3M Science. Applied to Life.™

THORNE & DERRICK INTERNATIONAL

+44 (0) 191 410 4292 uksales@thorneandderrick.co.uk powerandcables.com

We have your solution.

From start to finish, 3M provides reliable solutions to help you solve your challenging electrical installations for the renewable industry.

Presenter Name

Date

Agenda

- 3M Electrical Solutions for the Renewables Construction Projects
- Comparison of Medium Voltage Accessory Technologies
- Application Solutions
- 3M Services
- Conclusion

3M Electrical Solutions for Renewable Construction Projects


3M Science.
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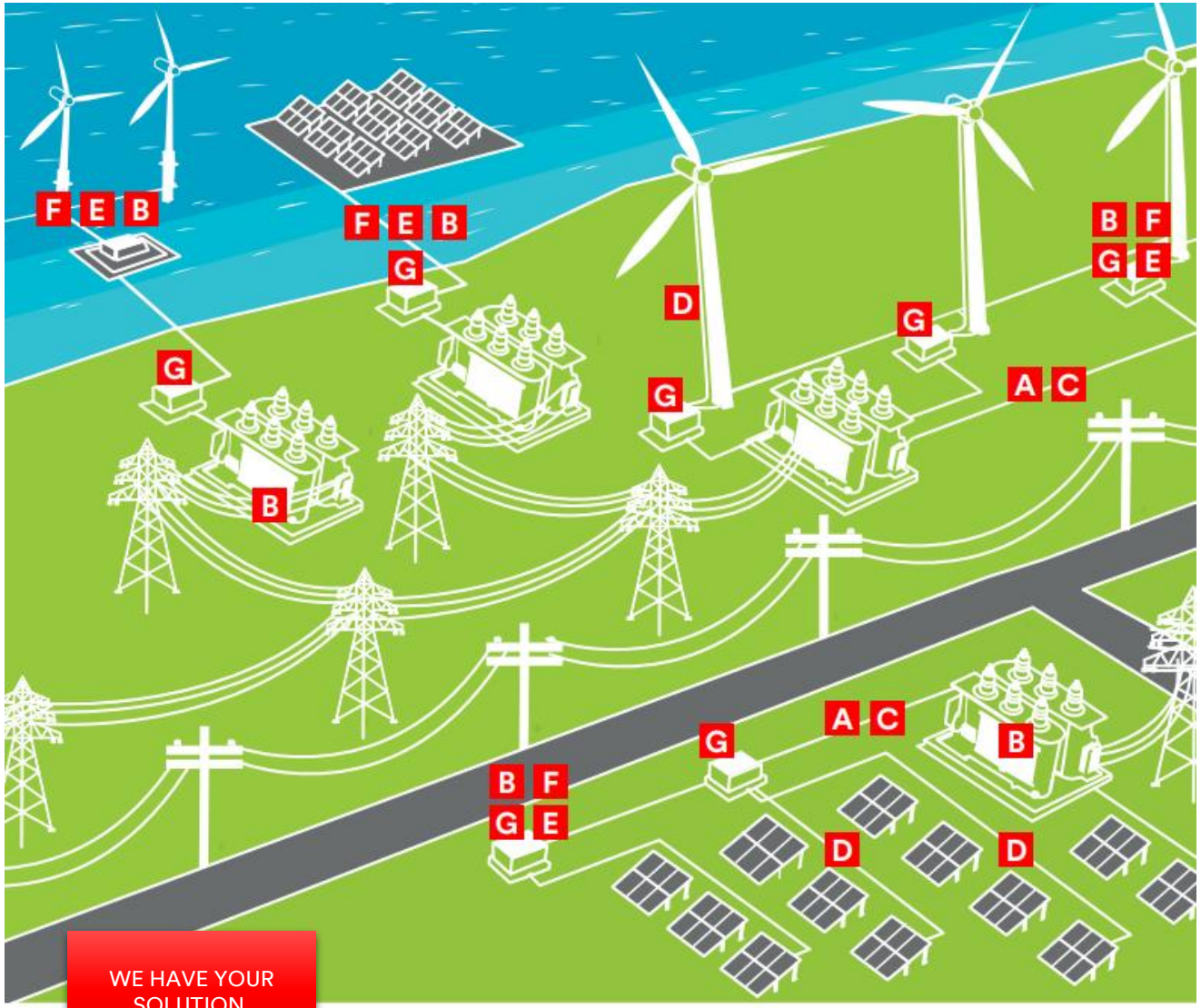
Renewable energy sources
and infrastructure are crucial

