	197.4	209.2	207.4
27.82	209.8	225.1	211
30.32	209.2	220.8	210.2
32.82	208.8	238.7	209.5
35.32	207.9	259.6	208.8
37.82	208.5	279.5	208.6
40.32	232.6	305.2	215.2
42.82	271.9	334.2	225.8
45.32	304.3	360.4	235.6
47.82	330.8	383.4	244.8
50.32	354.8	404.9	261.4
52.82	379.3	428.5	286.3
55.32	402.1	451.3	310.1
57.82	423.8	474.1	333.3
60.32	446.5	496	356.2

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	256	257	258	259
TIME(MIN.)				
0	89.3	88.2	88.3	88.2
2.5	89.3	94.3	107.3	97.3
5	89.6	101.6	128	125.1
7.5	90.5	102.5	139.4	171
10	96.4	150.6	163.7	239.7
12.82	106.3	144.4	173.7	260.6
15.32	119.4	169.6	186.7	293.4
17.82	138	62.5	200	331.4
20.32	159	78.8	225.8	384.6
22.82	173.3	225.7	265.6	436.8
25.32	181	153.9	309.4	461.3
27.82	202.3	218.8	386.9	504
30.32	211.9	393.8	486.6	534.7
32.82	213.3	461.6	577.9	551.7
35.32	217.1	688.6	664.4	553.1
37.82	235.1	773.6	777	614.4
40.32	264.8	798.1	838.4	656.7
42.82	303.4	835.8	770.2	695.9
45.32	345.1	880.4	821	748.5
47.82	383.7	922.8	911.4	734.5
50.32	416.4	966	920.3	785.3
52.82	444.5	1007	973.2	854.7
55.32	473.2	1042.9	1000.7	924.3
57.82	502	1071.8	1015.4	984.2
60.32	540.1	1096.1	1039.1	1033.3

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	260	261	262	263
TIME(MIN.)				
0	87.8	88.6	87.5	87.9
2.5	88.6	167	86.5	88.2
5	96.5	244.8	83.5	83
7.5	142.3	280.6	83.9	89.5
10	191.5	371.2	84.4	103.4
12.82	219.9	486.4	97.9	123.9
15.32	249.2	542.6	110.6	135.1
17.82	267.1	680.4	154.5	171.7
20.32	313.9	798.6	176.8	175.5
22.82	353.9	938.4	190.3	206.8
25.32	348.8	1015.5	213.7	205.9
27.82	386.5	1080.2	218.5	215.9
30.32	423.3	1148.4	216.5	228.4
32.82	440.2	1202.4	227.5	269.5
35.32	454.6	1245	233.7	257
37.82	477.2	1284.8	240	281.3
40.32	500.8	1307.7	260.3	331.1
42.82	517.4	1332.5	279.8	338.7
45.32	524.7	1345	299.9	383
47.82	536.4	1323.7	330.7	416.1
50.32	549	1296.6	373.7	421.6
52.82	566	1311.3	381.6	458.3
55.32	633.1	1357.6	323.6	470.7
57.82	695.3	1360.2	429.9	491.8
60.32	732.2	1258.5	455.2	496.8

3M COMPANY
JULY 14, 1983

CHAN(NOS.)	264	265
TIME(MIN.)		
0	88.1	91.5
2.5	91.1	157.6
5	101.1	251.2
7.5	164.8	340.4
10	246.9	405.7
12.82	245.6	468.7
15.32	239.9	505.4
17.82	245.7	534.1
20.32	263.7	583.2
22.82	322.1	807.2
25.32	364.2	924.5
27.82	411.6	1033.9
30.32	459	1122.5
32.82	474	1176.6
35.32	496.3	1213.7
37.82	514.7	1254.1
40.32	534.2	1303.7
42.82	567.1	1325.3
45.32	670.9	1341.4
47.82	732.9	1346.4
50.32	766.5	1334.7
52.82	797.7	1334.1
55.32	842.2	1355.1
57.82	901.7	1364.7
60.32	954.3	1373.8



UNDERWRITERS LABORATORIES INC.

300 PITTSTON ROAD, NORTH BEECHER, ILLINOIS 60062

an independent, not-for-profit organization testing for public safety

June 8, 1982

R10125
02NK9009

3M Company
3M Center
Building 207-18C
St. Paul, MN 55101

Attention: Mr. Michael O'Hara
Technical Ceramic Products Division

Subject: Report On Preliminary Surface Burning
Characteristics Investigation On Composite Fire
Barrier System

Gentlemen:

This is a Report summarizing the results of the preliminary tests conducted under the above Project.

GENERAL

This Report is to inform you of the preliminary test results conducted to date; it does not constitute evidence of Classification nor the establishment of UL's Follow-Up Service on the product submitted.

SAMPLES

The samples consisted of nominal 2 by 3 ft composite fire barrier sheets mechanically joined into 24 ft lengths with the butted joints protected. The composite fire barrier sheets consisted of a nominal 1/4 in. thickness of "Type FS-195" intumescent elastomeric material vulcanized to a No. 28 MSG galvanized steel plate on one surface and to an aluminum foil covering on the opposite surface. Prior to vulcanization, reinforced hexagonal size mesh (chicken wire) was placed over the elastomeric material, beneath the aluminum foil covering.

The mechanical joining system for the composite fire barrier sheets consisted of No. 12 gauge steel "Unistrut" channels, "Fire Barrier Mat," 1/2 in. welded hardware cloth, self-drilling, self-tapping steel screws, 5/8 in. diameter steel washers and aluminum foil tape. The details of the mechanical joining are shown in ILL. 1.

Three 24 ft long samples were prepared and tested. Each sample was tested with the foil facing of the composite fire barrier sheets downward (fire side). For two of the three tests, a slit was cut in the aluminum foil facing along the longitudinal centerline of the 24 ft long samples.

METHOD

The tests referenced in this Report were conducted in accordance with UL Standard Test Method for Surface Burning Characteristics of Building Materials, UL 723.

RESULTS

The results are tabulated below:


<u>Test No.</u>	<u>Product</u>	<u>Flame Spread</u>	<u>Fuel Contributed</u>	<u>Smoke Developed</u>
1	Foil Slit	17.53	0	197
2	Foil Intact	16.57	0	190
3	Foil Slit	18.88	0	231

The Classification Marking of Underwriters Laboratories Inc. on the product is the only method provided by Underwriters Laboratories Inc. to identify products which have been produced under its Classification and Follow-Up Service.


Since the anticipated work has been completed, we have instructed our Accounting Department to terminate the investigation and invoice you for the charges incurred to date.

Should you have any questions, please contact the undersigned,

Very truly yours,

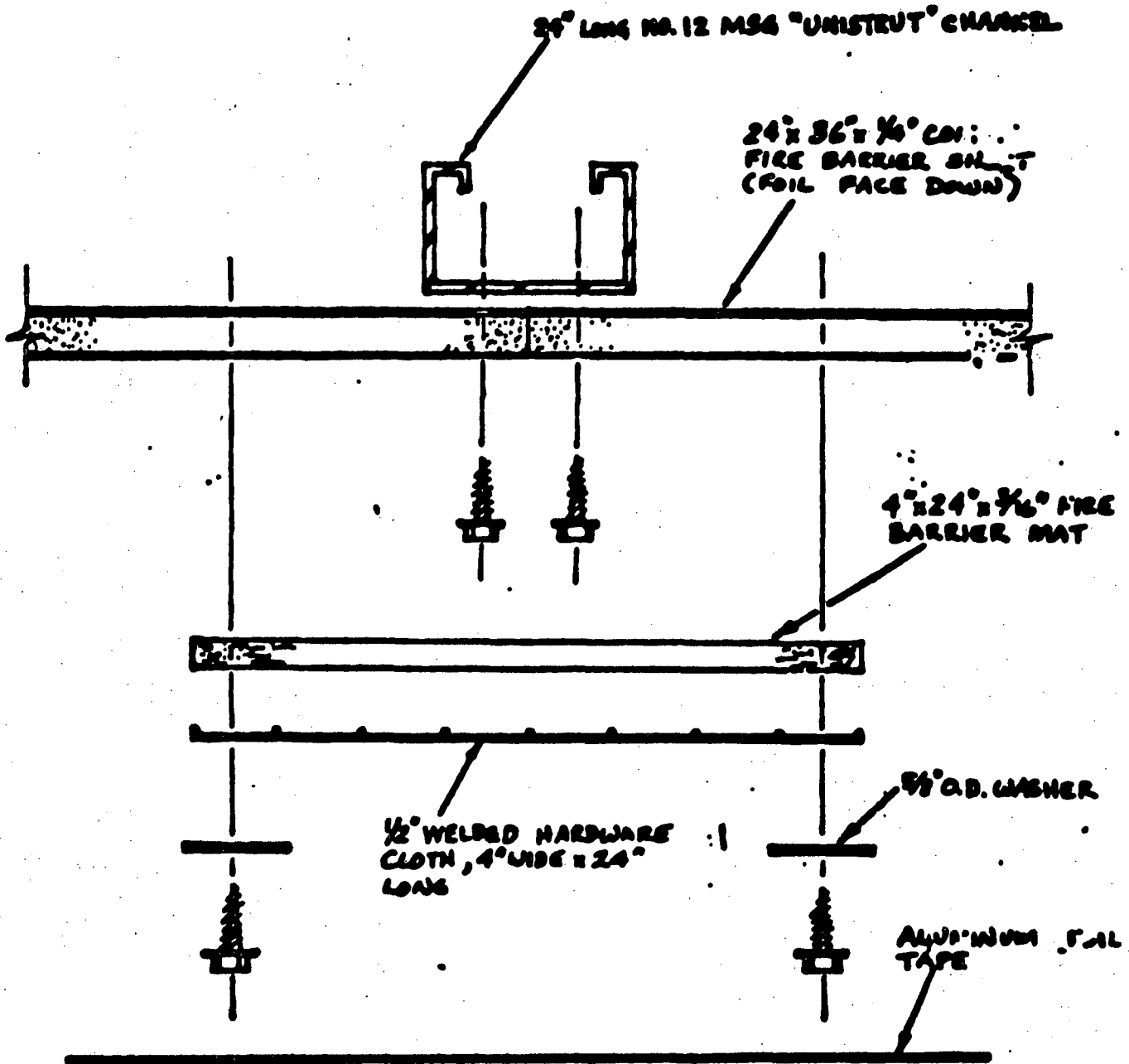

C. J. JOHNSON
Senior Engineering Assistant
Fire Protection Department

Reviewed by:


R. M. BERNING
Engineering Group Leader
Fire Protection Department

CJJ:pr

MECHANICAL JOINT DETAILS



NOTE: SCREWS LOCATED AT CENTER & AT BOTH ENDS OF SHEETS AT LOCATIONS SHOWN ABOVE.

APPENDIX 4 SUMMARY

REPORT #3410539908-18A

CONTENTS:

4 A. 3M CABLE CONTINUITY TEST

TEST #9380030601

4 B. INSTALLATION DRAWINGS

APPENDIX 4A

REPORT #3410539909-18A

3M CABLE CONTINUITY TEST

TEST #9380030601

OBJECTIVE: To determine the temperature failure point for specific Detroit Edison cable.

SM TEST. NUMBER: 9380030601

EQUIPMENT: Blue M Forced Air Oven
Monitor Labs' Thermocouple Indicator
Circuit Continuity Tester (110 volts DC)
"Cable Samples for Tray Wrap Testing," E. R. Bosetti to G. Markiewicz

PROCEDURE: The cable was placed in the oven as shown in Diagram #1. The cable was tested to show continuity and to establish that no faults existed between cable and ground rack. The oven was preheated to 90°C for 10 minutes to simulate cable at maximum operating temperature. The temperature was then increased following an established curve* (see Table 1 and Graph 1).

*Temperature curve was based on the following:

Part A - Underwriters Lab. Fire Test of 3M's Electrical Raceway Protection System (U. L. File #R10125-1, 2, Project 82NK21937). Based on temperature of smallest cable in the hottest tray system + 50°F.

Part B - Temperature soak at maximum temperature for thirty (30) minutes.

Part C - Increase temperature 5°F/min. until cable failure occurs.

The cables were tested to simulate cable under load. A Point loading, ten times the expected load was utilized. (Expected load was based on a 40% fill (100% visual condition) - see Diagram 1.

Circuit Integrity is monitored throughout the tests using the system shown in Diagram II.

TABLE II

Cable Failure Temperature

See Graph I

<u>Cable Types</u> <u>Detroit Edison No.</u>	<u>Failure Temperature</u>		<u>Observation</u> <u>Visual</u>
	<u>°C</u>	<u>°F</u>	
100	340	635	Blistered
066	330	625	No damage visible
003	320	610	Exposed conductor
022	426	800	Exposed conductor

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, however, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.

ISSUE	DATE	REV.	CM.
1	1-13-84		
NOT TO SCALE		CM	
DR	J.C. Peisert	APP	R. R. Licht

CABLE FAILURE TEMPERATURES

Ceramic Materials
Department/3M



Test #9380030601

TABLE I

Scheduled Oven Temperature Increase

	<u>Time</u>	<u>Temperature</u>	
		90°C	190°F
	Preheat		
	Start	121	250
	05	124	255
	10	126	260
	15	129	265
PART A	20	132	270
	25	149	300
	30	177	350
	35	204	400
	40	232	450
	45	246	475

PART B Hold temp., soak - 30 minutes

	1:15	246	475
	1:20	260	500
	1:25	274	525
	1:30	288	550
	1:35	302	575
	1:40	316	600
	1:45	330	625
	1:50	344	650
PART C	1:55	357	675
	2:00	371	700
	2:05	385	725
	2:10	399	750
	2:15	413	775
	2:20	426	800
	2:25	441	825
	2:30	454	850
	2:35	467	875

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, however, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.

