ENSTO

Installation handbook

Cable preparation for medium-voltage underground cable accessories

Better life.
With electricity.

Recommended practices
for correct medium-voltage
cable preparation.

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This handbook is aimed at installers of medium-voltage underground cable accessories, focused on cable preparation and correct usage concerning recommended tools. Complementary information of cable accessories, tubing technology and cable construction is also included.

Incorrect cable preparation is one of the main causes of failure in medium-voltage cable accessories. Examples of common errors in installation and cable preparation are also shown to raise awareness among installers.

The tools presented in this handbook are by no means the best or the only suitable ones for cable preparation, but rather, the ones we recommend based on our experience with internal use and the positive feedback received from customers and installers worldwide.

Table of Contents

Installers play a key role in the reliability of underground distribution networks.

Medium-voltage cable accessories

Cable accessories are used to connect two cables together or one cable to the terminal of another piece of equipment. They provide enough insulation, galvanic connection and control of the electric field. Ensto manufactures heat-shrink, fully cold-shrink and hybrid accessories for medium-voltage cables.

Cable joint

A cable joint is used to connect two cables together.

Straight joints are used when the insulation material of both cables is the same. Transition joints are used to connect a paper insulated cable to a polymeric insulated cable. Screen break joints enable cross bonding the screens of the three individual cable circuits.

Termination

A cable termination is used at the end of the line to permanently connect a cable to the terminal of a piece of equipment.

Given their exposure to UV radiation, environmental elements and dirt, cable terminations are designed for indoor or outdoor use.

Screened separable connector

A screened connector is used to terminate a cable with polymeric insulation onto transformers, motors or switchgears.

These connectors are touch-safe, free of maintenance and suitable for both indoor and outdoor use.

Heat-shrink technology

The mechanical robustness of heat-shrink accessories is the main advantage of the technology.

Heat-shrink accessories require a flame to shrink the tubes and to melt the glue and mastics underneath.

The typical heat-shrink components found in Ensto accessories are:

- Conductive, insulating and stress control tubes.
- Conductive and insulating cable break-outs.
- Rain sheds.

Ensto manufactures medium-voltage heat-shrink cable joints and terminations (for indoor and outdoor use) for polymeric insulated and paper insulated cables.

Stress control and sealing mastics are sensitive to heat and melt when the tubes are heated.

Cold-shrink and hybrid technology

The reliability of several components integrated into one body and shorter installation times are the main advantages of cold-shrink and hybrid technologies.

Cold-shrink accessories are the solution in places where hot work is not possible or permits are difficult to obtain. A silicone body with integrated components is molded and then pre-expanded on a spiral or tube, ready to be installed without using any flame.

Hybrid accessories include silicone bodies with heat-shrink outer sealing tubes, an alternative that combines the advantages of both cold and heat-shrink technologies.

The cold-shrink components found in Ensto accessories are:

- Silicone termination body with integrated geometric stress control cone.
- Silicone joint body with integrated conductive electrode and geometric stress control cones, painted with a conductive outer layer (in hybrid joints)
- Fully cold shrink silicone joint body with integrated conductive electrode, geometric stress control cones, grounding grater for screening and outer sheath for sealing and waterproofing.

Ensto manufactures medium-voltage cold-shrink and hybrid joints, terminations (for indoor and outdoor use) and screened separable connectors.

Why silicone?

- Great molding performance
- Resistant to environmental stress, such as UV radiation, heat, moisture, oil and ozone.
- Inorganic material that doesn't absorb dirt and humidity, therefore insulation properties remain excellent.

Cable preparation

In most cases, faults that occur in cable accessories are the result of errors in cable preparation.

The cable preparation process is critical. The accessory emulates the structure of the cable, layer by layer, and provides a safe and reliable transition when jointing with another cable or terminating the cable at the end of the line.

Polymeric insulated extruded cables

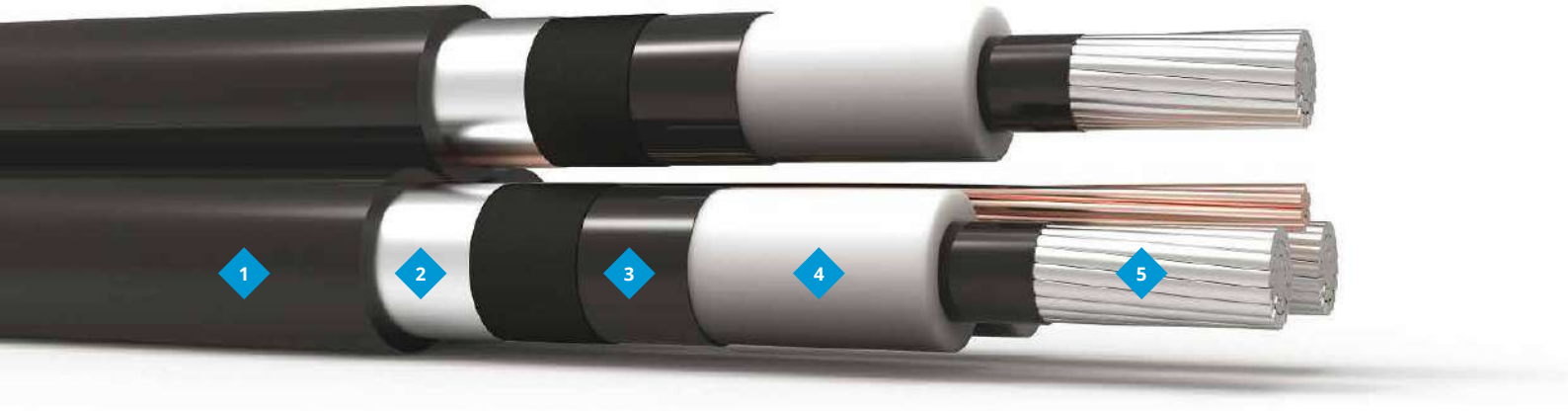
Cables with extruded polymeric insulation have a very consistent structure among different models and manufacturers. The main differences from the installer perspective are the types of insulation screen and the different methods and tools for correct handling.

Insulation material

The insulation material most widely used in modern underground polymeric insulated cables are cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR).

At the core of an underground cable, the conductor screen, the insulation and the insulation screen are co-extruded. Installers must carefully prepare the insulation and the screen, because the electrical behavior is controlled by these parts of the cable and their equivalent or corresponding part in the accessory kit.

Basic construction of an extruded cable



1

Outer sheath

Also known as outer jacket. The outermost layer of the cable that provides protection from the environment.

Certain components for armoring, earthing and/or waterproofing are bonded to the outer sheath or extruded underneath it. Installers select the correct set of tools based also on what material the outer sheath is made of. When the metallic screen is made of aluminum laminate, the use of flame is possible for outer sheath removal, and is even recommended in some cases.

2

Metallic screen

Also known as cable shield or cable screen. Provides an earth connection and a path for fault and leakage currents.

Aluminum (laminate or wires) or copper (wires or tape) are used to screen extruded medium-voltage cables.

3

Insulation screen

Also known as the semi-conductive layer. Provides a homogeneous distribution of the electric field around the external layer of the insulation.

The insulation screen can be bonded or strippable by hand. It also provides a smooth transition between the insulation and the metallic screen. From the installer's point of view, the removal of the insulation screen is the most critical step during cable preparation.

4

Insulation

The insulation thickness is defined by the rated voltage of the cable.

To prevent short circuits, a polymeric insulation is extruded around the conductor screen. The two most typical insulation materials used in medium-voltage extruded cables are cross-linked polyethylene (XLPE) and ethylene propene rubber (EPR).

