

# 3M™ Cold Shrink Splice Kits, QS-2000-3T Series



For 15 kV Trifurcating Transition Splice Kits

Data Sheet

October 2011

## Description

3M™ Cold Shrink Splice Kits, QS-2000-3T Series for 15 kV Trifurcating Transition Splice Kits are designed to splice 3-conductor PILC cable to three single conductor Poly/EPR cables. The Poly/EPR cables can be Concentric Neutral (CN), Jacketed Concentric (JCN), Tape Shield, Longitudinally Corrugated (LC), Wire Shield, Poly/EP Lead or UniShield®.

The splice kits meet the requirements of IEEE 404-1993. The oil stop is accomplished by restricting the expansion of thin wall EPDM rubber tubes with the application of a special White Restricting Tape. **The QS-2000-3T Series oil stop is designed and tested to withstand internal oil pressures to 65 PSI @110°C (212°F).** Oil Stop Tubes, QS-2000-3T Series Splice Bodies, and Jacketing Tubes are provided in an expanded state, mounted on removable inner supporting plastic cores. As supplied in this pre-stretched condition, the part is ready for field installation. During the installation, the cores are unwound, allowing the oil stop tubes, splice bodies and jacket tubes to shrink, forming tight seals.

## Kit Contents and Component Functions

Each kit contains sufficient quantities of the following materials to make one 3-conductor PILC to Poly/EPR trifurcating transition splice. Inside each kit carton the components are divided into five (5) numbered bags that correspond to the appropriate section of the kit instruction sheet. All of the components of one bag are used before proceeding to the contents of the next bag.

QS-2000-3T Series oil stop connectors are recommended for use with these splice kits:

### BAG #1:

1. **Large Cold Shrink Jacket Tube:** This semi-conductive CST is used to re-jacket the neutral connections of the shield sleeves to the lead, as well as finish the semi-conductive connection between the lead and the semi-conductive sheath seal.
2. **Plastic Sheath Seal Mold:** This blow molded plastic part is used as a mold to contain the 3M™ Scotchcast™ Electrical Insulating Resin 4. It includes stand off protrusions to allow resin to flow around the PILC cable under all circumstances. The cold shrink tube on the back is used to conform to the PILC cable and contain the resin in the mold without leaks.
3. **Cold Shrink Oil Stop Tube for Lead:** This thin wall tube is used to make an effective oil stop from the inner sheath seal onto the lead of the PILC cable.
4. **Folded Inner Sheath Seal:** This sheath seal is used to transition the oil stop from one large oil stop on the lead of the PILC cable to the three individual phase conductor oil stops.
5. **Mastic Pads:** The mastic pads in Bag #1 are used to fill voids caused by opening up the PILC cable. The mastic is packed into the breakout area and forces trapped air out during oil stop installation.
6. **Scotch® Super 33+™ Vinyl Electrical Tape:** This roll of tape is used for several miscellaneous tasks throughout the installation of the oil stop and splice joint.

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### Kit Contents and Component Functions, *continued*

QS-2000-3T Series oil stop connectors are recommended for use with these splice kits:

#### **BAG #2:**

1. Cold Shrink Oil Barrier Tubes: These three tubes are used to make the oil stop on the individual phase conductors from the folded inner sheath seal to the connectors.
2. Scotch® Linerless Rubber Splicing Tape 130C: This tape is used to fill the gap between the connectors and the insulation cutback on each of the three phase conductors. It is also used to build up the diameter of the PILC cable over the lead to meet the inner diameter of the folded inner sheath seal.
3. White Restricting Tape: This tape is used to restrict the expansion of the oil stop tubes on each of the three phase conductors and on the lead jacket of the PILC cable.
4. Outer Cold Shrink Sheath Seal: This conductive sheath seal with extended fingers is used to complete the resin mold in the breakout area, and to re-establish the semi-conductive shield on the outside of the oil stop.
5. Shield to Lead Continuity Strap: This strap is used to ensure continuity between the lead jacket of the PILC cable and the individual phase shield conductors.

