3M

Cold Shrink™ Termination Kits

Quick Term II 5800-Pb Series
For Single Conductor PILC Cable 15 kV - 25 kV

Data Sheet

1. Product Description

5800-Pb Series Quick Term II Cold Shrink™ Silicone Rubber Termination Kits are designed for oil/paper insulated power cable. **They meet the requirements of IEEE standard 48-1990, for class 1 terminations and applicable sections of IEEE 404-1986.** In addition they meet German standard VDE 0278 parts 5 & 100, British standard BS C-89, Spanish standard UNE 21-115-75 and Brazilian standard A.B.N.T.9314. Similar terminations using Quick Term II technology meet French EdF standards HN 33-E-01 and HN 41-E-01. Data on foreign standards are available upon request. The 3M Quick Term II consists of a high dielectric constant (High-K) stress control tube insulated with a molded silicone skirted insulator. There is a four skirt design rated 15 kV and a six skirt design rated 25/28 kV. Each insulator design incorporates an extended base feature which when combined with mastic ensures a seal at the cable jacket and where the shield ground strap is brought out. Quick Term II terminations are provided in an expanded state, mounted on a removable inner supporting plastic core. As supplied in this pre-stretched condition the termination is ready for field installation. During installation the core is unwound, allowing termination to shrink and form a tight seal. Collectively, these termination kits accommodate cable primary insulation diameters from: 0.59" (15 mm) to 1.90" (48 mm).

These kits can be used to terminate PILC power cables from:
4 AWG to 1250 kcmil at 15 kV and
2 AWG to 1000 kcmil at 25 kV
To ensure a positive oil seal and to conform with pressure test requirements, a sealed terminal lug or connector must be used with the 5800-Pb series kits. These kits can be specified with or without sealed copper lugs *(see selection table on page 2).*

Stress Control

The 3M termination controls the electric field surrounding the terminated cable insulation shield end, by use of a special high dielectric constant (High-K) material which is an integral part. The High-K material has a dielectric constant of about 25. By controlling the electrical field, the stress concentration in the applied termination materials and at the air interface is less than 15 volts/mil at rated voltage. In the shielded portion of 15 kV cable, the stress concentrations typically vary from 50 volts/mil at the shield to about 70 volts/mil at the conductor. When terminated, the stress in the cable underneath this unit is less than it is in the shielded portion of the cable.

Figure 1 shows an actual computerized stress plot of a Cold Shrink™ termination.

Cold Shrink™ Insulators

3M Quick Term II Skirted Insulators are constructed of non-tracking silicone rubber which minimizes leakage currents in wetted conditions for three reasons:

1. The smooth surface of the silicone rubber insures that a minimum amount of contamination will adhere to the termination.
2. Silicone rubber has a hydrophobic surface: When water comes in contact with the silicone it **beads** up and runs off the skirts rather than completely wetting these surfaces. Thus a less conductive path is formed on the silicone and leakage currents are lowered.
3. When leakage currents do increase and arcing occurs on the surface, the ash formed by erosion of the silicone insulator is non-organic or nonconductive. Continued degradation is thereby deterred.

Under heavy rain conditions, conventional skirted terminations with even-skirt diameter insulators tend to form drip paths or continuous water

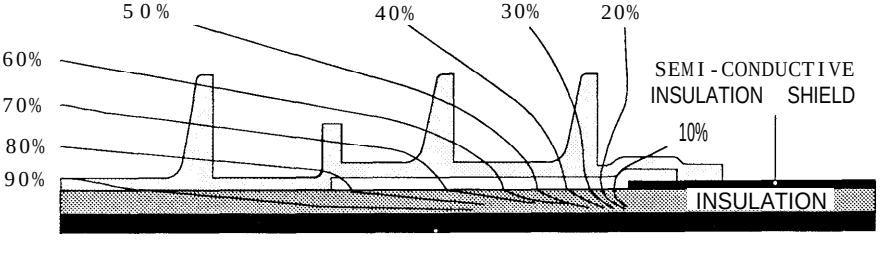


Figure 1

paths from insulator skirt tip to skirt tip. By comparison, 3M Quick Term II insulators are designed with unique, uneven skirt diameters. This feature allows water dripping from the upper skirt to fall free, avoiding the skirt to skirt conductive path that can develop with even-skirt diameter insulators. This design of the 3M Quick Term II termination optimizes performance under heavy rain conditions.