Renewables Construction Projects Overview



A 3M™ Cold Shrink Medium Voltage splice kit QS200 12-36 kV

B 3M™ Cold Shrink QT-II or QT-III Termination Kit 12-36 kV

C 3M™ Separable Connector Kit 12-36 kV

D 3M™ Cold Shrink Connector Insulators 1000 V

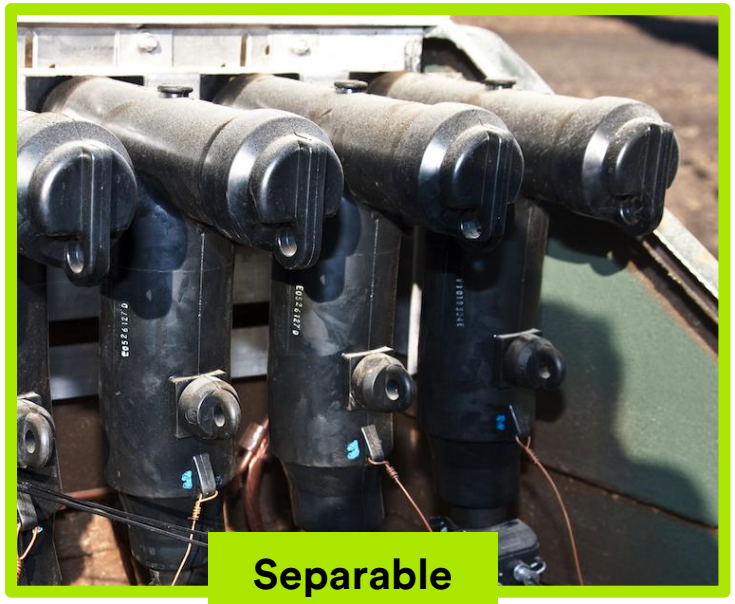
E 3M™ Cold Shrink High Voltage Splice kit QS3000 72.5 kV

F Cold Shrink High Voltage Termination kit QTEN Series 72.5 kV

G 3M™ Sensored Cable Accessories (SCA)

3M Power Cable Accessories

Splices



Separable Connectors

Terminations

Comparing Cable Accessories Technology

Cold Shrink vs. Heat Shrink

Safety:

Cold shrink does not carry the same safety concerns as heat shrink, which sometimes requires shutting down a facility before an installation to minimize the danger of explosions from combustible gasses.

Time Savings:

Cold shrink kits have minimal parts, which means fewer installation steps.
This helps minimize the chance for errors and reduces installation time, resulting in low failure rates.
Heat shrink torches require a hot work permit, which further increases the time and cost of each installation.

Installation:

Cold shrink offers consistent installation, independent of physical location. The cold shrink cord design allows for easy application. There are no special tools or heat sources required, which can be an advantage when installing in tight places such as switch-gear and joint bay/excavation, or in inclement weather conditions.

Electrical Performance:

Silicone cold shrink is UV resistant, water repellent, and chemical resistant, which help contribute to low failure rates.
3M's cold shrink splices produced failure rates of 0.067% and 0.022% for cold shrink terminations in a 2013 study*.

