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110 KV CABLES AND FITTINGS

Summary

This technical description (TD) sets out the requirements that apply to assembly and testing of 110 kV cables with cross-linked polyethylene extruded insulation and their fittings.

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1 Amendments

All amendment notes from older versions are laid out in Annex V in the revision index, Table V-01.

Table 1-01 Overview of amendments

Version	
Section	Topic
Whole document	Converting KG4023 into TD3514

2 Purpose

This technical description sets out the desired nominal state for technical parameters and other equipment properties and should be applied to procedures for equipment procurement and approval.

3 Scope

This technical description shall apply for work within the companies below:

Stromnetz Berlin GmbH

This TD replaces KG4023 "110 kV cables and their fittings".

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4 Supplementary documents

4.1 Regulations

None

4.2 Standards

This version of the TD should be used to supplement the relevant IEC, EN, HD and DIN VDE rules. The most recent version of the document in question is to be used for all undated references.

DIN VDE 0276-632-3 (+Part 4-D)	Power cables with extruded insulation and their fittings, for rated voltages above 36 kV (Um = 42 kV) up to 150 kV (Um = 170 kV)
DIN EN 60229 (VDE 0473-229)	Electric cables – Tests on extruded oversheaths with a special protective function

5 Copyright

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6 Parameters

Electrical parameters

The TD applies to single-core 110 kV cables with cross-linked polyethylene extruded insulation and their fittings (e.g. sleeves, connection terminals and outdoor cable terminations) with the following parameters:

- U_0/U = 64/110 kV (rated voltage)
- U_m = 123 kV (maximum voltage for equipment)
- U_{rB} = 550 kV (rated lightning surge voltage)
- $U_{??}$ = 230 kV (rated short-term AC voltage)
- I_a = 40 kA/1s (rated short-circuit current / rated short-circuit duration)

- $I_{??}$ = 100 kA (rated surge current)
- $I_{??}$ = 10 kA (earth fault current)

7 Authorisation

110 kV cables and their fittings may only be procured and used after successful completion of testing and approval by the technical department.

Manufacturers must notify the technical department of changes to the components or design of approved products. The testing required to obtain authorisation must be performed for any existing modifications. Any unnotified changes to the authorisation status will invalidate the authorisation.

8 Cable system requirements

8.1 Standard cables for the Berlin network

The conductor should be a stranded, compressed circular conductor.

The nominal cross sections for copper conductors are 300 mm², 630 mm² or 800 mm².

The nominal cross section for aluminium conductors is 1000 mm².

The copper sheath cross section (in the form of a geometric cross section of the shield wires and helix copper tape) is **35 mm²** and may only exceed these dimensions by max. 3.0 mm².

When using fibre optic cables (FOC) in the shield, a cross section of **50 mm²** may be required for structural reasons. In this case, all three conductors within the system (including those without FOC) must have a shield cross section of 50 mm².

Oversheaths with a special protective function

(optional, only provided at the client's specific request)

The cable sheath should be an oversheath with a special protective function according to DIN EN 60229 (VDE 0473-229) and shall be subject to the relevant tests. These tests must be documented and transmitted to the client accordingly.

Electrical tests after installation in line with DIN EN 60229 10 kV/1 min (Annex B to DIN EN 60229 Guidelines).

The oversheath should be an outer sleeve with a black, conductive covering. A graphitised version may not be used.

- Abbreviation: **>C<**

The PE cable sheath must be red (UV stabilised) .

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8.2 General fittings information

Only prefabricated, slip-on sleeve parts or stress cones may be used for cable terminations, connectors or sleeves.

This does not include the non-prefabricated oil side of transition sleeves for connecting XLPE cables with oil cables.

8.3 Standard fittings for the Berlin network

Due to the need to provide fittings and short supply recovery times in the case of a fault, only approved "standard fittings for the Berlin network" may be used in the case of a fault in the Berlin network.

8.3.1 Switchgear connection termination

The switchgear connection termination must have installation dimensions compatible with IEC 62271-209 (from Südkabel company type D) (voltage series 123 kV – 145 kV).

