

Covered conductors for overhead lines and the related accessories for rated voltages above 1 kV a.c. and not exceeding 36 kV a.c. Part 3: Guide to Use

Foreword

To be created by SecTC-20.

Contents

Introduction

1 Scope

The object of this annex is to provide general recommendations for the selection, storage, transportation and installation of the covered conductors and the related accessories specified in part 1 and 2 of this standard, unless otherwise specified. Safety regulations and environmental regulations as well as rules for installation and mechanical design are not considered in this Guide to Use, as they are covered by relevant national regulations and laws. Relevant national regulations are not considered in this guide, but shall always be consulted as appropriate.

Note: The term "national regulations" is used throughout this guide. It may include specific safety regulations, rules of installation and other relevant instructions which, depending upon the particular country or district, may exist in a legislative (mandatory) form, or as a non-mandatory code of practice. In addition certain specific utilities may have their own safety practices.

It is assumed that the design of installations, the purchase and installation of covered conductors and of the related accessories specified in this EN is entrusted to suitably skilled and competent people. In case of doubt as to the suitability of covered conductors and the related accessories for a particular use, further specific information shall be obtained from the manufacturer.

2 Normative references

EN 50397-1	Covered conductors for overhead lines and the related accessories for rated voltages above 1 kV AC and not exceeding 36 kV AC Part 1 Covered conductors
EN 50397-2 ¹	Accessories for covered conductors: Tests and acceptance criteria
EN 50182	Conductors for overhead lines - Round wire concentric lay stranded conductors

3 Definitions

¹⁾ At draft stage.

3.1

rated tensile strength (RTS)

an estimate of the conductor breaking load calculated using the specified tensile properties of the components wires (see EN 50397-1, 4.2.1)

3.2

specified minimum failure load (SMFL)

minimum load specified by the purchaser or declared by the supplier at which mechanical failure will not take place

NOTE From the probabilistic point of view, the specified minimum failure load corresponds to the value having the probability of e % in the distribution function of the strength of the fitting. The exclusion limit e % is usually taken within 2 % to 5 % with 10 % being the upper limit (see IEC 60826).

3.3

slippage factor (X-value)

defines the ratio between the tensile force on the covering of the conductor when a certain slippage starts to occur and the RTS of the conductor (see EN 50397-1, Annex D).

NOTE A X-value of e.g. 100% means that at a force up to RTS no relative slippage between the covering and the conductor does occur.

4 Guide to Use for covered conductors

4.1 Recommendations for selection of covered conductors

4.1.1 General

Covered conductors specified in EN 50397-1 are equipped with a polymeric covering as protection against accidental contact with grounded parts or other live covered conductors. Covered conductors are not touch proof, so they shall to be treated as non-protected plain conductors with regard to protection against electric shock.

The use of covered conductors is only permissible in air and mounted on suitable insulators, which are at least specified for the rated voltage of the overhead line.

4.1.2 Power frequency range

Covered conductors are intended to be used in the power frequency range of 49 Hz to 61 Hz.

4.1.3 Current rating

Reference shall be made either to Annex A of EN 50397-1, to EN 50182 or to the manufacturer's specifications to obtain the current ratings of the selected conductor cross sections and the maximum permissible conductor temperature for the covering material as given in sub-clause 4.2.3 of EN 50397-1.

If covered conductors in accordance with EN 50397-1 are exposed to strong solar radiation or high temperature ambient conditions, the current carrying capacity shall be reduced accordingly.

4.1.4 Operating conditions

In addition to the current ratings, due regard shall be given to:

- a) the capability of the covered conductor to withstand the worst anticipated fault conditions of the system;
- b) the earth loop impedance;
- c) the operating characteristics of the connected equipment;
- d) the voltage drop requirements for long distance conditions.

In certain cases longitudinal watertight conductor constructions can be necessary to avoid corrosive effects to the conductor and to obtain a sufficient life time of the overhead line system.