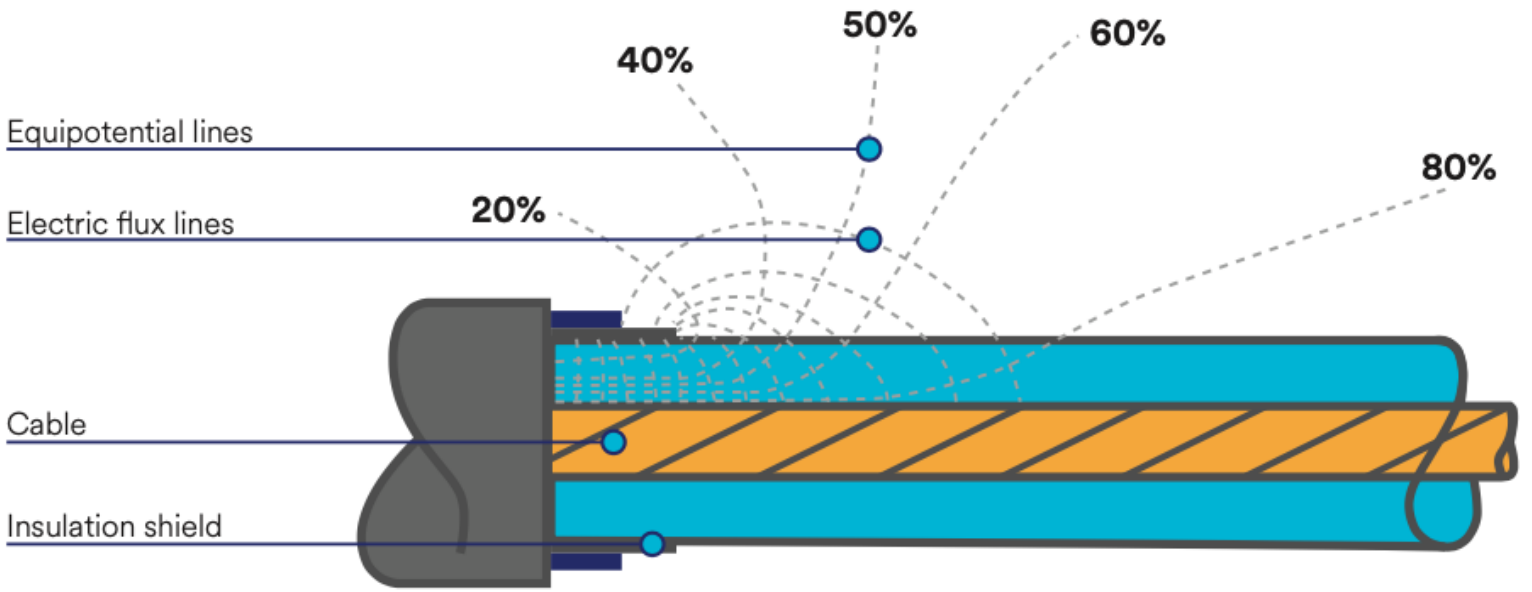
Cold Shrink Comparison

Safety, Time Savings, Electrical Performance

*Source: Based upon U.S. failure data of U.S. manufactured 3M Cold Shrink Medium Voltage Cable Accessories between 2009 and 2012.

Electrical Stress

When preparing a cable for an accessory installation, removing the insulation shield causes a discontinuity in the axial direction of the cable, resulting in a field that is no longer uniform along the axis. This process produces a high concentration of electrical stress closer to the insulation shield end.



White Paper:
Geometric vs. Capacitive Stress Control

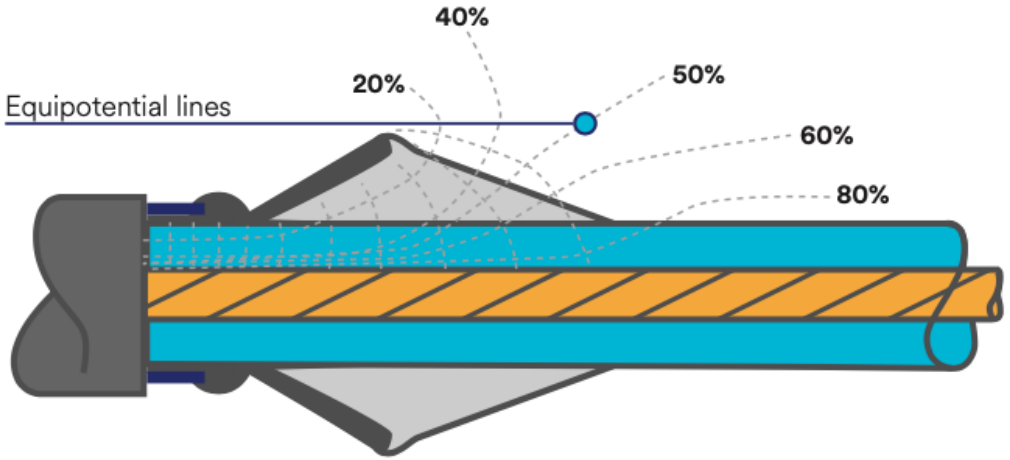
The removal of the insulation shield results in a discontinuity in the axial direction of the cable