ISSUE	DATE	REV.	CH.
1	1-13-84		
NOT TO SCALE		CH	
DR	J. C. Peisert	APP	R. R. Licht
Test #9380030601			

CABLE FAILURE TEMPERATURES

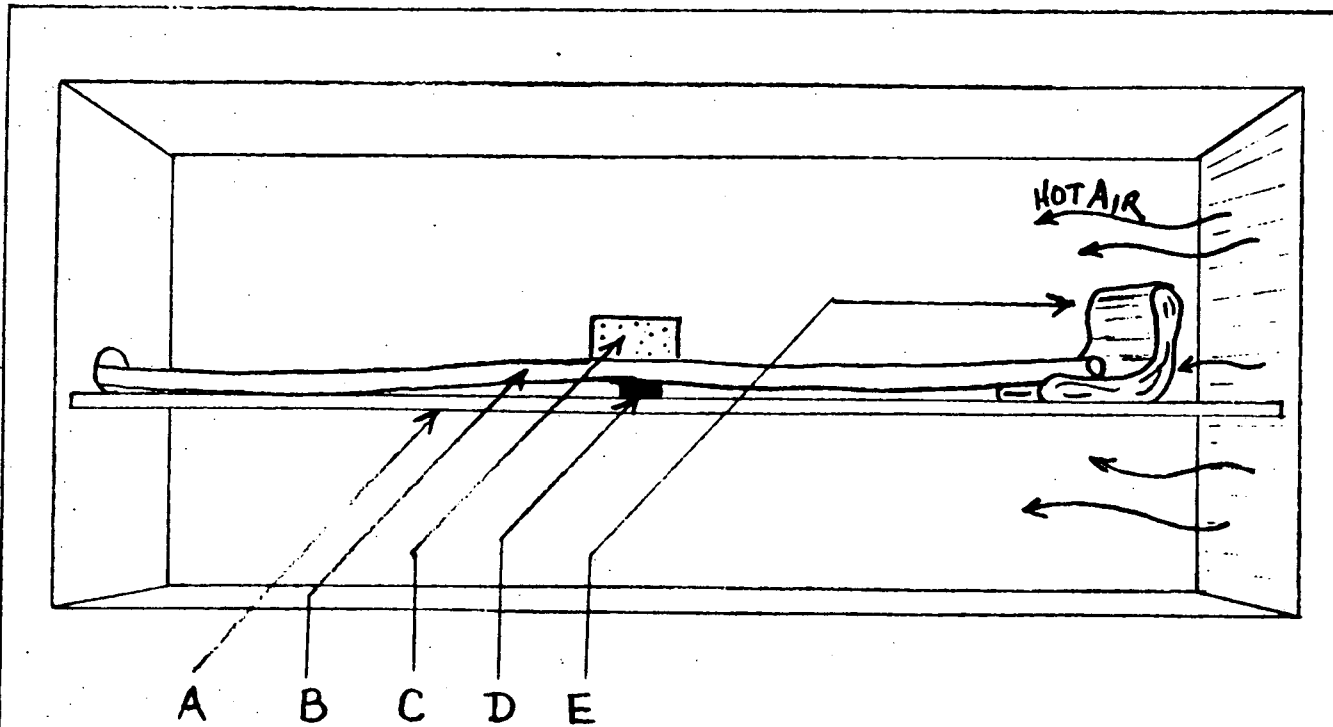
Ceramic Materials
Department/3M



DIAGRAM # 1

Cable Heat Testing Oven

- A - CABLE GROUNDING SHELF
- B - CABLE
- C - WEIGHT ON CABLE
- D - STEEL BAR (TO SIMULATE CABLE TRAY RUNG)
- E - AIR STREAM SHIELD



All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, however, unless the user follows the instructions are beyond our control. 3M shall not be liable for any damage, direct or consequential, resulting from the use of any of our products found to be defective.

Ceramic Materials
Department/3M



ISSUE	DATE	REV.	CH.
1	1-13-84		
NOT TO SCALE			

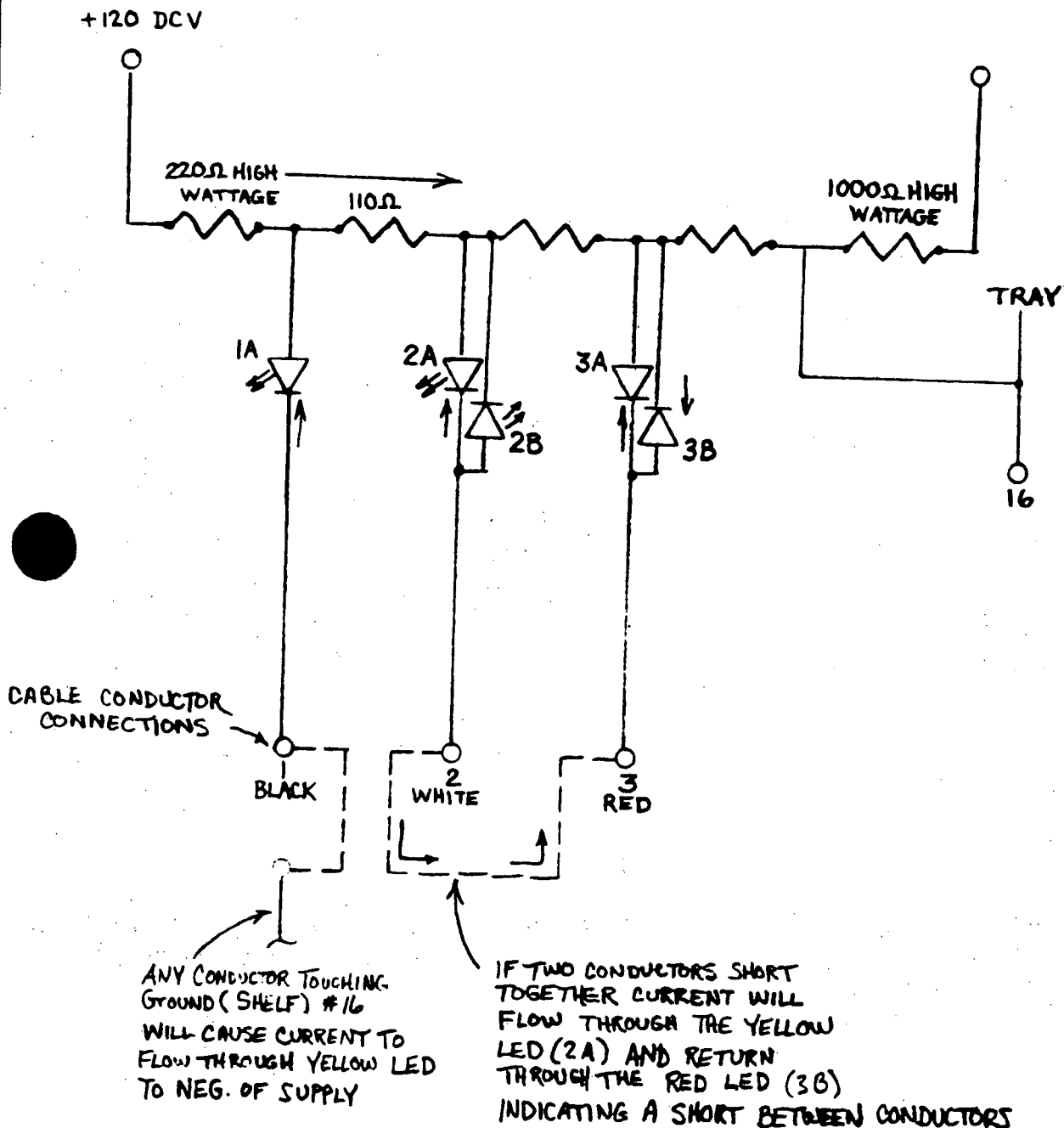
by JCPeiser
R. R. Licht

TEST #9380030601

CABLE FAILURE TEMPERATURES

CABLE CIRCUIT INTEGRITY

(CIRCUIT CONTINUITY TEST) C.C.T.



All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, however, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to repair or replace any of our products found to be defective.

ISSUE	DATE	REV.	CH.
1	1-13-84		
NOT TO SCALE		CH	
DR JCA eisert		APP R. R. Licht	

CABLE FAILURE TEMPERATURES

APPENDIX 4B

REPORT #3410539909-18A

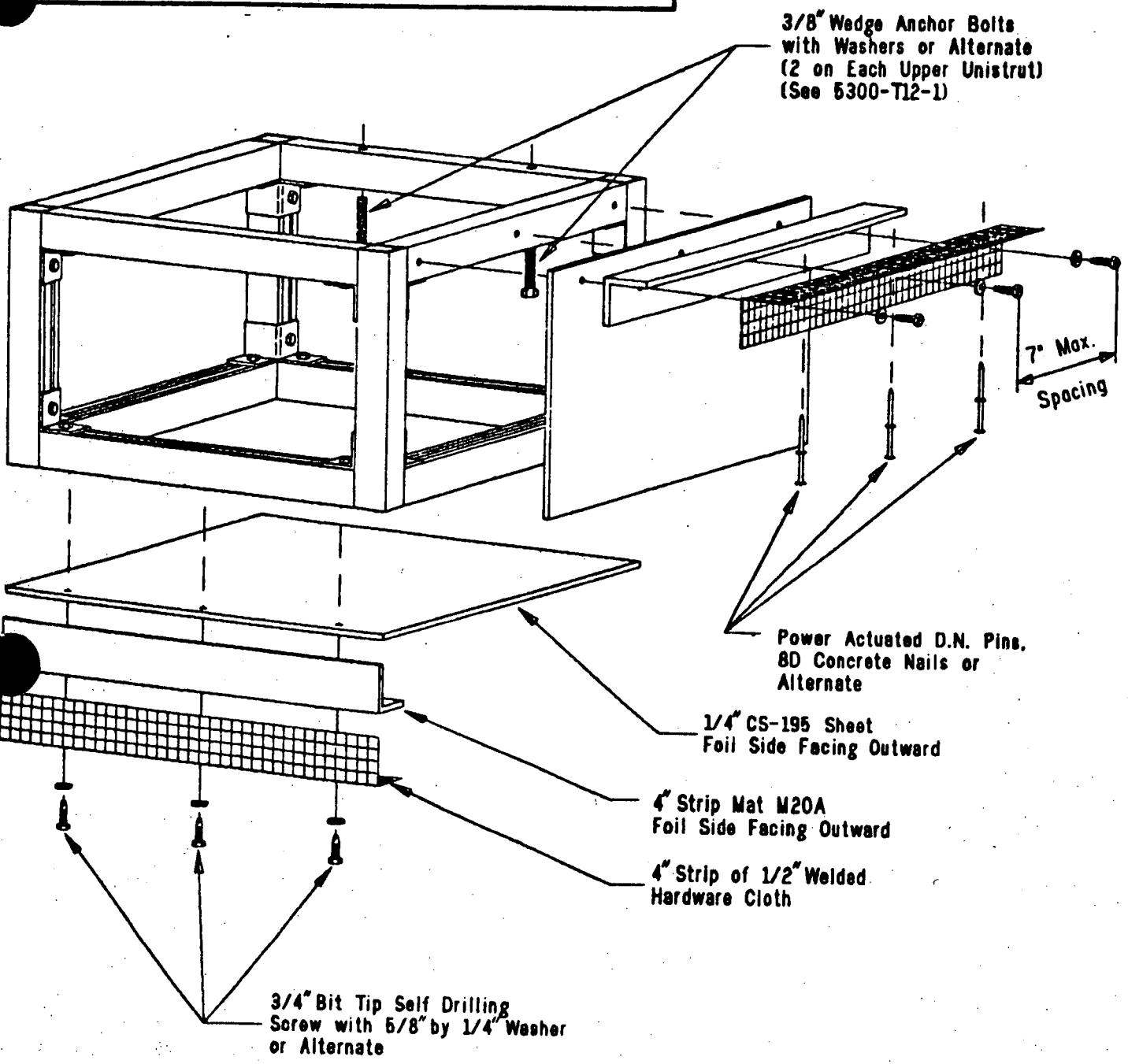
INSTALLATION DRAWINGS

REFERENCE PRINT

5300-J1-1
5300-J1-ML
5300-J2

REFERENCE DESCRIPTION

-- INSTALLATION INSTRUCTIONS
-- MATERIAL LIST
-- COMPLETED ASSEMBLY



All statements, technical information and recommendations contained herein are based on facts we believe to be reliable, however, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of our products or design. 3M's only warranty shall be to the effect that our products are not defective.