5

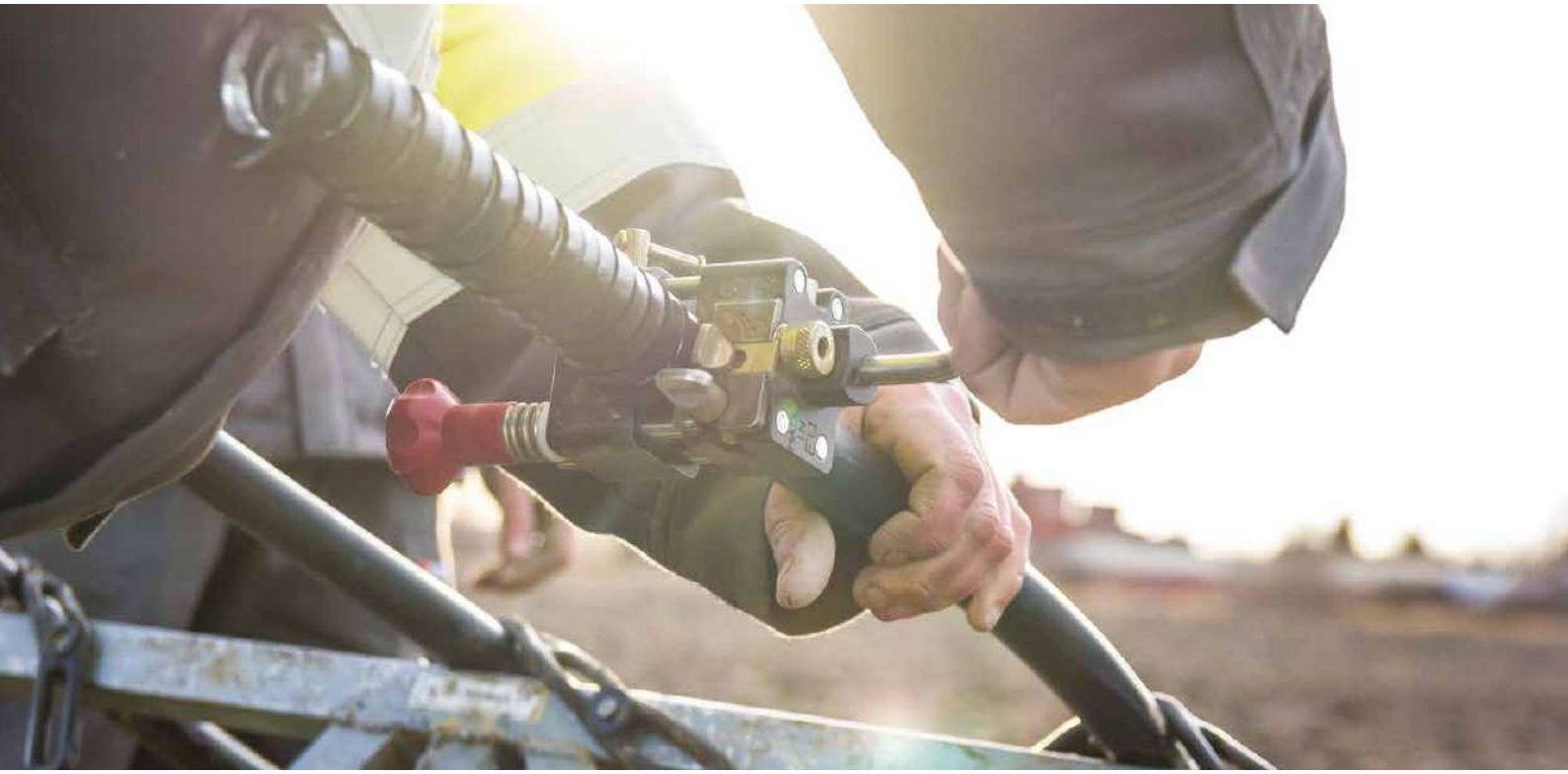
Conductors

The cross section defines how much current can flow through the cable.

Built in copper (more conductive) or aluminum (less heavy). Conductors have two types of construction, circular and sector-shaped. In both cases, compact stranded (several wires) or one solid conductor can be found. Sector-shaped construction is used to decrease the total diameter of the cable.

Around the conductors, an extruded screen provides a smooth transition between conductive and insulating materials, not allowing dangerous concentrations of electric field in the surface of the conductors. The conductor screen is removed along with the insulation.

Outer sheath and metallic screen



The metallic screen defines what tool can be used for removing the outer sheath.

Always clean the outer sheath before removal.

The outer sheath provides protection to the cable. It insulates the metallic screen from the ground and protects from corrosion and humidity.

The metallic screen keeps the field contained within the cable, contributes to waterproofing (in the case of aluminum laminate) and allows partial circulation of short-circuit currents.

Also, relevant information about the cable is marked or printed on the outer sheath, i.e., cable type, nominal voltage, cross section, manufacturer, phase marking, etc.

Function of the outer sheath

- Insulation and corrosion protection for the metallic screen
- Reduction of the contribution of cables to fire propagation
- Mechanical protection
- Information about the cable

Materials and features

The outer sheath must be fire retardant and protect the cable from the environment (animals and weather). PVC and PE are widely used for their mechanical strength and fire retardant properties, but corrosive and toxic fumes are released if the burning point is reached.

Halogen-free, fire-retardant materials are not as mechanically strong as PVC or PE but reduce the spread of fire and fumes harmful to personnel and equipment in case of fire.

The metallic screen is made of aluminum or copper. The two most typical screens in extruded cables are aluminum laminate and copper wires. The aluminum laminate is removed with the outer sheath and extended with a grounding grater or braid. Copper wires are treated independently and terminated or jointed by a lug or connector.

Outer sheath removal

Multifunction tool for outer sheath and insulation removal

Scan QR code for video demonstration or click here.

Multifunction tool Ensto ST281

- Removes outer sheath of single core cables with aluminum laminate.
- Removes all types of polymeric insulation.
- Teflon pads for minimum friction.
- Stopper included.
- Adjustable blade depth.
- Adjustable blade angle.

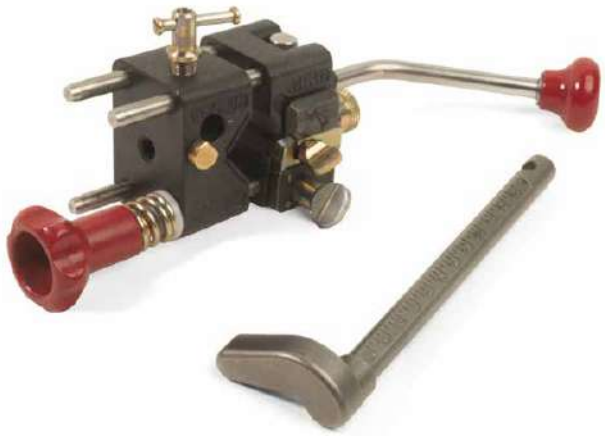
Instructions

- Place the tool at the cut edge of the cable.
- Adjust the depth of the blade no deeper than the aluminum laminate.
- Adjust the angle of the blade to its minimum.
- Rotate the tool through the desired length.
- Adjust the angle of the blade to its maximum when reaching the desired peeling length.
- Perform the final round cut.

For insulation removal, go to page 22.

Tips

- To avoid damaging the insulation screen, perform the rotating cut without damaging the semi-conductive water-swellable tape underneath the aluminum laminate.
- After removing the outer sheath, three additional longitudinal cuts are required to place the grounding grater. Split the outer sheath with the auxiliary tool ST285.



Outer sheath removal

Universal cable stripper with fast locking system

Scan QR code for video demonstration or click here.

Universal cable stripper Ensto ST257

- Removes outer sheath of single core cables with aluminum laminate.
- Round and longitudinal cuts.
- Hook for outer sheath removal.
- Blade depth adjustable by knob.

Instructions

- Measure the cable diameter with a Vernier caliper.
- Adjust the tool according to the cable diameter by knob.
- Lock the tool.
- Adjust the blade depth by knob.
- Perform the longitudinal cuts.
- Switch to round cut and keep the blade depth unaltered.
- Perform the round cut.

Tips

Longitudinal cut first.
Round cut after.

Before the longitudinal cut:

- Keep the cable as straight as possible.
- Test the depth of the blade in the first 50 to 60 mm from the cut edge of the cable. It is safe to test the tool there because the insulation will later be removed to install the cable lug or connector.
- Make sure the cut doesn't go through the semi-conductive water-swellable tape under the aluminum laminate. This will grant the integrity of the insulation and its screen along the cut.
- Do not perform the cut on the aluminum foil overlap. The extra thickness may make the cut ineffective.

Before the round cut:

- When turning the blade 90 degrees for the round cut, make sure the depth of the blade remains unaltered.

Outer sheath removal

Complementary tools

Ensto ST285 for outer sheath longitudinal cut. The tool splits the MV cable outer sheath and aluminum laminate for a distance of 40 mm. Application ø is 16-60 mm.

Scan QR code for video demonstration or click here.

Ensto ST259 is an outer sheath spreading wedge that is also used to help open or remove the outer sheath of single and three-core cables of different constructions.

Scan QR code for video demonstration or click here.

Ensto ST286 is used to spread the outer sheath and/or aluminum laminate. It does not harm the aluminum laminate or semi-conductive layer during spreading.

Scan QR code for video demonstration or click here.

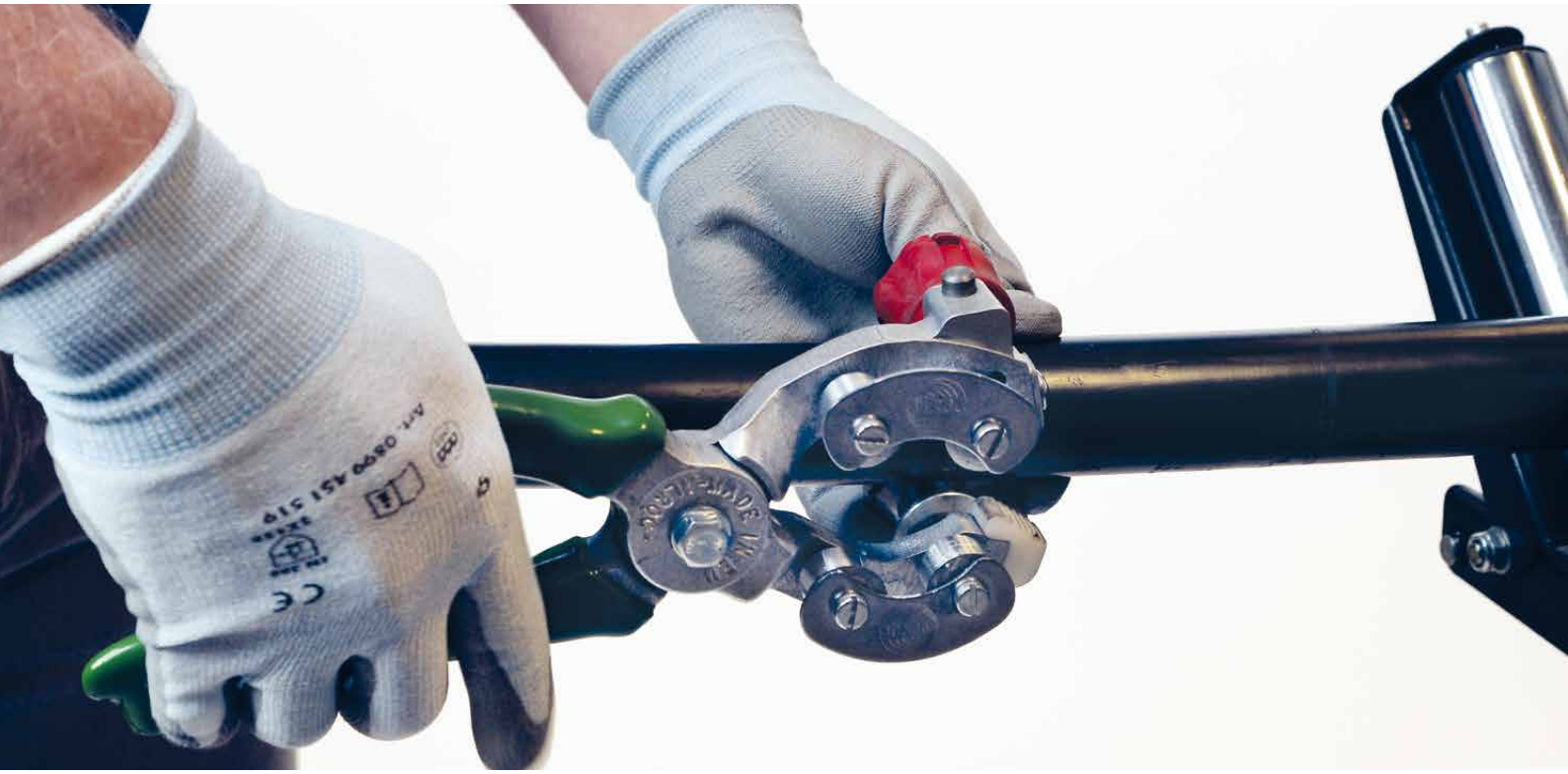
Ensto ST310 is for fastening metallic cable ties on the cable's outer sheath. With the metallic ties, the grounding grater makes an earthing contact to the aluminum laminate screen. The tool does the tightening and cutting of the exceeding tie.