The field is no longer axially uniform along the cable

Shield removal produces a high concentration of stresses

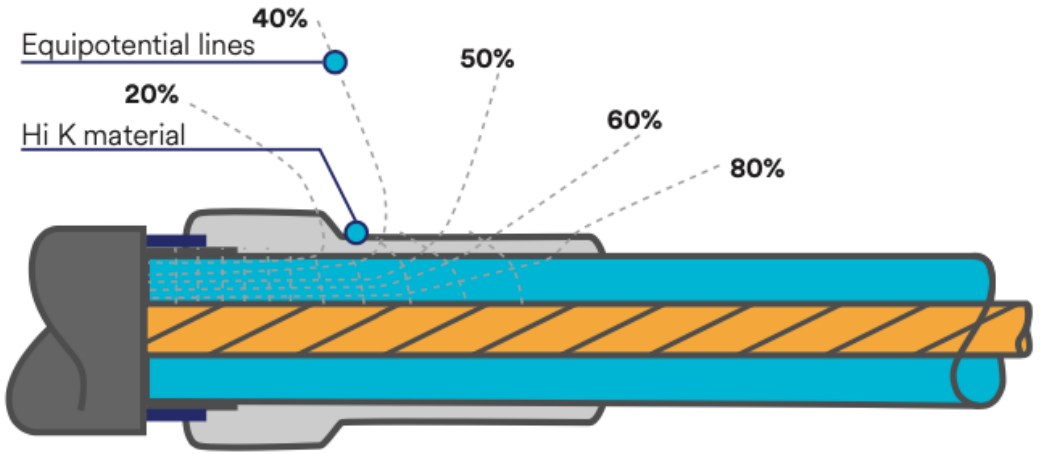
Steps must be taken to avoid cable insulation failure

Electrical Stress Control



Geometric

This method reduces the stress at the shield discontinuity by extending the shield and gradually increasing the thickness of insulation under the shield. The areas where there is higher electrical stress receive additional insulation, as shown above.



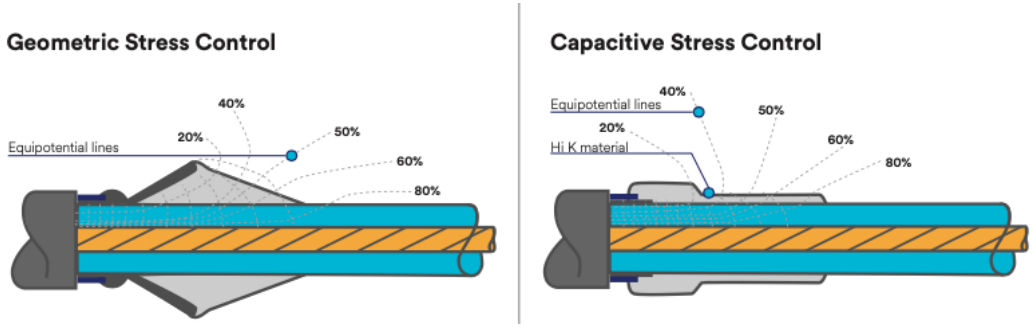
Hi-K

This method lowers the electrical stress at the point of shield discontinuity by refracting the electrical stress. This allows the equipotential lines to spread out along the cable insulation interface. By doing this, the surface stress of the accessory is greatly reduced, which improves cable accessory performance and life expectancy.

Termination Performance Testing

Study methodology
A test was conducted in a controlled laboratory environment to determine which method is most effective at controlling electrical stress.

The comparison: 3M™ Cold Shrink Products that use Hi-K capacitive stress control versus competitive cold shrink products that use geometric stress control.



Product	Stress Control Technology	Partial Discharge	1 Minute AC Withstand	15 Minute DC Withstand	BIL (10+/- Surges)	HOT BIL (10+/- Surges)	Partial Discharge	5 Hour AC Withstand	5 Minute AC Withstand	BIL (10+/- Surges)	Partial Discharge
Competitive Sample 2, 3, 4	Geometric	X	X	Cannot Test further. Samples failed.							
Competitive Sample 5	Geometric	✓	✓	✓	✓	✓	✓	X	Cannot Test further. Samples failed.		
Competitive Sample 6	Geometric	X	✓	✓	✓	✓	✓	X	Cannot Test further. Samples failed.		
3M (4 Samples)	**Hi-K**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Splice Design