4.2 Recommendation for storage and transport

4.2.1 General

Suitable protection, appropriate to the choice of covered conductors and the installation conditions, shall be provided against mechanical damage.

Covered conductors stored at temperatures which are below those recommended for installation shall not be subject to any mechanical stress including shocks, impact, bending and torsion. It is recommended not to store complete reels in conditions, where the maximum permissible conductor temperature as given in sub-clause 4.2.3 of EN 50397-1 is exceeded.

4.2.2 Sealing and drumming

4.2.2.1 Clearance and lagging

In general it is recommended to use lagging or other equivalent protection to avoid damage to the covered conductor. If lagging is used the thickness shall be appropriate.

The distance between the outer layer of the covered conductor on the filled drum and the ground or lagging shall be sufficient to avoid damage to the covered conductor. It is recommended to use a clearance of at least 5 cm.

4.2.2.2 Barrel diameter

The barrel diameter of delivery drums shall not be smaller than $30 \times D$, where D is the outer diameter of the covered conductor.

4.2.2.3 Sealing

The ends of covered conductors shall be sealed to prevent ingress of moisture during transport and storage. The possibility of damage to moisture seals during transport and storage shall be borne in mind. Where such a damage may have occurred, the conductor end shall be inspected and the seal remade.

4.2.2.4 Handling

When handling drums, suitable precautions shall be taken to avoid damage to the covered conductor and injury to people. Due regard shall be paid to the mass of the drum, the method and direction of rolling and the method of lifting. Drums shall be stored only on even and solid grounds.

4.2.2.5 Drum condition

Drums shall be regularly inspected during storage to assess their physical condition. Care shall be taken to avoid damage to the covered conductor caused by nails and staples used either in drum manufacturing or when applying laggings. Laggings, where applied, shall not be removed from drums until the covered conductor is about to be installed.

Care shall be taken to avoid deterioration of the drums. Drums shall be stored so that the drum flanges do not contact products on other drums. See fig. 1.

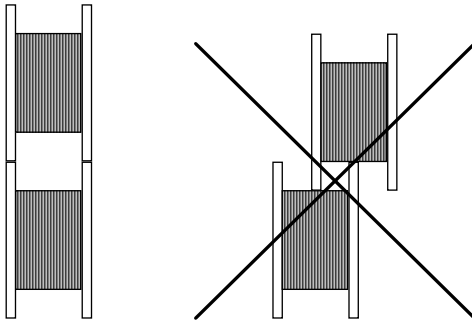


Figure 1 – View from the top

Drums shall be stored with the drum axis horizontal. See fig. 2, 3 and 4.

4.2.3 Transport

4.2.3.1 Carriers

Only suitable carriers shall be used.

4.2.3.2 Drum axis position

Drums shall be transported with the drum axis horizontal and any drum movement shall be avoided.

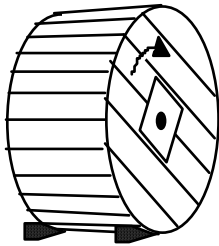


Fig 2: Keep the drum standing upright, using wedges in the heels of the flanges

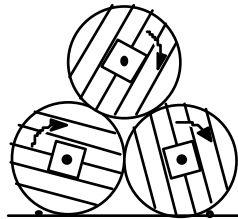


Fig 3: Only drums with protection lagging may be piled flange on flange. Lower layer to be secured over full drum width

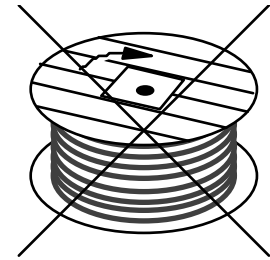


Fig 4: Not recommended

4.2.3.3 Loading and unloading

For loading and unloading of drums, suitable lifting and hoisting equipment shall be used. See fig 5. Drums shall not be dropped.

