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Serial No 90-159
July 12, 1990

Mr. Mark Spinelli
Electrical Engineering
Arkansas Power and Light Co.
TCBY Tower (TCBYT 17)
Broadway and Capitol
Little Rock, Arkansas 72201

Subject: MLEA Project 90009, Thermal Behavior of T-95 and Scotch 33

Dear Mr. Spinelli,

Enclosed for your information and use is MLEA Report 90009-001-3, Technical Evaluation of Okonite T-95 Taped Splices With Scotch 33 Jacketing Tape and Unjacketed, Thermal Aging Behavior at an Oven Temperature of 310°F. The enclosed report contains the results of an investigation into the physical and thermal properties of Okonite T-95 insulating tape and Scotch 33+ vinyl electrical tape to determine the reason(s) for the unusual behavior of these materials during approximately 40 hours at 310°F. Copies of References 1 through 5 of Report 90009-001-3 are available at ANO. Copies of References 6 through 9 are enclosed with the report.

It is interesting to note that the physical properties and thermal behavior of both T-95 and Scotch 33+ at elevated temperatures (i.e. above 105°C) are not contained in any of the published literature available to the purchaser of the products. In fact the information obtained by MLEA is not available in any published literature from the manufacturers, only in internal laboratory reports.

With the information contained in the enclosed report it is considered that it is possible to establish thermal aging parameters for Scotch 33+ jacketed T-95 tape which can be used to preage specimens for LOCA/HELB Simulation testing. These parameters will be the subject of separate correspondence. However, it is MLEA's judgement that a successful test of unjacketed T-95 (viz. Specimen 14) cannot be performed.

Should you have and qestions or comments on the enclosed report, please contact us at your earliest convenience.

Sincerely,

J. A. Murphy,
Project Manager

C. J. Crane,
Manager of Engineering

cc:
A. J. Wrape III (AP&L)
T. Ott (AP&L)
K. J. Iepson (ICE)

Document I.D. 90009-001-3
Date: July 12, 1990

TECHNICAL EVALUATION OF THERMAL AGING TESTING OF OKONITE T-95 TAPED SPLICES BOTH UNJACKETED AND WITH SCOTCH 33 JACKETING TAPE AT AN OVEN TEMPERATURE OF 310°F

Prepared by: Main Line Engineering Associates
967 E. Swedesford Road
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Prepared for: Arkansas Power and Light Co.
TCBY Tower
Broadway and Capitol
Little Rock, Arkansas

Prepared by: J. A. Murphy, Project Manager Date: 7/12/90

Reviewed by: C. J. Crane, Manager of Engineering Date: 7/12/90

I Introduction:

During the thermal aging (at 310°F) portion of an environmental qualification test of various splices using Okonite T-95 insulating tape with Okonite No.35 jacketing, Okonite T-95 insulating tape and Scotch 33+ jacketing tape, and Okonite T-95 insulating tape with no jacketing tape, it was discovered that, after 40+ hours of thermal aging, the unjacketed splice and the Scotch 33+ jacketed splices showed evidence of melting and flow of the T-95 material. Reference 1 contains a detailed description of the condition of the splices and an evaluation of the test conditions, equipment and instrumentation.

Since there was no indication of any anomalous behavior of T-95 insulating tape in the Okonite Product Literature or in the Okonite qualification test reports for the T-95, MLEA contacted Okonite engineering personnel to determine the possible cause of the observed behavior. References 2, 3, and 4 contain the substance of telephone conversations between MLEA personnel and Okonite personnel. Reference 5 is a letter from Okonite which discusses the characteristics of the T-95 material. The information contained in references 2 through 5 is summarized below:

- T-95 tape is an uncured (unvulcanized) EPDM material
- Because T-95 is uncured, it is basically a highly viscous liquid at room temperature
- At elevated temperatures, T-95 will flow unless restrained by a suitable covering (viz. No. 35 jacketing tape)
- The tendency to flow is a function of both temperature and load (force applied to the tape)
- The volumetric coefficient of expansion is between 1E-6 $in^3/in^3/°C$ and 5E-6 $in^3/in^3/°C$

Based on the information contained in references 2 through 5, MLEA has concluded the following:

- At some time between 24-30 hours of testing and 40+ hours of testing, the T-95 material expanded to the point where the ultimate strength of the Scotch 33+ jacket was exceeded.
- At that time the Scotch 33+ split, and the fluid T-95 oozed out through the split and flowed onto adjacent surfaces.