Material and Technology

Heat Shrink

- More installation steps.
- More room for installation errors.
- Uneven heat application can cause burning and uneven wall thickness.
- **Because of that, life expectancy of a heat shrink splice can be reduced.**

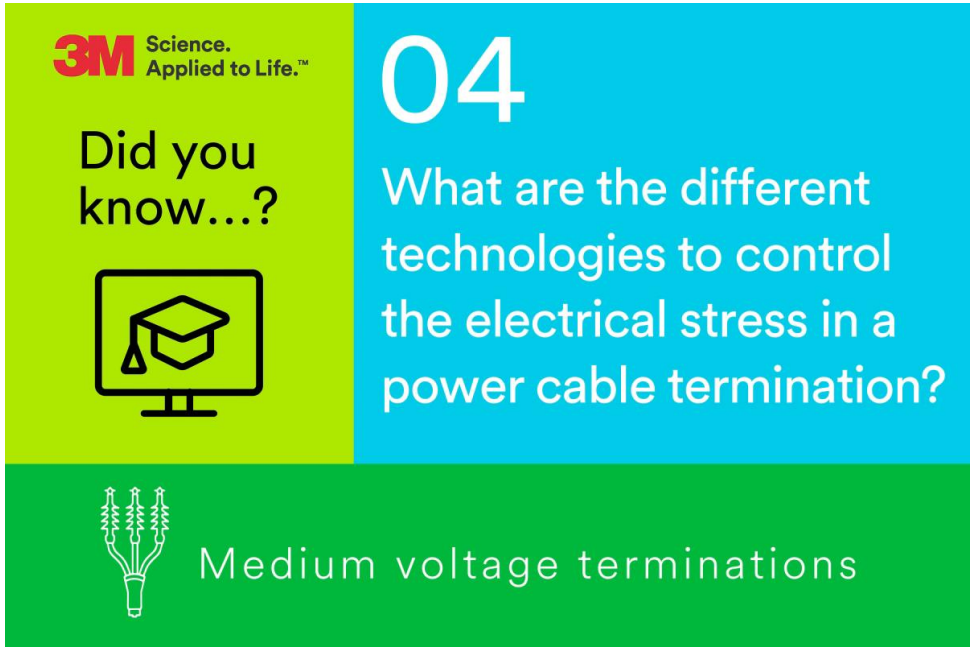
Pre-molded

- Cumbersome Installation.
- Limited tolerance.
- Splice pressure needs to be low enough to install but high enough not to fail.
- Up to 90% of the initial pressure is lost during heat cycles.
- **Because of that, life expectancy of a pre-molded splice can be reduced.**

Cold Shrink

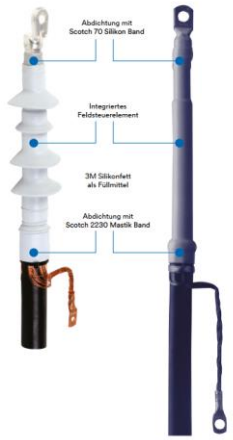
- **Long lasting, reliable design, when properly installed.**
- Firmly shrinks on cable, providing an active seal without loss of pressure due to cable heat cycling.
- Wide application range.
- Helps minimize potential installation errors.

Videos Stress Control



Application Solutions

The Transformer (Live Front)



3M™ Cold Shrink QT-II Termination Kit 12 -36 kV

3M™ Cold Shrink Medium Voltage Termination QT-II is designed using a unique Cold Shrink delivery system. Products are supplied pre-stretched on a removable core for efficiency and ease of installation. Electrical field control device pre-installed in the insulation body help to avoid complexity during the installation. The specific properties of the insulating silicon body allow to terminate wide range of cable cross sections. 3M™ MV termination kits are available both with and without mechanical lugs included.

3M™ Cold Shrink QT-III Termination Kit 12-36 kV

3M™ QT-III Termination is a further development of the QT-II. It has similar functionality but offers additional advantages for the end user. The main advantages of the QT-III Termination are that it contain fewer individual components. This eliminates time-consuming installation steps, which leads to fewer chances of error.

