

Heat-shrinkable joints for transitions from MIND paper insulated cables to plastic insulated cables up to 17.5 kV

With the introduction of heat-shrinkable cable accessories in the nineteen sixties, we created the first jointing system inherently suitable for both paper and plastic insulated cables at medium voltages. The increasing range of new cable constructions, rising installation costs, and shortage of experienced cable fitters led to wide adoption of our technique with its easy, fast installation and universal applicability. Experience with the large numbers of Raychem accessories that have now been in service for up to 30 years has demonstrated their long-term reliability in some of the severest field conditions. Development work to extend the benefits of our technique to cable joints resulted in a series of joints for paper cables up to 17.5 kV and plastic cables up to 36 kV, all based on heat-shrinkable materials and installed according to the same principles as Raychem terminations.

The heat-shrinkable components of Raychem joints have carefully controlled electrical characteristics, and are cross-linked in an electron beam. The resulting „elastic memory“ allows them to be supplied in an expanded form, and easily positioned on the cable. Heating then causes the components to shrink in diameter to a pre-determined size, tightly fitting the cable. This heat-shrinkable feature allows each joint to be used on a range of cable sizes of either round or sectorshaped construction with different screen types and varying manufacturing tolerances. No compounds or resins, special tools or heavy equipment are required, installation being carried out with a commonly-available gas torch, while the heat-shrinkable components' „memory“ automatically ensures the cable fitter obtains the required insulation wall thickness.



User experience with our system on both paper and polymeric cables has confirmed it as a reliable and efficient technique for jointing plastic insulated cables to existing paper cable networks.

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Construction and electrical design

Screening and sealing of the paper cable

Key to the design was the requirement for a fully screened joint lightweight enough to be installed without heavy equipment. Heat-shrinkable tubings are used to protect the cores, and a filler is applied in the cable crutch under the shrinking action of a breakout. This procedure is already familiar from the Raychem termination system. In this case, however, the tubing and breakout are both of conductive polymer, making a continuous screen over the cable crutch and each core. The paper cable is thus sealed and free from electrical stress between the phases, without requiring any poured filling medium.

1 Additional insulation

The insulation provided by the belt papers is replaced with clear tubing shrunk over the insulation papers of each core.

2 Screening

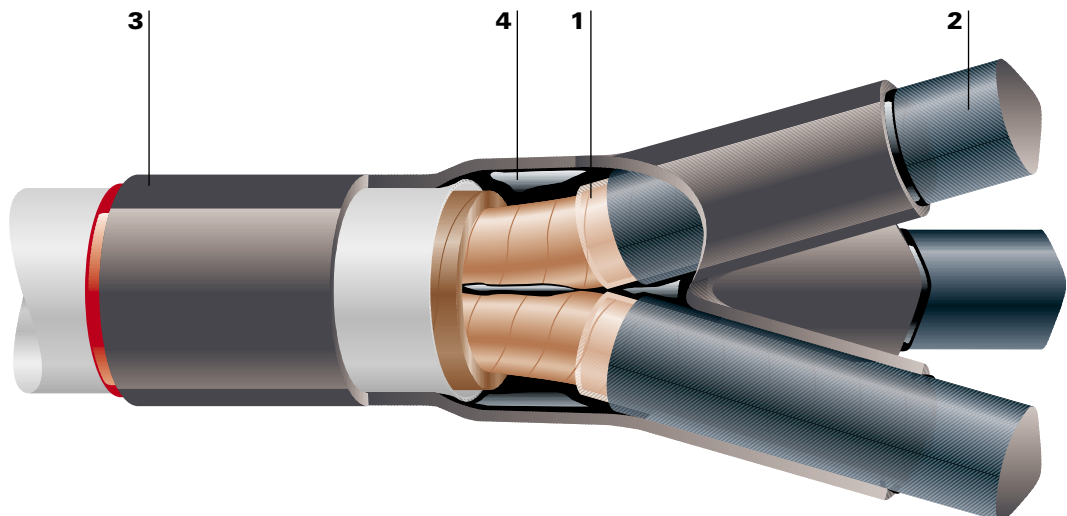
To avoid the use of compound or resin, electrical stress between the cores is eliminated by screening each phase individually. This is achieved with heat-shrinkable tubing made of an electrically conductive polymer. An electrical connection to the lead sheath at earth potential is made by the heat-shrinkable breakout, which is also of conductive material.

3 Sealing

The breakout is supplied in an expanded form with sealants pre-coated on the inside of the openings. The heat used to install the breakout melts the sealants, which then flow into place under the shrinking action. This technique for protecting paper cables from moisture is quick, easy and reliable, as wide adoption of our system has shown.

4 Cable crutch filling

To apply insulating filler in the cable crutch, the shrinking action of the breakout is utilized. This approach forces air out to prevent discharge. After installation, the breakout holds the filler in place to resist thermally-induced internal cable pressure.



Double seal

In the connector area additional adhesive-lined heat-shrinkable sleeves are used to keep moisture out of the paper insulated cable. The heat of installation causes the adhesive to melt and flow, sealing the connector insulating components against any water penetration from the plastic cable side.



Ease of installation

The components for insulation, screening and electrical field control in the connector area are supplied pre-packed in the correct nested sequence to be slid over the cable core ends. After joining the conductors and smoothing the connector area with a special void filler, each tubing in turn is positioned over the connector and shrunk into place. The heat-shrinkable components permit conductor joining by a variety of methods and accommodate different screen constructions. As no compound or resin are used, the trench may be back-filled and the joint taken into service immediately.

