



Cold Shrink™

Silicone Rubber Termination Kits, 5 – 34.5 kV 7640–S, 7650–S and 7660–S Series

Data Sheet

1. Product Description

3M™ Cold Shrink™ QT–III 7640–S, 7650–S and 7660–S Series Kits contain one piece, skirted, silicone rubber terminations, qualified as IEEE Standard 48–1996 Class 1 for outdoor weather-exposed applications. The termination assemblies consist of a skirted insulator, high dielectric constant (Hi-K) stress control tube, conformable Hi-K stress controlling compound and built-in silicone top seal. The insulator is made of a new dark gray silicone rubber with improved tracking resistant and hydrophobic characteristics.

The complete assembly is prestretched and loaded onto a removable core. The disposable core can be recycled. The kits are designed for terminating jacketed concentric neutral (JCN) and concentric neutral (CN) power cables rated 5 through 34.5 kV.

Kit Contents:

Each kit contains sufficient quantities of the following materials to make one single-phase termination (compression lug is not included in the kit).

- 1 Hi-K, Tracking Resistant, Silicone Rubber Termination
- 2 Strips Sealing Mastic
- 1 Instruction Sheet

Termination Features:

Conforms to IEEE Standard 48–1996 Class 1 requirements for 5, 8.7, 15, 25/28 and 34.5 kV terminations.

One-piece versatile design, allowing quick installation and accommodating a wide range of cable sizes.

Cold Shrink™ delivery system for easy installation. Simply place termination over prepared cable and unwind core to shrink into place (no force fit required).

Hi-K stress control. Specially formulated high dielectric constant material minimizes surface stress by more uniformly distributing the electrical field over the entire surface of the insulator.

Compact design provides for easier installation in restricted spaces.

Silicone rubber insulators, EPDM stress control tubes, stress controlling compound and silicone sealing compound are compatible with common solid dielectric insulations, such as polyethylene (PE), cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR).

Stress Control

The QT–III controls the electric field stress distribution with special Hi-K materials which are an integral part of the termination. The Hi-K materials, with a dielectric constant (K) of greater than 15, capacitively distribute the field that surrounds the termination.

The stress concentrations in a continuous length of shielded cable are typically 50 V/mil adjacent to the shield to about 70 V/mil at the conductor. The QT–III reduces the cable stresses at the termination to less than those in the continuous shielded portion of the cable.

Electrical flux is refracted to distribute the voltage stress in a controlled manner along the entire termination length extending beyond the cable shield cutoff. By controlling the electric field, the stress concentrations on the termination insulator surface are kept below 15 V/mil at rated voltage. This stress distribution permits high power frequency performance and impulse performance with a compact termination design.

Figure 1 below illustrates an actual computerized stress plot of the QT–III.

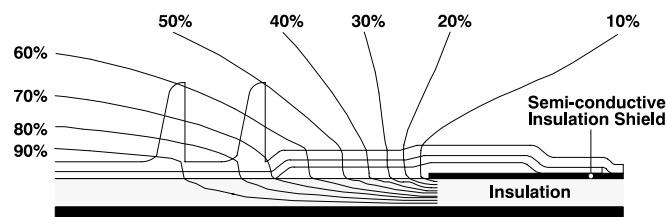


Figure 1

2. Applications

The 7640-S, 7650-S and 7660-S Series QT-III Silicone Cold Shrink™ Terminations are used to terminate Jacketed Concentric Neutral (JCN) and Concentric Neutral (CN) power cables rated 5 – 34.5 kV, having extruded solid dielectric insulation as follows: Polyethylene (high and low density), cross-linked polyethylene (XLP) and ethylene propylene rubber (EPR). The terminations are light weight for either free-hanging or bracket-mounting arrangements. They can be used in both protected and weather exposed

contaminated areas. The amount of airborne contamination determines the operating environment. Operating environments are described as areas having 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 below*).

Recommended Application Guide

Termination Kit	System Voltage	Operating Environment			
		Light	Medium	Heavy	Extremely Heavy
(2 Skirt) 7642-S-2	15 kV	✓	✓	✓	
(4 Skirt) 7652-S-4 — 7656-S-4	15 kV	✓	✓	✓	✓
(8 Skirt) 7663-S-8 — 7666-S-8	15 kV	✓	✓	✓	✓
(4 Skirt) 7652-S-4 — 7656-S-4	25/28 kV	✓	✓	✓	
(8 Skirt) 7663-S-8 — 7666-S-8	25/28 kV	✓	✓	✓	✓
(8 Skirt) 7663-S-8 — 7666-S-8	34.5 kV	✓	✓	✓	★

Recommended operating environments are marked with a check (✓).