Scan QR code for video demonstration or click here.

Outer sheath removal

Plier for outer sheath

Scan QR code for video demonstration or click here.



Plier

- Removes outer sheath of single- and three-core cables with copper wires.
- Fixed blade depth for round cut.
- Adjustable blade depth for longitudinal cut.
- Hook for sheath removal.

Instructions

- Perform the round cut by rotating the tool.
- Adjust the blade depth and perform the longitudinal cut.
- If needed, use the wedge ST259 and a hammer to spread the outer sheath.
- Remove the outer sheath with the help of the inbuilt hook.

Tips

Round cut first.
Longitudinal cut thereafter.

- Using a Vernier caliper, measure the thickness of the outer sheath of the cable and choose a plier with a suitable depth of the fixed blade.

Outer sheath removal

Waterproofing

Scan QR code for video demonstration or click here.

When installing heat-shrink or hybrid accessories, grind the outer sheath to provide a grip point to the heat-shrink outer sealing tube. Waterproofing is achieved by the sealing mastic and the glue of the sealing tube. Both will melt when heat is applied to shrink the outer sealing tube.

Instructions

- Grind the cutback of the cable outer sheath according to installation instructions. Grinding should be performed parallel to the cut of the cable **(1)**.
- Clean the cable outer sheath after grinding to ensure correct adhesion of the sealing mastic and the glue under the outer sealing tube **(2)**.

Make sure any cut around the outer sheath is smooth and straight, not to interfere with tools being used in further steps (e.g., insulation screen removal). Uneven shapes may cause the tools to bend and damage the screen of the insulation.

Always clean the outer sheath before removal and after grinding it.

Outer sheath removal

Hot opening

Apply heat symmetrically

Use a mid-to-high flame to heat the outer sheath. Keep the flame moving all the time around the cable and through the whole peeling length.

Cut and remove the outer sheath

Once the sheath is heated enough, use the cable stripping string for the round cut and drag it to the edge of the cable. This will split the sheath in two and ease the removal. Wear thick gloves to protect from burning.

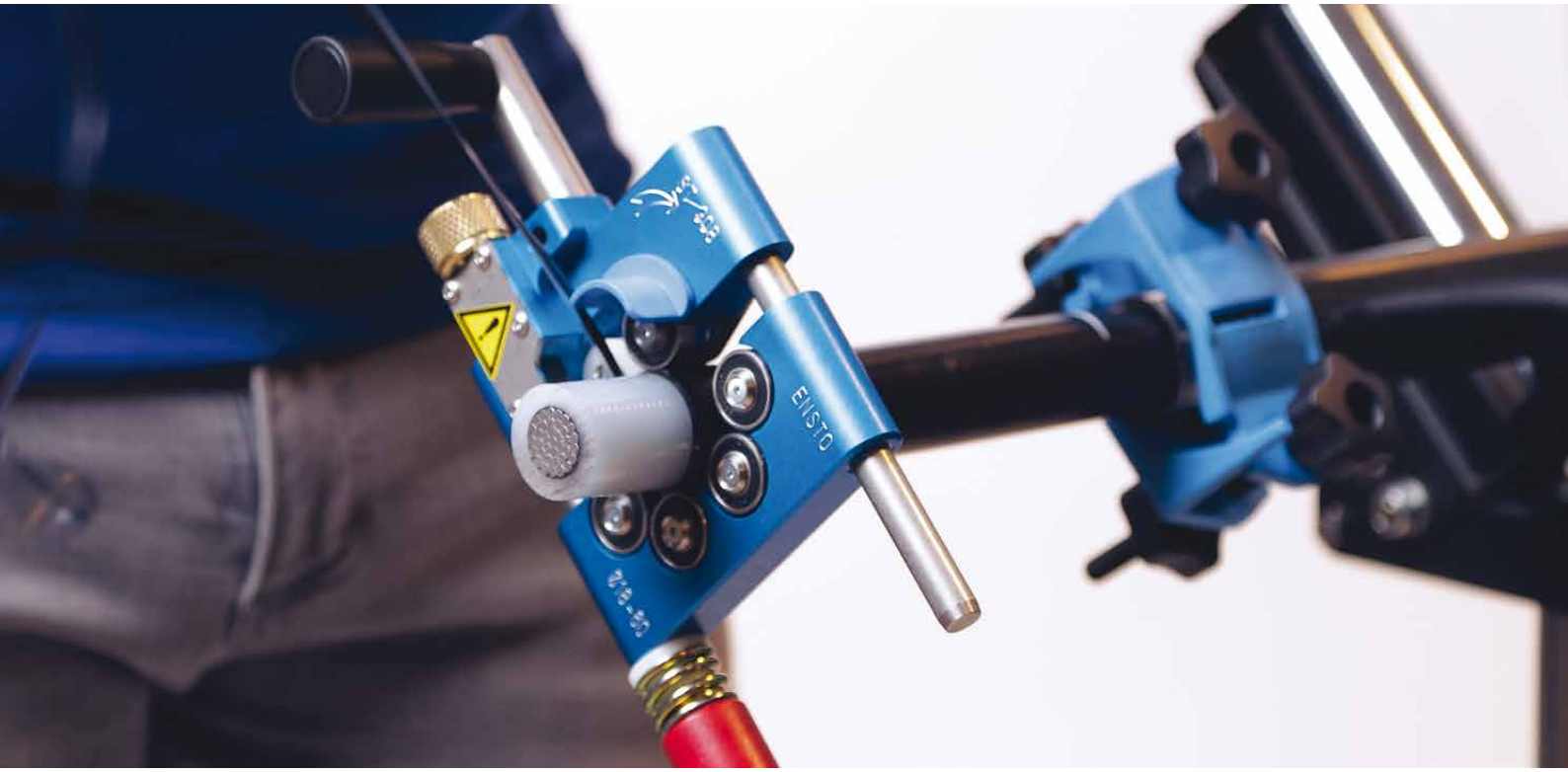
Grind the metallic screen

Grind the aluminum laminate to remove traces of glue and outer sheath. This grants a clean earth connection of the screen.

Remove aluminum laminate

Place a constant force spring and remove the unnecessary aluminum laminate.

Insulation screen



Insulation screen is also known as the semi-conductive layer. It prevents concentration of electrical field at the interface between the insulation and the metallic screen. It can be bonded or strippable. When terminating or jointing a medium-voltage cable, part of the insulation screen must be removed.

Bonded insulation screen

Consists of a black cross-linked compound that requires rotating stripping tools for removal. To avoid dangerous concentrations of electric field, avoid sharp edges in the edge of the semi-conductive layer. Grinding the insulation is recommended after removing a bonded insulation screen.

Strippable insulation screen

Also known as “easy strip”. Not fully bonded to the insulation and must be strippable by hand. Rotating tools with adjustable depth length are recommended for its removal. The use of unguarded knives is forbidden due to the risk of damaging the insulation and causing discharges. Cables with strippable insulation screen require no grinding of the insulation after screen removal.

Insulation screen removal

Bonded semiconductor stripper

Scan QR code for video demonstration or click here.

Bonded semi-conductive stripper Ensto ST308

- Insulation screen removal tool with chamfered end.
- Ball bearings for effortless turning.
- No greasing of the core is needed.
- Adjustable blade depth.
- Stopper included.

Instructions

- Place the stopper accordingly (if used).
- Tighten the tool on the cable with the red knob.
- Adjust the depth of the blade with the screw.
- Proceed with the rotating movement for peeling.
- Turn the red knob about 1/4 of a full round before the stopper.
- Proceed with the final cut.

Tips

To avoid leaving traces of semi-conductive layer on the insulation:
Make sure the cable is as straight as possible before starting and test the tool in the first 50 mm of the cable. Make sure that at least 1/3 of the strip is insulation before proceeding.

Notice that irregularities in the shape of the stripped part reflects how bent the cable is proportionally. Check the strip often and make sure there is a part of insulation all over it. If there is a full black part, it means that semi-conductive traces are still present on the insulation.

Insulation screen removal

Peelable non-vulcanized semiconductor stripper

Scan QR code for video demonstration or click here.

Peelable non-vulcanized semi-conductor stripper Ensto ST260

- Peelable semi-conductive stripper.
- Stopper clamp included.
- Adjustable blade depth.
- Adjustable cut angle.

Instructions

- Place the stopper clamp accordingly.
- Make two round cuts with the blade guide parallel to the edge of the tool.
- Turn the blade guide 45° and proceed to cut upward by rotating to the end of the cable.
- Start peeling the strip until the semi-conductive edge.
- Carefully accompany with a gentle pressure toward the edge of the cut when removing the final strip at the edge of the screen.

Tips

To avoid damaging the insulation:

- Test the depth of the blade in the first 50 mm of the cable.
- Verify the distance between the stopper and the cutting line.