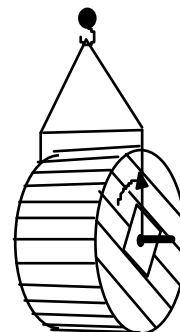
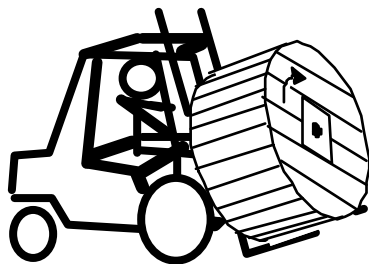


Fig 5: Drums may be lifted either by crane or fork-lift truck

4.2.3.4 Rolling of drums

Drums shall be rolled only for short distances over flat solid ground in the direction indicated on the flange. See fig 6.

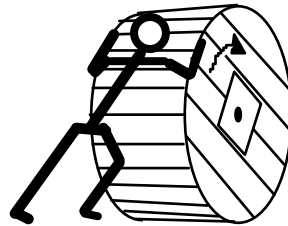


Fig 6: Rolling the drums

4.2.3.5 Rewinding

Rewinding shall be made as shown in fig 7 and 8. :

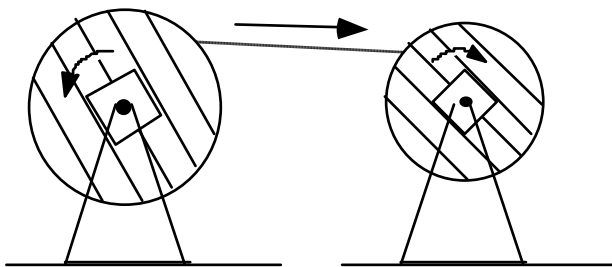


Fig 7: Recommended direction

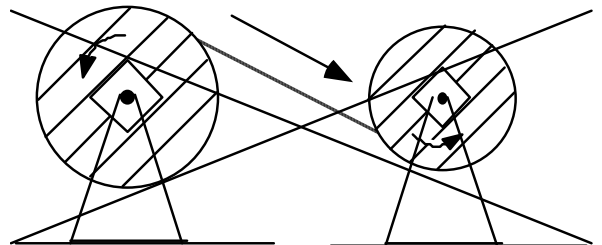


Fig 8: Not recommended direction

4.2.3.6 Fastening of conductor ends to the drum

Conductor ends shall be firmly attached to the drum during transport and storage without damaging the conductor ends. It is recommended that both conductor ends are accessible.

4.2.3.7 Conductor coils

Short lengths of covered conductors may be coiled. Coils shall be stored and transported horizontally on suitable palettes.

The inner coil diameter shall not fall below the minimum permissible barrel diameter of a suitable drum as given in sub-clause 4.2.2.2.

The coils shall be protected against mechanical stress and shocks.

4.3 Recommendation for installation of covered conductors

4.3.1 Applications

Covered conductors are used on new lines as well as for refurbishing or gentrifying existing overhead lines. Due to the reduced phase clearances and lanes covered overhead lines may be installed on routes formerly considered as too narrow or not suitable for bare overhead lines.

Covered overhead line systems may provide enhanced supply reliability, further reasons for using covered overhead line systems can be given in local regulations like protection of endangered birds etc.

4.3.2 Design of covered overhead line systems

The electrical, mechanical and chemical properties of covered conductors as described in EN 50397-1 shall be taken into account when planning a covered overhead line system. The route, pulling method, climatic conditions and service conditions (operating conditions and installation data) shall, together with national regulations, be taken into account when selecting the type of covered conductors.

In this context topics like the following should be considered:

- operating temperature;
- span length;
- sagging;
- uplift and downpull;
- solar radiation;
- ice loading;
- wind pressure and vibrations;
- mechanical stress due to tree falls;
- risk of tracking (e.g. due to chemically polluted rain);
- arc protection.