Live Front Connections

Medium voltage switchgear and cabinets are becoming smaller and smaller, while the power demand continues to increase. How can you fit many terminations in such a small space, especially if you have to use heat? 3M™ Cold Shrink Terminations have been engineered to be robust in design and fast to install, while maintaining a short and compact footprint and requiring no heat for installation. They can be used to connect medium voltage cables to switchgear, transformers, motors, as well as for pole-top transitions from underground cabling to overhead and in many other applications.

The Transformer (Dead Front)

3M™ Separable Connector Kit 12-36 kV

The Separable Connector is used to establish the connection between the cable and switchgear, transformer or other equipment. Products are molded using high quality EPDM and sold in packs of 3 phases and they come with stress control element, earthing set, mechanical cable lug and assembly instructions. The straight, elbow and T-plug connectors cover a wide range of cable cross sections. All kits are fully type tested to Cenelec HD 629.1 (DIN VDE 0278).

3M™ Sensored Cable Accessories (SCA)

3M™ Sensored Cable Accessories (SCA) are Medium voltage cable accessories including accurate current and voltage sensors to support the grid automation. It provides high accuracy voltage, current and phase angle with real time measurements when connected to secondary equipment, like RTUs or protection relays, at the medium voltage secondary substation. Moreover with a capacitive voltage sensor, the accessories provide reliable measurements over a wide temperature range and capable to capture up to the 50th harmonic (2500 Hz), offering a unique way to measure key parameters on the grid for use in prominent use-cases such as Real time monitoring, Fault detection and location, Voltage regulation and volt-var optimization, Power quality management and Asset health.

Dead Front Connections

More and more of the industry, especially in renewables, is moving to deadfront connections. This connection style, at switchgears and transformers, as well as other equipment, allows for the use of shielded separable connectors. These devices can be connected and disconnected easily, but they can also be stacked and configured in different ways to fit a certain connection. Unlike live front connections, these products are fully shielded on the outer surface, and allow for flexibility with placement, since no electrical clearance is required between products.

Inside a Junction Box or Sectionalizing Cabinet

3M™ Separable Connector Kit 12-36 kV

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Junction Box Application

Junction box or sectionalizing cabinets are convenient ways of organizing the collection of power from turbines using separable connectors. The sectionalizing cabinet essentially provides a 2-way, 3-way or 4-way, 3-phase connection point. This allows an operator to de-energize, ground or isolate portions of a circuit, while allowing the remaining power to flow-through.

Splicing and Grounding

3M™ Cold Shrink Medium Voltage splice kit QS200 12-36 kV

Designed from the ground up, these medium voltage splices are one of the pinnacles of 3M's performance, quality and reliability. These kits are used with 1-core and 3-core cables, armored or non armored. No special tools, torches or other heat sources needed.

3M™ Cold Shrink High Voltage Splice kit QS3000 72.5 kV

3M™ Cold Shrink High Voltage Splice QS3000 Series Kits are designed for inline splicing up to 72.5 kV Umax Voltage class, 1-core XLPE and HEPR cables systems with copper wire screen, lead sheath or aluminium sheath according to IEC 60840.

3M™ EMS Extended Range Ball Markers

These markers provide an effective way of accurately marking underground facility lines such as flush mounted facilities that are covered by backfill. It features a self-leveling design for precise and horizontal positioning. This passive underground marker with a water-resistant polyethylene shell does not react with chemicals or minerals. This ball marker effectively operates without the need for any external power source .

Splicing

Often splicing is an afterthought, a requirement that comes into play after an emergency or damage caused to a cable. Other times it is designed into the project, to achieve circuit lengths that far exceed even the longest cable reel lengths.

Whatever the reason, 3M™ Cold Shrink Splices help you easily, quickly and reliably connect two cables together so you can move on to your next challenge with peace of mind.

Substation

3M™ Cold Shrink QT-III Termination Kit 12-36 kV

3M™ QT-III Termination is a further development of the QT-II. It has similar functionality but offers additional advantages for the end user. The main advantages of the QT-III Termination are that it contain fewer individual components. This eliminates time-consuming installation steps, which leads to fewer chances of error.

3M™ Cold Shrink High Voltage Termination kit QTEN Series 72.5 kV

3M™ 3M™ Cold Shrink High Voltage Termination QTEN Series Kits. 1-core copper wire, lead sheath or aluminium sheath screened cables. The product options cover power cables up to 2500 mm² in size. The QTEN series, is designed for XLPE and HEPR cables up to 72.5 kV (U_max) according to IEC 60840. The kit includes silicone Cold Shrink body with integrated silicone rain sheds with a separate Cold Shrink stress control tube. Silicone Cold Shrink tubes are included to seal on cable lug and cable sheath. The creepage current collector is included for a defined earth potential at the end of the rain sheds.