★ Consult 3M sales representative.

Pollution Severity Level Guide

Light	Heavy
<ul style="list-style-type: none"> • Areas without industry and with low density housing. • Areas subjected to frequent winds and/or rainfall with low density industry and housing. • Agricultural areas. ☆ • Mountainous areas. <p>All of these regions should be situated at least 7 miles from the coast and should not be exposed to coastal winds. *</p>	<ul style="list-style-type: none"> • High density industrial areas and some urban areas with high density housing, especially those with infrequent rainfall. • 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.
Medium	Extremely Heavy
<ul style="list-style-type: none"> • Non polluting industrial areas subject to infrequent rainfall and with average density housing. • Areas subjected to frequent winds and/or rainfall with high density industry and housing. • Areas exposed to wind from the coast but generally over two miles from the coast. 	<ul style="list-style-type: none"> • 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.

3. Physical and Electrical Properties

3M Cold Shrink™ QT-III 7640-S, 7650-S and 7660-S Series terminations can be used on cables with a rated maximum operating temperature of 90°C and an overload rating of 130°C. 7640-S, 7650-S and 7660-S Series terminations meet all requirements of IEEE Standard

48-1996, “IEEE Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations” and are designated Class 1 for outdoor weather-exposed locations. The current rating of these terminations meets or exceeds the current rating of the cables on which they are installed.

Typical Dimensions

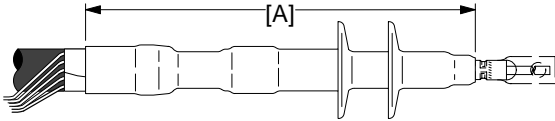
			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7642-S-2	9.8" (249 mm)	13.3" (338 mm)	9.8" (249 mm)

Table 1

Typical Dimensions


			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7652-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7653-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7654-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7655-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7656-S-4	13.25" (337 mm)	19.50" (495 mm)	13.25" (337 mm)

Table 2

Typical Dimensions


			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7663-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7664-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7665-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7666-S-8	21.50" (546 mm)	34.00" (864 mm)	21.50" (546 mm)

Table 3

A. Typical Physical and Electrical Properties

Silicone Sealing Compound

Hi-K Stress Control Tube

Physical Properties

Test Method	Typical Value*
• Tensile Strength (ASTM D412)	1500 psi
Modulus @ 100% Elongation	160 psi
Modulus @ 300% Elongation	500 psi

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (K) (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	22
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	0.10

Hi-K Stress Controlling Compound

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH 100 mil (2,54 mm) thickness	25
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH 100 mil (2,54 mm) thickness	0.9

Electrical Properties

Test Method	Typical Value*
• Dielectric Strength (ASTM D149) 75 mil (1,90 mm) thickness	300 V/mil

Silicone Rubber Insulator

Physical Properties

Test Method	Typical Value*
• Color	Dark Gray
• Tensile Strength (ASTM D412) Modulus @ 100% Elongation Modulus @ 300% Elongation	850 psi 130 psi 400 psi
• Hydrophobic Recovery (3M Test Method No. 406) > 90° Contact Angle	5.0 hrs.

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (S.I.C.) (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	3.6
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	0.003
• Dielectric Strength (ASTM D149) 75 mil (1,90 mm) thickness	500 V/mil
• Track Resistance (ASTM 2303) 3.5 kV	5.0 hrs.

* Typical values, not intended for specification purposes.

Termination Selection Guide

Kit Number	Cable Insulation O.D. Range	Conductor Size Range (AWG and kcmil)				
		5 kV 100% 133%	8.7 kV 100% 133%	15 kV 100% 133%	25/28 kV 100% 133%	34.5 kV 100% 133%
7642-S-2	0.64 – 1.08" (16,3 – 27,4 mm)	4/0 – 400 —	3/0 – 300 —	2 – 4/0 (35 – 120 mm ²)	— —	— —
7652-S-4	0.64 – 1.08" (16,3 – 27,4 mm)	4/0 – 400 —	3/0 – 300 —	2 – 4/0 (35 – 120 mm ²)	2 – 1/0 (35 – 50 mm ²)	— —
7653-S-4	0.72 – 1.29" (18,3 – 32,8 mm)	300 – 500 —	250 – 500 —	2/0 – 300 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)	— —
7654-S-4	0.83 – 1.53" (21,1 – 38,9 mm)	500 – 750 —	350 – 700 —	4/0 – 500 (120 – 240 mm ²)	2/0 – 250 (70 – 150 mm ²)	— —
7655-S-4	1.05 – 1.80" (26,7 – 45,7 mm)	700 – 1500 —	600 – 1250 —	500 – 1000 (240 – 500 mm ²)	250 – 800 (125 – 400 mm ²)	— —
7656-S-4	1.53 – 2.32" (38,9 – 58,9 mm)	1750 – 2000 —	1500 – 2000 —	1250 – 2000 (625 – 1000 mm ²)	900 – 1750 (500 – 800 mm ²)	— —