4.3.3 Installation conditions

Installation of covered conductors shall be done by authorised and skilled contractors only. All national regulations shall be taken into account. Covered conductors shall be installed and operated in such a way not to impair their properties. Care shall be exercised during installation to avoid any damage to the conductor covering and to the conductor itself.

4.3.4 Types of installation

Covered conductors shall only be installed in air and mounted on suitable insulators, which are at least specified for the rated voltage of the overhead line.

4.3.5 Preparation of lanes

The overhead line lanes shall be sufficiently prepared by clearing from obstacles such as trees, bushes, branches etc. as given in the national regulations.

4.3.6 Unwinding

Unwinding shall be made as shown in fig 9 and 10.

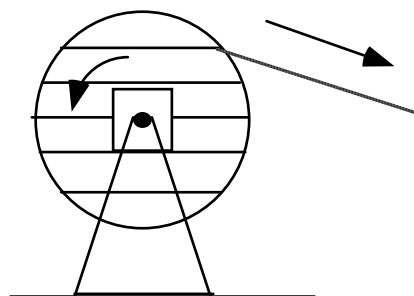


Fig 9: Unwind this way

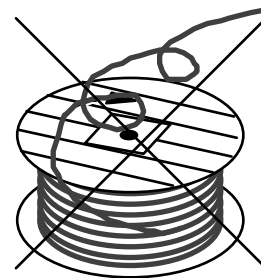


Fig 10: Never unwind this way

To prevent the covering from damage any abrasive contact with soil, stones etc. is not permitted.

4.3.7 Bending radii

Special attention shall be paid to avoid bending radii which can cause deterioration of any property of the covered conductor. In doubt the manufacturer of the covered conductor shall be consulted.

4.3.8 Prevention of moisture ingress

Care shall be exercised during installation to avoid any damage to the conductor covering.

Especially for watertight conductor designs using swelling materials the seal caps shall not be removed from the ends of the covered conductor until immediately prior to fixing, termination or jointing.

The possibility of damage to moisture seals during installation shall be borne in mind. Where such damage may have occurred, the seals shall be inspected and remade if necessary.

4.3.9 Protection of covered conductors during installation and operation

Rollers in appropriate diameter and quantity have to be provided for installation. The rollers shall have a smooth clean surface, no sharp edges and shall rotate easily.

To prevent the covering from damage any abrasive contact with soil or stone is not permitted. Abrasive contact of the covering with branches or similar shall be avoided.

4.3.10 Lowest temperature of installation

The lowest temperature of the covered conductors during installation is -25° C. This temperature is valid for the covered conductor itself and not for the surroundings.

When covered conductors are installed at a lower temperature than permitted they may be warmed up at least to the minimum temperature. It is recommended to perform this preheating in a closed room (storage, container, tent or similar), never using an open flame as heat source. This operation may take one or two days. For adjusting the required sagging this preheating has to be taken into account.

4.3.11 Pulling force during installation

Covered conductors shall be pulled by using appropriate pulling devices ensuring that the pulling force is distributed to the conductor. The pulling force shall be continuously monitored during the pull-up procedure and shall not exceed the permissible values.

The maximum recommended pulling force varies according to the pulling configuration.

- a) Pulling directly on the conductor with the covering removed:
The maximum pulling force shall not exceed 37% of the RTS of the conductor.
- b) Pulling on the covered conductor with the covering not removed:
The applicable pulling force depends on the adherence of the covering onto the conductor, defined by the X-value according to Annex D, subclause D.7 of EN 50397-1.

The maximum pulling force at 23° C shall not exceed the value calculated according to the following formula:

$$F = 0,27 \times (X / 100) \times \text{RTS}$$

where

F = Pulling force in kN

X = X-value in %

RTS = Rated tensile strength of the conductor in kN

Note: The rated tensile strength of the conductors can be found in Annex A of EN 50397-1 and in Annex F of EN 50182 with consideration of the requirements for compacted conductors.