Substation Applications

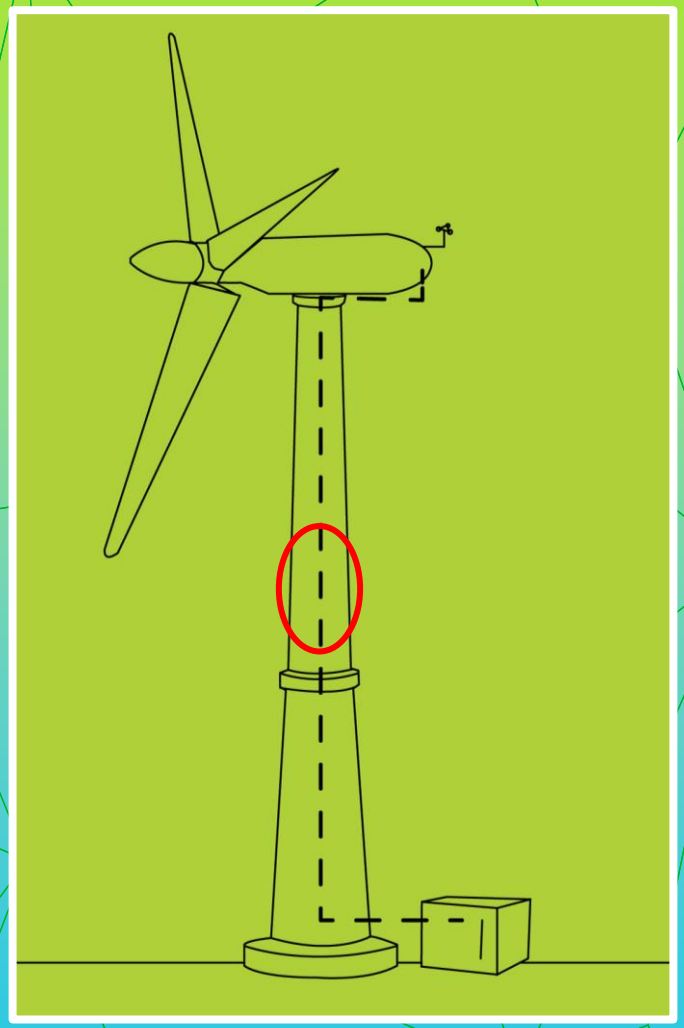
After all the power has been collected, it's time to step it up in voltage and send it to the grid. That's where the substation comes in. The collection system from the various turbines is terminated here, usually with an outdoor live-front connection.

With 3M™ Cold Shrink QT-III or QTEN Terminations, you can have a quick and easy connection to the substation that will operate reliably over time.

Down-Tower Applications

3M™ Cold Shrink Connector Insulators 1000 V

3M™ Cold Shrink Connector Insulators are useful as primary electrical insulation for all solid dielectric (rubber and plastic) insulated wire and cable splicing rated to 1000 V, both indoor and outdoor. They are often good in providing physical protection and environmental sealing for communication and other non-electrical applications, including sheath repairs. Operating temperature range is -40°C to 90°C. In applications where the product is continuously exposed to UV radiation it is good to overwrap with e.g. Scotch® Super 33+™ Vinyl Electrical Tape or Scotch® Self-Fusing Silicone Rubber Electrical Tape 70.



Cable Jacket Repair Application

Repair for minor damages

For repairing damages like scratches and grooves from sharp edges, please follow the steps below:

- Clean the cable surface with a solvent and sandpaper. We recommend using 3M™ Cable Preparation kit CC-3 or 3M™ Scotch® 1626 Degreasing and Cleaning.
- Half-lap Scotch® Cable Jacket Repair Tape 2234 over the damaged jacket area.
- Overwrap each end with Scotch® Super 33+™ Vinyl Tape. This tape will add radial pressure to ensure the best adhesion and sealing.

