

# 3M™ Cold Shrink Splice Kits

## QS2000-3T-WS Series

## For 15kV Trifurcating Transition Splice Kits

### Data Sheet

#### 1.0 Product Description

3M™ Cold Shrink Splice Kit QS2000-3T-WS series for 15 kV Trifurcating Transition Splice Kits are designed to splice three conductor PILC cable of belted or shielded design to three single conductor poly/EPR cables. The poly/EPR cables can be Concentric Neutral (CN), Jacketed Concentric Neutral

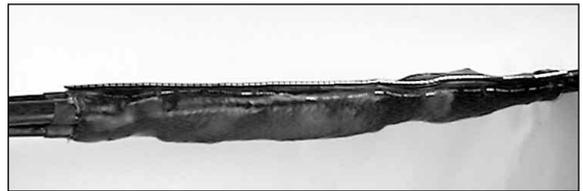
(JCN), Tape Shield, Longitudinally Corrugated (LC), Wire Shield, poly/EP Lead or UniShield®. **The splice kits meet the requirements of IEEE 404.** The oil stop is accomplished by restricting the expansion of thin wall EPDM rubber tubes with the application of a special White Restricting Tape. **The oil stop for these kits is designed and tested to withstand internal oil pressures to 65 PSI and hold 18 inches mercury vacuum.** Oil Stop Tubes and Splice Bodies in all kits install without the need of heat. The splice area is jacketed with an overall heat shrink wraparound jacketing sleeve. The wrap sleeve in combination with a heat shrink three finger breakout boot, install using a torch.

#### 2.0 Stress Control

Splice bodies in the 3M splice kit QS2000-3T-WS 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 15V/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 3M splice kit QS2000 splice bodies is less than in the cable insulation under the shielded portion of the cable.**

#### 3.0 Oil Stop and Sheath Seal

The oil is contained in PILC cable by installing a thin wall EPDM rubber Cold Shrink tube over each phase conductor and over the end of the cable lead. Scotch® Linerless Rubber Splicing Tape 130C is used to smooth the transition at connector ends and at the end of the Lead. White Restricting Tape is applied over the tape and tubes in contact with the cable oil to help prevent expansion of the rubber. An inner sheath seal boot is used to transition the seal from the end of the lead to the conductors.



Completed Splice

3M™ Scotchcast™ Electrical Insulating Resin 4N is injected between the inner boot and an outer boot and plastic sheath seal mold to help prevent the rubber from expanding where restricting tape is not applied. Continuity between the phase conductor shields and lead is ensured with a copper strap and constant force spring assembly.

#### 4.0 References

*"Studies on the diffusion of cable oil through elastomeric materials for splices and terminations"* by 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, September 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, September 15-20, 1996.

## 5.0 Kit Component Functions

Each kit contains sufficient quantity of material to make one three conductor PILC to Poly/EPR trifurcating transition splice. Inside each 3M™ Cold Shrink Splice Kit QS2000-3T-WS carton, the components are divided into four numbered bags. Each bag is numbered to correspond to 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.

3M™ Scotchlok™ Oil Stop Connectors 2000T series are recommended for use with these splice kits, however kits are not restricted to their use.

### 5.1 Bag #1

All of the components in bag #1 are used at the end of the PILC cable lead to seal and contain the oil inside the PILC cable.

### 5.2 Bag #2

The components in bag #2 are used to seal the phase conductors of the PILC cable. A shield to lead continuity strap is also included to ensure continuity between the lead of the PILC cable and the shield of the individual phase conductors. The continuity assembly is not used when installation is on belted cable.

### 5.3 Bag #3

Cold Shrink splice bodies, an overall shield sleeve and heat shrink breakout boot are in bag #3. The splice bodies 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. The breakout boot is used with the wraparound heat shrink jacket sleeve to seal the end where the Poly/EPR cables exit the splice.

### 5.4 Bag #4

Moisture sealing mastic materials, ground braid connectors and copper ground braids are in bag #4. The mastic components are used to make seals at Poly/EPR cable jacket ends. Ground braid connections are made using constant force springs or overlap connectors depending on the cable shield type.

### 5.5 Other Components

3M™ Scotchcast™ Electrical Insulating Resin 4N and a heat shrink wrap-around jacket sleeve are included in the kit carton, external from the bagged components. The Scotchcast resin is used to restrict the expansion of the inner sheath seal in the breakout area where effective taping is impossible. The wraparound sleeve is used to jacket the entire splice area. A torch is required to shrink the sleeve.