ISSUE	DATE	REV	CH.
2	12-05-83		
NOT TO SCALE		CH.	J.R. TUJINSKI
DR. P.A. leTOURNEAU		APP.	D.N. HUNTER

3M
FIRE BARRIER
Junction Box
Protection System
M20A - CS-195

Electro-Products Division/3M **3M**

5300-J1

3M MATERIAL USED -- SEE SHEET 5300-TT-1 FOR ORDERING INFORMATION

REFERENCE NAME	TRADE NAME
MAT M20A	3M BRAND FIRE BARRIER MAT M20A
CS-195	3M BRAND FIRE BARRIER COMPOSITE SHEET CS-195
ALUMINUM TAPE	SCOTCH BRAND ELECTRICAL TAPE #49 ALTERNATE APPROVED TAPE 3M BRAND #425
CAULK CP-25	3M BRAND FIRE BARRIER CAULK CP-25
PUTTY 303	3M BRAND FIRE BARRIER PUTTY 303

USER SUPPLIED MATERIALS

REFERENCE NAME	TRADE NAME
ANCHOR BOLTS	3/8" WEDGE ANCHOR BOLTS WITH WASHERS
BIT TIP SCREWS	3/4" (OR LONGER) BIT TIP SELF-DRILLING SCREWS WITH 5/8" X 1/4" WASHERS
HARDWARE CLOTH	1/2" WELDED HARDWARE CLOTH
UNISTRUT	UNISTRUT A3300 OR A1000
D.N. PINS	POWER ACTUATED D.N. PINS

ALTERNATE USER SUPPLIED MATERIALS

REFERENCE NAME	TRADE NAME
GALV SHEET METAL	GALVANIZED SHEET METAL
SHEET ALUMINUM	ALUMINUM SHEET
NUTS AND BOLTS	MAX. HEAD SIZE 5/8". MAX. BOLT O.D. 5/8"
FASTENER	REPLACEMENT FOR ANCHOR BOLTS
3/8" THREADED ROD	REPLACEMENT FOR ANCHOR BOLTS
SCREWS	3/4" OR LONGER SHEET METAL SCREWS IF APPLICABLE
CONCRETE NAILS	8D CONCRETE NAIL OR EQUIVALENT

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable. However, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of material or design. 3M's only warranty shall be to the effect that our products conform to the specifications of our products found to be defective.

ISSUE	DATE	REV	CH.
1	12-05-83		
NOT TO SCALE		CH. J. R. TUZINSKI	
DR. P.A. LeTOURNEAU		APP. V.N. HUNDER	
5300-J1-ML			

FIRE BARRIER **3M**
Junction Box
Protection System
Material List
CS-195/M20A



INSTALLATION INSTRUCTIONS

1. Wrap one layer of Mat M20A around the junction box so that it is completely covered except for the cover plate. Tape in place with the aluminum foil tape.
2. Install a box made of Unistrut or any other metal, such as sheet metal or aluminum sheet whose dimensions are 1 inch larger on all sides so that the CS-195 sheet is separated from the junction box by at least 1 inch. The box or box frame must be strong enough to be seismically qualified for the specific location on any nuclear site. Allowance must be made so that the box can be re-entered with ease.
3. The attachment to the concrete test slab was made with 3/8 inch threaded rods, nuts and washers. Any method of attaching the box to a wall or frame which is sesimically qualified is acceptable.
4. After the frame or box is completed it must be completely covered with the CS-195 Sheets. After the sides are covered with CS-195, a large piece of mat is installed over the cover plate of the junction box. This mat should be 2 inches larger than the cover plate on each side (4 inches on each edge). The mat should be stuffed into place over the cover plate between the junction box and the frame. Tapping with aluminum tape may be necessary.
5. The Mat M20A and hardware cloth covering the edges in the test were held to the frame with self-tapping screws and 5/8 inch O.D. washers. Any mechanically sound method of attachment, such as nuts and bolts, studs and winged nuts, or winged screws may be used as long as the O.D. of the fastener and/or washer is no larger than 5/8 inch.
6. The mat and hardward cloth were held to the slab with ordinary nails. Therefore, any method which is equal to nailing into soft concrete is acceptable. The following techniques have been analyzed:
 - A. Install with power driven fasteners, such as D. N. Pins, maximum spacing between pins - 12 inches.
 - B. Bolts through the fire wall (floor).

<small>All statements, technical information and recommendations contained herein are based on tests we believe to be reliable. However, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.</small>	ISSUE	DATE	REV.	CH.	FIRE BARRIER JUNCTION BOX PROTECTION SYSTEM MATERIAL LIST CS-195/M20A
	1	12-6-8			
	NOT TO SCALE		CR: R.T. 12/12 J.R. Tuzidski J. J. HEDER		
Electro-Products Division/3M	3M	5300-J1-1			

REFERENCE PRINT

5300-JI-1
5300-JI-ML

REFERENCE DESCRIPTION

-- INSTALLATION INSTRUCTIONS
-- MATERIAL LIST

Initial M20A
Wrap of Junction
Box Held by Alum.
Foil Tape

Junction Box

Apply M20A Cover
After Installing
Unistrut Frame
(See 5300-JI)

Floor
Slab

Aluminum
Tape

Mat M20A

2"
(min)

Mat M20A

Completed Junction
Box Covering
See 5300-JI for
Intermediate Steps

Self Drilling
Screws

CS-195 Sheet
Foil Side Facing
Outward

All statements, technical information and recommendations contained herein are based on facts we believe to be reliable. However, since the conditions of use and application are beyond our control, 3M shall not be liable for any damage, direct or consequential, resulting from the use of this material or design. 3M's only warranty shall be to replace any of our products found to be defective.

ISSUE	DATE	REV	CH.
2	12-07-83		
NOT TO SCALE		CH.	J.R. TUZINSKI
DR. P.A. LeTOURNEAU		APP.	D.N. HUNDER

3M
FIRE BARRIER
Junction Box
Protection System
M20A - CS-195

Electro-Products Division/3M



5300-J2

ATTACHMENT B

TECHNICAL REPORT

REPORT NO.:	E386-84-3037
SHEET NO.:	1 of 4 Sheets
DATE OF WORK:	3/8/84-3/12/84
DATE OF REPORT:	3/19/84

LOCATION: Central Laboratories Services, LA PSC 1-C
 SUBJECT: CABLE-FAILURE TEMPERATURE TESTS

COPIES SENT TO: Eugene Chitwood, Don B. Arp, ARMS, WWR

PREPARED BY: Harold Cummings, Joe Bennett, Don B. Arp

APPROVED BY: *H.A. Taff* H. A. Taff

INTRODUCTION

Seven cable samples were tested at elevated temperatures to determine at what temperature, if any, failure occurred. These tests were conducted to supplement Underwriters Laboratories (UL) Fire Barrier Test Data submitted under Watts Bar Nuclear contract 83KB5-832419. The fire barrier material was tested by UL to determine its compliance with 10CFR50 Appendix R for a one-hour fire rating.

UL certified the fire barrier material with the stipulation that the user (TVA) provide evidence that the cable inside the barrier will withstand the temperatures measured during actual fire test conditions. The current tests match the fire test conditions as closely as possible. Whenever conditions could not be precisely matched, the deviation was such as to assure a more severe test than was required.

RESULTS

One sample (7/c #12 AWG,PJJ) failed the test. See attached Table 1.

TEST SETUP

One, two, or three cable samples were placed in a hot air oven simultaneously and weighted as shown in Figure 1 (attached). The asbestos plate supported the weights and applied pressure to the cable. This plate was always supported at three points, at least two of which were provided by the cable. When three cable samples were run simultaneously, two separate setups were used, with one of the samples providing the third support point for each setup. For a two-sample run, two separate setups were used as shown, with a piece of firebrick supplying the third support point.

The weight was positioned so as to be distributed as evenly as possible on all three support points, making each support point bear close to one-third of the total weight.

The thermocouple was attached to the outer jacket of each test sample with high temperature electrical tape.

The weight applied to each support was more than the weight of a six-inch length of the heaviest sample in each group, multiplied by the appropriate factor computed by Don B. Arp of EN DES. The total weight for the setup was three times the computed value for each support, including the weight of the asbestos plate. The attached Table 2 lists the weights. The heaviest 6-inch sample in each group is underlined. Sample 1X is a repeat test, with less weight, on Sample 1.

The cable samples were prepared for testing as shown in Figure 2 (attached). All samples were approximately one foot in length. For the Group D cable (sample 7), the shield and semiconductor layer right underneath it were stripped back about three-quarters of an inch to prevent arcing through the air to the center conductor.

Figure 2 also shows the wiring diagrams. The one-ohm resistors in the ground leads were connected to an oscillograph which indicated precisely when any wire shorted to ground. Since a wire-to-wire short on a Group A or B sample would not necessarily involve a grounded wire, a voltmeter monitored the phase-to-phase voltage. Collapse of this voltage indicated a failure from phase to phase or both phases to ground. The voltmeter was also used to check the phase-to-ground voltages periodically.

DESCRIPTIONS AND CONCLUSIONS

Sample 1 (PJJ-Failed) - Both the outer jacket and the individual wire insulation melted readily at a relatively low temperature. The first electrical failure occurred at 346°F. The temperature was increased after failure to 570°F. After the test, the sample was completely blackened, and bare conductors could be seen where the support rungs had been located. The cable had compressed under the weight to a thickness of 0.18 inch, barely enough for the wire.

Sample 1 failed wire-to-wire, not wire-to-rung. The failure monitor on the rungs never showed a failure, but the voltage was removed 2 minutes, 51 seconds after initial failure. Wire-to-rung failure would have occurred later, judging by visual inspection.

Sample 1X (PJJ-Failed) - This was another sample of the same cable as sample 1. The weight load was only 27% of that used on sample 1. The first electrical failure occurred at 440°F, almost 100° higher than sample 1. The higher temperature failure was undoubtedly due to the lower weight load, plus the fact that the temperature was increased at a faster rate (closer to the fire test curve), allowing relatively less melting time.

Contrary to sample 1, sample 1X was removed from the oven almost immediately after failure. Since the temperature did not get as high, the original colors of the individual wire insulation could be seen. They were mixing together, however, indicating considerable melting had occurred. The thickness at the support points was about 0.35 inch. No conductors were visible. It could not be determined, by inspection, where the failure occurred.

Sample 1X, like sample 1, failed wire-to-wire. The voltage was removed, and the test terminated, one minute, 1 second after initial failure. No wire-to-rung failure occurred.

Sample 2 (PXMJ) - This sample fared very well. It was discolored, but not as black as the other samples. Neither the outer jacket nor the individual wire insulation was significantly melted or burned. No distortion could be seen at the support points.

Sample 3 (CPJJ) - The outer jacket of this sample melted just as did sample 1. The individual wire insulation fared better, though not as well as sample 2. There was evidence of melting and cracking, but no bare conductor could be seen. The thickness at the support points was 0.27 inch. This sample would probably have failed if the temperature had been raised much above the 570°F of the Group A test.

Samples 4 (Rockbestos) and 5 (Anaconda) - The individual wires of these samples fared well. The jacket and shield of sample 4 also fared well, though considerable cracking occurred in the jacket. The jacket of sample 5 was destroyed at the support points, and the shield was also damaged slightly. Though the shield-to-rung contact was not monitored, they obviously came in contact during the test on sample 5.

Sample 6 (CPJ) - The outer jacket melted, but the inner jacket around the conductor was still intact, though cracked slightly. The support points went completely through the outer jacket, but little or no distortion could be seen on the inner jacket.

Sample 7 (CPSJ) - The test on this sample was complicated by the need to apply 6.9 kV to it. The oven used had no openings for wires, so the 6.9 kV had to be run in through the main door, without cracking it excessively. A lead was fashioned by adding high temperature electrical tape to a length of teflon-coated hookup wire, while attempting to keep the bulk to a minimum. This worked well at low temperatures, but the tape lost dielectric strength at high temperatures. The test lead failed at 367°F. At the time, it could not be determined whether the test lead or the sample had failed. Since the test lead was suspected, the heating was continued. It was terminated after holding 475°F for 30 minutes.

Immediately after the heating was terminated, the oven door was opened and the lead failure was observed. The lead was pulled away from the oven frame, and the voltage reapplied. The sample passed the test. The temperature by that time was down to about 440°F. As a further test, the voltage was increased above 6.9 kV. Failure occurred at about 9 kV, but it was through the air, around the end. By now the temperature was down to about 400°F. Since the sample had successfully withstood 10 kV when cold, it was concluded that the semiconductor layer under the shield must have melted and spread over the stripped insulation (see Figure 2). A continuous cable would have stood more than 9 kV.

The outer jacket of this sample melted, and most of it drained off, leaving the shield exposed. The shield and inner insulation remained in good shape. The semiconductor layer may have melted, as explained above, but this would be of no consequence, except at an end of the cable. Contact would readily occur, however, between the shield and any other exposed conductor.

INSTRUMENTATION

Temperature - The samples were heated in a hot air oven intended principally for drying applications. It was a Partlow "Despatch," US-TVA 266362.

The temperatures of the sample jackets were measured with Type T (copper-constantan) thermocouples and Fluke 2165A digital thermometers. The thermocouples were fabricated in the laboratories out of standard thermocouple wire. The accuracy depends on the precision of the alloy, and according to ANSI C96.1, should be (above 200°F) within 0.75% of reading (about 3.6°F at 475°F). Our experience indicates they are usually much better (within 1 or 2 degrees F). The digital thermometers are specified at $\pm 2.4^\circ\text{F}$, but they are usually within $\pm 1^\circ\text{F}$. Certification reports of the three thermometers used are attached.

An overall calibration of each thermocouple and its thermometer was made at ambient temperature (about 75°F). All were within $\pm 1^\circ\text{F}$.

Voltage - While not recorded, the voltage on samples 1-6 was checked periodically and was always within 10% of the nominal voltage. A Fluke 8600A digital multimeter, US-TVA 486356, was used. A certification report is attached.

The voltage applied to sample 7 (6.9 kV) was taken from a Hipotronics OC-51-M oil tester, US-TVA 320305. It was monitored with a kV meter, Hipotronics KV50A, US-TVA 467412. The kV meter was certified on 12/21/83, and the report is in the laboratories files. It was also checked on 1/16/84, and found to be within ± 200 volts on the 10 kV range.

TECHNICAL REPORT

REPORT NO.:	E386-84-3037
SHEET NO.:	4 of 4 Sheets

Weight - The samples and weights used were weighed on a 10 kilogram scale, Mettler P11N, US-TVA 387139. It was certified on 10/4/83 and the report is in the laboratories files. It has an accuracy of ± 0.1 gram.

Failure Monitoring - The voltages across one-ohm resistors in the ground leads were recorded on an oscillograph, Soltec Visilight 5M, US-TVA 512797. The digital multi-meter and kV meter were also used (see Figure 2).