- At some time between 24-30 hours of testing and 40+ hours of testing, the unjacketed splice started to flow and, having no restraint, dripped under the force of gravity to the bottom of the test oven.

This report contains the data obtained on the physical and thermal properties of both Okonite T-95 tape and Scotch 3 + tape. Using these properties a technical evaluation of T-95 tape jacketed with Scotch 33+ is performed which establishes the root cause of the anomalous behavior described in Reference 1.

II Properties of T-95 (EPDM) Material:

In order to perform an analysis of how the T-95 tape behaves, it is necessary to determine various physical properties. The properties of Nordel (the source material for EPDM) and the source of the properties are contained in the following table.

Property	Value	Reference
Thermal Conductivity (k)	576E-6 Cal/(sec)(cm)°C*	Ref. 5
Heat Capacity	0.56 BTU/lb/°F	Ref. 6
Specific Gravity	0.86	Ref. 7
Coeff. of Expansion	1.0E-6 to 5.0E-6 in/in/°F	Ref. 5

* 576E-6 Cal/(sec)(cm)°C = 0.1393 BTU/(hr)(ft)°F

There is no available data on the properties of uncured (unvulcanized) EPDM material. The information obtained from DuPont in Reference 6 is based on a typical cured material. In Reference 6, DuPont stated that there was no known application for uncured material. The specific gravity obtained in Reference 7 is also for a typical cured EPDM, no information on uncured was identified. The coefficient of expansion identified in Reference 5 is a volumetric coefficient.

III Properties of Scotch 33+ Tape:

In order to determine the behavior of Scotch 33+ jacketing tape applied over Okonite T-95 tape it is necessary to establish the properties of the Scotch 33+ vinyl tape. Reference 8 is the 3M product information bulletin for Scotch 33+. From this bulletin the following properties are determined.

Property	Value	Reference
Elongation (@72°F)	250%	Ref. 8

Property	Value	Reference
Tensile Strength (@72°F)	3000 psi	Ref. 8
Break Strength	16 lbs/in	Ref. 8
Aging @ 113°C	60 days	Ref. 8

Reference 9 contains information provided by 3M on the elevated temperature behavior of Scotch 33+. Briefly the behavior of the Scotch 33+ tape at a temperature of approximately 300°F is as follows:

1. The plasticizers in the tape and adhesive volatilize in a relatively short time and the tape becomes brittle.

2. The Scotch 33+ tape will attempt to shrink to its original unstretched length.

IV Technical Evaluation:

From the information presented in Sections II and III above, it is apparent that as ambient temperature of a taped splice is increased above 105°C (221°F) the T-95 insulating tape expands and becomes less viscous while the Scotch 33+ softens permitting the T-95 to expand. As the temperature is increased to 150°C (302°F), the T-95 insulating tape continues to expand and become more fluid, but the Scotch-33+ starts to shrink slowly and starts to become brittle. After a period of time (24hr< t <40 hrs) the Scotch 33+ tape splits and the T-95 tape oozes out of the splits in the Scotch 33+.

The behavior of the splices made using T-95 insulating tape with Scotch 33+ jacketing tape during the thermal aging test at 310°F is consistent with the properties of the materials based on the information supplied by Okonite in Reference 5 and by 3M in Reference 9. However, the data supplied in References 5 and 9 are unpublished and not readily available to the purchaser of the produ

V Conclusion:

Based on the information supplied in References 5, 8, and 9, it appears that the upper temperature limit for aging of splices made with T-95 insulating tape and Scotch 33+ jacketing tape is 113°C (235.4°F).