## 6.0 Splice Shielding

Each splice body has an exterior semi-conductive silicone rubber insulation shield. Two shield braids are provided for each phase, plus all of the splices are covered with one overall shield sleeve. Constant force springs are provided in kits to make connections to the lead and to Poly/EPR tape

or LC type shields. Overlap connectors are provided in kits to make connections to cables with wire shields.

The combined braids for each phase of a QS2011-3T-WS splice have an area of 43,200 cir. mils.

Braids in the QS2012-3T-WS, QS2013-3T-WS and QS2012-13-3T-WS have a combined area of 81,600 cir. mils per phase.

The shield sleeve that covers all three splice bodies in the QS2011-3T-WS kit has an area of 61,000 cir. mils.

The other splice kits in the series have a shield sleeve having an area of 72,000 cir. mils.

## 7.0 Cable Connectors

Scotchlok connector 2000T series are recommended for use with 3M splice kit QS 2010-3T-WS series. Within this connector line, there are copper inline connectors, aluminum inline connectors and aluminum reducer connectors. Use copper oil stop connectors to join copper conductor cables to copper conductor cables of the same size. Use aluminum connectors to join copper to copper conductors or to join copper to aluminum cable conductors. The Scotchlok connector 2000T series are aluminum for installation on copper or aluminum conductors. The Scotchlok connectors 2000T series meet the requirements of ANSI C119.4 tests.

## 8.0 Splice Jacketing

The spliced conductors are jacketed with one 3M™ Wraparound Heat Shrink Sleeve. The 3M wraparound heat shrink sleeve HDCW is made from modified cross-linked polyolefin, with a hot-melt adhesive liner on the inner side of the sleeve. Upon heating, the sleeve shrinks and adhesive melts, creating a water-tight bond between sleeve and mastic sealing collars installed around cables at sleeve ends. 3M wraparound heat shrink sleeves meet HDCW ANSI C119.1 requirements.

### 8.1 Features

- Complete kit: Everything needed to make one trifurcating splice (except connectors) are included in kit. Bagged kit components correspond to section of installation instruction.
- Cold Shrink factory tested splice bodies. No torches, heat guns or special tool are required when installing splice bodies.
- Kits have a heat shrink wraparound jacket sleeve: Installs in tight manholes where parking space on cable is minimal. Requires a torch for installation.
- Eliminates requirement to "sweat" lead.
- Kits accommodate a wide range of cable sizes.
- Seals tight: Stable mastics used in conjunction with heat shrink jacket sleeve 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

## 9.0 Applications

The 3M™ Cold Shrink Splice Kit QS2000-3T-WS series can be used on PILC cables with an operating temperature of 90°C and an emergency overload rating of 110°C (reference AEIC #1). These kits installed on shielded or belted PILC cables meet the requirements for 15 kV in IEEE Standard Test Procedures and Requirements for High Voltage Cable Splices (IEEE Standard 404). The current rating of 3M splice kit QS2000-3T-WS meet the current rating of PILC cables. 3M cold shrink splice kits will accommodate the following cable sizes:

Product	PILC Cable Size Range	Poly/EPR Cable Size Range	Poly/EPR Cable Insulation OD Range
QS2011-3T-WS	#4 - 3/0 AWG (25-95 mm <sup>2</sup> )	#2-4/0 AWG (50 - 100 mm <sup>2</sup> )	0.64" - 1.07" (16,3 - 27,2 mm)
QS2012-3T-WS	3/0 AWG - 250 kcmil (70 - 120 mm <sup>2</sup> )	4/0 AWG - 500 kcmil (100 - 240 mm <sup>2</sup> )	0.88" - 1.36" (22,0 - 34,6 mm)
QS2012/13-3T-WS	350 - 500 kcmil (195 - 240 mm <sup>2</sup> )	250 - 500 kcmil (120 - 240 mm <sup>2</sup> )	0.91" - 1.36" 23,0 - 34,6 mm

3M™ Cold Shrink Splice Kit QS2000-3T-WS series can be used to splice three (3) conductor PILC cables (having either round or sector shaped conductors) to the following single (1) conductor cable types:

- CN (Concentric Neutral) Cable
- JCN (Jacketed Concentric Neutral) Cable
- LC (Longitudinal Corrugated Shield) Cable
- Unishield® Cable (registered trademark of BICC)
- Tape Shield Cable
- Wire Shield Cable
- EP - Lead or XLP - Lead