HBC:KM

Attachments: Tables 1 and 2
Figures 1 and 2
Temperature Curves (3)
Reports of Calibration (4)

<u>Cable Group</u>	<u>Test Sample</u>	<u>DESCRIPTION</u>	<u>Test Voltage</u>	<u>Test Results</u>
A	1	7/c, #12 AWG, PJJ, 600 V, Mark WGG	120 VAC	FAILED
A	2	7/c, #12 AWG, PXMJ, 600 V, Mark WGG-1	120 VAC	PASSED
A	3	7/c, #12 AWG, CPJJ, 600 V, Mark WLG	120 VAC	PASSED
B	4	2/c, #16 AWG w/shield, Mark WVA (Rockbestos)	120 VAC	PASSED
B	5	2/c, #16 AWG w/shield, Mark WVA (Anaconda)	120 VAC	PASSED
C	6	1/c, 400 MCM, CPJ, 600 V, Mark WDO	480 VAC	PASSED
D	7	1/c, 2/0 AWG, CPSJ, 8 kV, Mark WNB	6900 VAC	PASSED

TABLE 2

<u>Test Sample</u>	<u>Length, Inches</u>	<u>Weight</u>	<u>Weight Per 6" Length</u>	<u>Weight Factor</u>	<u>Minimum Wt. Per Support</u>	<u>Minimum Total Wt.</u>	<u>Wt. Actually Applied</u>
1	12.050	122.5 gm	61.0 gm	25			
2	12.050	149.4 gm	<u>74.4 gm</u>	25	1860 gm	5580 gm	5694 gm
3	12.060	145.0 gm	72.1 gm	25			
1X	12.050	122.5 gm	61.0 gm	≈7			1531 gm
4	12.075	30.0 gm	14.9 gm	40			
5	11.975	31.4 gm	<u>15.7 gm</u>	40	629 gm	1888 gm	& 1931 gm 1940 gm
6	12.050	799.4 gm	<u>398.0 gm</u>	10	3980 gm	11941 gm	11954 gm
7	12.075	357.0 gm	<u>177.4 gm</u>	10	1774 gm	5322 gm	5452 gm

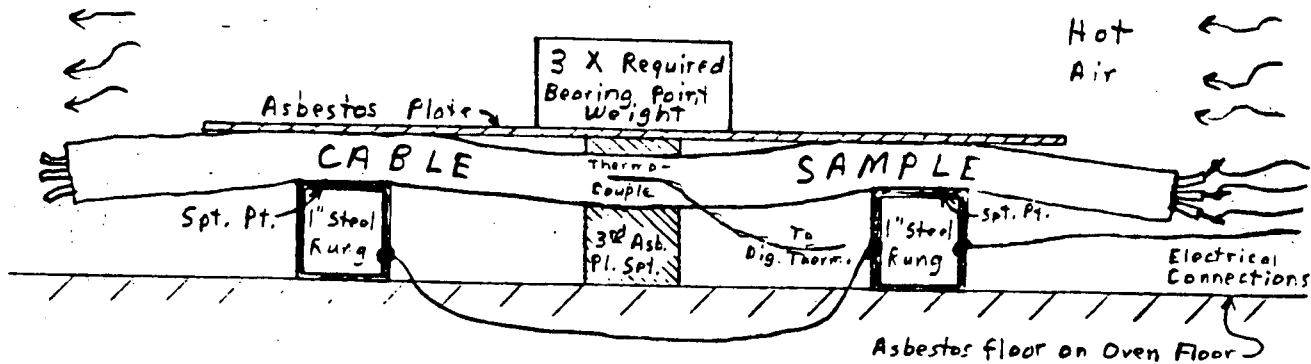


FIGURE 1 - TEST SETUP - SCALE 1" = 2"

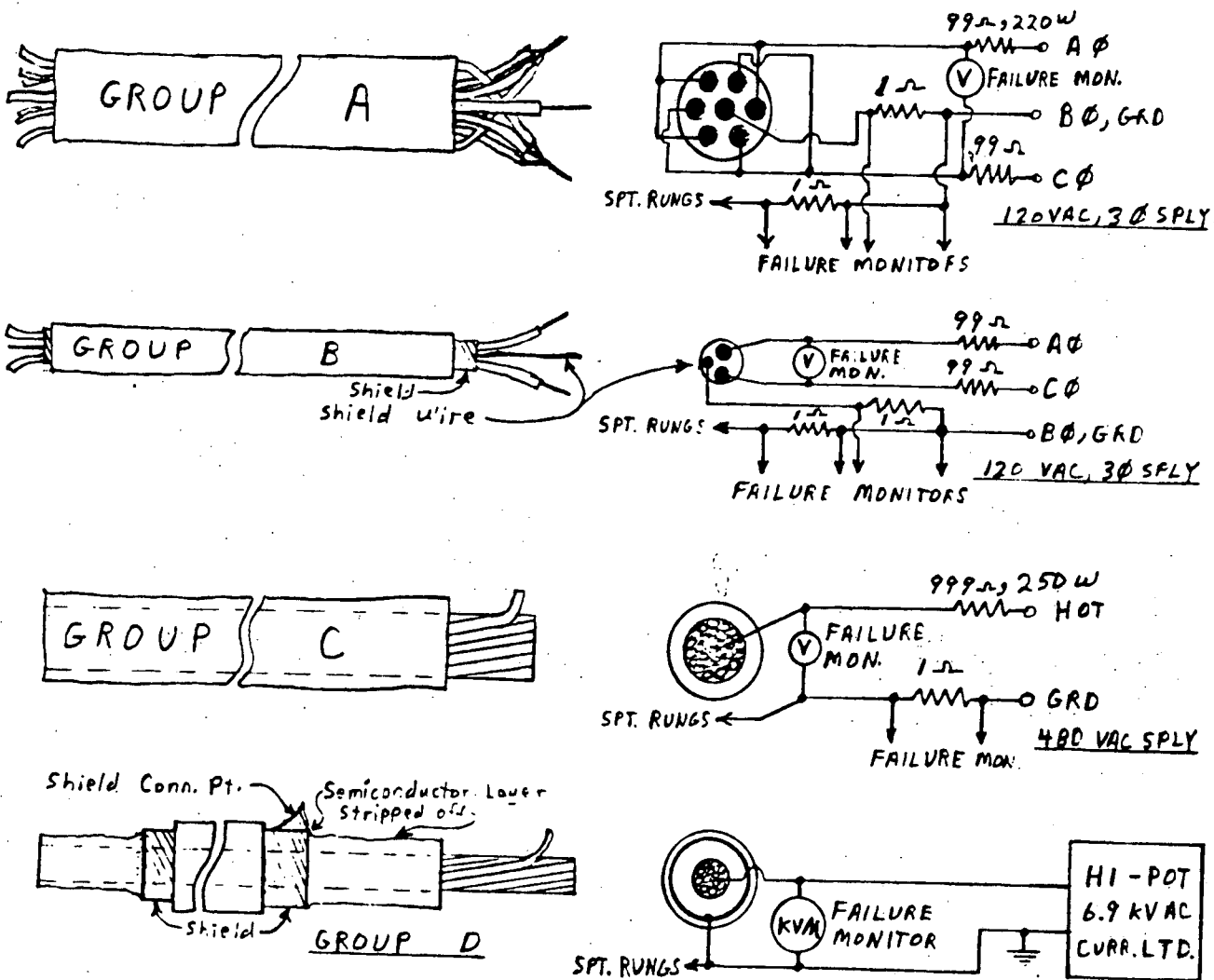
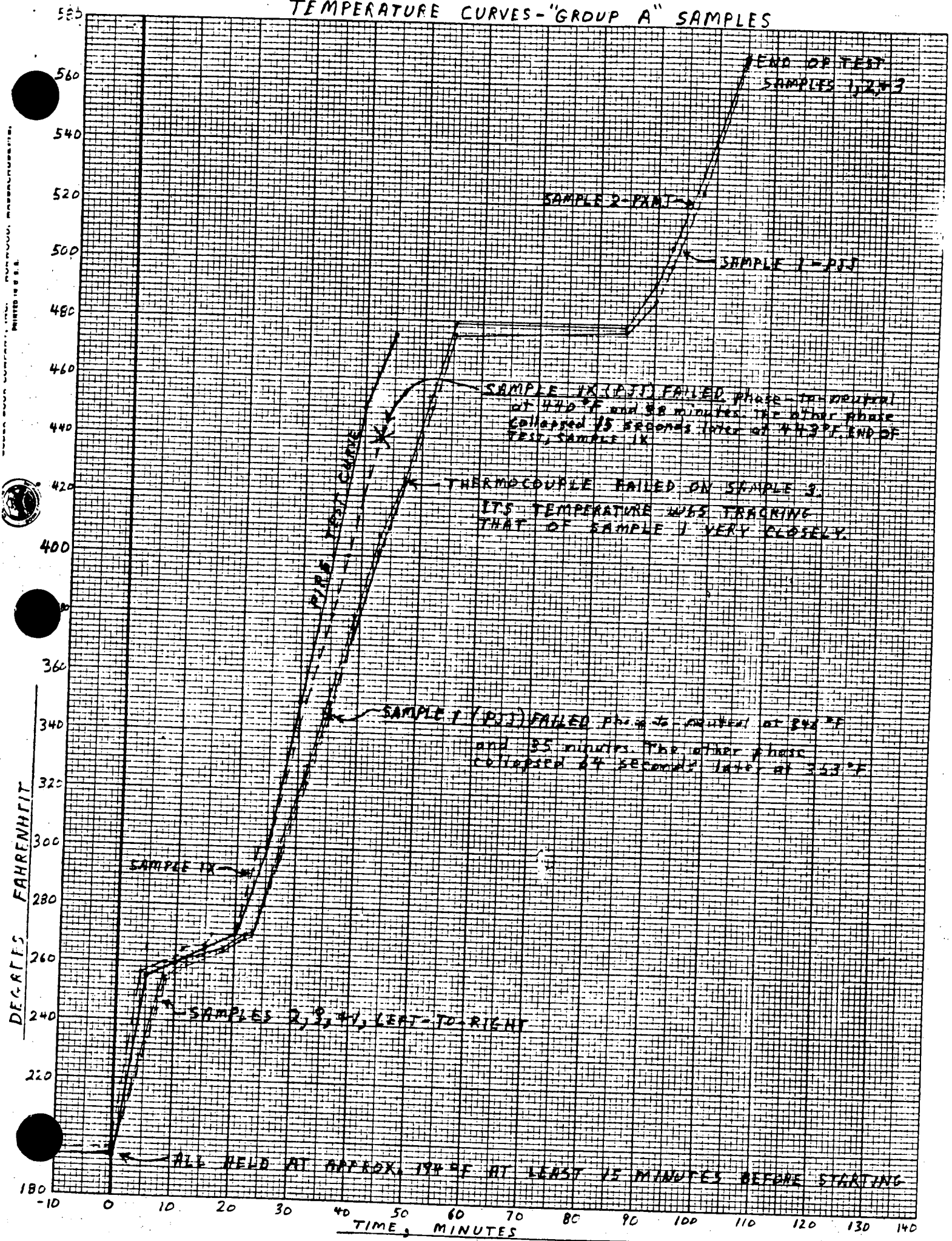


FIGURE 2 - SAMPLE PREPARATION AND WIRING DIAGRAMS

TEMPERATURE CURVES - "GROUP A" SAMPLES



THESE DATA WERE OBTAINED FROM THE PORTLAND CEMENT LABORATORY, BUREAU OF STANDARDS, WASHINGTON, D.C. PRINTED IN U.S.A.

DEGREES FAHRENHEIT

TIME, MINUTES

SAMPLE 1X

SAMPLES 2, 3, 4, LEFT-TO-RIGHT

ALL HELD AT APPROX. 194°F AT LEAST 15 MINUTES BEFORE STARTING

PIPE TEST CURVES

SAMPLE 1X (PJT) FAILED phase-to-neutral at 470°F and 58 minutes. The other phase collapsed 15 seconds later at 473°F. END OF TEST, SAMPLE 1X.

THERMOCOUPLE FAILED ON SAMPLE 2. ITS TEMPERATURE WAS TRACKING THAT OF SAMPLE 1 VERY CLOSELY.