#### **BAG #3:**

1. Cold Shrink Splice Jacketing Tubes: These tubes are used to re-jacket each of the three cold shrink splices.
2. Cold Shrink Splice Bodies: These splice bodies are to contain and control the electrical field of the high voltage over the connector. The semi-conductive tube on one end of the splice is to ensure proper placement of the semi-conductive shield under the splice.
3. Shield Sleeves: The copper shield sleeves are used to re-establish the metallic shield across the joint and contact all semi-conductive parts forcing their voltage potential to zero. The tubing pre-applied to the sleeve serves as a moisture barrier where the sleeve might otherwise be exposed to the elements.
4. P55/R Red Grease: The red grease is used to fill any and all voids on the cable and splice body interfaces. The grease also ensures consistent splice installation length.

#### **BAG #4:**

1. Long Mastic Strips: These strips of mastic are used to make an effective moisture seal around grounding braids, conductors, or the cable jackets.
2. Rubber Mastic Tape: This tape is used to build up cable diameters to ensure an effective moisture seal with the cold shrink re-jacket tubes.
3. U-Shaped Ground Braids: These ground braids are installed if the customer wants a ground connection to the cable joint. These braids pass through the moisture seals to attach the cable neutrals to an external ground.
4. Constant Force Springs: These springs are used to make shield sleeve and ground braid connections for certain types of cable the customer may wish to splice to.
5. Mastic Pads: The mastic pads in Bag #4 are used to make moisture seals around one end of the tubing on the shield sleeves.

## 3M™ Cold Shrink Splice Kits, QS-2000-3T Series

### Kit Contents and Component Functions, *continued*

QS-2000-3T Series oil stop connectors are recommended for use with these splice kits:

<b>BAG #5:</b>
1. <u>3M™ Scotchcast™ Electrical Insulating Resin 4</u> : This resin is used to restrict the expansion of the folded inner sheath seal in the breakout area where effective taping is impossible.
2. <u>Armorcast Wrap</u> : The Armorcast is used to mechanically hold the three splices together in a group. This protects the cured resin in the breakout from mechanical stress due to a fault on the line or personnel moving the joint around in the vault.
3. <u>Constant Force Springs</u> : These springs are used to make shield sleeve connections to the lead jacket on the PILC cable.
4. <u>Mastic Pads</u> : The mastic pads in Bag #5 are used to make moisture seals around the ends of the tubing on the shield sleeves.

### Component Functions:

#### Splice Shielding

Each splice body has an exterior semi-conductive silicone rubber installation shield. The metallic shield component for each splice body is provided by an overall copper screen sleeve equivalent to 3M™ Splice Grounding Accessory Kit SG-2. Connections to Poly/EPR cable shields and to the lead on the PILC side are accomplished using constant force springs. The springs are appropriately sized for the cable conductor sizes applicable for each kit. When PILC cable is joined to Poly/EPR cable having concentric neutral wires, a “C” or “H” style connector is recommended to make the connection between the copper sleeve wires and cable neutral wires. The copper screen sleeve and connections tested on LC shield cable has a fault current capacity of 15,000 amps for 15 cycles.

#### Cable Connectors

3M™ Scotchlok™ Oil Stop Connectors, 2000-T Series are recommended for use with 3M™ Cold Shrink Splice Kits, QS-2000-3T Series. Within this connector line, there are copper inline connectors and aluminum reducer connectors. Use copper oil stop connectors to join copper conductor cables to copper conductor cables. Use aluminum connectors to join copper to copper conductors or to join copper to aluminum cable conductors. The 3M™ Scotchlok™ Reducer Connectors, 2000T Series are aluminum for installation on copper or aluminum cable conductors. The 2000-T Series connectors meet the requirements of ANSI C119.4 tests.

#### Splice Jacketing

- Each splice body is individually jacketed with two EPDM cold shrink rubber tubes. The jacket tubes contain no chlorides or sulfurs. When parked on the cable, one tube will park over the other to minimize parking space. Mastic is used at tube ends to ensure a seal where shield sleeves extend from splice.