5 Electrical field control

Heat-shrinkable tubing with a precisely defined impedance characteristic smoothes the electrical field over the connector and screen ends. The shrinking action during installation causes the special low viscosity void filler to flow into position round the connector area at the same time. Pencilling of the polymeric conductor insulation at the connector is not necessary.

6 Insulation

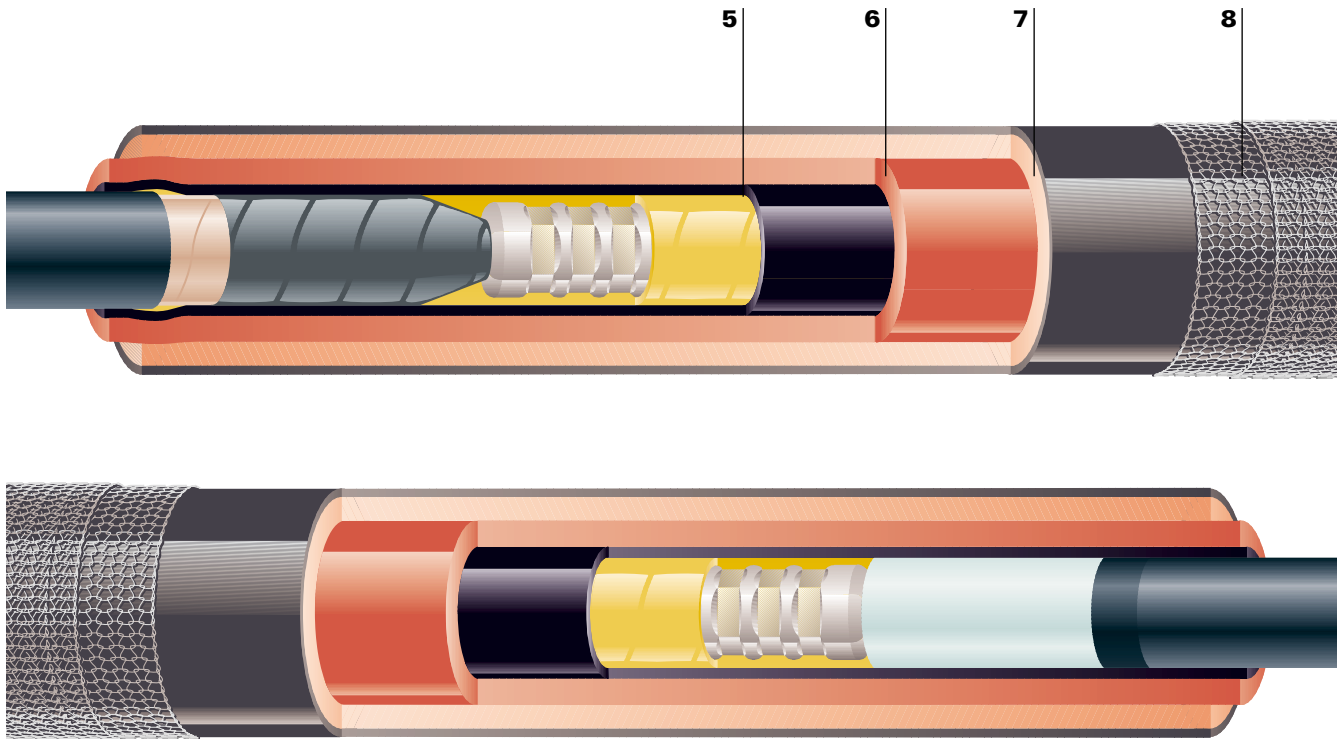
The conductor insulation is restored with high voltage insulating tubing. The material's elastic heat-shrink memory ensures the correct insulation thickness, without requiring special attention from the installer.

7 Insulation screen

A single dual-wall tubing enables the final insulating layer (red) to be installed complete with a conductive polymeric screen (black). This technique saves time and ensures a flawless bond between insulation and screen.

8 Metallic shielding

Copper braid connects the metal shield of the plastic cable to the paper cable's lead sheath, and makes electrical contact with the outer screen of the joint.



Mechanical strength

The proven mechanical and sealing strength of Raychem heat-shrinkable tubings and adhesives is utilized to restore the impact and corrosion protection of the cable oversheath. Additional strength and earth fault capacity for armoured cables is provided by a lightweight composite joint case with a galvanized steel liner.



Minimum performance for Raychem joints for transitions from MIND paper insulated cables to plastic insulated cables up to 17.5 kV

Test Sequence		Test Voltage			Result
		Highest Voltage for Cable U_m [kV]			
		7.2	12	17.5	
Impact	4 kg wedge dropped 6 times from 2 m armoured cables only				no functional damage
A.C. Voltage Withstand	1min	27	35	45	no breakdown and no flashover
Impulse Voltage Withstand	10 positive and 10 negative, 1.2/50 μ s, between conductor and grounded screen	70	95	110	no breakdown and no flashover
Load Cycling	63 cycles 5h heating, 3h cooling Conductor temperature: Paper cables: 75°C	6.5	11	15	no breakdown and no flashover
Thermal Short Circuit	1 s symmetrical fault with conductor temperature as for cable specification 1 s earth fault with sheath temperature as for cable specification				no visible signs of damage
Load Cycling	as above with cable in 1 m water	6.5	11	15	no breakdown and no flashover
A.C. Voltage Withstand	4h	14	24	36	no breakdown and no flashover
Impulse Voltage Withstand	repeat	70	95	110	no breakdown and no flashover
D.C. Voltage Withstand	30 min	28	48	72	no breakdown and no flashover
Dynamic Short Circuit	63 kA				no visible signs of damage
Notes:	1. U_m is the highest phase to phase voltage. All other voltages are stated as phase to ground values. 2. Further details are given in Raychem specification PPS 3013.				

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