To smooth the insulation after peeling:

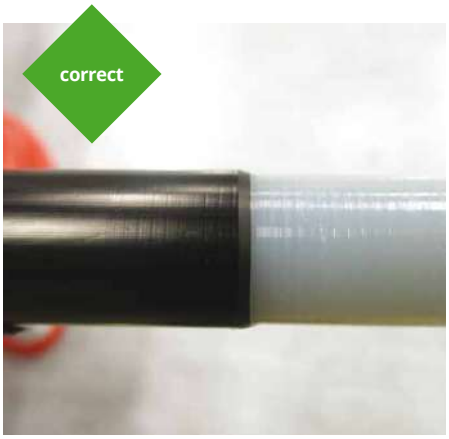
If the use of fire is permitted, it is possible to smooth the insulation surface from marks by using a flame.

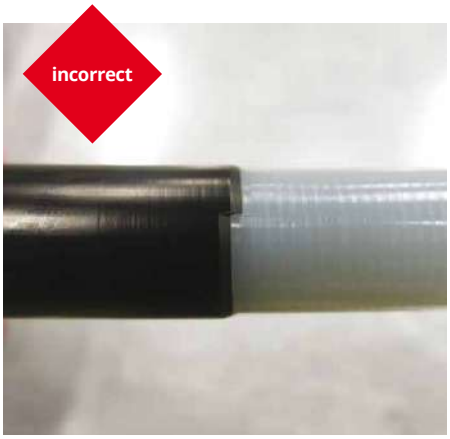
- Apply a medium flame through all the peeling length.

Additional comments on the insulation screen

Avoid sharp edges

Sharp edges in the insulation screen is a common error. The transition between the screen and the insulation must be smooth, achieved by a straight final cut.





Avoid leaving traces of semi-conductive layer

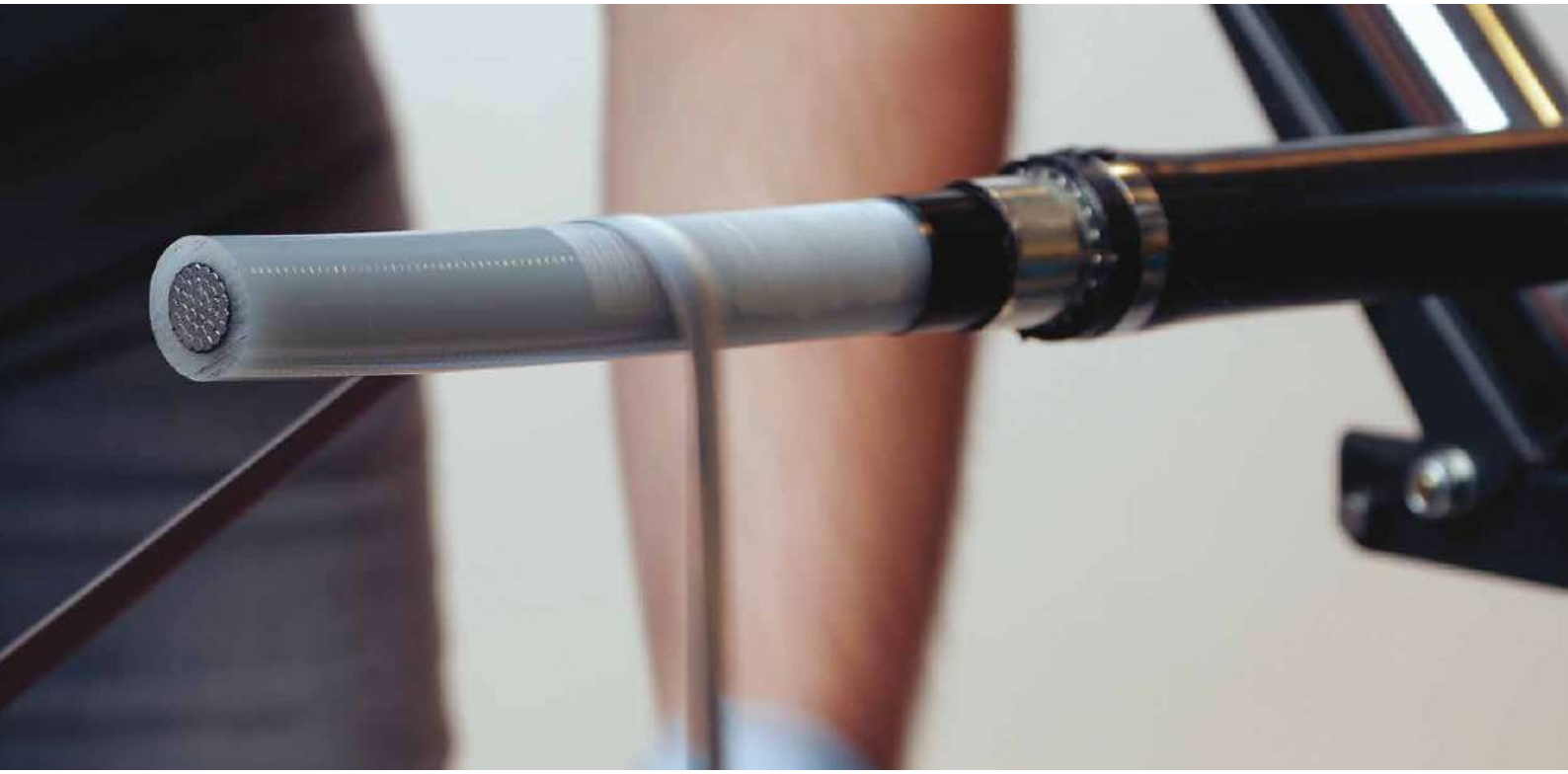
When parts of the strip look partially or totally black, it means that traces of the semi-conductive insulation screen were left on the insulation. To avoid this, keep the cable as straight as possible and follow the strip during the peeling, keeping at least 1/3 of the strip as insulation. The higher the voltage class of the cable, the bigger the proportion of insulation can be, up to a maximum of 1/2 of the strip.

How to fix mistakes

If traces of black semi-conductive insulation screen are still present on the insulation, remove them with a scrapper. Never try to remove them by grinding, because conductive black particles will be spread all over the insulation and cause discharge. Grinding of the insulation is performed to smooth its surface after stripping all traces of the semi-conductive layer.

Scan QR code for video demonstration or click here.

Insulation



The insulation thickness is defined by the rated voltage of the cable. Cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR) are common insulation materials.

Extrusion

Plastic polymeric insulated cables are three-layer extruded:

- **Conductor screen:** Semi-conductive, between the conductors and the insulation material.
- **Insulation:** High resistivity
- **Insulation screen:** Semi-conductive, between the insulation material and the metallic screen.

Treating the insulation

After removing the insulation screen, part of the insulation is removed for connecting a lug or connector. The remaining peeled insulation must have a smooth surface and may require grinding, depending of the tool used and the skill of the installer. When jointing two cables, it is recommended to chamfer the edge of the insulation.

The conductor screen is removed together with the insulation. When in place, it ensures a good contact and fills any voids between the conductors and the insulation, while diminishing the concentration of field at the surface of the conductors.

- Save the bags of the tubes, joint or termination bodies to cover the insulation and use them after screen removal and before grinding as protection for the insulation or the silicone body parts.
- When cleaning the insulation, always begin from the external side and continue up to the screen. Never do the opposite, otherwise conductive particles or dirt could be dragged to the insulation and cause discharge.

Insulation removal

Multifunction tool for outer sheath and insulation removal

Scan QR code for video demonstration or click here.

Multifunction tool Ensto ST281

- Removes outer sheath of single-core cables with aluminum laminate.
- Removes all types of polymeric insulation.
- Teflon pads for minimum friction.
- Stopper included.
- Adjustable blade depth.
- Adjustable blade angle.

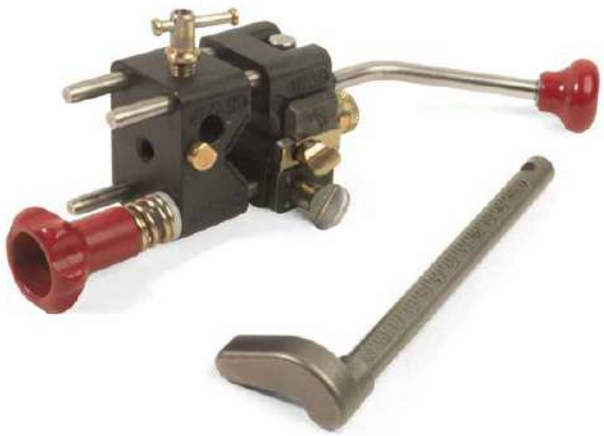
Instructions

- Clean the inner Teflon wards.
- Put the tool in place and fasten it tightly.
- Set the blade depth above the conductor screen.
- Place the stopper and lock it at the desired peeling length.
- Adjust the angle of the blade to its minimum.
- Rotate the tool to remove the insulation.
- The stopper grants a straight final cut.

Tips

- Clean the Teflon wards located in the inner part of the tool to avoid damage to the insulation, caused by sand particles or dirt that might be there after removing the outer sheath.
- Before proceeding with the cut, place the stopper into the multifunctional tool at the desired peeling length. It is sufficient to set the blade depth slightly over the conductor screen to prevent damage to the blade and the shape of the conductors.

For outer sheath removal, go to page 11.



Insulation removal

Ensto ST252 is designed to remove the cable insulation of 10 and 20 kV MV cables with cross-section 25 up to 240 mm². Stripping length adjustable from 20 to 100 mm using the device built into the handle. Set including rigid case with stripping inserts for cross-sections from 25 to 240 mm².

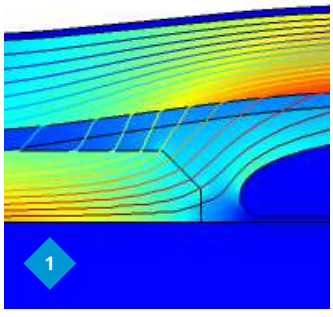
Scan QR code for video demonstration or click here.