For conductor cross sections of up to 800 mm², the **plug contact** cross section must be **60 mm** (see Appendix 1).

Pure manufacturer systems (plug + socket) must be provided for conductor cross sections of 1000 mm² or over.

8.3.2 Outdoor cable termination with composite insulator

The Berlin Network uses composite insulators made of glass-fibre reinforced plastic (GRP) with cast-on, parallel (rather than screwed on) shields made out of electrical high-quality silicone rubber.

The minimum creepage distance is 2460 mm (equivalent to pollution layer class 2 under VDE 0111-2: 1997-09, Table 1).

8.3.3 Outdoor cable termination in air core design

The use of outdoor cable terminations in air core design with and without support (but with a support insulator) is only permitted with technical department approval and upon gaining type approval.

The minimum creepage distance is 2460 mm (equivalent to pollution layer class 2 under VDE 0111-2: 1997-09, Table 1).

8.3.4 Connection sleeves

Only prefabricated, silicone slip-on sleeve parts (one-piece or three-piece) may be used.

Glass fibre reinforced sleeves with integrated metal diffusion barriers must be used to protect against external damage and to act as water vapour barriers.

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8.4 Modifications to cables or fittings

In principal, no other designs (for cables or fittings) which diverge from that laid out in the type approval may be used. If modifications are necessary after type approval, the client and manufacturer must agree upon said changes before starting any bids for tender or production of equipment. For significant modifications, enough time must be set aside for a new type approval.

In order to avoid an additional type approval after this TD, the required product function checks may be carried out in conjunction with the technical department.

9 Cable design

9.1 Conductor

The conductor must conform with DIN EN 60228 .

The conductor design should be either that of a stranded, compressed circular conductor made from copper or aluminium, or a solid circular aluminium conductor (depending on client authorisation and request). To minimise skin effect, all conductors with cross sections of 1200 mm² or above should have a segmented conductor design with at least five segments.

There must be semi-conductive tape over the conductor.

9.2 Insulation

The insulation must be made out of single-layer extruded and cross-linked polyethylene compound. Only triple extruders may be used. The cross-linking must be dry and peroxydic.

An air separator and magnetic separator must be used when feeding in insulation.

9.2.1 Requirements for conductor insulation for conductor cross section of up to 800 mm²

In insulation for cables with conductor cross sections below or equal to 800 mm², the wall thickness must have a median and nominal value of 18.0 mm.

The minimum value may not be lower than 17.30 mm.

The ratio between maximum and minimum measured values must not exceed a ratio of 1.07 within one sectional plane.

T max / T min ≤ 1.07

9.2.2 Requirements for conductor insulation for conductor cross section of 1000 mm² or above

For cables with conductor materials made from aluminium, a median and nominal value of 16.0 mm applies for all cross sections of 1000 mm² or above.

The minimum value may not be lower than 15.4 mm.

The ratio between maximum and minimum measured values must not exceed a ratio of 1.07 within one sectional plane.

T max / T min ≤ 1.07

9.2.3 Additional insulation requirements

Measurement of individual values for insulation must ensure proper measuring and documentation of the thickest and thinnest point in the insulation. Additional measurements are to be carried out if more than six measurements (with 60° increments) are required in order to obtain these values.

Inner and outer conductive layers must be excluded when calculating the insulation layer thickness.

The insulating cover cross section may not be larger or smaller than the values below (necessary individual values for wall thickness measurement):

Cross section	**Min. diameter**	**Max. diameter**
300 mm²	58.00 mm	62.00 mm
630 mm²	68.50 mm	72.00 mm
800 mm²	73.00 mm	78.00 mm

9.2.4 Irregularities in the insulation

Irregularities in the insulating cover can only be tolerated when isolated (maximum of two per 250 mm sample length – irrespective of size). The following requirements apply:

- There cannot be any irregularities larger than 0.10 mm at their widest point.
- Irregularities smaller than 0.10 mm at their widest point must be inspected in conjunction with the client, then assessed and individually approved (regardless of the inspection results).
- Additional checks (follow-up tests) must be carried out if irregularities are discovered in the insulation. (See 10.4 Repetition of tests)
- Irregularities in the insulating cover must not extend into the inner conductive layer by more than 0.060 mm.