Kit Contents

Each kit contains sufficient quantities of the following materials to make one termination:

1 Hi-K Silicone Rubber Skirted Termination
1 Silicone Cold Shrink™ Tube (gray)
1 EPDM Rubber Thinwall Cold Shrink™ Tube (black)
1 Roll Scotch™ 23 Rubber Tape
1 Roll Scotch™ 13 Semi-con Tape
1 Roll White Restricting Tape
2 Scotch™ 70 Silicone Rubber Tape Strips (gray with clear release liners)
2 Mastic Seal Strips (1 for 5801-Pb Kit) (black with white release liners, bagged)
1 Constant Force Spring
1 Ground Braid Strip
1 Pack of Silicone Grease (clear 5cc tube with green letters)
1 Lug *(if specified-see table below)*
1 Instruction Sheet

2. Applications

The 5800-Pb series Quick Term II Silicone Cold Shrink™ Terminations are used to terminate PILC power cable rated 15 kV, 25 kV and 28 kV. The terminations are light weight for either free-hanging or bracket-mounting arrangements. They can be used in both protected and weather exposed contaminated area. The amount of airborne contamination determines the operating environment. Operating environments are described as areas having a varying degree of airborne contaminant or pollution severity that may, or may not effect the long term performance of terminations. These operating environments are defined as light, medium, heavy and extremely heavy variations of pollution severity. The appropriate termination selection depends on the system voltage and operating environment. *(See tables on page 3).*

3. Data: Physical and Electrical Properties

The 5800-Pb series Quick Term II terminations can be used on cables with a rated operating temperature of 75°C and an emergency overload rating of 105°C, (reference: AEIC No. 1). These kits meet the requirements for 15 kV and 25 kV Class 1 terminations in IEEE Standard Test Procedures and Requirements for High-Voltage Cable Terminations (IEEE Standard 48-1990). (See Section 5, "Performance Tests"). The current rating of Quick Term II terminations meets and exceeds the current rating of the cables.

NOTE: A sealed lug, capable of withstanding a minimum internal pressure of 25 PSI, must be used with 5800-Pb series terminations. Kits with copper lugs can be selected from the table below.

Product Number	Primary Insulation O.D. Range Inches (mm)	Conductor Range		Lug (*) (For Copper Conductors Only)
		Stranded	Solid	
15 kV				
5801-Pb-2	0.59 - 0.90 (15 - 23)	2	1	OS-0001 (1-Hole)
5801-Pb-1/0	0.59 - 0.90 (15 - 23)	1/0	2/0	OS-0010 (1-Hole)
5801-Pb-2/0	0.59 - 0.90 (15 - 23)	2/0	3/0	OS-0020 (1-Hole)
5802-Pb-3/0	0.71 - 1.01 (18 - 26)	3/0	4/0	OS-0030 (1-Hole)
5802-Pb-4/0	0.71 - 1.01 (18 - 26)	4/0	250	OS-0040 (1-Hole)
5802-Pb-250	0.71 - 1.01 (18 - 26)	250	-	OS-0250 (2-Hole)
5803-Pb-350	0.94 - 1.36 (24 - 35)	350	-	OS-0350 (2-Hole)
5803-Pb-500	0.94 - 1.36 (24 - 35)	500	–	OS-0500 (2-Hole)
25 kV				
5806-Pb-2	0.71 - 1.01 (18 - 26)	2	1	OS-0001 (1-Hole)
5806-Pb-1/0	0.71 - 1.01 (18 - 26)	1/0	-	OS-0010 (1-Hole)
5807-Pb-2/0	0.94 - 1.36 (24 - 35)	2/0	3/0	OS-0020 (1-Hole)
5807-Pb-3/0	0.94 - 1.36 (24 - 35)	3/0	4/0	OS-0030 (1-Hole)
5807-Pb-4/0	0.94 - 1.36 (24 - 35)	4/0	250	OS-0040 (1-Hole)
5807-Pb-250	0.94 - 1.36 (24 - 35)	250	-	OS-0250 (2-Hole)
5808-Pb-350	1.2 - 1.9 (30 - 48)	350	-	OS-0350 (2-Hole)
5808-Pb-500	1.2 - 1.9 (30 - 48)	500	-	OS-0500 (2-Hole)

* Oil-Seal Lugs, including a 2-hole 750 kcmil (OS0750) and 2-hole 1000 kcmil (OS1000), can be ordered separately using the listed numbers.