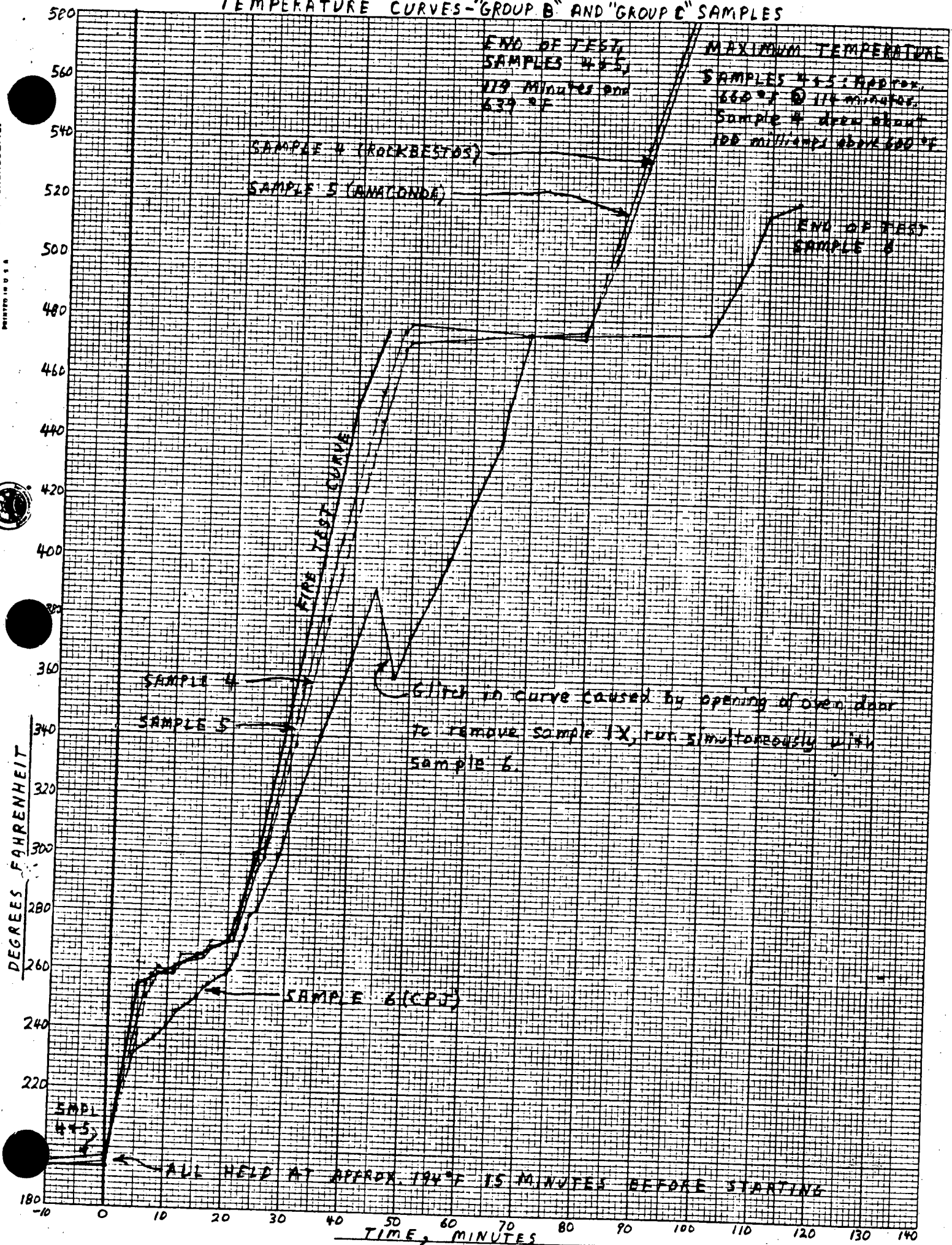
SAMPLE 1 (PJT) FAILED phase-to-neutral at 348°F and 35 minutes. The other phase collapsed 24 seconds later at 353°F.

SAMPLE 2-PART

SAMPLE 1-PART

END OF TEST SAMPLES 1, 2, 3

TEMPERATURE CURVES - "GROUP B" AND "GROUP C" SAMPLES

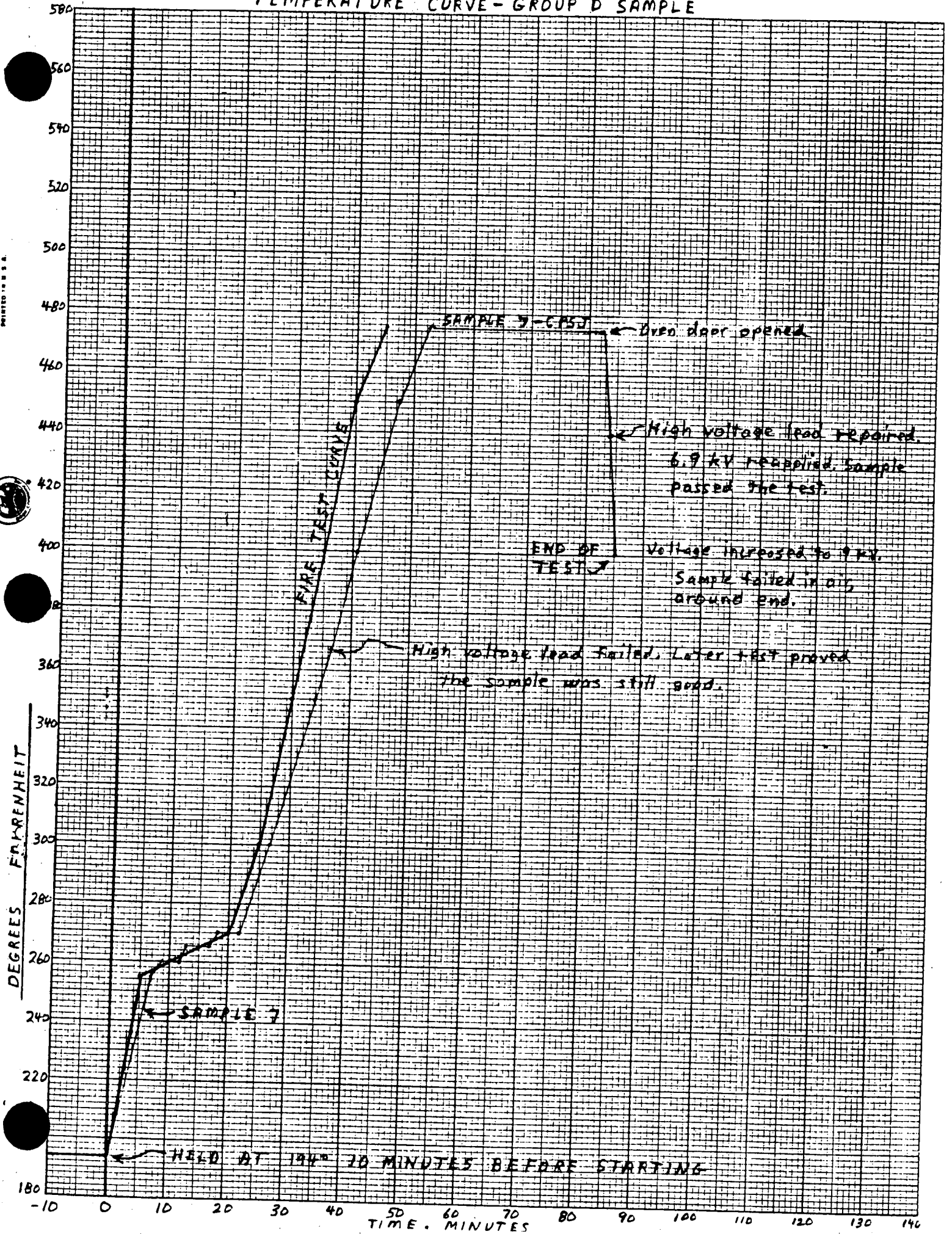


CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS.
 PRINTED IN U.S.A.

DEGREES FAHRENHEIT

TIME, MINUTES

TEMPERATURE CURVE - "GROUP D" SAMPLE



REPORT OF CALIBRATION
Central Laboratories

Const.	P.P.	E.U.	Number US TVA 462373
Plant EN DES - OEDC			Date 3-13-84

Instrument **Digital Thermometer**
Mfg/Model **Fluke/ 2165A**

Instrument Accuracy
-28 to +32 ± 4.2 F; 32 to 732 F ± 2.4 F

Standards Used **DMM US TVA 416185, Ice Bath, IPTS 68, P-3 Voltmeter US TVA 166925**

Test Procedure **411.1-2**

As Found Test Within Tolerance Out of Tolerance Not Required

As Left Test Within Tolerance Test Incomplete Not Required

The instrument was tested and calibrated according to prescribed test procedures and the condition of the instrument is indicated.

Signed *Billy J. Lynch* Date **3-13-84** Checked By *K. J. [Signature]*

Cal. Date	Last	Next	Interval	<input type="checkbox"/> Certification Label Affixed
	N/A	N/A	N/A wks.	

Disposition of Instrument To User To Stock Other

Remarks/Data

"As Found"

STD	WWT
°F	F
732.0	732
72.0	72
-28.0	-28

Internal Temperature Rise Passed Failed

Open Circuit Test Passed Failed

Overload Test Passed Failed

Line Voltage Regulation Test Passed Failed

Copies to: _____

Approved by: *[Signature]* Sheet **1 of 1**

REPORT OF CALIBRATION
Central Laboratories

Const.	P.P.	E.U.	Number US TVA
			462378
Plant			Date
EN. DES - OEDC			3-13-84

Instrument: Digital Thermometer
Mfg/Model: Fluke/ 2165A

Instrument Accuracy: $-28 \text{ to } +32 \text{ }^\circ\text{F} \pm 4.2 \text{ }^\circ\text{F}$; $32 \text{ to } 732 \text{ }^\circ\text{F} \pm 2.4 \text{ }^\circ\text{F}$
Standards Used: DM, US TVA 416188; Ice Bath, IPTS 68, P-3 Voltmeter US TVA 161925
Test Procedure: 411.1-2

As Found Test: Within Tolerance Out of Tolerance Not Required
As Left Test: Within Tolerance Test Incomplete Not Required

The instrument was tested and calibrated according to prescribed test procedures and the condition of the instrument is indicated.
Signed: *Billy J. Lind* Date: 3-13-84 Checked By: *K. T. Wang*

Cal. Date: N/A Last: N/A Next: N/A Interval: N/A wks. N/A
 Certification Label Affixed

Disposition of Instrument: To User To Stock Other

Remarks/Data: "AS FOUND"

STD	MMT
°F	°F
732.0	732
72.0	72
-28.0	-28

Internal Temperature Rise: Passed Failed
Open Circuit Test: Passed Failed
Overload Test: Passed Failed
Line Voltage Regulation Test: Passed Failed

Copies to: _____ Approved by: *[Signature]* Sheet 1 of 1

REPORT OF CALIBRATION
Central Laboratories

Const.	P.P.	E.U.	Number US TVA 462381
Plant EN. DES. - OEDC			Date 3-13-84

Instrument Digital Thermometer
Mfg/Model Fluke/2165A

Instrument Accuracy
-28 to +32°F ± 4.2°F ; 32 to 732°F ± 2.4°F

Standards Used DMM US TVA 41618P, Ice Bath, IPTS 68,
P-3 Voltmeter US TVA 166925
Test Procedure 411.1-2

As Found Test Within Tolerance Out of Tolerance Not Required

As Left Test Within Tolerance Test Incomplete Not Required

The instrument was tested and calibrated according to prescribed test procedures and the condition of the instrument is indicated.

Bolly? Lynd
Signed

3-13-84
Date

K. J. Wh...
Checked By

Cal. Date	Last (Next)	Interval	<input type="checkbox"/> Certification Label Affixed
N/A	N/A	N/A wks.	N/A

Disposition of Instrument To User To Stock Other

Remarks/Data

" AS FOUND "

STD	UNT
°F	°F
732.0	732
72.0	72
-28.0	-28

Internal Temperature Rise Passed Failed

Open Circuit Test Passed Failed

Overload Test Passed Failed

Line Voltage Regulation Test Passed Failed

Copies to: _____ Approved by: *[Signature]* Sheet 1 of 1

REPORT OF CALIBRATION
CENTRAL LABORATORIES

US-TVA 486356
3 / 15 / 84

DIGITAL MULTIMETER
FG/MODEL: FLUKE-8600
STANDARD USED: 7505B

KNOXVILLE-OEDC
ENGINEERING DESIGN
TEST PROCEDURE: 808

'AS FOUND' TEST WITHIN TOLERANCE

'AS LEFT' TEST NOT REQUIRED

INSTRUMENT TESTED & CALIBRATED ACCORDING TO PRESCRIBED TEST PROCEDURES.
CONDITION OF INSTR IS INDICATED BELOW. FOR INSTR ACCURACY SEE TOL COL.

[Signature] 3-15-84 *Paul W. Landrum*

SIGNED DATE CHECKED BY

CAL. LAST NEXT INTERVAL
DATE NA NA NA

REMARKS/DATA:

TEST-FUNC	RNG	FREQ HZ	TEST READING	INST	AS FOUND STD READ	TOLERANCE
1	MV DC	200	-190		-189.946	.1152
2	MV DC	200	190		189.964	.1152
3	V DC	2	1.9		1.8996	.000576
4	V DC	2	-1.9		-1.8997	.000576
5	V DC	20	19		18.999	.00576
6	V DC	20	-19		-18.999	.00576
7	V DC	200	190		189.989	.0576
8	V DC	1200	1000		1000.005	.3552
9	V DC	2	1.1111		1.111	.0003867
10	V DC	2	1.2222		1.2221	.0004133
11	V DC	2	1.3333		1.3333	.00044
12	V DC	2	1.4444		1.4443	.0004667
13	V DC	2	1.5555		1.5554	.0004933
14	V DC	2	1.6666		1.6665	.00052
15	V DC	2	1.7777		1.7776	.0005466
16	V DC	2	1.8888		1.8886	.0005733
17	V DC	2	.9999		.9998	.00036
18						
19						
20						
21						
22	MV AC	200	65	190	190.53	.648
23	MV AC	200	1	K 190	189.95	.648
24	V AC	2	65	1.9	1.9015	.00492
25	V AC	2	1	K 1.9	1.9	.00492
26	V AC	20	65	19	19.003	.0492
27	V AC	20	1	K 19	19.004	.0492
28	V AC	200	65	190	189.94	.492
29	V AC	200	1	K 190	189.97	.492
30	V AC	1200	65	1000	999.8	4.832
31	V AC	1200	1	K 1000	999.5	4.832
32	OHM	200		100	99.94	.156

REPORT OF CALIBRATION (PAGE 2)