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## Features

- Complete kit: Everything needed to make one trifurcating splice (except connector) is included in kit. Bagged kit components correspond to sections of installation instruction.
- Cold shrink and tape design: No torches, heat guns or special tools required.
- Eliminates requirements to “sweat” lead.
- Kits accommodate a wide range of cable sizes.
- Seals tight; Stable mastics used in conjunction with cold shrink splice tubes retain resiliency and seal even after years of aging and exposure.
- Water resistant, Jacketing: Jackets meet the requirements of ANSI C119.1.
- Resists fungus.
- Resists acids and alkalis.
- Resists ozone.

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## Stress Control

Splice bodies in 3M™ Cold Shrink Splice Kits QS-2000-3T Series are molded of silicone rubber. A special high dielectric constant (High K) silicone compound is used to control the electric field in the splice. By controlling the electric field, the stress concentration at the end of the cable insulation shield is less than 15 V/mil, as compared to 50 V/mil at the shield and about 70 V/mil at the conductor, in the shielded portion of a 15 kV cable. **The stress in QS2000-3T Series splice bodies is less than in the cable insulation under the shielded portion of the cable.**

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## Applications

3M™ Cold Shrink Splice Kits, QS-2000-3T Series can be used on PILC cables with an operating temperature of 90°C (194°F) and an emergency overload rating of 110°C (230°F) (reference AEIC NO.1). These kits meet the requirements of 15 kV in IEEE Standard Test Procedures and Requirements for High Voltage Cable Splices (IEEE Standard 404-1993). The current rating of QS-2000-3T Series kits splices meet the current rating of PILC cables. The kits will accommodate the following cable sizes:

Kit Number	PILC Cable Conductor Size Range	Poly/EPR Cable Conductor Size Range	Poly/EPR Cable Insulation OD Range
QS-2011-3T	4 – 3/0 AWG (25 – 95 mm <sup>2</sup> )	1 – 4/0 AWG (50 – 120 mm <sup>2</sup> )	0.70” – 1.07” (17,8 – 7,2 mm)
QS-2012-3T	3/0 AWG – 350 kcmil (70 – 195 mm <sup>2</sup> )	4/0 AWG – 500 kcmil (100 – 240 mm <sup>2</sup> )	0.88” – 1.36” (22,0 – 34,6 mm)
QS-2013-3T	400 – 800 kcmil (200 -400 mm <sup>2</sup> )	500 – 1000 kcmil (240 – 500 mm <sup>2</sup> )	1.12” – 1.70” (28,0 – 43,0 mm)

The QS 2000-3T Series kits can be used to splice three (3) conductor (3/C) PILC cable (having either round or sector shaped conductors) to the following single conductor (1/C) cable types:

- CN (Concentric Neutral) cable
- JCN (Jacketed Concentric Neutral) cable
- LC (Longitudinal Corrugated shield) cable
- UniShield® cable (registered trademark of General Cable Technologies, Inc.)
- Tape shield cable
- Wire shield cable
- EP-Lead or XLP-lead

## 3M™ Cold Shrink Splice Kits, QS-2000-3T Series

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### Oil Stop and Sheath Seal

The oil stop and seals use 3M patented concepts. On each phase conductor, an oil stop is obtained by installing a thin wall EPDM rubber cold shrink tube. The expansion of the rubber is restricted by applying White Restricting tape. The seal at the end of the lead is accomplished by applying multiple wraps of Scotch® Linerless Rubber Splicing Tape 130C at the end of the lead and covering the tape with a thin wall EPDM rubber cold shrink tube. The expansion of tape and tube is restricted with White Restricting Tape. An inner sheath seal boot is used to transition the seal to the three phase conductors. 3M™ Scotchcast™ Electrical Insulating Resin 4 is injected between the inner boot and an outer boot and plastic sheath seal mold. Continuity between the phase conductor shields and lead is ensured with a copper strap and constant force spring assembly.

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### References

*“Studies on the Diffusion of Cable Oil Through Elastomeric Materials for Splices and Terminations”* by Dr. R. Garcia-Ramirez of 3M;

The paper discusses the oil stop design using elastomeric EPDM rubber applied directly to the oil/paper insulated cable layers and restricting the expansion of the rubber using restricting tape. Since the restricting tape prevents the rubber from swelling, the oil does not cause any chemical degradation of the elastomer even under the most severe cable rated conditions of temperature and mechanical stress. This paper was presented at the IEEE T&D Conference and Exposition Los Angeles, CA, Sept. 15-20, 1996 as part of *IEEE Transactions on Power Delivery*.