Pollution Severity Level Guide

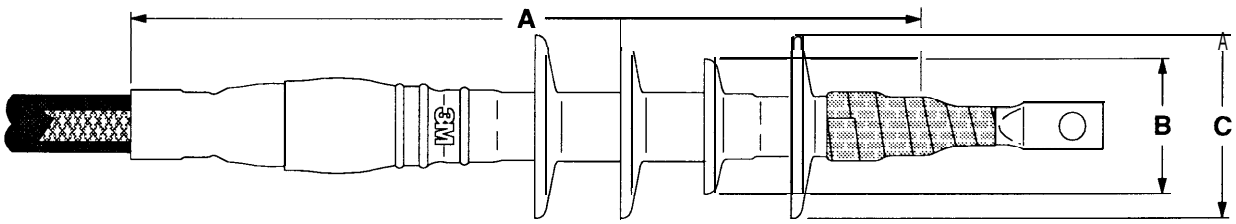
Light	Medium	Heavy	Extremely Heavy
• Areas without industries and with low density housing. • Areas subjected to frequent winds and/or rain fall with low density of industries or housing. • Agricultural areas. ☆ • Mountainous areas. All of these regions should be situated at least 7 to 15 miles from the coast and should not be exposed to coastal winds. *	• Non polluting industrial areas subject to infrequent rain fall and/or with average density housing. • Areas subjected to frequent winds and/or rainfall with high density industries and/or housing. • Areas exposed to wind from the coast but generally over two miles from the coast.	• High density industrial areas and some urban areas with high density housing, especially those with infrequent rain fall. • Areas subjected to a moderate concentration of conductive dust, particularly industrial smoke producing deposits. • Areas generally close to the coast and exposed to coastal spray or to strong winds carrying sand and salt, and subjected to regular condensation.	• Usually very limited areas having extremely heavy pollutants from industrial sites especially those located near oceans and subjected to prevailing winds from the sea. • Very small isolated areas where terminations are located immediately adjacent to a pollutant source, especially downwind (cement plants, paper mills, etc.)

* Use of fertilizers by spraying, or the burning of crop residues, can lead to a higher pollution level due to dispersal by wind.
* Distances from coast depend on the topography of the coastal area and on the extreme wind conditions.

Recommended Application Guide

Termination Kit	System Voltage	Operating Environment			
		Light	Medium	Heavy	Extremely Heavy
(Four Skirt) 5801-Pb - 5804-Pb	15 kV	Y	Y	Y	
(Six Skirt) 5806-Pb - 5808-Pb	15kV		Y	Y	Y
(Four Skirt) 5801-Pb - 5804-Pb	25/28 kV	Y			
5806-Pb -5808-Pb	25/28 kV	Y	Y	Y	☆

Recommended operating environments are marked with a (Y).
* Consult 3M Sales Representative



FOUR-SKIRTTERMINATION

A. Typical Dimensions

Product Number	A	B	C	Creepage Distance	Arcing Distance
5801-Pb	17.25" (max) (438 mm)	1.67" (42 mm)	2.68" (68 mm)	22.50" (572 mm)	17.75" (max) (451 mm)
5802-Pb	17.25" (max) (438 mm)	1.82" (46 mm)	2.75" (70 mm)	22.50" (572 mm)	17.75" (max) (451 mm)
5803-Pb	18.25" (max) (463 mm)	2.00" (51 mm)	3.25" (83 mm)	24.50" (622 mm)	18.75" (max) (476 mm)
5804-Pb	18.50" (max) (470 mm)	2.00" (51 mm)	3.55" (90 mm)	24.75" (606 mm)	19.00" (max) (483 mm)

B. Termination Selection Table

Product Number	Primary Insulation O.D. Range inches (mm)	Conductor Range (AWG / Kcmil)	
		15kV	25 kV**
5801-Pb	0.59 0.90 (15 - 23)	4-2/0	-
5802-Pb	0.71 - 1.01 (18 - 26)	2/0 - 250	2-1/0
5803-Pb	0.94 - 1.36 (24 - 35)	350-600	210 - 250
5804-Pb	1.2 - 1.9 (30-48)	750 - 1250	350 - 1000