9.3 Conductive layers

Cables must have an inner conductive layer for field boundaries with the conductor, or an outer conductive layer for those with the insulating layer.

The conductive layers must be connected to the insulation via a triple extrusion. The extrusion must have a triple extrusion head.

The conductive layers must be made of an extruded, conductive polymer compound.

The conductive layer wall thickness must not be below 0.50 mm.

The difference between the highest and lowest values for wall thickness measurements must not exceed 0.80 mm (within one sectional plane).

9.3.1 Inner conductive layer

Contact cables under the inner conductive layer must establish electrical contact between the conductor and the inner conductive layer. The inner conductive layer must not extend so far into the outer wire layers of the conductor that they affect the boundary layer with the insulation.

There should not be any significant protrusions or indents on the inner conductive layer. Isolated irregularities can be tolerated if they are in line with the following:

- Irregularities on the inner conductive layer may not extend more than 0.060 mm into insulating cover.
- Irregularities with height h ≥ 0.040 mm must have a difference of ≥ 3 between the base (b) and height (h).
- Irregularities with height (h) smaller than 0.040 mm are not counted.

When exposed to the maximum authorised short-circuit force (Berlin = 40 kA/1s), the inner conductive layer and contact cables must not be affected in any way which would stop the cable from functioning properly.

9.3.2 Outer conductive layer

Shield wires may only extend very slightly into the outer conductive layer. This must not fall below the minimum required wall thickness (0.50 mm).

9.4 Wire

Degasification of manufactured wires must be performed in a suitable heating cabinet and documented. This log must be transmitted to the client. The log must include clear information on the starting point (date, time), end point (date, time) plus the temperature (measurements taken during this period). Furthermore, the relevant degasification work instruction must be provided.

9.5 Shield

The specific resistance for shield components must not exceed the following value: 0.01786 ohm x mm²/m at a temperature of 20°C.

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Cables in the shield must be laid in a longitudinally and transversely watertight manner. Use of unbound swelling powder is prohibited. No toxic materials may be used to ensure longitudinal watertightness. The relevant material safety data sheets must be submitted.

The shield must consist of copper wires and one or two helix copper tape(s). The shield must be laid directly over the outer conductive layer binding.

The minimum required diameter for shield wires is 0.50 mm. The minimum thickness for helix copper tape is 0.10 mm. The following requirements apply to the amounts and dimensions of helix copper tape: either a helix copper tape with a diameter of minimum 1.00 mm² may be used, provided that the distance between two neighbouring tapes along the cable longitudinal axis does not exceed 4D, or two helix copper tapes with diameters of minimum 0.50 mm² may be used, provided that the distance between two neighbouring tapes does not exceed 2D (where D = constructed value for diameter under the shield).

The wires should be evenly distributed over the circumference. The average interval (based on measurements of five largest and smallest intervals over a circumference) between individual wires and any other metallic components (e.g. steel tubes for fibre optic cables) may not exceed 4.0 mm. The interval between individual wires and any other metallic components must never exceed 8.0 mm.

Permissible bends in shield wires may be ≥ 150°.

The shield cross section is calculated as a geometric cross section. At least 10% of the wires must be measured. The required shield cross section is calculated by adding the geometric cross sections of individual components (individual wires + helix copper tape; minus aluminium foil on the transversal water barrier).

9.6 Separation layer

There must be a suitable, **conductive** separation layer (semi-conductive tape) between the shield wires and the aluminium foil, acting as a transversal water barrier for the sheath.

When exposed to the maximum authorised short-circuit force, the separation layer must not be affected in any way which would prevent the cable from functioning properly (including impairment of longitudinal watertightness).