*“New Oil Stop Contains High Pressure of PILC Cables.”*

Co-authored by William L. Taylor of 3M and Gary D. Hendley of TU Electric;

The paper discusses the different types of oil found in PILC cables in the US and the pressures that can be generated in the cables from thermal expansion of the oil contained in the cables. The oil expanding when heated from current in the cable and ambient temperatures can cause pressures in excess of 100 PSI in some cables. Vacuums as high as 20 inches of mercury can also occur in these cables. 3M's oil stop is designed to contain both the high pressures and the vacuum without leaking oil or allowing moisture into the cable. This paper was presented at the IEEE T&D Conference and Exposition, Los Angeles, CA, Sept. 15-20, 1996.

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### Product Specifications

#### Open Specifications

The splice must be a 15 kV Class device capable of trifurcating Paper Insulated Lead Covered (PILC) cable to three single conductor Poly/EPR insulated cables and meet the requirements of IEEE 404-1993. The splice must provide an effective way to seal and contain the cable oil inside the PILC cable up to pressure of 65 psi. without the need of heat or solder. The splice bodies must each be a one-piece, molded silicone rubber device mounted on a removable inner supporting plastic core. Shielding and jacketing is to be provided for each splice body that again installs without the need of heat or solder. The splice bodies should nest together in an unstaggered manner. A component that installs without the need of heat is to be provided for the purpose of holding the jacketed splice bodies in nested position. The splice must be capable of continuous operation at 90°C (194°F) with an emergency overload rating of 110°C (230°F).

#### Closed Specification

Trifurcate transition splice all 15 kV Class 3-conductor PILC cable, in accordance with instructions provided with 3M™ Cold Shrink Splice Kits, QS-2000-3T Series. The kits will splice 3-conductor PILC cables sized 4 AWG – 800 kcmil to Poly/EPR insulated cable sizes 1 AWG – 1000 kcmil. Either cable type could have copper or aluminum conductors.

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# 3M™ Cold Shrink Splice Kits, QS-2000-3T Series

## Performance Tests

Typical Results per IEEE Std. 404 Test		
IEEE Std. 404 Test	QS-2000-3T Series Splice	
	Requirement	Result
6 hr. AC Withstand (kV-RMS)	35	Pass
15 minute DC Withstand (kV-DC)	55	Pass
BIL, room temperature, kV-Crest/Surges	+110/10 -110/10	Pass
BIL, 110°C (230°F), kV-Crest/Surges	+110/10 -110/10	Pass
30 Day Cyclic Aging @ 110°C (230°F), AC Withstand (kV)	In Water 17.4 In Air 17.4	Pass
High-Voltage Time 6 hr. AC Withstand in Water (kV-RMS)	35.0	Pass
Connector: Thermal/Mechanical	ANSI C119.4 – 1991	Pass

### Pressure Tests

The 3-conductor PILC cable develops internal pressure as the cable is heated by the transmission of current. The emergency overload temperature rating of PILC cable is 110°C (230°F). As determined by early tests, the worst possible case for containing the pressure is when the cable is at the emergency overload temperature. Pressure tests were conducted on cables by cycling current long enough to ensure that the cable and breakout arrangement were stable at emergency overload temperature.

The test is a cyclic aging test that runs for a minimum of 7 days. The conductors are heated for 12 hours each day at the current which will give a stable conductor temperature of 110°C (230°F). The conductors are then allowed to cool for 12 hours each day. Pressure is applied for 8 hours each day, and relieved for 16 hours each day. Observation for oil leaks are made throughout the test. If any leaks are detected, the test is terminated.