4.3.12 Tension force during operation

The maximum permissible tension force shall be taken out of the relevant national rules.

4.4 Other recommendations

Incineration of scrap conductors shall only be undertaken in accordance with national regulations.

Covered conductors may be harmed by exposure to corrosive products or solvents, especially petroleum based vapours.

The standard covering compounds used on these conductors do not provide any protection against damage by rodents, termites, etc..

5. Accessories

5.1 General

Accessories used with covered conductors shall comply with EN 50397-2. Installation of accessories for covered conductors shall be done by authorised and skilled line men only. All national regulations shall be taken into account and manufacturer's instructions shall be followed.

Any contamination which may have a negative impact on the electrical and mechanical properties shall be avoided resp. removed before installation.

In general it is recommended to install the whole system in an appropriate way to maintain the continuity of the covering as much as possible. Any uncovered life part of the system like earthing devices, arc horns etc. may be considered as electrically weak points although technically required.

5.2 Joints

When jointing the covered conductor all types of joints suitable for bare conductors such as compression, explosive, preformed or automatic joints may be used. All joints shall be covered after installation by an appropriate method to maintain the electrical and watertightness properties of the covered conductor system.

All joints shall reach the required mechanical values as given in the applicable standards, national regulations or as agreed between customer and purchaser.



Fig 11: Example of a joint

5.3 Insulators

Covered conductor may be installed on different types of approved insulators. However the insulator type has to be checked if the covered conductor can be properly attached to the top groove or side groove of the insulator.

The insulators may be installed in horizontal or vertical position on cross arms or similar equipment according to national regulations.

Depending on the applicable national rules a reduced phase clearance may be used than in bare conductor systems.

5.4 Fittings

5.4.1 Suspension clamps

The covered conductor may be installed by means of different types of suspension clamps, mounted either on post type insulators (rigid) or standard suspension insulators (flexible).

For post type insulators bolted attached clamps and ties may be used, for standard suspension insulators bolted clamps, roller clamps and ties may be used.

5.4.1.1 Bolted attached clamps

These clamps shall be installed in accordance to the manufacturer's instructions. These clamps can be used with the covering of the conductor removed or not removed, depending on the X-value of the covered conductor and the application. In general it is recommended to keep the covering on the conductor when the X-value is sufficient.

5.4.1.2 Roller clamps

These clamps shall be installed in accordance to the manufacturer's instructions. These clamps shall be used with the covering of the conductor not removed.

5.4.1.3 Ties

Ties may be preformed or hand made. Usually the friction area of preformed ties is bigger and may be therefore favourable. Ties can be used with the covering of the conductor removed or not removed, depending on the X-value of the covered conductor and the application. In general it is recommended to keep the covering on the conductor when the X-value is sufficient.



Fig 12: Example of a preformed tie

5.4.2 Tension clamps

The covered conductor may be installed by means of different types of tension clamps as bolted, preformed helical, compression type or wedge type.

NOTE Due to different designs and constructions on the market it is recommended to verify the compatibility of the covered conductors and the fittings.

Tension clamps are always combined with an insulator made of e.g. composite, porcelain or glass.

5.4.2.1 Bolted tension clamps

These clamps shall be installed in accordance to the manufacturer's instructions and can be used with the covering of the conductor removed or not removed, depending on the X-value of the covered conductor and the application. In general it is recommended to keep the covering on the conductor when the X-value is sufficient.

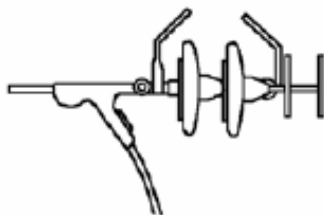


Fig 13: Example of a bolted tension clamp

helical fitting

5.4.2.2 Preformed

These fittings shall be installed in accordance to the manufacturer's instructions and can be used with the covering of the conductor removed or not removed, depending on the X-value of the covered conductor and the application. In general it is recommended to keep the covering on the conductor when the X-value is sufficient.