9.7 Oversheath

Compliant with DIN VDE 0276-632-3, Table 7, ST_7

9.7.1 PE-copolymer coated aluminium sheath

The oversheath must be an aluminium/polyethylene polymer coated sheath (Al/PE-copolymer coated aluminium = overlapping, metallic foil held in place by a PE sheath). It must be manufactured via an extrusion process. Use of other substances in order to obtain minimum wall thickness is prohibited, as is any removal of the sheath for a second extrusion. **The oversheath should not have a conductive layer unless specifically requested by the client.**

The median wall thickness for the PE-oversheath is 4.0 mm. The layer of aluminium foil should be excluded from the calculation of the oversheath wall thickness. At no point may the thickness be under the minimum limit of 3.3 mm.

The layer of aluminium foil must be excluded from the calculation of the sheath wall thickness.

9.7.2 Metallic foil

A longitudinally inserted layer of aluminium foil of at least 0.2 mm should be used.

The entire surface of the aluminium foil layer must be securely glued to the PE sheath. There must not be any air bubbles or creases.

The aluminium foil overlap must be at least 15 mm and must be securely glued across the whole surface without any creases.

There should not be any detached parts which have peeled off the aluminium foil overlap area. Individual peeled-off parts can be tolerated under the following circumstances:

- if the individual strips are of max. 1 mm
- if the wall thickness (as measured from the tip of the detached strip of aluminium foil on the PE sheath to the outside of the PE sheath) is not below the median wall thickness of the PE sheath.

9.7.3 Labelling on oversheath

Each cable oversheath must display the manufacturer name, the product model, description, date of manufacture, four-digit metre designation, an indication of the semi-conductive cable sheath and a cable code number. Labelling on the oversheath must be repeated at least every 100 cm.

All labelling, including metre designation, should be stamped onto the cable sheath (embossed or stamp-pressed).

Colour printing processes are not permissible. If the contractor justifies use of such a process when no other alternative is possible, then approval must first be obtained from the client's technical department before cable production commences. Proof that print labelling is resistant to abrasion (e.g. under DIN VDE 0276-605) must be assessed and documented so that the durability of printed labelling can be verified.

9.7.4 External diameter

The diameter across the oversheath must not exceed the following dimensions:

Conductor cross section	**Max. diameter**
300 mm²	76.0 mm
630 mm²	85.0 mm

800 mm²	90.0 mm

10 General test conditions

Ambient temperature during testing should be 15 to 25°C, unless agreed otherwise.

More specifically, the **following section of the standard on measuring resistance** should be used:

- **DIN VDE 0276-632-3; Section 10.5 – Measuring the electrical resistance of conductors and metal shields/sheaths.**

11 Tests on cables

11.1 Routine cable inspection and testing

Table 1 of this TD must be used for these tests, in addition to DIN VDE 0276-632-3.

11.2 Screening of cables

Table 2 of this TD must be used for these tests, in addition to DIN VDE 0276-632-3.

11.3 Official acceptance to be carried out with client present

Appointments for these tests must be made and agreed upon **at least eight weeks** in advance.

The client must be present for 30% of all routine inspection and testing.

A technical fact sheet including electrical characteristics must be submitted for approval.

The following electrical tests must be performed:

- voltage testing of cables on the cable delivery drum
- PD measurement
- measuring electrical resistance in the conductor and metal shield
- measuring capacity
- tan δ measurement
- sheath testing, where necessary.

Samples should be taken from cable ends for screening, with the client present. The following non-electrical screening tests are to be performed:

- assembly checks for cables (one sample from cable outer end – 1 m)

  - External diameter
  - coating (adherence)
  - position of shield wires, shield wire intervals, bends in shield wire
  - shield cross section, number of shield wires
  - diameter of outer conductive layer
  - conductor diameter, number of conductor wires
- measurement of conductor wire wall thickness (two samples from both cable ends)
- measurement of oversheath wall thickness (two samples from both cable ends)
- silicone transparency test (for every two axial and radial samples from both cable ends)
- thermal expansion/hot set test (two samples from both cable ends).

11.4 Repetition of tests

As specified in DIN VDE 0276-632-3.

If a sample fails the tests set out in DIN VDE 0276-632-3 and in this TD, the following steps should be taken:

As well as further samples taken from two other parts of the same batch, two additional samples should also be taken from the section which initially failed the tests, and tested according to DIN VDE 0276-632-3.