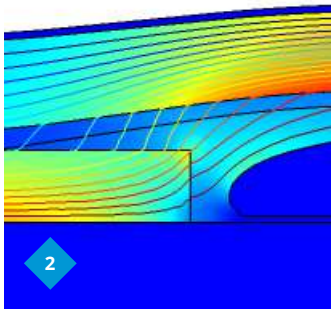
Ensto ST280 is designed to chamfer the primary insulation near the connector or lug in MV cables. This provides a smooth transition from insulation to connector or lug for the accessories installed. The application range ø is 15-60 mm and the chamfer is 45°.

Scan QR code for video demonstration or click here.

Chamfering decreases the density of the electric field at the edge of the insulation. The results of a simulation using Comsol show a lower density in the chamfered insulation in Picture 1. On the other hand, Picture 2 shows a a higher density at the sharp edge of the unchamfered insulation.

From a mechanical perspective, chamfering is highly recommended when installing cold-shrink joints. It prevents damage on the silicone joint body if heavy objects (rocks for example) hit the joints.





Installation grease is applied to the insulation to set the silicone bodies and to help positioning them.

Additional comments on the insulation

Grinding, polishing and cleaning

Scan QR code for video demonstration or click here.

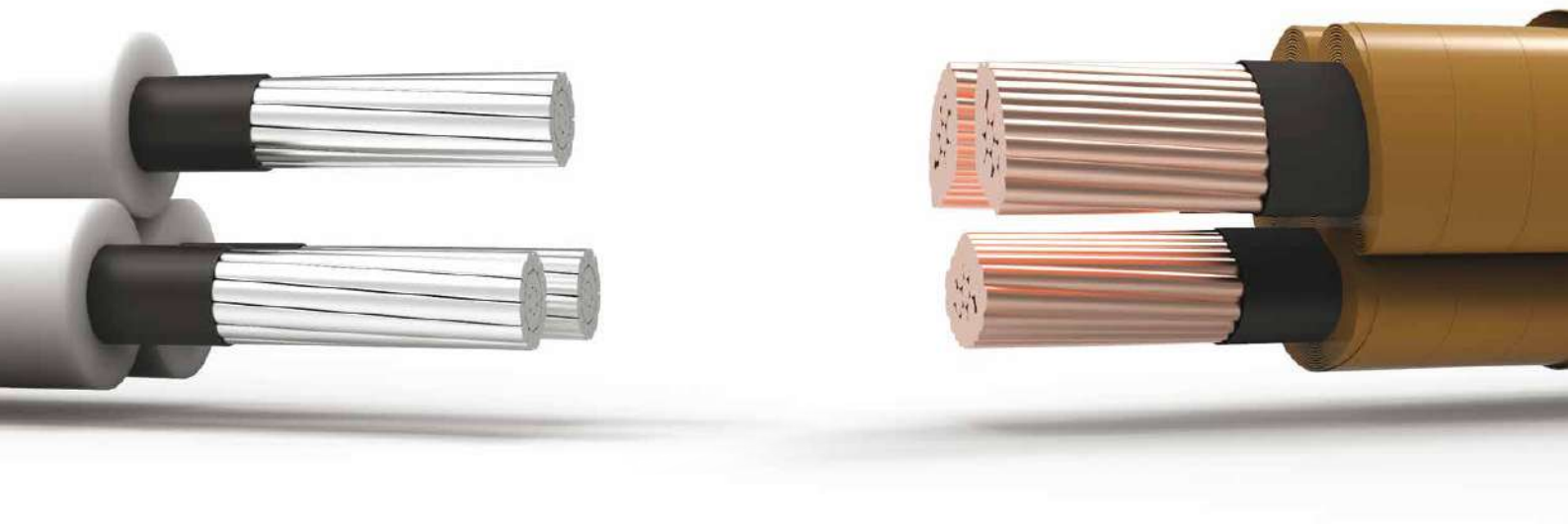
Grinding and polishing

To avoid air gaps where discharges can occur, the insulation surface must be smooth. Use long and thin strips of grinding paper. Perform carefully and do not grind the insulation screen.

Cleaning

Thoroughly clean the insulation, always toward the insulation screen. Never use the same side of a cleaning tissue twice. The insulation must be clean of conductive particles and dirt.

Conductors



Typical cross section values in medium-voltage underground cables range from 35 up to 1000 mm². With stranded or solid conductors, cables are circular or sector-shaped.

Aluminum or copper

Conductors are made of aluminum or copper, to carry current under normal, overload and short-circuit operating conditions. As copper is more conductive, it takes 65% more aluminum to electrically replace copper (1 mm² of copper equals 1.65 mm² of aluminum). On the other hand, aluminum is cheaper per ampere than copper and lighter in weight, allowing more length installation and requiring less jointing.

Classification

Classification of cables is also made according to the construction and shape of conductors:

Circular conductors are used in both single- and three-core cables.

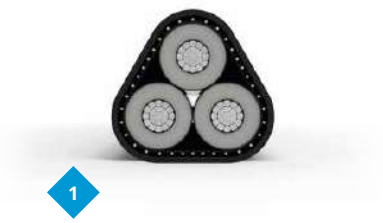
- Class 1 circular: Circular solid
- Class 2 circular: Circular stranded

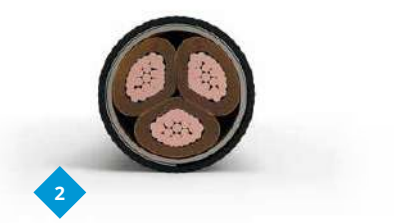
Sector-shaped conductors are used in three-core cables to minimize the cable diameter.

- Class 1 sector: Sector-shaped solid
- Class 2 sector: Sector-shaped stranded

Conductors are also designed to withstand mechanical stress when being pulled during installation.

Classification examples
(1) Class 2 circular aluminum stranded
(2) Class 2 sector copper stranded

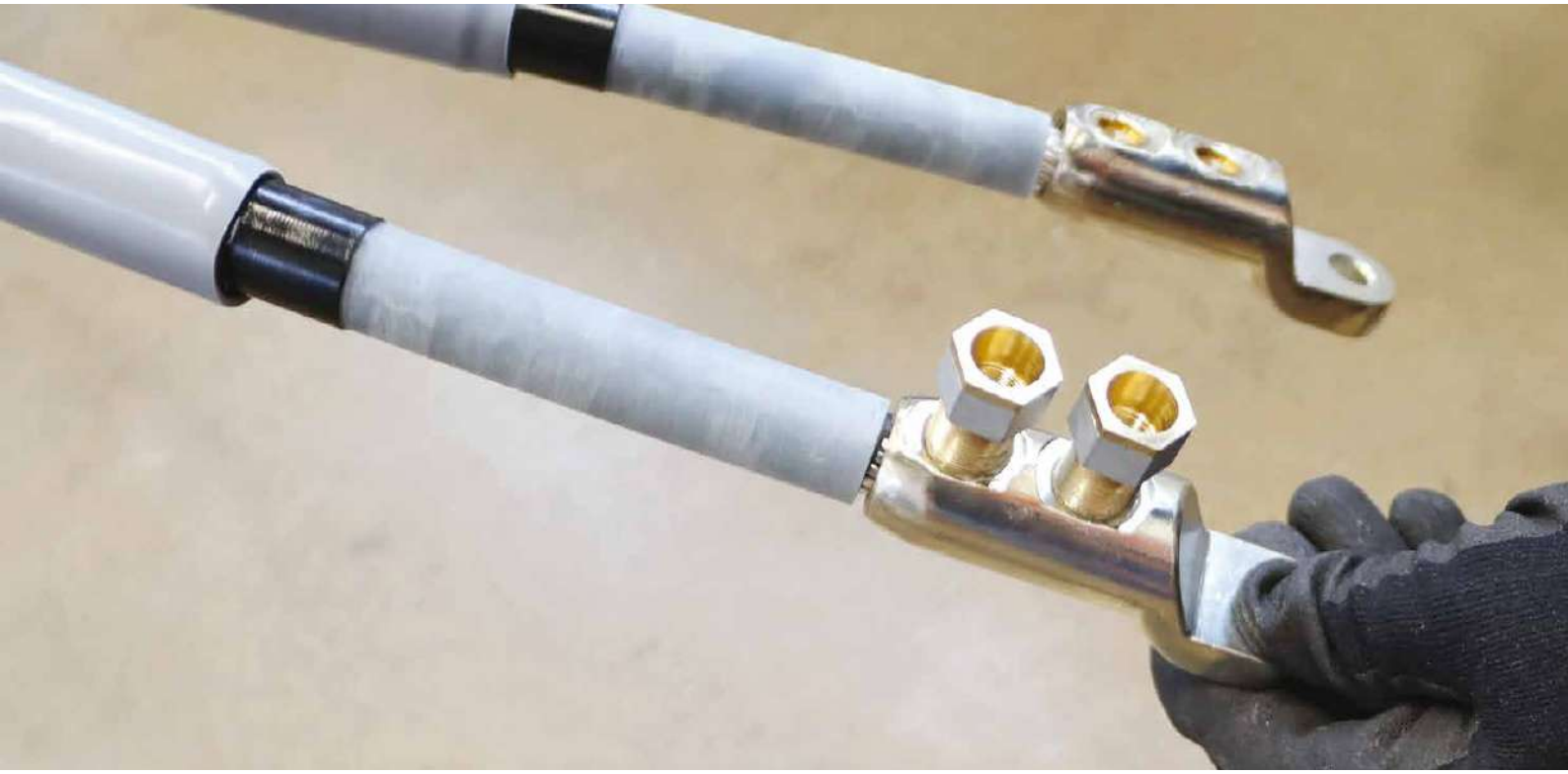




Conductors

Cable lugs and connectors

Scan QR code for video demonstration or click here.



Cable lugs are used when terminating a cable. Connectors are used when jointing two cables.