Table 4

Termination Selection Guide

Kit Number	Cable Insulation O.D. Range	Conductor Size Range (AWG and kcmil)				
		5 kV 100% 133%	8.7 kV 100% 133%	15 kV 100% 133%	25/28 kV 100% 133%	34.5 kV 100% 133%
7663-S-8	0.72 – 1.29" (18,3 – 32,8 mm)	300 – 500 —	250 – 500 —	2/0 – 300 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)	2 – 2/0 (35 – 70 mm ²)
7664-S-8	0.83 – 1.53" (21,1 – 38,9 mm)	500 – 750 —	350 – 700 —	4/0 – 500 (120 – 240 mm ²)	2/0 – 250 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)
7665-S-8	1.05 – 1.80" (26,7 – 45,7 mm)	700 – 1500 —	600 – 1250 —	500 – 1000 (240 – 500 mm ²)	250 – 800 (125 – 400 mm ²)	3/0 – 600 (95 – 325 mm ²)
7666-S-8	1.53 – 2.32" (38,9 – 58,9 mm)	1750 – 2000 —	1500 – 2000 —	1250 – 2000 (625 – 1000 mm ²)	900 – 1750 (500 – 800 mm ²)	700 – 1500 (325 – 800 mm ²)

Table 5

4. Specifications

Product

The cable termination must have a voltage class rating equal to or greater than the cable being terminated. The rating shall be 5, 8.7, 15, 25/28 or 34.5 kV as an IEEE Standard 48–1996 Class 1 termination. It must have a maximum continuous operating temperature rating of 90°C, with an emergency overload rating of 130°C. The termination stress control shall be capacitive and constructed of a Hi-K stress control compound and a Hi-K EPDM rubber tube. The installation procedure shall not require using silicone grease. The termination insulator shall be of a skirted design, constructed of tracking resistant silicone rubber, dark gray in color. The termination must be of a prestretched Cold Shrink™ design, installed without the application of a heat source. The

termination kit shall include all materials required (except lug and vinyl tape) and shall accommodate jacketed concentric neutral (JCN) and concentric neutral (CN) cables. The Class 1 termination kits shall be used with listed copper or aluminum compression lugs.

Engineering/Architectural

Terminating of all 5, 8.7, 15, 25/28 and 34.5 kV shielded power cables, shall be performed in accordance with instructions included in the 3M 7640–S, 7650–S and 7660–S Series Cold Shrink™ QT–III silicone rubber termination kits. This shall include all outdoor weather-exposed areas for jacketed concentric neutral (JCN) and concentric neutral (CN) cables. The termination kits shall be used in conjunction with 3M Scotchlok™ 30000 or 40000 Series or 3M SC Series stem connectors.

5. Performance Tests

Typical Results, IEEE Standard 48 Short-Term Test Sequence

Insulation Class Test	15 kV (2 Skirt)		15 / 25 kV (4 Skirt)		34.5 kV (8 Skirt)	
	Requirements	Results	Requirements	Results	Requirements	Results
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Power Frequency Voltage 1 min. Dry Withstand	50 kV	85 kV*	50 / 65 kV	95 / 100 kV*	90 kV	125 kV*
Power Frequency Voltage 10 sec. Wet Withstand	45 kV	65 kV*	45 / 60 kV	70 / 75 kV*	80 kV	100 kV*
Power Frequency Voltage 6 hour Dry Withstand	35 kV	75 kV*	35 / 55 kV	85 / 90 kV*	75 kV	115 kV*
Direct Voltage 15 min. Dry Withstand	75 kV	Passed	75 / 105 kV	Passed / Passed	140 kV	Passed
Lightning Impulse Voltage Withstand (BIL)	110 kV	135 kV*	110 / 150 kV	165 / 175 kV*	200 kV	240 kV*
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV

* At higher voltages, flashover occurs without breakdown.