11.5 Type approvals

11.5.1 Type approval (electrical properties)

See Table 3 for details of tests to be carried out. The tests set out in this table are to be performed on a length of cable in the order specified. The cable length must be at least 20 m long without fittings, or should measure 10 m between the terminal and other fittings.

The cable length between (non-terminal) fittings must be at least 5 m long.

Type approval for cables must be performed as a system test including fittings. Section 12 in this TD also applies to fittings.

The selection of fittings must be carried out and agreed upon before commencing tests. All fittings included in the type approval process must first be subject to routine inspection and testing with the client present (as set out in Table 5) before commencing type approval.

The testing system should normally include two outdoor cable terminations, a CB sleeve and a (Vattenfall-standard) connector solution.

11.5.2 Type approval (non-electrical properties)

See Table 4 of this TD for details of tests to be carried out.

11.5.3 Repetition of type approvals

As specified in DIN VDE 0276-632-3.

11.6 Silicone transparency test

The silicone transparency tests require sufficiently large, cylindrical beakers and clear, clean silicone oil as well as a suitable light source (evenly illuminated surface). The test is performed in silicone oil.

Axial test samples must be at least 300 mm long (with a minimum of 250 mm for the silicone oil for transparency test + 50 mm for rotation of sample in the oil). The outer conductive layer should be removed in a way which strips away as little insulation as possible. The person performing these tests must have suitable protective clothing made available to them (safety goggles, suitable gloves).

Furthermore, radial test samples with an outer conductive layer and without a conductor must be produced for testing. They must be at least 80 mm long. The visible surface of the insulation should be treated in a way which provides a clear, unobstructed view of the insulation.

Both ends of the cable on each drum should undergo a silicone transparency test, which is to be performed and documented. These logs must be sent to the client's technical department before delivery.

If any abnormalities are observed during the silicone transparency test then further tests must be performed. The client and contractor should agree upon the number of additional tests to be performed. However, at least three additional samples must be taken from the section of cable showing abnormalities for further silicone transparency tests. If abnormalities are still observed in these test samples, then the cable has failed the silicone transparency test and the cable section will not be approved.

12 Fitting requirements

12.1 Sleeve transverse watertightness

The sleeve must be an effective water vapour barrier with integrated metal diffusion barriers.

There must be an electrically conductive interconnection between this water vapour barrier and the cable shield.

12.2 Connecting the transversal water barrier and cable shield

Sleeves and terminals must have a current-conducting connection between the cable's metal (aluminium foil) transversal water barrier and the shield.

13 Fitting tests

13.1 Routine inspection and testing of fittings

Routine inspection and testing of **all** prefabricated and pre-testable sleeves, cast resin parts and stress cones for terminals or connectors must be carried out with the client present.

Electrical strength and lack of partial discharge must be verified as part of routine electrical inspection and testing of prefabricated sleeves, cast resin parts and stress cones.

Inspection for any mechanical damage to sleeve parts and stress cones following the electrical tests can be carried out by visually checking the cleaned test units. No deviations from desired nominal state can be tolerated.

See Table 5 for details of routine inspection and testing to be carried out.

13.2 Type approval for fittings (electrical properties)

13.2.1 General

All fittings included in the type approval process must first be subject to routine inspection and testing with the client present (as set out in Table 5) before commencing type approval.

See Table 6 for details of tests to be carried out. The tests set out in this table are to be performed on a sample in the order specified.

The fittings are to be fitted onto a length of cable which should conform to "the technical description for 110 kV cables with cross-linked polyethylene insulation". There must be at least 5 m of cable separating the fittings.

Fitting type approval can be carried out at the same time as cable type approval.

In addition to electrical tests, all fittings must be taken apart and evaluated with the client present.

13.2.2 Leak tests using variable pressure and DC voltage tests for the sleeve outer protective jacket

Pressure cycling tests must be used to verify sleeve impermeability, with 20 cycles in the air and 20 cycles in water (water temperature at 70°C). This test can be combined with the pressure cycling tests under Table 6, Section 4.1.

The water pressure part of the test should involve the sleeve being exposed to water pressure in a 1 m water column. The test must be set up so that all sealed parts of the outer casing are subject to water pressure.