VI References:

1. Report of Trip dated June 20, 1990, ANO Tape Splice Test, Investigation of Reported Anomaly

2. Memorandum to File dated June 19, 1990, Information Received from Okonite Regarding Thermal Properties of Okonite T-95 Splicing Tape

3. Memorandum to File dated June 21, 1990, Information on T-95 Tape from Okonite

4. Okonite Bulletin 22.9.0, The Fundamentals of Splicing and Terminating Electrical Cables, 1981

5. Okonite Letter from J. S. Lasky to J. A. Murphy (MLEA) dated June 25, 1990

6. Memorandum to File dated July 9, 1990, Thermal Properties of Nordel (EPDM)

7. Handbook of Plastics and Elastomers, Charles A. Harper, Editor in Chief, McGraw Hill, Table 35

8. 3M Product Data, Scotch 33+ Vinyl Plastic Electrical Tape E-MTD33-5(3110)R

9. Memorandum to File dated July 11, 1990, Elevated Temperature Behavior of Scotch 33 Insulating Tape

REFERENCE 6

MEMORANDUM

To: File

From: J. A. Murphy

Date: July 9, 1990

Subj: Thermal Properties of Nordel (EPDM)

On Friday, July 6, 1990, I called the DuPont technical information service center to request information on the thermal conductivity and heat capacity of Nordel (the source material for EPDM products). I received a recorded message saying that the technical information center was closed, to leave my name, telephone number, and information requested, and they would call back on Monday morning.

On Monday July 9, 1990 The DuPont technical information service returned my call and provided the following information:

Thermal conductivity of a typical Nordel product = 576E-6 Cal/(sec)(cm²)(°C/cm)

Heat Capacity = 0.56 Cal/gm°C or BTU/lb°F

I asked if there was any information on uncured Nordel and was told that DuPont was unaware of any application for uncured material and therefore had no data on uncured material. I was told that no significant difference in thermal conductivity or heat capacity would be expected, but that the fillers used in compounding the cured material tended to increase the thermal conductivity and reduce the heat capacity because the fillers usually contained metal oxides, metal carbonates and metal silicates.

TABLE 35 Properties of elastomers[a] (Continued)