US-TVA 486356
3 / 15 / 84

TEST-FUNC	RNG	FREQ HZ	TEST READING	INST	AS FOUND STD READ	TOLERANCE
33 K OHM	2		1		1	.00132
34 K OHM	20		10		10	.0072
35 K OHM	200		100		100.002	.072
36 K OHM	2000		1000		1000	.72
37 M OHM	20		10		10	.0252
38 UA DC	200		190		189.95	.252
39 MA DC	2		1.9		1.9002	.00252
40 MA DC	20		19		19.004	.0252
41 MA DC	200		190		189.98	.252
42 MA DC	2000		1900		1900.4	4.8
43 MA AC	2000	65	1900		1892.8	6.76
44 MA AC	200	65	190		190.05	.876
45 MA AC	20	65	19		19.01	.0876
46 MA AC	2	65	1.9		1.9011	.00876
47 UA AC	200	1 K	190		190.03	.876

DISPOSITION OF INSTRUMENT : TO STOCK

APPROVED BY Harold B. Cummins III

PAGE 2 OF 2

EN DES CALCULATIONS

TITLE METHOD USED TO DETERMINE THE AMOUNT OF WEIGHT NEEDED FOR CABLE FAILURE TEMPERATURE TEST, CONTRACT 83KB5-832419		UNID SYSTEM(S) N/A	PLANT/UNIT WBN 1&2 BAR SECTION(S)								
PREPARING ORGANIZATION EB Procurement		REV (FOR MEDS USE) <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; padding: 5px;">R0</td> <td style="padding: 5px;">840323F0043</td> <td style="width: 10%; padding: 5px;">R1</td> <td style="padding: 5px;"></td> </tr> <tr> <td style="padding: 5px;">R2</td> <td style="padding: 5px;"></td> <td style="padding: 5px;">R3</td> <td style="padding: 5px;"></td> </tr> </table>		R0	840323F0043	R1		R2		R3	
R0	840323F0043	R1									
R2		R3									
APPLICABLE DESIGN DOCUMENTS EP 3.03	BRANCH/PROJECT IDENTIFIERS	MEDS ACCESSION NUMBER 3 EEB '840307 918									
KEY NOUNS											

REV	R0	R1	R2	R3
DATE	3-5-84			
PREPARED				
CHECKED	<i>Don B. Arp</i>			
SUBMITTED	<i>R. A. McArthur</i>			
ATTACHMENTS MICROFILMED:				
LIST ALL PAGES * ADDED BY THIS REV:				
LIST ALL PAGES * DELETED BY THIS REV:				
ALL PAGES * ADDED BY THIS REV:				

STATEMENT OF PROBLEM
 Calculate the amount of weight on a cable in the bottom row of a cable tray, when that tray is at its maximum allowable fill.

TRACT Calculations were performed to determine the total amount of weight applied to a cable on the bottom row of a full cable tray.

The calculated weight was then used for oven testing of cables being performed at Central Laboratory (Chattanooga Power Service Center).

(Refer to Watts Bar Nuclear Plant contract 83KB5-832419 specifically E. Chitwood's memorandum to H. Taff dated March 2, 1984, copy attached).

Please return originals to: Don Arp, W8D185 C-K

1.0 Purpose

The purpose of these calculations is to document the method used in determining the amount of weight to be applied to a single cable in the bottom row of a cable tray which is filled with the maximum allowable amount of cable.

These calculations are used to support testing being performed at Central Laboratory (Chattanooga Power Service Center).

The data received from these tests will supplement Underwriters Laboratories (UL) Fire Barrier Test Data submitted under Watts Bar Nuclear Plant contract 83KB5-832419. The vendor for this contract is 3-M Company and material is Fire Barrier Material. The Fire Barrier Material was tested by UL for 3-M to determine its compliance with 10CFR50 Appendix R for a one hour fire rating.

UL has certified the material for compliance with the Appendix R requirements with the stipulation that the user (TVA) provides evidence that the cable inside the barrier will withstand the temperatures measured during actual fire test conditions.

2.0 Assumptions

For testing purposes we chose the temperature measured on the smallest conductor in the hottest tray. The time vs temperature data taken from actual test data was supplied to TVA by 3-M [refer to the vendors letter dated February 8, 1984 (EEB 840209 009)].

The cable being tested is either exactly the same as installed or a representative sample of the cable actually installed. The representative samples were chosen as closely as possible in accordance with the guidelines of IEEE 383-1974 Table 1, Representative Cables for Type Tests.

Assumed each category of cable tray was filled to the maximum allowable fill in accordance with guidelines of Watts Bar Design Criteria WB-DC-30.5.

The cable was assumed to be on the bottom row with the cables stacked directly on top of each other. This method was chosen for simplicity in the calculations and for conservatism.

3.0 Sources of Information

1. 3-M letter dated February 8, 1984 (EEB 840209 009).
2. UL Report, Reference No. R10125, 82NK21937 [filed under (EEB 840221 910)].
3. EN DES Standard Specification SS.E-13.2.01R4 Metal Cable Trays and Fittings.
4. Watts Bar Nuclear Plant Design Criteria for Power, Control, and Signal Cables for use in Category 1 Structures WB-DC-30.5.

4.0 Data

Cable Mark WGC:

O.D. (approximate) = .615 inches
Circuit application = 120V ac control
Maximum allowable tray fill = 60%

Cable Mark WVA:

O.D. (approximate) = .385 inches
Circuit application = low voltage signal
Maximum allowable tray fill = 60%

Cable Mark WDP:

O.D. (approximate) = 1.16 inches
Circuit application = 480V ac power
Maximum allowable tray fill = 30%

Cable Mark WNB:

O.D. (approximate) = Not needed*
Circuit application = 6.9-kV ac power
Maximum allowable tray fill - N/A
*Cable of this type are installed in sets
of three and in triangular form

Cable tray size: 18" x 3.75" with rungs on 6" centers
rungs are in shape of C channel, dimensions
1" wide x 5/8" depth

5.0 Computations:

5.0.a The following abbreviations are used:

R_s	= number of cables in a single row in tray
A_c	= cross-sectional area of one cable
A_t	= area of tray filled to allowable limits
C_t	= maximum number of cables in a full tray
R_t	= number of rows of cable in a full tray
W	= width in inches of tray
D	= depth in inches of tray
P	= percentage
od	= outside diameter
A_1	= area of tray taken up by a single row of cable Mark WGG
A_2	= area of tray to be filled with cable Mark WDP

C_t (WDP) = maximum number of mark WDP cable needed to fill A_2

W_0 = weight in pounds per foot of copper conductor for size stated

W_1 = weight of 2 rows of 400 MCM copper conductor

W_2 = weight of 5 rows of 7/c, No. 12 AWG copper conductor

5.0.b Cable Mark WGG

No. of cables in a single row in tray:

$$R_s = \frac{W}{od} = \frac{18}{0.615} = 29.27$$

Cross-sectional area in square inches of one cable:

$$A_c = (od)^2 \times \pi/4 = (.615)^2 \times \pi/4 = .297$$

Maximum allowable area in square inches in tray assuming 60% fill:

$$A_t = W \times D \times P = 18 \times 3.75 \times .60 = 40.5$$

Maximum number of cables in tray assuming 60% fill:

$$C_t = \frac{A_t}{A_c} = \frac{40.5}{.297} = 136.4$$

Maximum number of rows of cables in tray assuming 60% fill:

$$R_t = \frac{C_t}{R_s} = \frac{136.4}{29.27} = 4.6$$

5.0.c Cable Mark WVA

Number of cables in a single row in tray:

$$R_s = \frac{W}{od} = \frac{18}{.385} = 46.75$$

Cross-sectional area in square inches of one cable:

$$A_c = (od)^2 \times \pi/4 = (.385)^2 \times \pi/4 = .116$$

Maximum allowable area in square inches in tray assuming 60% fill:

$$A_t = W \times D \times P = 18 \times 3.75 \times .60 = 40.5$$

Maximum number of cables in tray assuming 60% fill:

$$C_t = \frac{A_t}{A_c} = \frac{40.5}{.116} = 349.14$$

Maximum number of rows of cables in tray assuming 60% fill:

$$R_t = \frac{C_t}{R_s} = \frac{349.14}{46.75} = 7.5$$

5.0.d Cable Mark WDP

Number of cables in a single row in tray:

$$R_s = \frac{W}{od} = \frac{18''}{1.16} = 15.5$$

Cross-sectional area in square inches of one cable:

$$A_c = (od)^2 \times \pi/4 = (1.16)^2 \times \pi/4 = 1.057$$

Maximum allowable area in square inches in tray assuming 30% fill:

$$A_t = W \times D \times P = 18 \times 3.74 \times .30 = 20.25$$

Minimum number of cables in tray assuming 30% fill:

$$C_t = \frac{A_t}{A_c} = \frac{20.25}{1.057} = 19.15$$

Maximum number of rows of cables in tray assuming 30% fill:

$$R_t = \frac{C_t}{R_s} = \frac{19.15}{15.5} = 1.24$$

5.0.e The following shows the amount of weight applied to a cable on the bottom of a full tray. The following assumptions were used:

- a. The tray was 60% full.
- b. The bottom of the tray is uniformly covered with cable Mark WGG.
- c. The balance of the tray area is filled with cable Mark WDP.

Area in square inches of a single row of cable Mark WGG:

$$A_1 = R_s \text{ (WGG)} \times A_c \text{ (WGG)} = 29.27 \times 297 = 8.69$$

Remainder of available area in square inches to be filled with cable Mark WDP:

$$A_2 = A_t - A_1 = 40.5 - 8.69 = 31.81$$

Number of cable Mark WDP required to fill A₂:

$$C_t = \frac{A(WDP)}{A_c(WDP)} = \frac{31.81}{1.16} = 30.09$$

Number of rows of cable Mark WDP required to fill A (WDP):

$$\frac{C_r(WDP)}{R_s(WDP)} = \frac{30.09}{15.5} = 1.94$$

Weight of 2 rows of 400 MCM Copper (WDP):

$$W_1 = W_0 \times 1.94 = 1.544 \times 1.94 = 2.995 \text{ lbs}$$

Weight of 5 rows of 7/c No. 12 AWG Copper (WGG):

$$W_2 = W_0 \times 7 \times 5 = .02 \times 7 \times 5 = .7 \text{ lbs}$$

Comparison of the amount of weight applied to the bottom of a tray of 5 rows of WGG to 2 rows of WDP:

$$\frac{W_1}{W_2} = \frac{2.995}{.7} = 4.23$$

This calculation shows that by conservatively increasing the conductor size to complete a tray fill the amount of weight applied to the tray would be 4.23 times greater.

6.0 Discussion of Results

For testing purposes the calculated number of rows was rounded up to the nearest whole number.

In performing the computations we assumed that the tray was uniformly filled with the same cable Mark. To accommodate for the various cable Marks used to fill the different levels of trays we used a conservative estimate (refer to section 5.0f of the computations). In these computations we assumed a single row of 7/c, No. 12 AWG cables along the bottom of the tray and the balance of the tray was filled with 400 MCM cable. By using the weight of the copper conductors of these cables we showed the weight on the lower cables was 4.23 times greater than if the tray had been filled with 7/c, No. 12 AWG. Therefore, for conservatism in the test, we multiplied the weight of the test specimen by the appropriate number of rows required to fill the tray, and then multiplied the product by 5.

Cables designated as Mark WNB are always installed in groups of three individual conductors. The group is in the form of a symmetrical triangle. This type of arrangement distributes the weight of one cable to the other two at a 60 degree angle. For calculation purposes and for conservatism we assumed the cable which formed the upper portion of the triangle was stacked directly above one of the lower conductors resulting in twice the normal load on the lower conductor. For an additional amount of conservatism we multiplied that weight by 5.

The testing lab is to weigh a six-inch test specimen and use this weight in calculating the amount of force to be applied to the cable during testing. The reasoning for choosing a six inch specimen is that the cable tray rungs are spaced on six-inch centers. The optimum position to place the weight on the specimen while testing for shorts to ground would be directly over the rung.

7.0 Conclusion

These calculations document that the physical loads placed on cables specimen being tested at Central Laboratory (Chattanooga Power Service Center) are accurate and that the actual installed configuration is adequately represented.

H. Taff, CPSC-LAB-C

E. Chitwood, W8C135 C-K

March 2, 1984

WATTS BAR NUCLEAR PLANT
MISCELLANEOUS ELECTRICAL EQUIPMENT
FIRE BARRIER MATERIAL
CONTRACT 83KB5-832419

Please provide the required facilities and personnel to perform testing in accordance with the attached procedure.

The cable for the tests is being sent to you from Singleton Materials Engineering Laboratory. The account number for this test is NO30-385-30-00.

Data taken in these test will be used to support fuel loading at Watts Bar Nuclear Plant. In view of this please expedite the completion of this test. Please inform my office of the time of the test so that we may witness them.


E. Chitwood

DBA
KEP
DBA:BB
Attachments

Principally Prepared By: D. B. Arp, Extension 4794.

Cable Failure Temperatures Test Procedure

Objective. To determine the failure point temperatures for specific cable types used in cable trays, conduits, and junction boxes at Watts Bar Nuclear Plant.

Test Samples.

1. 7/C, No. 12 AWG, PJJ, 600V, Mark WGG
2. 7/C, No. 12 AWG, FXMJ, 600V, Mark WGG-1
3. 7/C, No. 12 AWG, CPJJ, 600V, Mark WLG
4. 2/C, No. 16 AWG, Signal Cable, Mark WVA (Rockbestos)
5. 2/C, No. 16 AWG, Signal Cable, Mark WVA (Anaconda)
6. 1/C, No. 400 MCM, CPJ, 600V, Mark WDO
7. 1/C, No. 2/0 AWG, CPSJ, 8KV, Mark WNB

Procedure.

1. The test samples are to be grouped into four categories as listed below:

Group A items 1, 2, and 3 (120V control)
Group B items 4 and 5 (low voltage signal, 120V)
Group C item 6 (480V power)
Group D item 7 (6.9kV power)
2. The amount of weight to be applied to the cables is to be calculated by the following method.
 - a. Weigh a six-inch length of each cable. Multiply the heaviest cable in each group by the appropriate number listed below.