Clamp device

Ensto ST251 is used to hold the lug or connector while tightening the bolts. Especially suitable for underground shear head bolt connectors with diameters from 14 to 40 mm. Suitable for work on live parts with voltages up to 1000 V AC and 1500 V DC. Insulated in compliance with EN60900/IEC900 standards.

Scan QR code for bolt tightening sequence of the connector.

When installing a lug or a connector

- Pay attention to the shape and cross section of the conductors. Put the centering ring on if needed.
- Brush the conductors just before installing a lug or connector.
- Use the clamp device ST251 to hold the lug or connector.
- Perform the pre-tightening and tightening sequences, from the outer bolts to the inner ones. Scan the QR code for a video demonstration.
- Wrap the insulation with a plastic or fabric before breaking the shear head bolts.
- Clean the insulation thoroughly and remove the conductive particles and dirt.
- If there is a ground connector for external grounding wires, do not connect it close to the joint bodies.

Brushing lowers the probability of additional heating of the lug or the connector by lowering the resistance at the connection point.

Transition joints and paper-insulated cables

Transition joints are used to connect paper insulated cables to polymeric insulated cables.

Cellulose paper is not a good insulation material by itself, but the high dielectric strength of the mineral oil used to impregnate the paper provides a satisfactory insulation level in low, medium- and high-voltage applications.

Before polymeric insulated cables became a worldwide trend during the 1980s, different types of paper-insulated cables were installed by utilities and industries. This is why paper cables are still in service in many distribution networks and installers are required to know how to work with them.

Installing transition joints from oil-impregnated paper cables on polymeric insulated cables is the most typical task some installers may ever perform in the field, therefore, it is important to be familiar with the types of paper cables and how to handle them.

Handling old paper cables

Paper-insulated cables do not require special tools, but they do require more skill from the installer. Follow these recommendations when handling old paper cables:

- Manipulate the cable with care because the armor may have been corroded, leaving the cable with no mechanical protection.
- Bend the phases very carefully. Cracking the paper insulation will result in failure during operation.
- Perform the installation until the end after removing the lead or aluminum sheath to prevent moisture from being absorbed by the cable.
- Wear gloves while manipulating the lead sheath.

Parts of a paper insulated cable

Outer sheath / Serving coat

Paper-insulated cables typically have a polymeric outer sheath or bitumen-impregnated hessian tape as the most external layer. For optimal removal of bitumen-impregnated serving coats, it is sufficient to apply enough heat and then proceed to remove it by hand. A constant force spring, PVC tape or screw clip can be used to have a fixed and straight cut at the desired length. If the outer sheath is made of PVC or MDPE, refer to the Plier for medium-voltage cable outer sheath.

Armor and bedding

The armor provides mechanical protection against crushing forces and can also be used as a neutral conductor together with the cable sheath. There are three ways to armor cables:

- STA: Steel tape armor, used in multi-core cables (magnetic)
- SWA: Steel wire armor, used in multi-core cables (magnetic)
- AWA: Aluminum wire armor, used in single-core cables (non-magnetic)

The reason behind using magnetic or non-magnetic armoring is related to overheating. In three-core cables, the current flowing induces a magnetic field from each phase, but the vector sum is always close to zero, resulting in very small induced currents in the armor. In single-core cables, non-magnetic aluminum is used to prevent this from happening. In this procedure, the armor is laid over the bedding, which is typically made of wrapped layers of paper and bitumen hessian tape. The bedding serves as a surface for the armor and protection for the sheath underneath and the laid-up cores.

For correct removal of armor and bedding, use a constant force spring to keep the armor in place and a hacksaw to cut the armor. Once the outer sheath is exposed, heat up the bitumen with a medium flame and then use wax help to remove the bitumen from the sheath and clean it.

Sheath

In most cases, an extruded sheath of lead or lead alloy is applied to protect the paper insulation, but aluminum is also used. Connected to the armor, it provides a path for fault and leakage current. The main advantages of an extruded lead sheath are waterproofing and corrosion resistance, but on the other hand it has a limited short circuit capacity, it is made of an expensive material and because of its toxicity, its use is being restricted. A lead sheath can be removed with a knife or with a Plier for medium-voltage cable outer sheath.

Belt insulation, belt screen and fillers

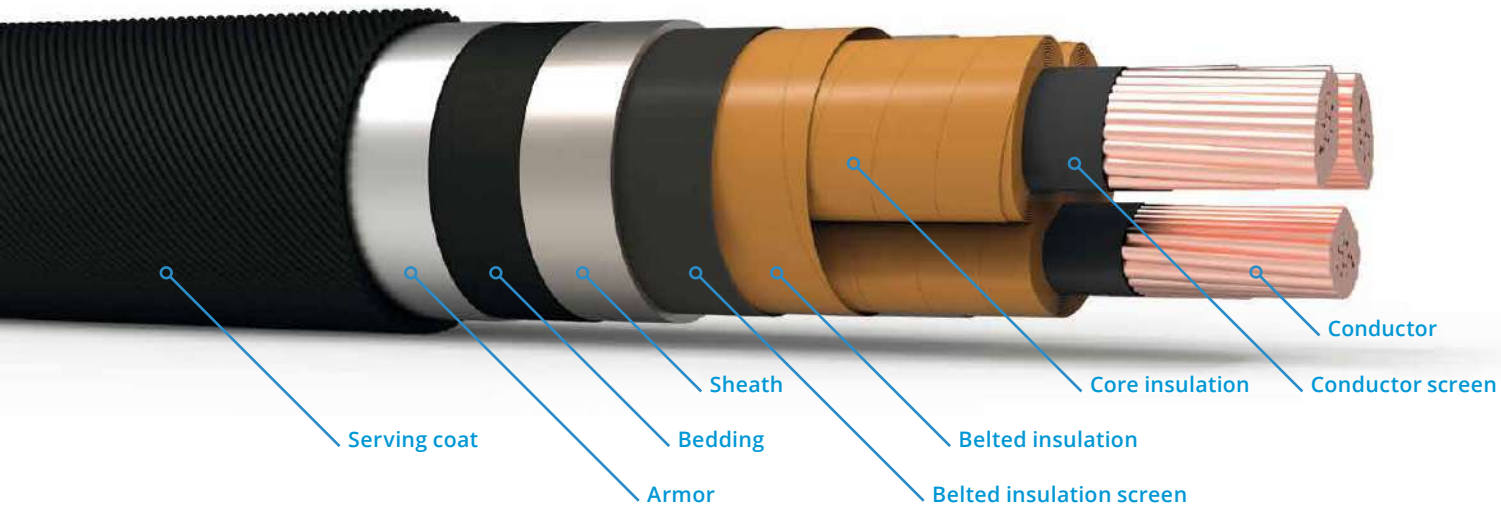
The belt insulation and fillers are typically made of paper, impregnated with a mass-impregnated non-draining (MIND) compound. The belt screen is made of carbon paper tapes.

Insulation screen and insulation

The impregnated paper tapes are helically lapped around the conductors up to the thickness defined by the voltage level. In belted cables, there is no insulation screen at all, but in type H and HSL, it is made of carbon paper tapes and a copper tape or aluminum foil.

Types of medium-voltage paper-insulated cables

Belted



Unscreened phases

The unscreened phases are laid up and insulated to withstand full line-to-line voltage.

Common lead sheath

An additional layer of oil-impregnated insulation paper known as the belt layer, hence the name, is applied around the three phases and then the cable is lead-sheathed.

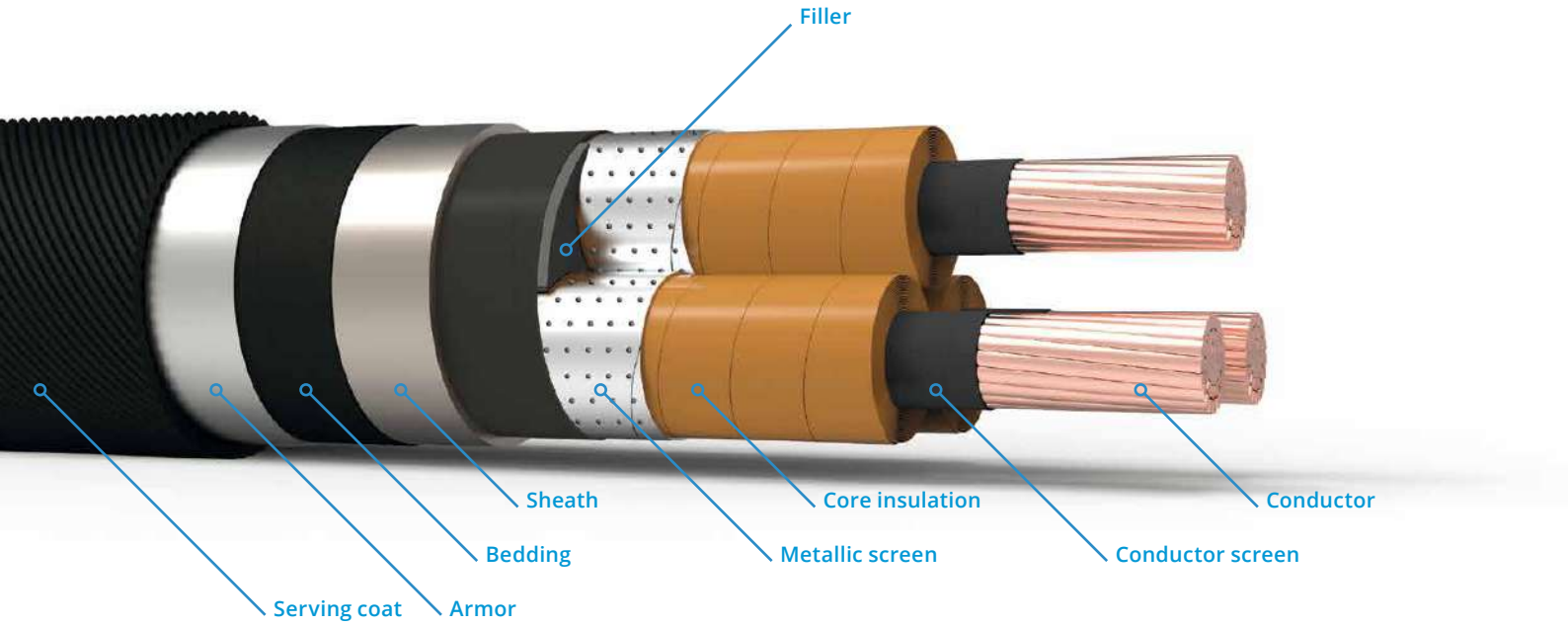
Armor and serving coat

If the cable is armored, a layer of bedding for the armor is added together with a serving coat, which is the most external layer that provides protection from the environment. If the cable is unarmored, then a bitumen layer is added on top of the lead sheath to prevent corrosion and a PVC outer sheath is extruded.