Table 6

Typical Results, IEEE Standard 48 Long-Term Test Sequence

Insulation Class Test	15 kV (2 Skirt)		15 / 25 kV (4 Skirt)		34.5 kV (8 Skirt)	
	Requirements	Results	Requirements	Results	Requirements	Results
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Cyclic Aging 30 days, 130°C conductor temperature Power Frequency Voltage Withstand	26 kV	Passed	26 / 43 kV	Passed / Passed	60 kV	Passed
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Lightning Impulse Voltage Withstand (BIL)	110 kV	135 kV*	110 / 150 kV	165 / 175 kV*	200 kV	240 kV*

* At higher voltages, flashover occurs without breakdown.

Table 7

Partial Discharge (Corona) Tests

The purpose of corona testing is to ensure that all properly installed terminations operate corona-free at a minimum of 150% of their operating voltage. For the test, an applied test voltage is gradually increased until discharges appear on the test set oscilloscope display. The voltage at which these discharges reach a magnitude of 3 picocoulombs is recorded as the corona starting voltage (CSV). The applied voltage is then lowered until the discharge level drops below 3 picocoulombs, and this is recorded as the corona extinction voltage (CEV).

Power Frequency (AC) Withstand Tests

All 7640-S, 7650-S and 7660-S Series terminations exceed the IEEE Standard 48-1996 requirements for a Class 1 termination.

Lightning Impulse Tests

For these tests a 1.2 x 50 microsecond voltage wave is applied to the termination lug. The testing consists of both positive and negative polarity surges per IEEE Standard 48-1996 BIL requirements. The 7640-S, 7650-S and 7660-S Series terminations exceed these BIL requirements.

Sealing Tests

Termination top and bottom seals are tested by applying 7 psi (0.05 MPa) to the cable conductor strands with the termination submerged in water. Both seals withstand this internal air pressure for 6 hours without leaking.

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 hydrophilic surfaces typified by porcelain

(Figure 2). The surface of 3M QT-III 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. However, the silicone insulator surface will re-establish its hydrophobic surface within 24 hours. This prevents the surface from becoming increasingly hydrophilic with time, which would result in premature failure or flashover. This unique ability of the QT-III silicone is a major factor to insure long service life.

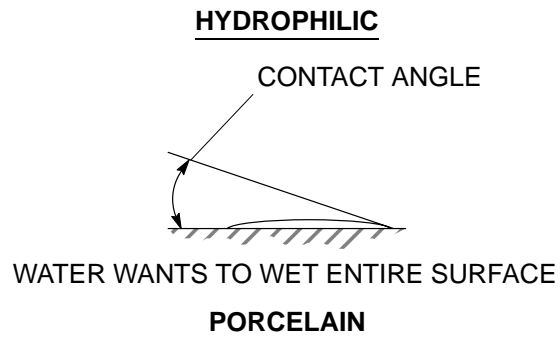


Figure 2

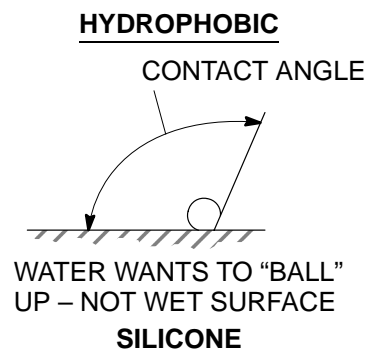


Figure 3

6. Installation Techniques

Detailed instructions are included in each kit to provide the installer with all information required to properly install the appropriately sized 3M 7640-S, 7650-S or 7660-S Series Cold Shrink™ Silicone Rubber Termination. A brief summary of the installation steps for jacketed concentric (JCN) cable is outlined as follows:

1. Prepare cable according to standard procedure.
2. Apply bottom mastic seal (*Figure 4*).

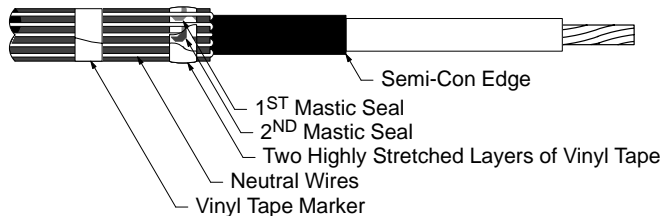
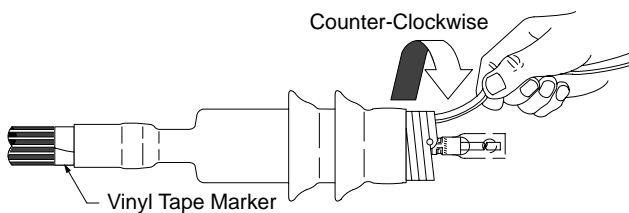


Figure 4

3. Install lug using a listed crimping tool and die.
4. Install termination onto cable and unwind core, allowing termination to shrink into place (*Figure 5*).