Group A = 25
Group B = 40
Group C = 10
Group D = 10

The result of the above will be the minimum amount of weight to be applied to the corresponding group.

3. One sample of each cable should be placed side by side (if applicable) with the other cables in its group and placed in the oven in a manner similar to that shown in Diagram 1. Note. One common weight per group is acceptable.
4. Energize cables at voltages shown in step 1 above. Current limiting devices shall maintain a current of 1 amp. Test samples shall be wired to monitor shorts from conductor to conductor or conductor to ground. The test samples are to be wired as shown in Diagram No. 2.

5. Heat oven with cables in place to 90° C (194° F) and maintain that temperature until cable jacket temperature has stabilized at rated conductor operating temperature. While monitoring jacket temperature continue heating in accordance with Table 1.
6. Record all failure times, temperature, and apparent cause of failure.
7. Record visual observations of tested cables.

Documentation. Test documentation shall include the following:

Description of test equipment, calibration dates, etc.

Description of test samples.

Wiring diagrams showing voltage, current, etc.

Description of test setup.

Time vs. temperature profile.

Cable failure temperatures.

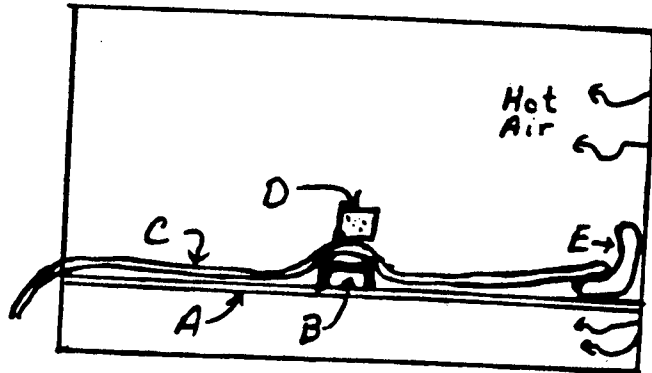
Cause of failure (if known).

Visual appearance of tested cable.

TABLE 1

<u>Time</u>	<u>Temperature (°F)</u>
0 min.	194
0:05	255
0:10	260
0:15	265
0:20	270
0:25	300
0:30	350
0:35	400
0:40	450
0:45	475

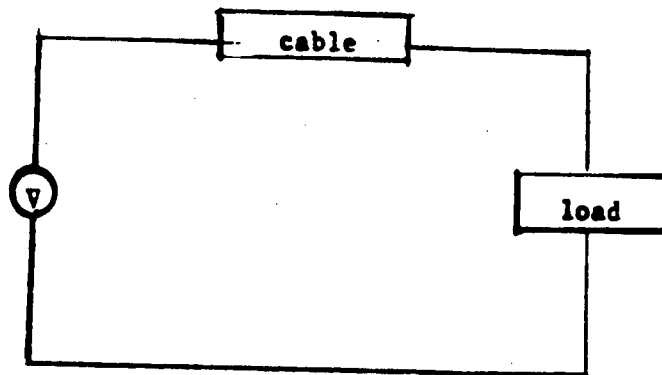
Hold temperture for 30 minutes then continue at a rate of 5° F per minute until failure occurs.



- A. Cable grounding shelf
- B. Steel bar or C type channel to simulate cable tray rung (approximate dimensions 1" wide by 5/8" deep)
- C. Cable
- D. Weight
- E. Air stream shield

Diagram Number 1

034053.02



- Notes.
1. Cables shall be wired in such a manner that the individual conductors of the cable are energized simultaneously at the voltage stated in step 1 of the procedure.
 2. All shielded cables shall have the shield grounded.
 3. Circuits should be monitored for shorts from conductor to ground, conductor to conductor, or conductor to shield.
 4. The above drawing is intended to show a typical setup. Detailed connection diagrams shall be furnished with the Test Documentation.

Diagram Number 2

ATTACHMENT C



UNDERWRITERS LABORATORIES INC.

333 PFINGSTEN ROAD - NORTHBROOK, ILLINOIS 60062

an independent, not-for-profit organization testing for public safety

April 18, 1984

EEB '84 0420 001

3M Company
Mr. Richard Licht
207-1S 3M Center
St. Paul, MN 55144

*WBN
misc elect
832419*

ELEC ENGR	
APR 20 '84	
FWC	
GT-1	
K-R	
EC	
JW	
B G R	
AFP	
MRB	
E J P R	
MJS	
WG GR CS	
A G Mc	
HPC	
HBR	
RBR	
JLS	
WEK	
C G PH A	

Our Reference: R10125, 82NK21937

Subject: Fire Endurance Test Of Conduit Protective Systems

Dear Mr. Licht:

This is to confirm that, on March 13, 1984, a fire endurance test of conduit protective systems was conducted at the 3M Company facility in St. Paul, Minnesota. The test was witnessed by a member of the engineering staff of Underwriters Laboratories Inc.

Three conduit protective systems were included in the March 1984 fire endurance test. One of the conduit protective systems consisted of a nominal 3/4 in. diameter rigid steel conduit wrapped with five layers of 3M Company Type M20A intumescent mat. Another conduit protective system consisted of a nominal 3 in. diameter rigid steel conduit wrapped with three layers of 3M Company Type M20A intumescent mat. The third conduit protective system consisted of a nominal 2 in. diameter rigid steel conduit wrapped with five layers of 3M Company Type M20A intumescent mat.

The nominal 3/4 in. and 2 in. diameter rigid steel conduits each contained a single 2/C-No. 16 AWG cable. The insulation on the copper cable conductors was cross-linked polyethylene (XLPE). The fillers within the cable construction were polyester strands. The conductors and fillers were wrapped with a polyester film and covered with a neoprene jacket. The outside diameter of the cable was 0.345 in. The cable jacket was marked "2/C 16 AWG ROCKBESTOS R XLPE/NEO 600 V."

The nominal 3 in. diameter rigid steel conduit contained seventeen 2/C-No. 16 AWG cables. Twelve of the cables were of the same type used in the nominal 3/4 in. and 2 in. diameter conduits. The remaining five cables each contained two XLPE insulated copper conductors and an uninsulated No. 18 AWG grounding conductor. The fillers within the cable construction

4 771

Look For The Listing or Classification Mark On The Product

were polyester strands. The conductors and fillers were wrapped with aluminum foil, glass fiber fabric and a mylar film and covered with a neoprene jacket. The outside diameter of the cable was 0.340 in. The cable jacket was marked "BRAND REX TWA 81K5-828072 MS-WVA 2/C #16 AWG 600 V."

The temperatures of the conduit and cable in each of the three conduit protective systems were measured with twenty-one thermocouples located as shown on the attached ILL. 1.

Each conductor of each cable was energized with a dc voltage and monitored for electrical faults on an electrical fault monitor panel. The electrical fault monitoring circuitry is shown schematically on the attached ILL. 2.

The conduit protective systems were subjected to a 1 h fire endurance test with the furnace temperatures controlled in accordance with the standard time-temperature curve outlined in the Standard, Fire Tests Of Building Construction And Materials, UL 263 (ASTM E119, NFPA No. 251), and as shown in the following table:

AVERAGE FURNACE TEMPERATURE

<u>Test Time,</u> <u>min</u>	<u>ASTM E119</u> <u>Standard Time-</u> <u>Temperature Curve</u>	<u>Average Furnace</u> <u>Temperature</u>
0	68 °F	33 °F
10	1300 °F	1319 °F
20	1462 °F	1534 °F
30	1550 °F	1524 °F
40	1613 °F	1590 °F
50	1661 °F	1653 °F
60	1700 °F	1691 °F

After 1 min of fire exposure, smoke and steam began issuing from the ends of the conduit protective systems which protruded from the test furnace. The smoking and steaming continued throughout the fire endurance test. At 58 min, the light emitting diodes (LED's) associated with the conductors and ground of the 2/C-No. 16 AWG cables in the nominal 3 in. diameter conduit protective system commenced glowing dimly. The furnace fire was extinguished at 60 min, at which time only the LED's associated with the nominal 3 in. diameter conduit system were illuminated.

The temperatures measured by the various thermocouples during the test were recorded at 1 min intervals using an automatic data logger. These temperatures are shown on the attached ILLS. 3 through 14 and are summarized in the following tables:

TEMPERATURE DATA SUMMARY

NOMINAL 3/4 IN. DIAMETER RIGID STEEL CONDUIT
 CONTAINING ONE 2/C-NO. 16 AWG CABLE (17.5 PERCENT
 CABLE FILL) AND WRAPPED WITH FIVE LAYERS OF
 3M COMPANY TYPE M20A INTUMESCENT MAT

Test Time, min	Average Conduit Temperature, °F	Maximum Individual Conduit Temperature, °F	Maximum Individual Conduit Temperature Rise, °F	2/C-No. 16 AWG Cable Temperature, °F
0	46	47	0	41
10	46	48	1	40
20	174	201	154	112
30	216	240	193	184
40	254	286	239	209
50	427	450	403	323
60	603	625	578	511

NOMINAL 2 IN. DIAMETER RIGID STEEL CONDUIT
 CONTAINING ONE 2/C-NO. 16 AWG CABLE (4.5 PERCENT
 CABLE FILL) AND WRAPPED WITH FIVE LAYERS OF
 3M COMPANY TYPE M20A INTUMESCENT MAT

Test Time, min	Average Conduit Temperature, °F	Maximum Individual Conduit Temperature, °F	Maximum Individual Conduit Temperature Rise, °F	2/C-No. 16 AWG Cable Temperature, °F
0	49	51	0	51
10	50	54	3	50
20	100	182	131	54
30	180	209	158	147
40	225	246	195	201
50	306	323	272	248
60	435	461	410	358

NOMINAL 3 IN. DIAMETER RIGID STEEL CONDUIT
 CONTAINING SEVENTEEN 2/C-NO. 16 AWG CABLE (21.3 PERCENT
 CABLE FILL) AND WRAPPED WITH THREE LAYERS OF
 3M COMPANY TYPE M20A INTUMESCENT MAT

Test Time, min	Average Conduit Temperature, °F	Maximum Individual Conduit Temperature, °F	Maximum Individual Conduit Temperature Rise, °F	2/C-No. 16 AWG Cable Temperature, °F
0	44	46	0	45
10	81	92	46	57
20	165	197	151	117
30	330	348	302	223
40	439	454	408	337
50	536	549	503	444
60	635	648	602	566

Immediately following the fire endurance test, the electrical cables were removed from each of the three conduit protective systems and were allowed to cool. The neoprene jacket on the Brand Rex 2/C-No. 16 AWG cables from the nominal 3 in. diameter conduit protective system contained numerous small cracks, but the jacket remained pliable. Beneath the jacket, the mylar film had disappeared and the glass fiber fabric and aluminum foil wraps were discolored. The polyester fillers within the cable construction were fused. The XLPE insulation on the cable conductors appeared undamaged. Other than discoloration of the jacketing material and fusing of the polyester fillers, the Rockbestos 2/C-No. 16 AWG cables from the three conduit protective systems appeared undamaged.

Following the fire endurance test, each of the nineteen cables from the three conduit protective systems were tested for insulation resistance with an applied voltage of 500 V dc. The measured insulation resistance of the 2/C-No. 16 AWG Rockbestos cable from the nominal 3/4 in. diameter conduit protective system was 1000 megohms. The insulation resistance of the remaining eighteen cables was greater than 1000 megohms.

As indicated earlier in this letter, the LED's in the electrical fault monitoring panel associated with the 2/C-No. 16 AWG cables in the nominal 3 in. diameter conduit protective system commenced glowing at 58 min. Based on an analysis of the electrical fault monitoring circuitry and based on the results of the insulation resistance tests conducted immediately after the fire endurance test, it was determined that no electrical faults occurred in any of the three conduit protective systems during the 1 h fire endurance test. Rather, the illumination of the LED's at the conclusion of the fire endurance test was determined to be an indication of leakage current caused by the temperature effect on insulation resistance.

The configuration of the test furnace at the 3M Company facility in St. Paul, Minnesota differs from that of the test furnace at UL's Northbrook Testing Station which is used for Classification investigations of electrical circuit protective systems. In order to correlate the fire exposure conditions in the two test furnaces, one of the three conduit protective systems in the March 13, 1984 fire test was configured to essentially duplicate a conduit protective system previously tested at UL's Northbrook Testing Station. Specifically, the nominal 2 in. diameter conduit protective system described herein essentially duplicated the nominal 2 in. diameter conduit protective system included in the full-scale assembly tested at UL on December 21, 1984. The details and results of the December 21, 1984 fire test investigation are described in Report R10125-1, -2 dated October 19, 1983.

The maximum individual temperatures measured on the nominal 2 in. diameter rigid steel conduit in the assembly tested at UL on December 21, 1982 are shown in the following table:

<u>Test Time,</u> <u>min</u>	<u>Maximum</u> <u>Individual</u> <u>Conduit</u> <u>Temperature, °F</u>	<u>Maximum</u> <u>Individual</u> <u>Conduit</u> <u>Temperature Rise, °F</u>
0	67	0
10	140	73
20	208	141
30	205	138
40	234	167
50	275	208
60	383	316

R10125
April 18, 1984
Page 6

In order to correlate the severity of fire exposure conditions in the two test furnaces, the maximum individual temperature rise on the nominal 2 in. diameter rigid steel conduit in the December 21, 1982 fire test at UL and in the March 13, 1984 fire test at 3M were plotted on a graph, as shown on the attached ILL. 15. The maximum individual temperature rise on the nominal 3/4 in. and 2 in. diameter rigid steel conduits in the March 13, 1984 fire test at 3M are also depicted on the graph.