Commonly ≤ 12 kV

Types of medium-voltage paper-insulated cables

Type H



Commonly ≤ 36 kV

Individually screened phases

The insulation of each phase is individually screened with a metallic laminate. The cores of the cable are insulated to withstand full line-to-earth voltage, and laid so that the metallic screens are in contact with each other.

Common lead sheath

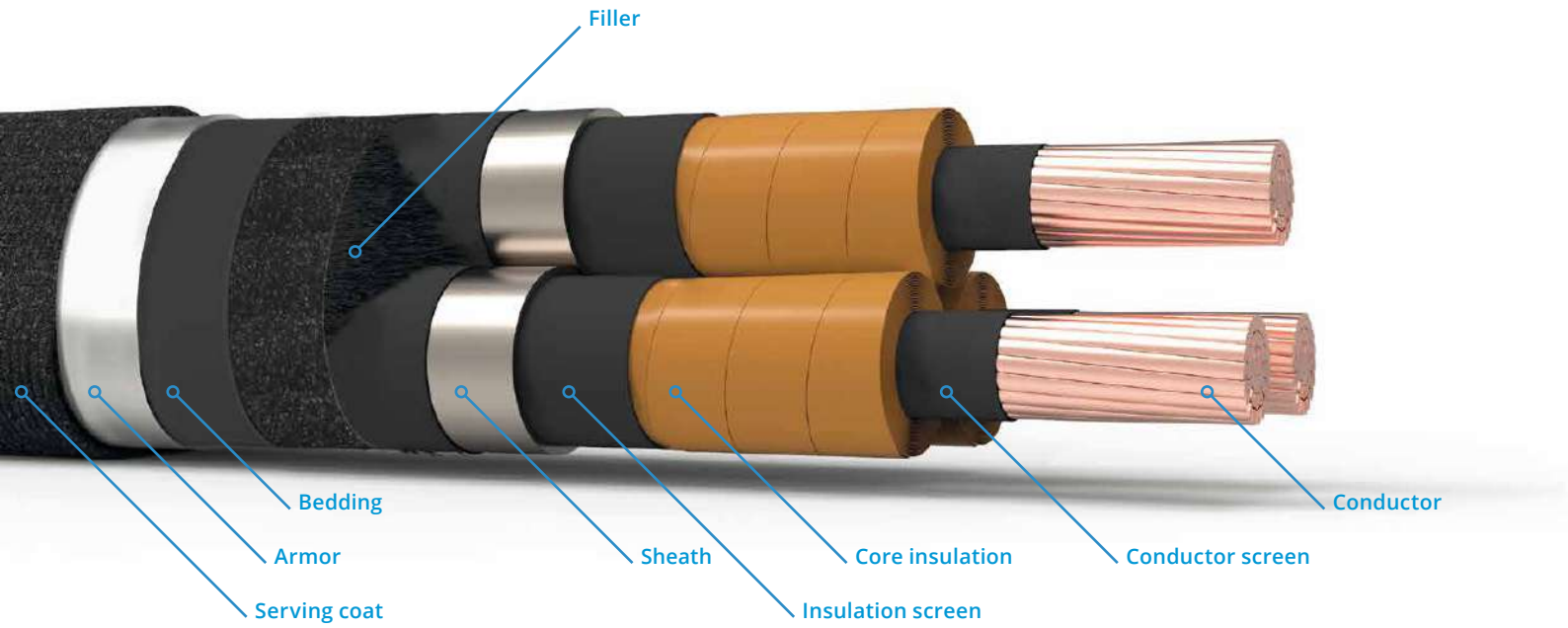
Underneath the lead sheath, a layer of oil impregnated paper is added enclosing the phases and the filler parts.

Armor and serving coat

If the cable is armored, a layer of bedding for the armor is added and a serving coat as the most external layer provides protection from the environment. If the cable is unarmored, then a bitumen layer is added on top of the lead sheath to prevent corrosion and a medium-density polyethylene (MDPE) outer sheath is extruded.

Types of medium-voltage paper-insulated cables

Type HSL



Individually screened and sheathed phases

Insulated to withstand full phase-to-earth voltage, each core is built up as an individual single-core cable and then enclosed by a bedding made of wrapped taped paper and bituminized hessian tape. Each phase is individually screened and sheathed.

Armor and serving coat

The cable is armored with metallic wires of plates. An extruded outer sheath made of PVC, or a bitumen impregnated hessian tape as serving coating, protects the cable from the environment.

Commonly ≤ 36 kV

Preparation before the installation

Accessory kit

Verify that the kit contains all the components listed in the bill of materials.

Always remember to:

- Wash your hands before manipulating the components of the kit
- When jointing two cables, place all the tubular components in one cable before cable preparation

Installation site

The conditions of the installation site may suddenly change due to weather conditions. Expect those changes and be prepared with plastic mattresses, portable roofs, lanterns, pallets and cable stands.

Cable preparation tools

- Check the conditions of the tools and the availability of spare parts beforehand.
- If a hybrid or heat-shrink accessory will be installed, check the gas level of the torch.
- Keep the tools in a clean tray.

Ensto ST277 cable joint stand locking mechanism keeps cable ends in place during cable preparation and makes jointing easier.

Installation errors

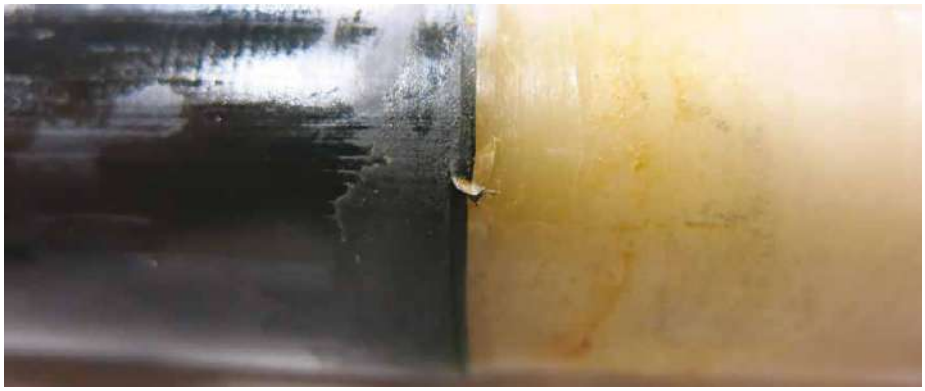
Example of mistakes that cause faults in cable accessories

Sharp bolt

Shear head bolts break when the right torque is achieved. Always use the correct tools for tightening the bolts and never try to break the bolts using other methods. Sharp edges or other shape irregularities will cause the accessory to fail. **This is not a problem when installing Ensto step-less screw connectors.** Once the screw breaks, a semi-conductive cover is placed on top of it.

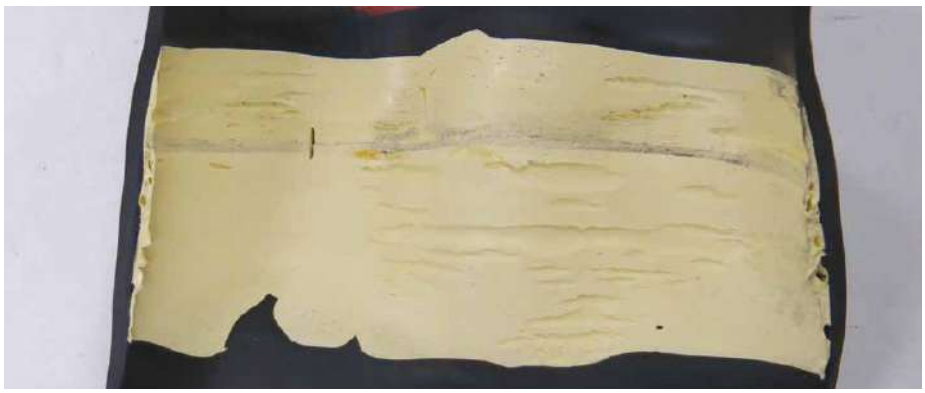
Joint body not centered

In the worst, critical areas of the cable are left without any stress control and discharge eventually occurs.



Irregular edge of the insulation screen

When the edge of the black semi-conductive layer has sharp edges or an irregular shape, a dangerous concentration of electric field occurs in the most critical part of the cable. This is particularly dangerous in heat-shrink accessories.



Air gaps in stress control mastic

When stress control mastic is not melted or was not applied correctly, air gaps remain and discharge occurs.