Property	Epichlorohydrin homopolymer and copolymer	Fluorosilicone	Ethylene propylene (EPDM)	Chloro-sulfonated polyethylene (Hypalon)	Fluorocarbon elastomers	Propylene oxides	Styrene-isoprene-styrene, and styrene-butadiene-styrene block polymers
Physical properties:							
Specific gravity	1.32–1.49	1.4	0.86	1.11–1.26	1.4–1.95	1.02	0.94–1.15
Thermal conductivity, Btu/(h)(ft²)(°F/in.)	...	0.13	...	0.065	0.13	...	0.087
Coefficient of thermal expansion, 10^{-5}/°F	...	45	...	27	8.8	...	7.5
Tear resistance	Fair	Poor	Poor	Good	Excellent	Poor	Poor
Colorability	Good	Good	Excellent	Excellent	Good	Good	Good
Mechanical properties:							
Hardness (Shore A)	30–95	40–70	30–90	45–95	65–90	40–80	35–90
Tensile strength, 1,000 lb/in.²							
Pure gum	...	1	<1	4	<2	>1	0.7–4.5
Reinforced	2–3	<2	0.8–3.2	1.5–2.5	1.5–3	>2	
Elongation, %							
Reinforced	320–350	200–400	200–600	250–500	100–450	500–670	350–1,350
Resilience	Poor to excellent	Good to fair	Good	Good	Fair	Very good	Good
Compression-set resistance	Very good	...	Good	Fair to good	Good to excellent	Fair	
Hysteresis resistance	Good	Good	Good	Good	Good	Very good	
Flex-cracking resistance	Very good	Good	Good	Good	Good	Very good	Good
Slow rate	Very good	Good	Good	Good	Good	Very good	Good
Fast rate	Good	Good	Good	Good	Good	Good	
Tear strength	Good	Fair	Poor to fair	Fair to good	Poor to fair	Excellent	Fair to good
Abrasion resistance	Fair to good	Poor	Good	Excellent	Good	Good	Good
Electrical properties:							
Dielectric strength	Fair	Good	Excellent	Excellent	Good	...	Good
Electrical insulation	Fair	Good	Very good	Good	Fair to good	...	Good
Thermal properties:							
Service temp, °F							
Min for continuous use	−15 to −80	−90	−60	−40	−10	−80	−60 to −80
Max for continuous use	300	400	<350	<325	<500	<250	150
Low-temp stiffening, °F	−15 to −80	< −100	−20 to −60	−30 to −50	20 to −30	...	−60 to −80
Corrosion resistance:							
Weather	Excellent	Excellent	Excellent	Excellent	Excellent	Very good	Fair
Oxidation	Very good	Excellent	Excellent	Excellent	Outstanding	Very good	Good
Ozone	Good to excellent	Excellent	Excellent	Excellent	Excellent	Very good	Fair
Radiation	...	Good	Excellent	Fair to good	Fair to good	...	Poor
Water	Good	Excellent	Good to excellent	Good	Good	Excellent	Good
Acids	Good	Very good to excellent	Good to excellent	Excellent	Good to excellent	Good	Good
Alkalies	Good	Very good	Good to excellent	Excellent	Poor to good	Very good to excellent	Good
Aliphatic hydrocarbons	Excellent	Excellent	Poor	Fair	Excellent	Poor to fair	Poor
Aromatic hydrocarbons	Very good	Excellent	Fair	Poor to fair	Excellent	Poor to fair	Poor
Halogenated hydrocarbons	Good	...	Poor	Poor to fair	Good	Poor	Poor
Alcohol	Good	...	Good	Very good	Excellent	...	Good
Synthetic lubricants (diester)	Fair to good	Excellent	Poor to fair	Poor	Fair to good	Fair to good	Poor
Hydraulic fluids:							
Silicates	Very good	Excellent	Fair to good	Good	Good		
Phosphates	Poor to fair	Excellent	Good to excellent	Poor to fair	Poor		
Uses	Diaphragms, print rolls, belts, oil seals, molded mechanical goods; gaskets, hose for petroleum handling; low-temp parts	Parts requiring resistance to high-temp solvents or oils; seals, gaskets, O rings	Electrical insulating and jacketing; footwear, sponge, proofed fabrics, automotive weather stripping, hose, belts, auto, appliance parts, parts requiring outstanding ozone and heat resistance	Flex chemical and petroleum tube and hose, rolls, tank linings; high-temp belts; wire and cable; shoe soles and heels; flooring; building products; extruded and molded parts	O rings, brake seals, shaft seals, gaskets, hose and ducting, connectors, diaphragms, carburetor needle tips, lined valves, packings, roll coverings	Electrical insulation, molded mechanical goods	Thermoplastic grades: molded mechanical goods, packaging, sports equipment, disposable pharmaceutical items. Solution grades: adhesives, coatings, calking, sealants

Product Data

FAX TRANS
TO: JOE MURPHY
DEPT:
FAX #: 415-969-9979
FROM: 3M Co
PHONE: 219-638-6305
CO: Rob Bracken
FAX: 219-638-6355
NO. OF PAGES: 4
Post-it brand fax transmittal memo 7671

Scotch® 33 +
Vinyl Plastic Electrical Tap

1. Product Description

Scotch Brand 33 + Electrical Tape is a conformable 7 mil thick vinyl plastic insulating tape which can be applied under all weather conditions and is designed to perform in a continuous temperature environment up to 105°C (220°F). It has excellent resistance to: abrasion, moisture, alkalies, acid, corrosion, and varying weather conditions (including sunlight). 33 +, with its combination of memory (elasticity), adhesion characteristics and 7 mil thickness provides moisture-tight electrical and mechanical protection with minimum bulk. Scotch 33 + passes Underwriters' Laboratory tests for plastic electrical tape.

Tape Features are:

- Polyvinyl chloride (PVC) backing.
- Pressure-sensitive, rubber-based adhesive.
- Flexibility and adhesion at 0°F, allowing conformance to almost any substrate.
- Memory of the tape allows it to hold tightly and provide pressure to underlying substrate without slipping or flagging.
- Highly resistant to physical abuse, chemical attack and ultraviolet light.
- Compatible with all solid dielectric cable insulations.
- Usable for either indoor or outdoor applications.
- Compatible with rubber and synthetic splicing compounds as well as epoxy and polyurethane resins.
- Meets U/L requirements for 80°C.
- Meets proposed 105°C (220°F) rating requirements.*
- Maintains high-voltage protection despite high-moisture concentrations.