Following pressure cycling tests, the test cable length must be allowed to cool down to room temperature. Then DC voltage tests can be carried out, at 25 kV for a duration of 1 minute.

Voltage is applied between the cable shield and a counter electrode placed across the whole surface of the sleeve outer casing.

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13.2.3 Electrical strength of shield break for cross-bonding sleeves

See Table 6 Point 8 for details of tests to be carried out.

DC voltage tests and surge voltage tests must be carried out on the interval between cable shields on the cable ends to be connected (including outer conductive layers) and the outer casing surface, as well as between the conductive layers. Before these tests, the sleeve must undergo pressure cycling tests with 20 cycles in the air and 20 cycles in water (water temperature at 70°C). This pressure cycling test can be combined with the pressure cycling tests under Table 6, Section 4.1.

Surge voltage tests and subsequent DC voltage test are to be performed on the conductive layers and the surface of the outer sleeve casing.

The surge voltage test on the conductive layers (Table 6 Point 7.3.2) requires 10 surges each of both positive and negative polarity. Test voltage must be 75 kV.

DC voltage tests (Table 6 Point 7.3.1) are to be performed at 25 kV for a duration of 1 minute.

The surge voltage test (Table 6 Point 7.3.3) on the conductive layers and surface of the outer sleeve casing requires 10 surges each of both positive and negative polarity. Test voltage must be 37.5 kV. As part of this test, the cable sheath on the test section must also be tested. A suitable counter electrode must be applied to the cable sheath in order to do this.

DC voltage tests (Table 6 Point 7.3.1) are to be performed at 25 kV for a duration of 1 minute.

13.2.4 Repetition of type approvals

If the samples do not pass the tests set out in this technical description, the entire type approval shall be deemed to have been failed and must be repeated.