Tubes shrank asymmetrically

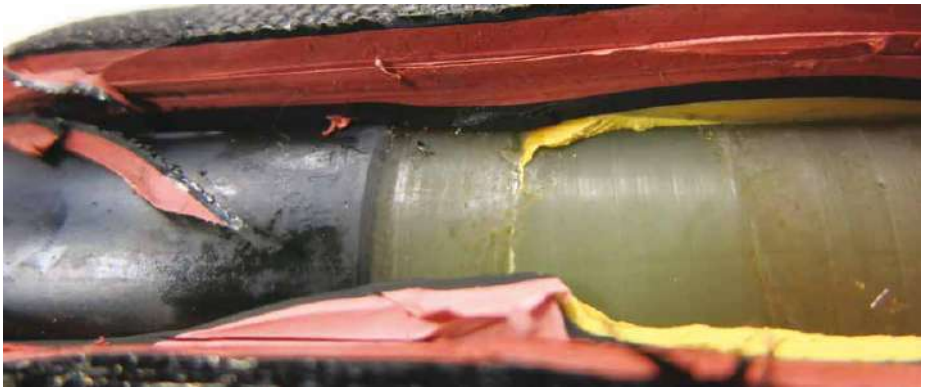
Flame must be in constant movement and applied symmetrically all around the heat-shrink tubes.

Grinding the insulation screen

This cause conductive particles to spread all over the insulation, causing partial discharges.

Dirt between tubes

If the outer sheath is not clean or the tubes are not cleaned after shrinking, sand, dirt and/or small stones can be trapped between tubes and cause severe damage.



Mastics pulled out from original position

When positioning the tubes, pay attention not to pull or drag the mastics underneath. The picture shows an area of the insulation screen left unprotected when part of the stress control mastic was pulled away from its position while placing the tube.

Installation errors

Example of mistakes that cause faults in cable accessories

Sand and dirt

Installation has high cleanliness requirements. Respect them.

Treeing marks

Discharge occurs in air gaps on untreated insulation. The damage of this discharge is progressive and eventually causes the accessory to fail.

Ensto Pro
and Installer Certification

Ensto offers more than products: a complete package with reliable solutions, professional service, and customized support. We want to share our experience in electricity network building and have created Ensto Pro training and Installer Certification concepts.

Ensto Pro is a technical training concept targeted to Enstos' customers, partners and our own personnel. The aim is to support sales and create loyal customer relations by sharing knowledge. We wish to learn from customer experiences and truly understand customers' requirements, thereby becoming able to develop our products to best meet those precise needs.

Ensto Pro training is unique:
- Local service in the local language.
- Customized trainings.
- Consistent and engaging training methods and presentations.
- Easy-going and easily approachable professionals.
- Emphasis on two-way learning.

Customer benefits from Ensto Pro training:
- Time, cost, and energy savings.
- Fewer installation errors.
- Confidence and motivation.
- The opportunity to have an influence.
- New perspectives.

Variety of Training Types
Our customer training ranges from small installation sessions to large lecture-type events. Installation trainings can happen in the field or in virtual. Also, we are ready to teach about a host of topics as customer needs and wishes dictate. We also arrange, or are involved in, sessions attended by professionals from various institutions, such as cable manufacturers and energy-market authorities. By offering all the necessary information in one session, we save time and energy. We care about your success.

Ensto Installer Certification
Installer Certification means a screening test for the installation of Ensto's low and medium voltage underground cable accessories, which aims at the correct installation. The starting point is the need for network companies to reduce failure interruptions due to installation errors, which is a global problem.

Installer Certification has many benefits for the DSO's, contractors and installers.
- Correctly installed solutions and longer lifespan.
- Reliability to the network.
- Time and cost savings – avoiding electrical outages.
- Motivated professionals.
- Professional know-how.
- Extended warranty.
- Certified quality.

6000 units yearly – zero installation faults
The Finnish DSO Enerke has already certificated of all their installers. The original certificates were valid for five years and in 2020 it was time to re-certify. Enerke sees certification very important and certification is in place to make sure that everyone can produce top quality.

Enerke terminates yearly 2000 units of 3-phase cables resulting to 6000 terminations. In normal year there has been not a single fault. Enerke believes in Ensto as a partner that helps in many ways to achieve the high quality and reliability criteria they have set for themselves.

Ask more of Ensto Pro training and Installer Certification from sales.

Cable tools

Our selection includes peeling tools for the insulation, insulation screen and sheath of medium voltage cables.

Medium voltage insulation removal tools

Product code	GTIN	Description
ST252	6418677457418	Insulation removal set for 20 kV cables
ST252.1	6418677457425	Spare blade for ST252
ST261	6438100314446	Insulation stripping handle for inserts ST265-273
ST266.10	6438100330286	Insulation removal insert 10kV 35 mm² for ST261
ST267.10	6438100330293	Insulation removal insert 10kV 50 mm² for ST261
ST269.10	6438100340346	Insulation removal insert 10kV 95 mm² for ST261
ST270.10	6438100330309	Insulation removal insert 10kV 120 mm² for ST261
ST271.10	6438100330316	Insulation removal insert 10kV 150 mm² for ST261
ST272.10	6438100330323	Insulation removal insert 10kV 185 mm² for ST261
ST273.10	6438100330330	Insulation removal insert 10kV 240 mm² for ST261
ST265	6438100316099	Insulation removal insert 20kV 25 mm² for ST261
ST266	6438100314453	Insulation removal insert 20kV 35 mm² for ST261
ST267	6438100316105	Insulation removal insert 20kV 50 mm² for ST261
ST268	6438100316112	Insulation removal insert 20kV 70 mm² for ST261
ST269	6438100316129	Insulation removal insert 20kV 95 mm² for ST261
ST270	6438100316136	Insulation removal insert 20kV 120 mm² for ST261
ST271	6438100316143	Insulation removal insert 20kV 150 mm² for ST261
ST272	6438100316150	Insulation removal insert 20kV 185 mm² for ST261
ST273	6438100316167	Insulation removal insert 20kV 240 mm² for ST261
ST274	6438100316174	Insulation removal tool ø 15-52 mm
ST274.1	6438100330354	Spare blade for ST274

Insulation screen removal tools

Product code	GTIN	Description
ST250	6418677457388	Bonded insulation screen removal tool 10-52 mm
ST250.1	6418677457395	Spare blade for ST250
ST308	6438100324117	Bonded insulation screen removal tool 18-60 mm
ST308.1	6438100330026	Spare blade for ST308
ST260	6438100313128	Peelable (non-vulcanized) insulation screen removal tool ø 16-41 mm
ST260.1	6438100317935	Spare blade for ST260

Cable tools

Outer sheath removal tools

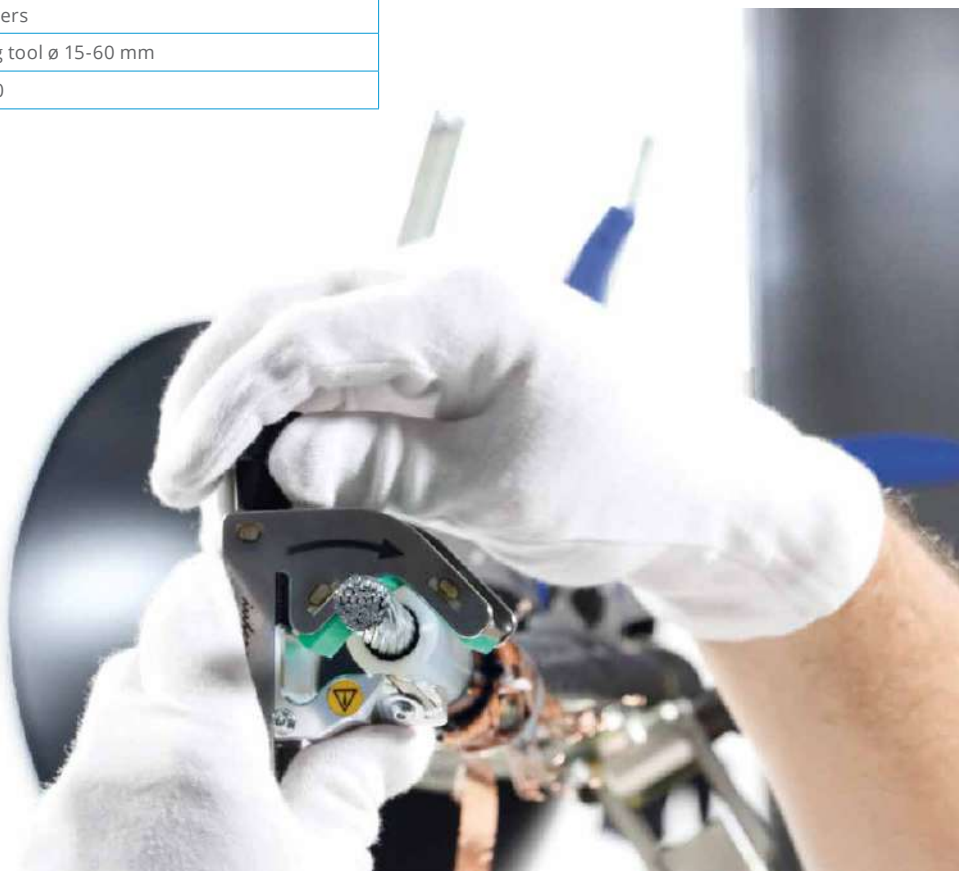
Product code	GTIN	Description
ST257	6438100311940	Outer sheath/aluminium laminate removal tool ø 16-54 mm
ST257.1	6438100321383	Spare blade for ST257
ST281	6438100320232	Outer sheath/aluminium laminate removal tool ø 16-40 mm
ST281.1	6438100330002	Spare blade for ST281
ST285	6438100320270	Outer sheath/aluminium laminate splitting tool ø 16-60 mm
ST285.1	6438100330019	Spare blade for ST285
ST291	6438100329990	Outer sheath/aluminium laminate removal tool ø 16-58 mm

Cable stands

Product code	GTIN	Description
ST277	6438100317089	Cable jointing stand

Additional tools

Product code	GTIN	Description
ST251	6418677457401	Holding tool for connectors/lugs
ST259	6438100312367	Wedge for spreading the outer sheath and aluminium laminate
ST286	6438100320287	Tool for spreading the outer sheath and aluminium laminate
ST258	6438100312015	Metal tie tightening tool
ST310	6438100327903	Metal tie fastening pliers
ST280	6438100318666	Insulation chamfering tool ø 15-60 mm
ST280.1	6438100324483	Spare blade for ST280



Notes

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