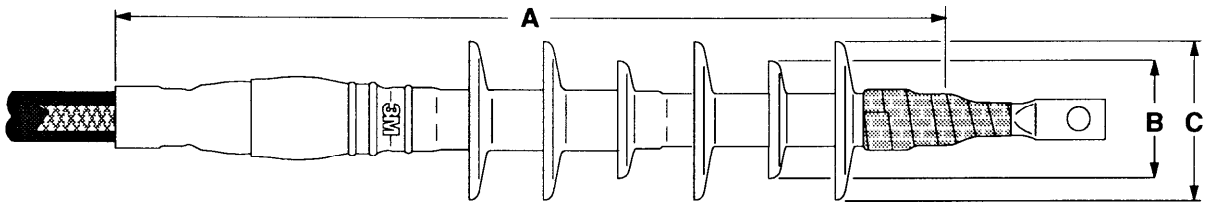
** See Recommended Application Guide, on page 3.

C. Typical Results per IEEE STD. 48-1990 Tests

IEEE Std. 48 Test	15 kV Class		25 kV Class	
	Requirement	Results	Requirement	Results
60 sec. w/s ac	50 kV	85 kV*	65 kV	90 kV*
10 sec. w/s wet ac	45 kV	65 kV*	60 kV	75 kV*
6 hours w/s ac	35 kV	80 kV*	55 kV	85 kV*
Corona @ 3 pc. CSV†	-	33 kV	-	36 kV
CEV	13 kV	28 kV	21.5 kV	32 kV
15 min. w/s dc	75 kV	Pass 75 kV	105 kV	Pass 105 kV
Impulse w/s	110 kV	+165 kV* - 150 kV*	150 kV	+180 kV* - 165 kV*
30 day Cyclic Aging @ 130°C w/s ac	17 kV	Pass	29 kV	Pass
Impulse +10	+110 kV	Pass	+150 kV	Pass
-10	- 110 kV	Pass	- 150 kV	Pass
Ionization Factor (%)	0.60 max	< 0.20	0.40 max	< 0.20

* At higher voltage flashovers occur.

† Cables with laminated insulation systems are often unstable in Corona Discharge Measurement Continuity. Therefore, 3M 5800-Pb series terminations were Corona tested on XLPE-insulated power cable.



SIX-SKIRT TERMINATION

A. Typical Dimensions

Product Number	A	B	C	Creepage Distance	Arcing Distance
5806-Pb	20.25" (max) (514 mm)	1.82" (46.2 mm)	2.75" (69.8 mm)	28.25" (718 mm)	20.75" (max) (527 mm)
5807-Pb	21.75" (max) (552 mm)	2.00" (50.8 mm)	3.25" (82.5 mm)	31.00" (787 mm)	22.25" (max) (565 mm)
5808-Pb	21.75" (max) (552 mm)	2.00" (50.8 mm)	3.55" (90.2 mm)	24.00" (610 mm)	22.25" (max) (565 mm)

B. Termination Selection Table

Product Number	Primary Insulation O.D. Range inches (mm)	Conductor Range (AWG / Kcmil) 15 kV	25/28 kV**
5806-Pb	0.71 - 1.01 (18 -26)	2/0 - 250	2-1/0
5807-Pb	0.94 - 1.36 (24 - 35)	350 - 600	2/0 - 250
5808-Pb	1.20 - 1.90 (30 - 48)	750 - 1250	350 - 1000

** See Recommended Application Guide, on page 3.

C. Typical Results per IEEE STD. 48-1990 Tests

IEEE Std. 48 Test		15 kV Class		25/28 kV Class §	
60 sec. w/s ac		Requirement 50 kV	Results 100 kV*	Requirement 65 kV	Results 100 kV*
10 sec. w/s wet ac		45 kV	70 kV*	60 kV	80 kV*
6 hours w/s ac		35 kV	95 kV*	55 kV	105 kV*
Corona @ 3 pc.	CSV†	-	33 kV	-	36 kV
	CEV	13 kV	28 kV	21.5 kV	32 kV
15 min. w/s dc		75 kV	Pass 75 kV	105 kV	Pass 105 kV
Impulse w/s		110 kV	+ 195 kV* - 180 kV*	150 kV	+ 210 kV* - 195 kV*
30 day Cyclic Aging @ 130°C w/s ac		17 kV	Pass	29 kV	Pass
Impulse	+ 10	+110 kV	Pass	+150 kV	Pass
	-10	-110 kV	Pass	- 150 kV	Pass
Ionization Factor (%)		0.60 max	< 0.20	0.40 max	< 0.20

§ 25 kV Class 5800-Pb series terminations will also meet prorated values for 28 kV systems.