14 Geometry of the insulation connector

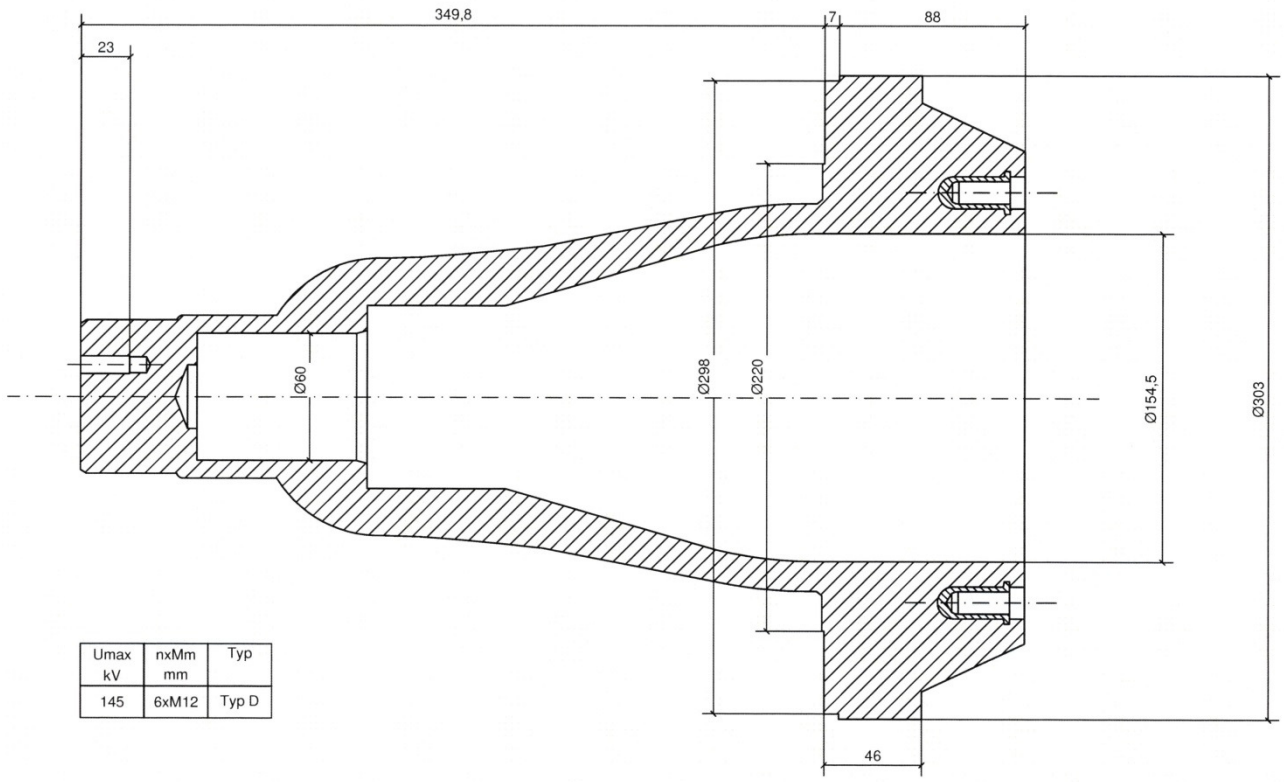


Illustration 14-1 *Geometry of the insulation connector*

Geometry of the insulation connector equipment for 110 kV SF6 switchgears and 110 kV transformers – layout drawing (excerpt from drawing 3-1-0257-1 dated 15 April 2013).

15 Test tables

15.1 Routine inspection and testing of 110 kV XLPE cables

Table 15-1 Routine inspection and testing of 110 kV XLPE cables

	Tests	Requirements	Testing method
1.	Order of tests	Sections 2 to 8 in this table	
2.	Electrical tests on oversheath without conductive layer	No disruptive breakdown	DIN EN 60229 Section 3.2
3.	Voltage test - Sample: delivery length - Test voltage 3.0 U_0 - Duration of testing 30 min.	No disruptive breakdown	DIN VDE 0276-632-3 Part 4-D
4.	Partial discharge test (to be performed immediately after test 3) - Sample: delivery length - Strength of calibration pulse 2 pC - Permissible interference level $\leq$1 pC - Test AC voltage 2.5 U_0	No partial discharge from test specimen observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
5.	tan **δ** measurement	DIN VDE 0276-632-3 Table 3	DIN VDE 0276-632-3 Section 12.4.5
6.	Conductor resistance - Conductor - Shield	DIN EN 60228 Table 2 Table 2 Current TD, Section 9.5	DIN EN 60228 Section 5.3 Section 5.2
7.	Capacity	Manufacturer fact sheet	DIN VDE 0276-632-3 Section 10.10
8.	Electrical tests on oversheath with conductive layer	No disruptive breakdown	DIN EN 60229 Section 3.1

Note:

Testing for partial discharge test must be carried out immediately following the voltage test and during voltage reduction.

15.2 Screening of 110 kV XLPE cables

Table 15-2 Screening of 110 kV XLPE cables

	Tests	Requirements	Testing method
1.	Conductor - Number of individual wires - Diameter	DIN EN 60228 Current TD, Section 9.1	DIN EN 60228 Visual checks DIN VDE 0276-605
2.	Conductive layers - Wall thickness - Irregularities	 Current TD, Section 9.3 Current TD, Section 9.3	 DIN EN 60811-201 DIN VDE 0276-605 Section 2.1.10.2
3.	Insulation - Wall thickness - Diameter across insulating cover - Minimum wall thickness - Consistency of wall thickness - Irregularities/silicone transparency test - Thermal expansion/hot set test	 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 11.6 DIN VDE 0276-632-3	 DIN EN 60811-201 DIN EN 60811-203 DIN EN 60811-201 DIN EN 60811-201 Current TD, Section 11.6 DIN VDE 0276-605 Section 2.1.10.2 DIN EN 60811-507
4.	Shield - Measures and nominal cross section (geometric) - Shield wire intervals - Specific resistance of shield structure	 Current TD, Section 9.5 Current TD, Section 9.5 DIN VDE 0276-632-3	 DIN VDE 0276-605 DIN EN 60228
5.	Oversheath - Wall thickness - Minimum wall thickness - External diameter	 Current TD, Section 9.7 Current TD, Section 9.7 DIN VDE 0276-632-3 Current TD, Section 9.7	 DIN EN 60811-202 DIN EN 60811-202 DIN EN 60811-203
6.	Labelling	Current TD, Section 9.7	Visual checks