NOTE: The material being removed at this step is polypropylene and can be recycled with  waste.

Figure 5

5. Shelf Life

Maximum recommended storage temperature is 43°C (110°F). The termination assemblies are not affected by freezing storage temperatures. Normal stock rotation is recommended. As provided, in the expanded state, 7640-S, 7650-S and 7660-S Series terminations have an on-shelf storage life of three years from the date of manufacture.

6. Field Maintenance

Hypotting

These terminations can be field-tested by using normal cable testing procedures (reference: ANSI/IEEE Standard 400 “Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field”).

Surface Cleaning

QT-III terminations are not harmed by field surface cleaning. Established techniques for cleaning insulators and terminations in extremely contaminated areas such as high pressure water and pulverized corn cobs are acceptable.

7. Availability

3M Cold Shrink™ QT-III 7640-S, 7650-S and 7660-S Series Silicone Rubber Termination kits are available for terminating shielded power cables rated 5 through 34.5 kV. They are available from your local authorized 3M electrical distributor.

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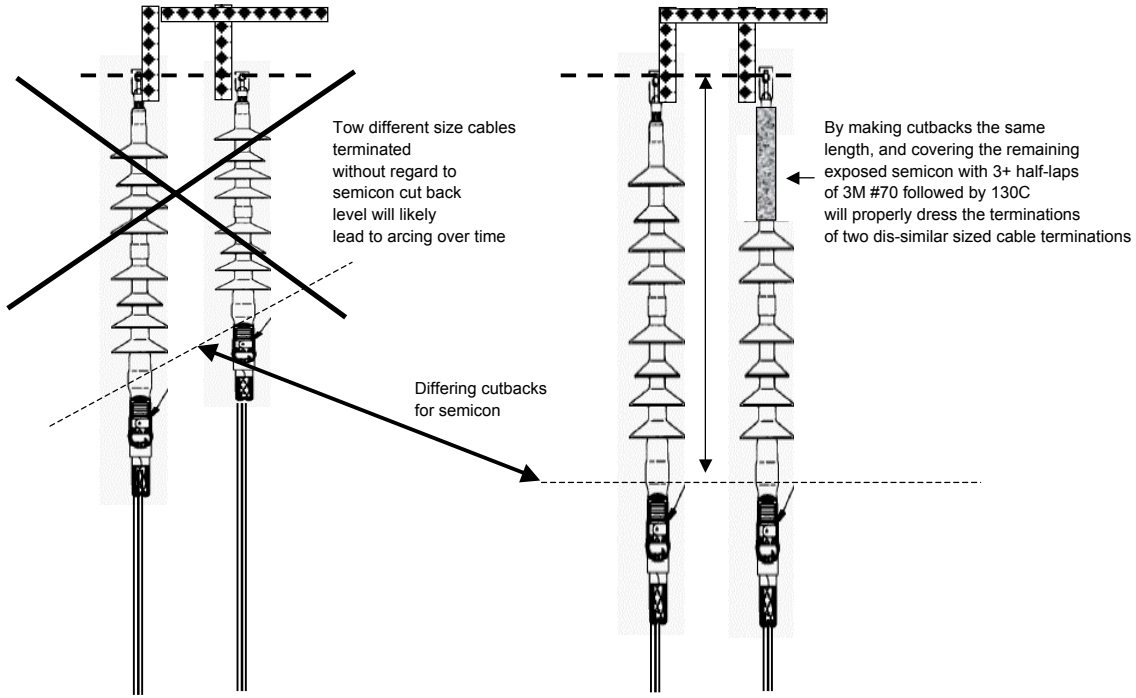


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PROPER TERMINATING OF
MULTIPLE DISSIMILAR SIZED 35 KV CABLE CONNECTIONS



When applying termination kits to varying sizes of cable at a voltage of 35 kV, care must be taken to be sure that the Semicon cut-back be very close to the same. Resultant errors will likely cause failures over time from the the arcing caused by potential differences in that area, to ground. If one cable is much smaller in size, or if the connectors have differing lengths of barrel for compression, a differential is possible. Cut both cables to the same length from the tongue of the lug to the cut back. Apply both termination kits from the cutback upward to the lug. Any semicon remaining exposed will need to be covered with an appropriate tripple layering of 1/2-lap 3M #70 silicone track-resistant tape followed by wrap of 3m# 130C. This will properly dress the termination..

If the Lug itself overlaps the edge of the connecting pad, a layer of 3M #24 shield tape followed by a layering of 3M #130C and #33 will provide a satisfactory d-edging of the connection, eliminating any problems.