For very long spans or exceptional high RTS values the use of helical dead end sets (reinforcing rods + dead ends) is recommended.

5.4.2.3 Compression tension clamps

These clamps shall be installed in accordance to the manufacturer's instructions and shall be used with the covering of the conductor removed.

5.4.2.4 Wedge type tension clamps

These clamps shall be installed in accordance to the manufacturer's instructions and can be used with the covering of the conductor removed or not removed, depending on the X-value of the covered conductor and the application. In general it is recommended to keep the covering on the conductor when the X-value is sufficient.

5.4.3 Tee off

A tee off may be realized by using a tension free jumper. The jumper shall be connected to the main line by using a penetration connection clamp (with the covering of the conductor not removed) or by e.g. a parallel groove clamp (with the covering of the conductor removed).

If hot line working is requested and legally allowed special designed penetration clamps shall be used (see Fig 15).

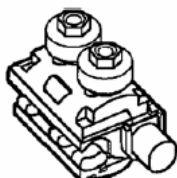


Fig 14: Example of a penetration connection clamp



Fig 15 : Example of a live working penetration tee off clamp

5.5 Earthing devices

Installation of earthing devices may be required by national regulations or technical rules and can have different reasons, e.g. as system protection, general safety rules or working safety. These requirements may also include additional informations like distance between earthing points etc..

Earthing devices may be realized by using one or two penetration connection clamps together with a bare earthing rod or earthing conductor. See fig. 16.

Existing fittings like arc also used as earthing

horns or compression clamps may be contact points.



Fig 16: Example for an earthing device

5.6 Arc protection devices

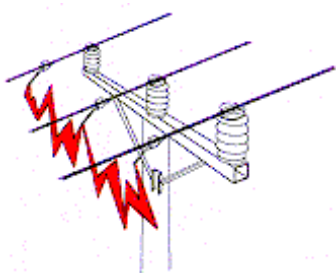


Fig 17. Arc between phase to phase

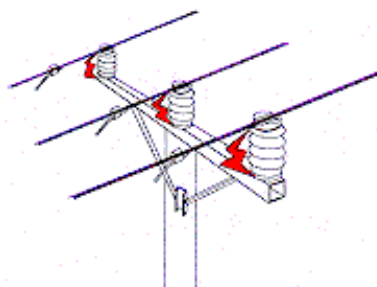


Fig 18: Arc between phase to crossarm

Very high voltage can be emerged from the atmosphere. These high voltage can ignite an arc between phase to phase (see fig. 17) or phase to cross arm (see fig. 18). which can burn off the conductor.

Installation of arc protection devices may be required by national regulations or technical rules to avoid arcs from burning off the covered conductors. These requirements may also include additional informations like where such devices have to be installed out of safety reasons e.g. like line ends, road crossings, places where the covering has been removed and angle poles.

In general the installation may be made by a penetration connection clamp combined with a horn mounted on the covered conductor and it's counterpart under the insulator. See fig. 19. The gap between the arc horn and it's counterpart shall be adjusted according to the rated voltage of the line.



Fig 19: Example of arc protection device

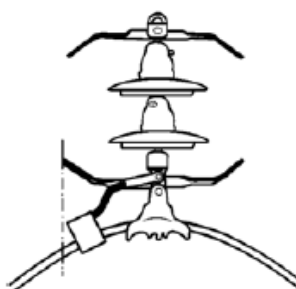


Fig 20: Example of arc protection device for angle constructions

5.7 Surge arresters

Installation of surge arresters for the protection of covered conductors is considered as not necessary unless required or recommended by national regulations.

5.8 Bird protection

In general covered conductors provide enhanced bird protection if the covering is intact. Additional bird protection may be used where bare life parts are exposed. National regulations for animal protection shall be taken into account.

5.9 Corona protection

Special attention shall be paid to the avoidance of corona effects and partial discharges of the complete system.