### Pressure Test Results

Unit Number	Conductor Size	Current (Amps)	Peak Temperature of Lead	Pressure Applied	Test Results
1	500 kcmil	710	80°C (176° F)	65 psi	No Oil Leak
2	500 kcmil	705	75°C (167° F)	65 psi	No Oil Leak

Four samples of the breakout design (two breakouts per unit) held 65 psi for the test period required. The 3M™ Scotchcast™ Electrical Insulating Resin 4 did not soften at temperature, nor did it yield to the 65 psi internal pressure. The three layers of restricting tape held the internal pressure on each of the three conductors as they came out of the breakout arrangement. The 3M breakout design holds internal pressure up to 65 psi at emergency overload temperatures for extended periods of time.

The IEEE Std. 404-1993 requires all transition joints to compete a 30 day cyclic aging test at a conductor temperature of 110°C (230°F). This test doesn't include any pressure data, but we have seen 3-conductor PILC cables at 110°C (230°F) build up pressure in excess of 40 psi. Twelve 3M transition joints (each including one breakout), six in water and six in air, passed this test without leaking oil.

## 3M™ Cold Shrink Splice Kits, QS-2000-3T Series

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### 3M™ Scotchlok™ Connectors 2000T Series

#### 3M™ Scotchlok™ Reducer Connectors 2000T Series

The 3M™ Scotchlok™ Reducer Connectors 2000T Series are aluminum inline sleeves that are applicable for both aluminum and copper conductors for use with 3M™ Cold Shrink Splice Kits, QS-2000-3T Series. The barrel diameters at connector ends are different, to allow connecting conductors of different size.

They can be used on concentric, compressed and compact strand conductors. When used with sector shaped conductors, a rounding die is recommended to round-out the sector shape. These connectors have a solid center oil stop and meet ANSI Standard C-119.4.

Aluminum Reducer Connectors Conductor Size (AWG/kcmil)		
Connector Number	O.D. (inch)	Length (inch)
2000T 2-1/0 CU/AL	0.640	4.740
2000T 1/0-2/0 CU/AL	0.910	4.700
2000T 2/0-4/0 CU/AL	0.910	4.700
2000T 4/0-350 CU/AL	1.125	4.700
2000T 250-350 CU/AL	1.125	4.690
2000T 350-500 CU/AL	1.320	4.700
2000T 500-750 CU/AL	1.600	6.250
2000T 500-1000 CU/AL	1.625	6.250
2000T 750-1000 CU/AL	1.625	6.250

**Connectors for cable sizes not listed are available with approval.**

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## 3M™ Cold Shrink Splice Kits, QS-2000-3T Series

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### 3M™ Scotchlok™ Connectors 2000T Series

#### 3M™ Scotchlok™ Connectors 2000T Series

The 3M™ Scotchlok™ Connectors 2000T Series connectors are copper inline sleeves for use with copper conductors cables of the same size with 3M™ Cold Shrink Splice Kits, QS-2000-3T Series. They can be used to connect copper cable to copper cable only.

They can be used on concentric, compressed and compact conductors. When used with sector shaped conductors, a rounding die is recommended to round-out the sector shape. These connectors have a solid center oil stop and meet ANSI Standard C-119.4.

Copper Connectors Conductor Size (AWG/kcmil)		
Connector Number	O.D. (inch)	Length (inch)
2000T -2 CU	0.700	5.320
2000T -1/0 CU	0.700	5.320
2000T -2/0 CU	0.700	5.320
2000T -4/0 CU	0.880	5.250
2000T -250 CU	0.880	5.250
2000T -350 CU	0.875	5.250
2000T -400 CU*	1.125	6.900
2000T -500 CU	1.125	6.900
2000T -750 CU	1.299	6.900
2000T -1000 CU	1.500	6.900

**\*No quantity of this connector size is maintained. Connector is available with 12 week lead time.**

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#### Shelf Life & Storage

As provided in the expanded state, the QS-2000-3T Series Splice Kits have an on-shelf life of 3 years from date of manufacture when stored in a humidity controlled storage (10°C/50°F to 27°C/80°F and <75% relative humidity).

Kit components are not impaired by freezing, however, they should be warmed to at least 32°F (0°C) before installing.

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#### Availability

Please contact your local distributor; available from [3M.com/electrical](http://3M.com/electrical) [Where to Buy] or call 1-800-245-3573.

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