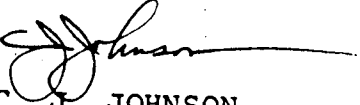
As shown on the graph in ILL. 15, the fire exposure conditions within the 3M Company test furnace during the March 13, 1984 test were more severe, from the standpoint of heat transfer to the steel conduits, than those present within the UL test furnace during the December 21, 1982 fire test. The plotted data indicates that, for the fire test conducted on March 13, 1984, a 53 min fire endurance test conducted on the 3M Company test furnace is equivalent to a 60 min fire endurance test conducted on the UL test furnace at the Northbrook Testing Station.

At 53 min, the maximum individual conduit temperature rise on the nominal 3/4 in. and 3 in. diameter conduits was 466 °F and 531 °F, respectively. The temperature rise of the cable within the nominal 3/4 in. and 3 in. diameter conduits at that time was 333 °F and 432 °F, respectively.

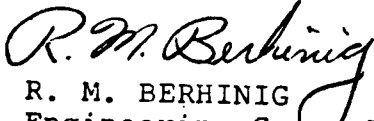
The data from the March 13, 1984 fire test is being included in the data base being compiled for the Type M20A mat conduit protective system. Upon completion of the test work, we will be revising Electrical Circuit Protective System No. 3 in UL's Building Materials Directory to incorporate a tabulation of the layers of Type M20A mat required to attain thermal protection for various sizes of rigid steel conduit.

As you requested, we are forwarding a copy of this letter to Mr. K. W. Brown at Tennessee Valley Authority in Knoxville, Tennessee.

Very truly yours,

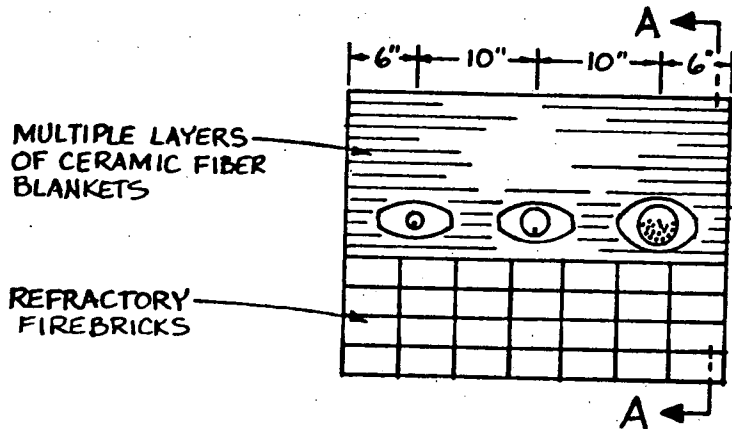
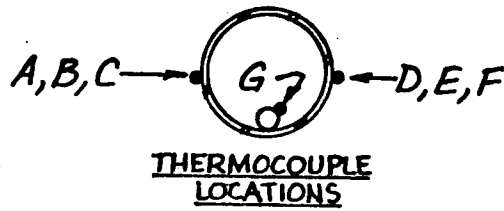
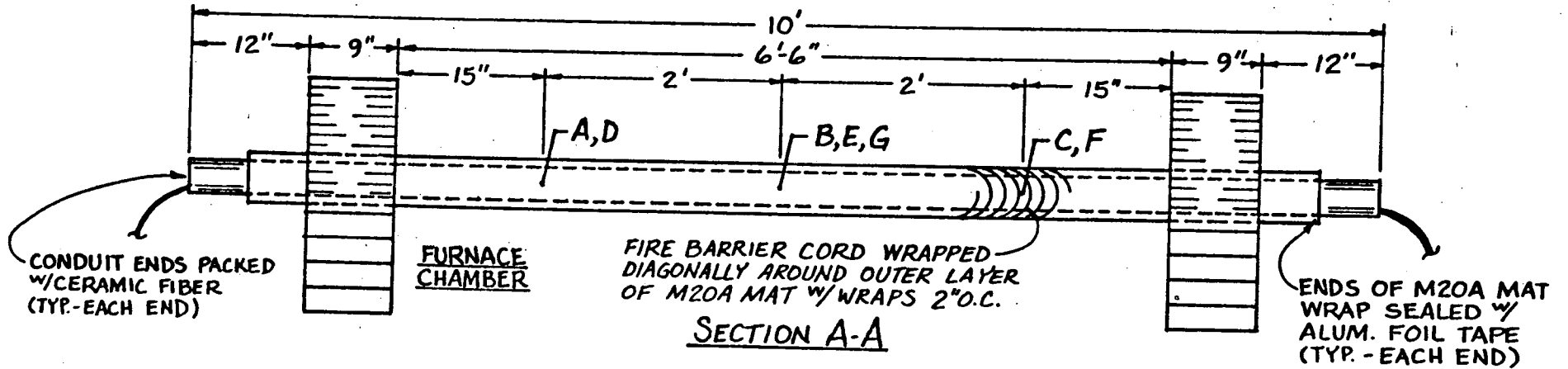

C. J. JOHNSON
Engineering Associate
Fire Protection Department

Reviewed by:


R. M. BERHINIG
Engineering Group Leader
Fire Protection Department

CJJ/RMB:pr
LETR3

4/20/84 - FWC:WMF
cc: MEDS, W5B63 C-K, w/attachments



NOM. COND. ϕ	LAYERS M20A	THERMOCOUPLE NOS.						
		A	B	C	D	E	F	G
3/4"	5	16	17	18	19	20	21	0
2"	5	22	23	24	25	26	27	28
3"	3	10	11	12	13	14	15	29

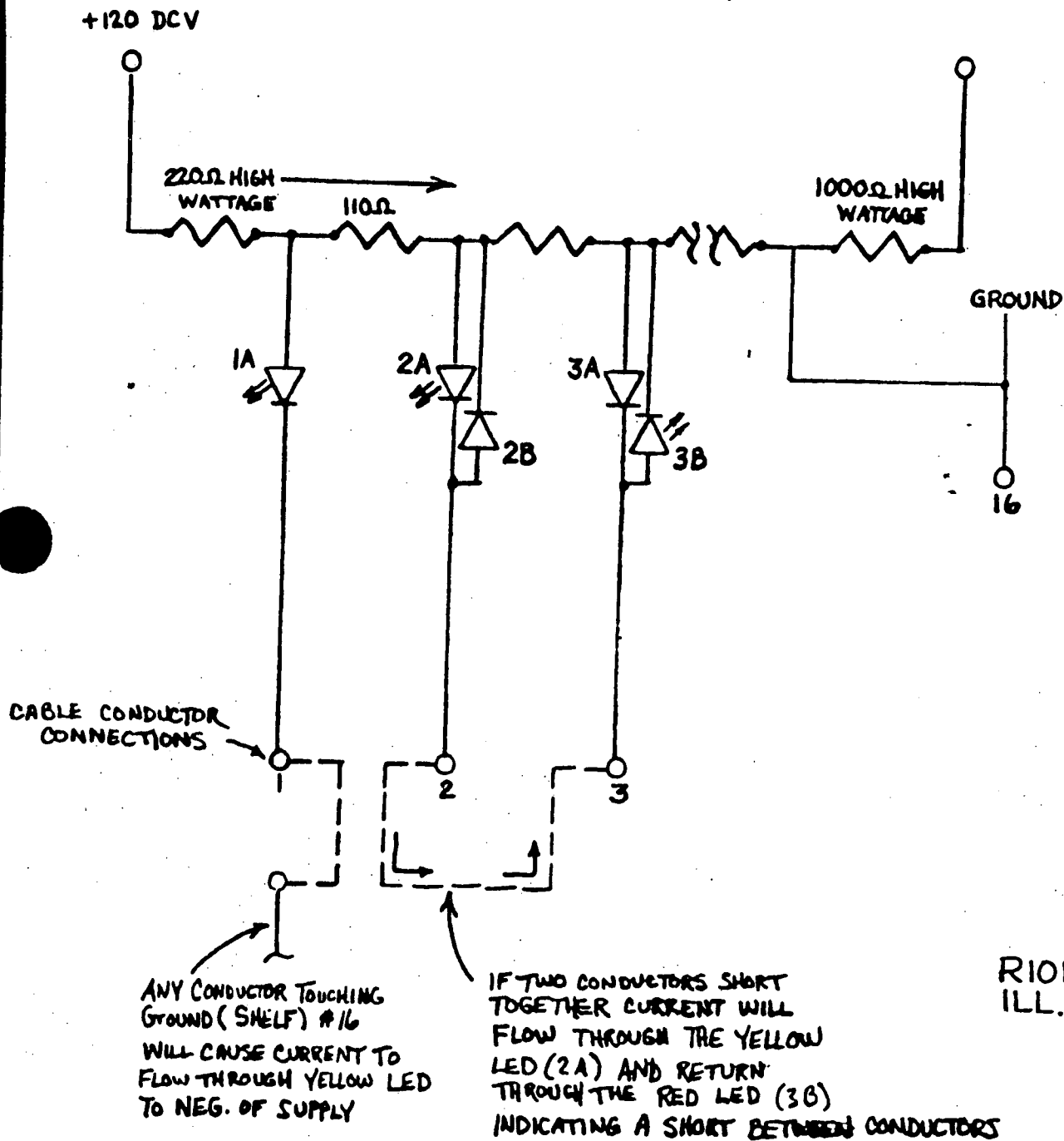
(THERMOCOUPLE NOS. 1-9 LOCATED WITHIN FURNACE CHAMBER)

DETAILS OF TEST ASSEMBLY

RI0125
ILL. 1

CABLE CIRCUIT INTEGRITY

(CIRCUIT CONTINUITY TEST) C.C.T.



All statements, technical information and recommendations contained herein are based on tests we believe to be reliable. However, since the conditions of use and application are beyond our control, 3M shall not be liable for any injury, direct or consequential, resulting from the use of 3M's products or design. 3M's only warranty shall be to replace any of our products found to be defective.

ISSUE	DATE	REV.	CH.
1	1-13-84		
NOT TO SCALE		CH	
BY JCA		APP R. R. Licht	

CABLE FAILURE TEMPERATURES

Ceramic Materials
Department/3M



TEST #9380030601

29 44.9°F
 28 49.7°F
 27 50.1°F
 26 49.3°F
 25 45.2°F
 24 49.8°F
 23 49.9°F
 22 45.2°F
 21 45.0°F
 20 45.5°F
 19 44.1°F
 18 44.9°F
 17 46.7°F
 16 44.2°F
 15 48.5°F
 14 46.3°F
 13 43.8°F
 12 50.2°F
 11 50.2°F
 10 47.7°F
 9 944.4°F
 8 911.0°F
 7 940.5°F
 6 862.9°F
 5 1027.3°F
 4 915.2°F
 3 870.6°F
 2 842.3°F
 1 857.5°F
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R10125
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 16 43.4°F
 15 44.9°F
 14 44.5°F
 13 41.8°F
 12 46.1°F
 11 46.8°F
 10 44.2°F
 9 784.0°F
 8 737.5°F
 7 772.8°F
 6 664.8°F
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 10 41.6°F
 9 586.3°F
 8 531.5°F
 7 568.9°F
 6 451.5°F
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 3 477.2°F
 2 458.0°F
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 19 44.0°F
 18 45.0°F
 17 46.3°F
 16 43.8°F
 15 44.4°F
 14 44.0°F
 13 41.4°F
 12 44.4°F
 11 44.4°F
 10 41.1°F
 9 378.9°F
 8 329.3°F
 7 359.8°F
 6 263.0°F
 5 451.3°F
 4 336.2°F
 3 285.5°F
 2 275.1°F
 1 266.2°F
 0 39.4°F

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 24 51.0°F
 23 50.7°F
 22 46.0°F
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 17 47.4°F
 16 44.9°F
 15 45.8°F
 14 45.0°F
 13 41.9°F
 12 45.3°F
 11 45.1°F
 10 41.7°F
 9 33.1°F
 8 32.3°F
 7 33.8°F
 6 32.7°F
 5 34.3°F
 4 33.1°F
 3 32.3°F
 2 32.8°F
 1 32.3°F
 0 40.8°F

P 000:00:31:34

PRE-TEST
 TIME=0

29 53.5°F
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 25 46.5°F
 24 52.7°F
 23 50.3°F
 22 46.1°F
 21 45.8°F
 20 46.0°F
 19 44.5°F
 18 46.3°F
 17 47.6°F
 16 46.6°F
 15 72.3°F
 14 70.3°F
 13 70.3°F
 12 83.7°F
 11 86.5°F
 10 82.2°F
 9 1292.3°F
 8 1280.1°F
 7 1294.6°F
 6 1274.4°F
 5 1331.7°F
 4 1284.8°F
 3 1266.6°F
 2 1258.7°F
 1 1263.5°F
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 18 45.7°F
 17 46.8°F
 16 45.5°F
 15 68.8°F
 14 65.5°F
 13 64.8°F
 12 74.5°F
 11 77.6°F
 10 74.5°F
 9 1247.2°F
 8 1233.7°F
 7 1249.6°F
 6 1225.7°F
 5 1293.9°F
 4 1238.2°F
 3 1215.4°F
 2 1208.3°F
 1 1214.0°F
 0 39.8°F
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29 47.8°F
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 25 45.6°F
 24 50.6°F
 23 49.9°F
 22 45.5°F
 21 45.2°F
 20 45.9°F
 19 44.2°F
 18 45.5°F
 17 46.7°F
 16 44.3°F
 15 65.2°F
 14 61.2°F
 13 58.8°F
 12 65.6°F
 11 69.0°F
 10 65.8°F
 9 1196.3°F
 8 1179.6°F
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