* At higher voltage flashovers occur.

† Cables with laminated insulation systems are often unstable in Corona Discharge Measurement Continuity. Therefore, 3M 5800-Pb series terminations were Corona tested on XLPE-insulated power cable.

D. Typical Physical & Electrical Properties

Silicone Rubber Insulator

Physical Properties

Test Method	Typical Value*
Color	Munsel Gray
Permanent Set	8%
22 hours @ 100°C (212°F)	
100% elongation	
5 minute recovery	
Ultimate Tensile Strength	1200 psi
(ASTM D42-68)	(8.28 MPa)

Electrical Properties

Test Method	Typical Value*
Dielectric Constant (K)	
(ASTM D- 150-70)	
23°C (73°F)	3.4
90°C (194°F)	3.0
130°C (266°F)	2.7
Dissipation Factor	
(ASTM D150-70)	
23°C (73°F)	0.4%
90°C (194°F)	1.3%
130°C (266°F)	1.2%
Dielectric Strength	
(ASTM D 149-64	
Reapproved 1970)	507 Volts/mil
75 mil gap	(20 MV/m)
Track Resistance	
(ASTM 2303-68)	
2.4 kV, 10 k Ohms	30 hrs.
3.25 kV, 560 k Ohms	10 hrs.

EPDM Rubber High-K Stress Control Tube

Physical Properties

Test Method	Typical Value*
Ultimate Tensile Strength	1394 psi
(ASTM D42-68)	(9.6 MPa)
Permanent Set	16%
22 hours @ 100°C (212°F)	
100% elongation	
15 minute recovery	

Electrical Properties

Test Method	Typical Value*	
Dielectric Constant (K)		
(ASTM D 150-70)		
60 Hz; @ 60% strain		
	@400V	@3 kV
23°C (73°F)	25.7	28.8
65°C (149°F)	24.5	27.2
90°C (194°F)	25.2	27.7
vs. frequency @ 23°C (73°F)		
150 Hz	35	
1,000 Hz	29	
10,000 Hz	24	
100,000 Hz	20	
Dissipation Factor		
(ASTM D 150-70)		
60 Hz; @ 60% strain		
	@400V	@3 kV
23°C (73°F)	0.096	0.166
65°C (149°F)	0.093	0.165
90°C (194°F)	0.132	0.161
vs. frequency @ 23°C (73°F)		
150 Hz	0.16	
1,000 Hz	0.15	
10,000 Hz	0.14	
100,000 Hz	0.12	

*Average values, not intended for specification purposes.

4. Specification Guide

Open Specification

The cable termination must be a two-piece Cold Shrink™ 15 kV or 25/28 kV Class device and meet all 15 kV, 25 kV (+ prorated 28 kV) requirements for Class 1 terminations as recorded in IEEE Standard 48-1990. The termination must be a molded rubber unit where the built in stress relief mechanism uses the concept of high dielectric constant capacitive stress grading. The molded rubber insulator must be made from silicone rubber.

Closed Specification

Terminate all 15 kV and 25/28 kV Class single conductor, non-pressurized PILC cable in accordance with the instructions provided with 3M Brand, 5800-Pb Series Quick Term II Silicone Rubber Termination Kits.

5. Performance Tests

Ionization Factor

This test determines accessory integrity and stability with respect to dielectric loss. It is a ratio of power factors measured at two stress levels (20 volts/mil and 100 volts/mil) at a common, 60 Hz, frequency. See applicable tables **"Typical Results per IEEE STD. 48-1990 Tests"** for results.

Internal Pressure/Vacuum Test

5800-Pb series terminations have been pressure-tested to levels which exceed those encountered under field service conditions.

While "Riser Cable" is recommended at pole-mount locations, only the cable company(s) can advise their maximum installation height to avoid oil draining.

3M, 5800-Pb series terminations are rated to withstand a continuous internal pressure of 25 PSI with an emergency overload pressure of 100 PSI for 36 hours.

The oil stop used in the 3M, 5800-Pb Series terminations exceeds the pressure and vacuum requirements of IEEE-48-1990, which requires 30 PSI for 1 hour and .02" Hg vacuum for 30 minutes. The oil stop was tested for many weeks at both pressures and vacuums. It was tested at pressures exceeding 100 PSI and has held a vacuum of 18" Hg for over 4 weeks.