Repair for substantial damage

When dealing with more significant damage where a portion of the cable jacket is torn, first check if the inner layers of the cable are untouched. Then please proceed as follows:

- Remove the torn edges of the cable jacket. Clean the cable surface with a solvent and sandpaper. We recommend using 3M™ Cable Preparation kit CC-3 or 3M™ Scotch® 1626 Degreasing and Cleaning Spray.
- Fill and seal the holes with 3M™ Scotchfil™ Electrical Insulation Putty.
- Overwrap the whole repair length with Scotch® Cable Jacket Repair Tape 2234.

Cable Jacket Repair

3M and Scotch brand cable jacket repair tape can help reduce downtime until the cable can be replaced. For wind, solar farms and construction tasks, cables can sustain minor damages or substantial damages.

At The Solar Panel

3M™ Scotchflex™ Cable Ties

Cable ties made of high-quality nylon 6/6 are available in standard, mountable and steel-barb formats. Steel-barb ties are designed with a stainless-steel barb that, when engaged, presses into the strap and grips tight.

3M™ Cold Shrink Connector Insulators 1000 V

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Solar Panel Cable Routing and Splicing

Once connected to the panel, the PV wire needs to be routed and held in place along the structures. With 3M™ Cable Ties you can make quick work of the fastening process, so you can move on to your next challenge.

When you need to splice the PV wire or transition it to a larger size, look no further than 3M™ Cold Shrink Splice WF kits. These will help you quickly and reliably splice the PV wire while maintaining the higher voltage rating.

Locating and Marking

3M™ EMS Point Markers

Unlike surface features, maps and other methods of recording position, our Point Markers are a point of reference you can depend on.

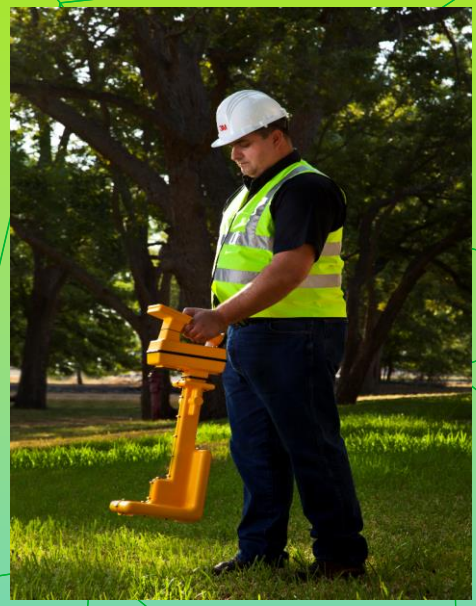
- Operate in all soil types; under asphalt, cement, and wet or dry soil
- Provide easy positive identification with each utility having its own frequency
- Colour-coded to APWA standards

3M™ Path Marking Tape

3M™ Electronic Marking System (EMS) Warning Tape 7900-XT Series and 3M™ EMS Caution Tape 7900 Series provide a virtually maintenance-free solution for marking and locating the path of underground plastic pipes and conduits. Together, they help eliminate problems and costs associated with tracer wire and test stations.

3M™ Dynatel™ Locator XE Series

The Dynatel XE Series Locators allow you to quickly locate underground assets. They are equipped with Bluetooth® wireless technology receivers, along with improved software and GPS capabilities. All models are available both as full kits including transmitter and as stand-alone locators.



Locating and Marking application for Wind and Solar Sites

3M™ Locators and Markers provide a complete system for locating, marking and mapping vital underground assets. Marker identifies the location of splices that connect the power generation units to the main hub. High value assets are critical to pinpoint connections for maintenance and to expand site. Markers provide improved reliability compared to tracer wire.

3M Services

Construction Services & Technical Support

- **Training** – online and onsite field support
- **Custom kits with 3M Construction Services**
- **Project-specific instructions**
- **Proven and trusted technology**
- **Premium performance** – high reliability and quality
- **Application engineer support**

Customized Kits

- Everything you need for your job, in one box
- Customized instructions and kit lableing
- Tailored solutions
- Enhanced productivity
- Improved reliability by including only approved components

Energy Academy & Training

Different training formats (online, virtual, face-to-face) are available to support you in carrying out your work and satisfying your customers with an exceptional level of professionalism, reliability and productivity.

Helping you to reinforce the confidence you have in the market is fundamental for us, so we will support you so that you have a very well-trained team in our solutions.

Conclusion

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