### Typical Results per IEEE Std. 404 Test

IEEE Std. 404 Test	IEEE Std. 404 Test	QS 2000-3T Series Splice Requirement	Result
6 Hour AC Withstand (kV-RMS)		35	Pass
15 minute DC Withstand (kV-DC)		55	Pass
BIL (room temperature)			
(kV-Crest/Surges)		+110/10	Pass
(kV-Crest/Surges)		-110/10	Pass
BIL (110°C)			
(kV-Crest/Surges)		+110/10	Pass
(kV-Crest/Surges)		-110/10	Pass
30 Day Cyclic Aging @ 110C		In Water 17.4	Pass
AC Withstand (kV)		In Air 17.4	Pass
High-Voltage Time			
6 Hour AC Withstand in Water (kV-RMS)		34.8	Pass
Connector			
Thermal/Mechanical		ANSI C119.4-1991	Pass

## 10.0 Pressure Tests

The three 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. 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 seven (7) days. The conductors are heated for 12 hours each day at the current which will give a stable conductor temperature of 110°C. 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

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

## 11.0 Pressure Test Results

Four samples of the breakout design (two breakouts per unit) held 65 PSI for the test period required. The 3M™ Scotchcast™ Electrical Insulating Resin 4N 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 three conductor breakout design holds internal pressure up to 65 PSI at emergency overload temperatures for an extended period of time.

The IEEE Std. 404 requires all transition joints to complete a 30 day cyclic aging test at a conductor temperature of 110°C. This test doesn't include pressure data, but we have seen three conductor PILC cables at 110°C build up pressure in excess of 40 PSI.

Twenty-four 3 conductor transition joints, twelve on shielded cable and twelve on belted cable (each including one breakout), twelve in water and twelve in air, passed this test without leaking oil.

## 12.0 3M™ Scotchlok™ Connector 2000T Series

Scotchlok connector 2000T series connectors are aluminum inline sleeves that are applicable for both aluminum and copper conductors for use with 3M Cold Shrink Splice Kits QS2000-3T. They can be used on concentric, compressed and compact stand conductors. When used with sector-shaped conductors, a rounding die is recommended to round out sector shape. These connectors have a solid center oil stop and meet ANSI Standard C-119.4.

### Aluminum Reducer Connectors Conductor Size (AWG/kcmil)

<b>Connector Number</b>	<b>O.D. (inch)</b>	<b>Length (inch)</b>
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 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

\* No quantity of this connector size is maintained. Connector is available with 12 week lead time.  
Connectors for cable sizes not listed are available with approval.

### 13.0 3M™ Scotchlok™ Connector 2000T

Scotchlok connector 2000T series are copper inline sleeves for use on cables with copper conductor of the same size.

They can be used to connector copper cable to copper cable only.

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

#### Copper Inline Connectors Conductor Size (AWG/kcmil)

Connector Number	O.D. (inch)	Length (inch)
2000T-2 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-500 CU	1.125	6.900
2000T-750 CU	1.299	6.900

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

## 14.0 Specifications

### 14.1 Open Specification

The splice must be a 15 kV class device capable of trifurcating 15 kV Paper Insulated Lead Covered (PILC) cable of shielded or belted design to three single conductor 15 kV Poly/EPR insulated cables and meet the requirements of IEEE 404. The splice must provide an effective way to seal and contain the cable oil inside the PILC cable up to a pressure of 65 PSI without the need for solder or lead wiping. The splice bodies must each be a one-piece, molded silicone rubber device mounted on a removable inner support core. Shielding and jacketing is to be provided for splice bodies that install without the need of solder. The splice bodies should nest together in an unstaggered manner. The splice must be capable of continuous operation at 90°C with an emergency overload rating of 110°C.

### 14.2 Closed Specification

Trifurcate transition splice all 15 kV class three conductor PILC cable in accordance with instructions provided with 3M™ Cold Shrink Splice Kits QS2000-3T-WS series. Kits will splice three conductor PILC cable sizes 4 AWG - 500 kcmil to Poly/EPR insulated cable sizes 2 AWG - 500 kcmil. Either cable type could have copper or aluminum conductors.

## 15.0 Maintenance

3M Cold Shrink Splice Kits QS2000-3T-WS are packaged one splice per carton. These kits have a shelf life of three years from date of manufacture. Each splice carton is day coded with the manufactured date. Maximum recommended storage temperature is 110°F (43°C).

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