*See test method in Section 5 "Characteristics and Test Data."

2. Applications

- Primary electrical insulation (especially in moisture and solvent vapor areas) for all wire and cable splices up to 600 volts and 105°C (220°F).
- Forms a protective jacket (excellent abrasion resistance for high-voltage cable splices and terminations).
- For fixture wire splices up to 1000 volts.
- For wire and cable harnessing.

3. Data

Typical Properties

Physical Properties

Normal Temperature Rating — UL	80°C
3M — See Section 5	105°C
Color	Black
Thickness ASTM D-1000-79	7 mils
Adhesion to Steel ASTM D-1000-79	
72°F	21 oz./in.
0°F	50 oz./in.
Adhesion to Backing ASTM D-1000-79	
72°F	20 oz./in.
0°F	50 oz./in.
Breaking Strength ASTM D-1000-79	
72	16 lbs./in.
Flammability UL	1 sec.
Accelerated Aging MIL I 7798 A	80%
Resistance to Penetration at Elevated Temp.* ASTM D-1000-79	80°C
Ultimate Elongation ASTM D-1000-79	
72°F	250%
0°F	50%

*Also specified in MIL I 7798A

Electrical Properties

Dielectric Strength: After Standard Conditions ASTM D-1000-79	10,000 volts
Dielectric Strength: After Humidity Conditioning ASTM D-1000-79	90% of standard conditioning value
Insulation Resistance ASTM D-1000-79	1×10^{6} Megohms

Chemical Properties

Water Absorption ASTM D-570-63	1%
Resistance to Ultraviolet Light 3M, See Section 5	Pass
Electrolytic Corrosion 3M, See Section 5	1.0 ratio
Resistance to Alkalies	Excellent

These are typical properties and are not to be used for specification purposes.

4. Specifications

Product

The plastic tape is based on polyvinyl chloride (PVC) and/or its copolymers and has a rubber-based pressure-sensitive adhesive. The tape must be applicable at temperatures ranging from 0°F through 100°F without loss of physical or electrical properties. The tape must not crack, split, slip or flag when exposed to various environments (indoor or outdoor). The tape must also be compatible with all synthetic cable insulations as well as cable splicing compounds.

Engineering/Architectural Specifications

Primary electrical insulation branch wiring in wet or dry locations. All splices for 600 volt wire rated 105°C (220°F) and below shall be insulate

with a minimum of two half-lapped layers of Scotch 33 + Vinyl Plastic Electrical Tape. All connectors having irregular surfaces shall be padded with Scotchfil Brand Putty or Scotch Brand 23 Tape prior to insulating with Scotch 33 + Electrical Tape.

Forms a protective jacket for High-Voltage Cable Splices and Terminations.

All rubber and thermoplastic insulated high-voltage cable splices and terminations shall be overwrapped with at least two half-lapped layers of Scotch 33 + Vinyl Plastic Electrical Tape.

Fixture Wiring: All splices up to 1000 volts and 105°C (220°F) or less, requiring insulation shall be overwrapped with a minimum of two half-lapped layers of Scotch 33 + Vinyl Plastic Electrical Tape.

5. Characteristics and Test Data

The Added + of 33 +

Low Temperature

A plastic tape, to be easily handled at any temperature, must have good elongation and adhesion. Scotch 33 + has good elongation and very high adhesion even at temperatures as low as 0°F. 33 + Tape will adhere to irregular surfaces and to most substrates under very extreme temperatures.

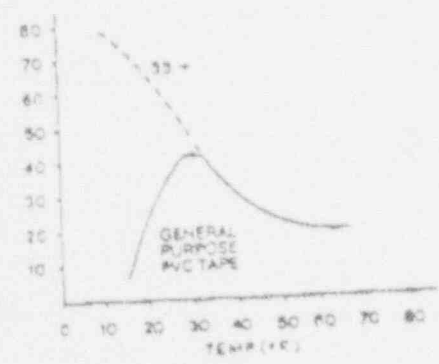

Figure 1.

Room Temperature

Scotch 33 + Electrical Tape has been designed to be easily applied by any workman. At room temperature the tape can be elongated easily while the force required to break the tape has been lowered. This means that less effort is required to produce a smooth, well-wrapped splice.