Impulse Tests (BIL)

In this test a nominal 1.2 x 50 microsecond wave, both positive and negative, is used. Ten consecutive impulses at each polarity are applied. All Quick Term II terminations meet the BIL requirements as recorded in IEEE Standard 48-1990 with a considerable amount of safety margin.

Alternating Current Withstand Tests

All terminations meet ac withstand tests as specified in IEEE Standard 48-1990. See applicable tables **"Typical Results per IEEE STD. 48-1990 Tests."**

The average value of voltage which will arc over the termination surface in air, from the cable connecting lug to the ground strap at the termination base, is shown in the table below.

To determine dielectric strength, terminations are immersed in SF6 gas. The SF6 gas, having a higher dielectric strength than air, prevents termination flashover. The ac breakdown values are shown in table below.

AC Flashover and Breakdown Tests

Product Number	AC Flashover		AC Breakdown in SF_6	
	15 kV Class	25 kV Class	15 kV Class	25 kV Class
5801-Pb - 5804-Pb	85 kV	95 kV	130 kV	155 kV
5806-Pb - 5808-Pb	105 kV	115 kV	130 kV	155 kV

Environmental Performance

When airborne contaminants are deposited on a termination surface destructive leakage currents can be initiated when the surface becomes wet. Fog and drizzle are worse than rain. Rain tends to wash the pollutants off the termination while fog will wet the pollutants making the surface conductive to varying degrees promoting leakage current formation. This is most typical of hydrophillic surfaces typified by porcelain (Figure 2). The surface of 3M Quick Term II silicone insulator is hydrophobic which makes it less likely to erode or track because the surface does not wet readily (Figure 3). This either prevents or minimizes leakage current formation. On occasion severe environmental conditions can be sustained for long time periods and cause any polymeric surface to lose its hydrophobicity. Because of this, EPDM polymers tend to lose their hydrophobicity over time, and porcelain surfaces become increasingly hydrophillic with time, which will result in premature failure or flashover. However, the silicone surface will re-establish its hydrophobic surface within 24 hours (Figure 4). This unique ability of the Quick Term II silicone is a major factor to insure long service life.

References

L. A. Johnson* and W.C. Osborn*, "Contamination Testing of Distribution Class Cable Terminations", IEEE Underground T and D Conference, Pub. 76 CH 119-7-PWR, 1976.

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S.M. Gubanski and J.G. Wankowicz, "Distribution of Natural Pollution Surface Layers on Silicone Rubber Insulators and Their UV Absorption", IEEE Transactions on Electrical Insulation, Vol. 24 No. 4, 1989.

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*Members of the 3M Electrical Products Division Technical Community.

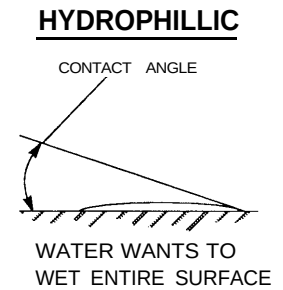


FIGURE 2

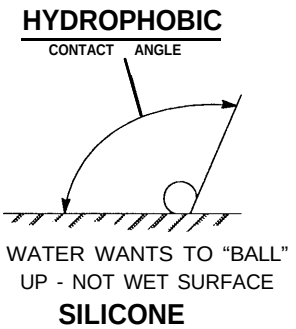


FIGURE 3

Sealing Tests

The bottom seal on PILC cable is formed by mastic placed under and over a solder-blocked ground braid which is then over-wrapped with tape. The tape compresses the mastic around the ground braid. A jacket-seal Cold Shrink™ tube covers the jacket end and tape/mastic region to complete the seal.

The lug seal is provided by the combination of an oil-stop rubber tube and restricting tape. A final layer of Scotch #70 silicone tape provides continuity in surface track-resistance from lug barrel to termination body.

The seals are tested by immersing the lug end in water and applying air pressure to the conductor. Both seals will withstand an internal air pressure test per IEEE Standard 48-1990.