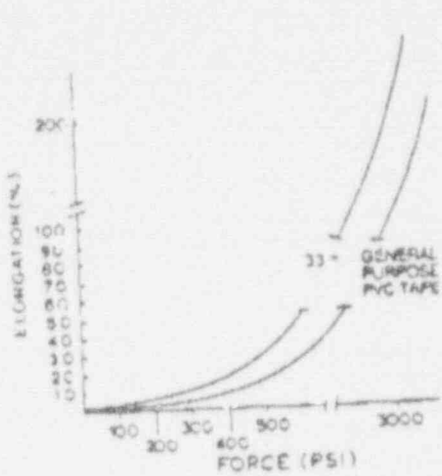

Figure 2.

NOTE: Lower force is required with 33 + Tape, as shown, to obtain initial elongation. Some elongation (10 to 15%) is required to obtain conformance. Force required for 33 + Tape is at a level which allows easier taping and thus provides maximum protection in the shortest possible time.

High Temperature

Through specialized compounding and unique processing techniques a more temperature stable plastic tape has been produced. 33 + Tape outperforms other plastic tape when tested as shown in following paragraphs, "Exposure to Heat."

A maximum temperature rating of 80°C can be given to a plastic tape. This temperature rating is in accordance with Underwriters' Laboratories specification. 3M has raised the test temperature to simulate a 105° rating. 33 + Tape was designed to meet the stringent requirements of this test.

Exposure to Heat

1. A thermoplastic insulating tape shall not crack when flexed, or otherwise be adversely affected, after being subjected to a temperature of 113°C (235°F) for 60 days.

2. To determine whether a tape complies with the requirements in the preceding paragraph, four tape-insulated splices are to be made with Type T, TW, THW, or THWN wire and four with Type R, RH, RW or RHW wire, as described in the succeeding paragraph. The conductor is to be No. 12 AWG solid copper and the solid copper conductor of a Type R, RH, RHW, or RW wire is to be metal coated.

3. For each splice, use two 12-inch (304,8 mm) lengths of insulated conductors and strip a 2-inch (50,80 mm) length of insulation from one end of each. Connect the two bared conductors together by means of an inline (Western Union) splice (see Figure 3 below). The ends of the conductor shall be crimped down with pliers to avoid sharp projections.

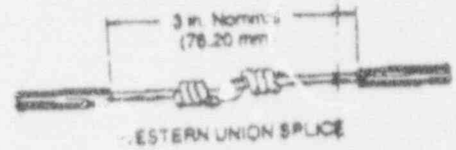

Figure 3.

4. While supporting a weight of 2-1/2 pounds, a strip of tape of suitable length is to be held vertically with the upper end of the tape held against the insulated wire just adjacent to the splice. Initially, the major axis of the splice is located approximately horizontally, and the tape is caused to wrap the wire and splice by rotating the splice about its major axis. The major axis of the splice is tipped from the horizontal so that each turn of the tape is to overlap the preceding turn by one-half the width of the tape. After the bared conductors and approximately one tape width of the wire insulation have been completely wrapped, a second wrapping is to be similarly applied, with direction of advance of the turns of tape reversed from that of the first wrapping. Finally, a third wrapping of tape is to be similarly applied with the direction of advance opposite to that of the second wrapping. Thus six thicknesses of tape will result at each point along the splice.

The insulated splices are then to be placed in an oven maintained at 113°C (235°F). After 24 hours, two of the splices employing thermoplastic insulated T wire and two of those employing rubber insulated R wire are to be removed from the oven and subjected to flexing as described below. If failure occurs after 24 hours, the test shall be terminated and the 60 day samples removed from the

oven. The other four samples are to remain in the oven for a total of 60 days, and are then to be removed from the oven and flexed. In each case, the samples are to be cooled at room temperature (23 ± 2.0°C) for no less than 16 nor more than 96 hours before being flexed.