Ultraviolet Resistance

After 1,000 hours of testing in a Weather-O-Meter according to Specifications ASTM D750 and ASTM G23, the silicone insulator exhibited no crazing, cracking or change in surface appearance. Silicone rubber, unlike carbon based elastomers, is inherently stable under exposure to sunlight. This is because of the silicone molecular back bone (the silicone- oxygen bond) has a bond strength greater than the ultraviolet energy of sunlight while the carbon-carbon bond of an EPDM elastomer is less than sunlight.

RECOVERY OF CONTACT ANGLE FOR QTII SILICONE RUBBER.

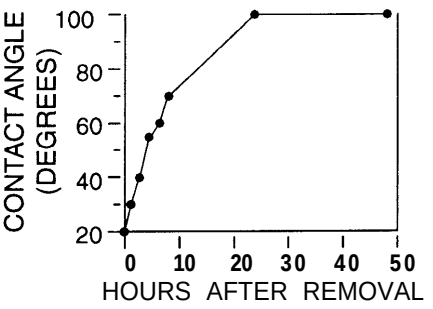


FIGURE 4

Installation Techniques

A detailed instruction sheet regarding proper installation is included in each kit. A brief summary of these procedures is as follows:

A. Prepare cable according to standard procedure *(Figure 1).*

B . Fill lead sheath step using Scotch™ 23 tape and install terminal lug *(Figure 2).*

C. Install Cold Shrink™ oil-barrier tube *(Figure 3).*

D. Apply white restricting tape *(Figure 4).*

E. Install solderless ground braid and establish shield location using Scotch™ 13 tape *(Figure 5).*

F. Install silicone rubber Cold Shrink™ termination components *(Figure 6).*

Field Maintenance

Hypotting

These terminations can be tested according to the instructions given in IEEE Standard 400-1980, "Guide for Making High Direct Voltage Tests in the Field."

Surface Cleaning

It is not uncommon in areas of extreme contamination for users to periodically clean terminations and other insulators. Energized or de-energized, established techniques for cleaning cable terminations can be used, e. g. high pressure water and pulverized corn cobs.

Availability

3M 5800-Pb Quick Term II Silicone Rubber Termination Kits can be purchased through your local authorized 3M electrical distributor.

Shelf Life

3M 5800-Pb Quick Term II Silicone Rubber Termination Kits are packaged one termination per carton. As provided in the expanded state, terminations have an on-shelf storage life of three years.

Maximum recommended storage temperature is 110°F (43°C). They are not effected by freezing storage temperatures. The year and quarter of manufacture is molded into the base of each Quick Term II termination. Stock rotation practice is recommended.

FIGURE 1

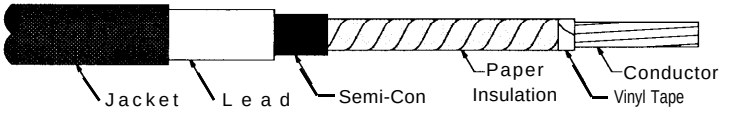


FIGURE 2

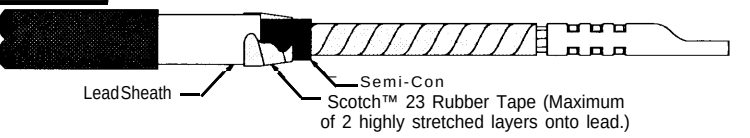


FIGURE 3

FIGURE 4

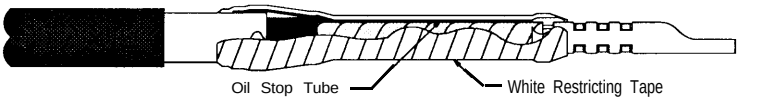


FIGURE 5

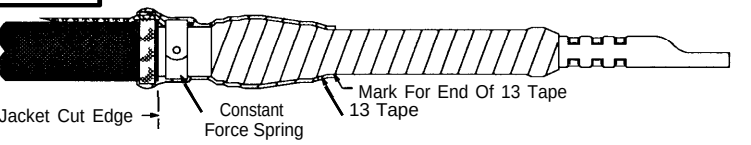
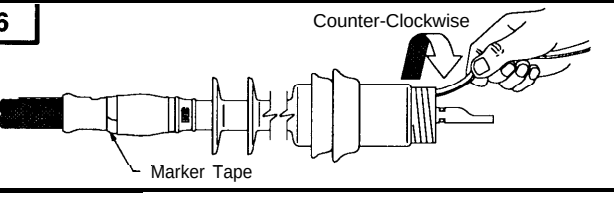


FIGURE 6



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