4A. The flexing is to be performed by holding the wire of the assembly approximately 1 inch to the left of the splice firmly against a horizontally fixed 1/2 inch diameter steel mandrel. The end of the assembly which includes the splice is then wrapped tightly around the mandrel in a clockwise direction until approximately one inch of the wire to the right of the splice is wrapped around the mandrel. The direction of the wrap is then reversed and continued in the counterclockwise direction until approximately one inch of the wire to the right of the splice is wrapped around the mandrel. Five clockwise operations and five counterclockwise operations followed by a clockwise unwrap completes the flexing procedure.

All operations shall be conducted at a uniform rate such that the full flexing procedure is completed in 20 ± 5 seconds.

The tape shall not crack or bubble after being flexed.

The conductor shall show no adverse effects after removal of the tape from the splices.

Electrolytic Corrosion

In insulating wires, electrolytic corrosion caused by insulating tape can result in failure. When subjected to stress under high humidity, an insulating material serves as an electrolyte or a medium for the solution of copper wire when leakage current exists. The 3M electrolytic corrosion test is a scientific method of measuring the effect of corrosion caused by an insulating tape on a copper wire. It is based on tensile strength measurement of a copper wire which has been exposed to electrolytic corrosion.

A preparation board is made by wrapping No. 32 gauge copper wire so that sets of two wires are spaced 1/4" apart. Additional sets may be placed 1/2" apart. The wires should be snug, but must not be stretched or kinked. The tape is applied over the two wires and firmly rolled down with a rubber roller. The wires are cut flush at one end of the board with two inches of wires extended at the other end. The board is then hung in a conditioning chamber maintained at 95 ± 1% R.H. One wire from each sample is connected to the positive side of a 250 volt DC supply and the other wires are connected to the negative side.

250 volts DC are applied across the samples for 24 hours. See Figure 4.

The samples are then removed, the tapes removed from the wires and the wires are tested for tensile strength. The corrosion factor is found by calculating:

$$\frac{\text{Tensile of positive wire}}{\text{Tensile of negative wire}}$$

Electrolytic corrosion will not affect the copper wire connected to the negative side of the DC supply. However, any electrolytic corrosion caused by the tape will result in the dissolving of a small amount of the wire connected to the positive side of the DC supply resulting in a lower tensile strength.

A tape whose electrolytic corrosion factor is less than one could be considered to be damaging any copper wires it comes into contact with at high relative humidities. Scotch 33+ Electrical Tape has an electrolytic corrosion factor of 1.00.

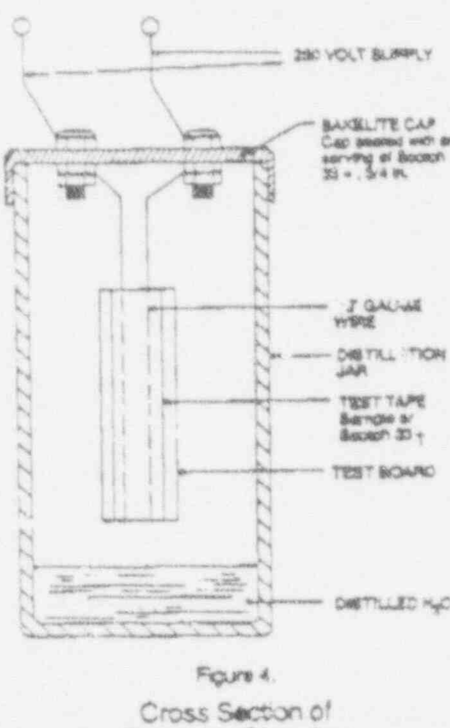

Figure 4.

Cross Section of Corrosion Chamber

Resistance to Ultraviolet

Scotch 33+ Electrical Tape, as well as all available competitive vinyls, are continuously undergoing ultraviolet exposure tests. 3M maintains an outdoor aging facility at Sugarland, Texas, selected because of the high number of sunshine days. The salt air present also accelerates the aging conditions.

Various tapes are wrapped on various types of 1/4-inch rods (copper, aluminum, steel) and mounted on test boards. The boards are positioned in such a manner as to allow exposure to the maximum sunlight. Samples of the tapes are also placed on stainless steel plates and likewise mounted on test boards.

All tapes being exposed in outdoor aging are tested initially in order to establish before-exposure data. At six-month intervals the rods and plates are removed and sent to the St. Paul labs for testing. The tapes are tested for the following properties:

1. Observation of surface
2. Color
3. Adhesive condition
4. Adhesive condition on rod
5. Corrosion on rod
6. Adhesion value (oz./inch)
7. Tensile strength (lb./inch)
8. Elongation (%)
9. Dielectric strength (volts/inch)

Scotch 33+ Electrical Tape has been designed such that its properties remain virtually unaffected in this outdoor or aging test.

Conformability

Type "A" tape is a strong oriented film type product. It is difficult to elongate and when stretched beyond the low yield point it does not recover. Consequently, it does not conform to irregular surfaces and provide adequate splice protection from moisture even though it is "moisture resistant tape." See Figure 5.

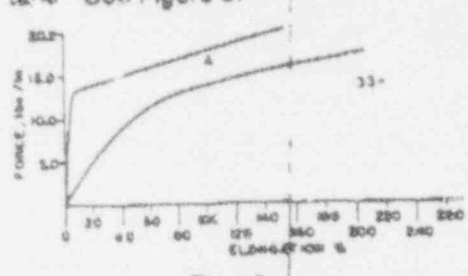

Figure 5.

The Scotch 33+ Electrical Tape curve illustrates that when the tape is applied with normal tension a neat,

self-snugging splice is obtained. The result is a good looking, moisture-proof splice that provides excellent physical and electrical protection.

6. Installation Techniques

The tape shall be applied in half-lapped layers with sufficient tension to reduce its width to 5/8 of its original width. On pigtail splices, the tape shall be wrapped beyond the end of the wires and then folded back — leaving a perfect protective cushion which will resist wire cut-through. Always wrap tape uphill. DO NOT STRETCH LAST INCH.

CAUTION: The adhesive of 33+ Tape is not oil resistant. It should not be used for sole insulation on cables which contain oil or slippery compounds. The tape should not be used where oil can attack and soften the adhesive.

7. Maintenance

Scotch 33+ Electrical Tape is stable under normal storage conditions. Special slitting techniques result in a tape which will not telescope. A specially formulated rubber based adhesive remains stable under all weather conditions.

8. Availability

Scotch 33+ Vinyl Plastic Tape is available in the following roll sizes from your electrical distributor:

3/4 in. x 66 ft.
3/4 in. x 44 ft.
3/4 in. x 20 ft.

3/4 in. x 66 ft. is also available in a handy, plastic dispenser.

Other lengths and widths are available by special request.

Complete Product and Use Specifications are available through the Electro-Products Division, 3M Company.

Electro-Products Division/3M
225-4N, 3M Center
St. Paul, Minnesota 55144

3M

MEMORANDUM

To: File

From: J. A. Murphy

Date: July 11, 1990

Subj: Elevated Temperature Behavior of Scotch 33 Insulating Tape

The product information bulletin on Scotch 33+ vinyl electrical insulating tape supplied to MLEA does not contain any information concerning the behavior of the product at temperatures above 113°C (235.4°F). I therefore contacted the 3M Electrical Specialties Div in Austin Texas (512-984-5657). The operator connected me with Mr. Steve Meyer (International Technical Services) and asked if there was any information on the behavior of Scotch 33+ at elevated temperature (viz. 300°F). He provided the following information:

- At 300°F after a period of time the plasticizers used in both the tape and adhesive will volatilize and the tape becomes brittle.

- The tape, if it has been stretched during application, will also attempt to shrink to its unstretched configuration.

- There is a threshold temperature for this behavior and it is probably above 250°F but he could not provide a specific number.

I asked if there was any question about the behavior of the tape at 113°C. He stated that the tape should routinely pass the test conditions stated in the product bulletin. He also stated that above 105°C the tape and adhesive softens somewhat but could not quantify this information.

I told him that we had been running a thermal aging test in which Scotch 33+ was used as a jacket over Okonite T-95 insulating tape at about 300°F and that after about 40 hours the Scotch 33+ split and was brittle. He stated that the observed behavior could be expected based on the fact that the plasticizers had volatilized and the tape had attempted to shrink.

I thanked him for the information. (There is no published data on this behavior because the product information limits use of the tape to 105°C)