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15.3 Type approval for 110 kV XLPE cables (electrical properties)

Table 15-3 Type approval for 110 kV XLPE cables (electrical properties)

	Tests	Requirements	Testing method
1.	Order of tests - Sample: whole cable	Section 2 to 8 in this table	
2.	Bending testing followed by rated power frequency withstand voltage test and partial discharge test		
2.1	Bending testing - Bending diameter: 20 (d + D) +5% D = outer diameter, actual value d = conductor diameter, actual value		DIN VDE 0276-632-3
2.2	Rated power frequency withstand voltage test - Test AC voltage 230 kV - Duration of testing 1 min.	No disruptive breakdown	
2.3	Partial discharge test (ambient temperature) - Strength of calibration pulse 2 pC - Permissible interference level $\leq$1 pC - Test AC voltage 2.5 U_0	No partial discharges from test subject observed	DIN EN 60885-3
3.	tan δ measurement	DIN VDE 0276-632-3 Table 3	DIN VDE 0276-632-3 Section 12.4.5
4.	Pressure cycling tests followed by partial discharge test		
4.1	Pressure cycling test - Heating the sample via conductor heating - Heating cycle: 24 hours Heat sample for eight hours at 5 to 10 K above the permitted conductor temperature, maintaining this temperature for at least two hours before 16-hour cool-down - Test AC voltage 2.5 U_0 - Number of cycles 20		DIN VDE 0276-632-3 Part 4-D

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4.2	Partial discharge test - Strength of calibration pulse 2 pC - Permissible interference level ≤1 pC - Test AC voltage 2.5 U_0	No partial discharges from test subject observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
5.	Surge voltage test followed by AC voltage test		
5.1	Lightning surge voltage test (at increased temperature) - Heat the sample at 5 to 10 K above the permitted conductor temperature, maintaining this temperature for at least two hours - Surge voltage amount 550 kV - Number of surges: - 10 surges of positive polarity - 10 surges of negative polarity	No disruptive breakdown	DIN VDE 0276-632-3 Part 4-D DIN EN 60230 DIN EN 60060
5.2	Voltage test - Test AC voltage 2.5 U_0 - Duration of testing 4 hours	No disruptive breakdown	DIN VDE 0276-632-3 Part 4-D
6.	Partial discharge test - Strength of calibration pulse 2 pC - Permissible interference level≤1 pC - Test voltage 2.5 U_0	No partial discharges from test subject observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
7.	Testing the oversheath - DC Voltage 20 kV/1 min. - Surge voltage 37.5 kV - Number of surges - 10 surges of positive polarity - 10 surges of negative polarity	No disruptive breakdown No disruptive breakdown	DIN EN 60229
8.	Visual checks	DIN VDE 0276-632-3	DIN VDE 0276-632-3

15.4 Type approval for 110 kV XLPE cables (non-electrical properties)

Table 15-4 Type approval for 110 kV XLPE cables (non-electrical properties)

	Tests	Requirements	Testing method
1.	Tests on insulation		
1.1	Mechanical properties a) before ageing b) after ageing in heating cabinet	DIN VDE 0276-632-3	DIN EN 60811-501 DIN EN 60811-401
1.1	Contraction	DIN VDE 0276-632-3	DIN EN 60811-502
1.2	Thermal expansion/hot set test	DIN VDE 0276-632-3	DIN EN 60811-507
2.	Tests on oversheath		
2.1	Mechanical properties a) before ageing b) after ageing in heating cabinet	DIN VDE 0276-632-3	DIN EN 60811-501 DIN EN 60811-401
2.2	Heat/pressure resistance	DIN VDE 0276-632-3 DIN EN 60811-508	DIN EN 60811-508
2.3	Stress-fracture resistance	HD 620, Part 1 Table 4 B, DMP 2	EN 60811-406 Follow testing method B but change duration to 1000 h
2.4	Soot content	DIN VDE 0276-632-3	DIN EN 60811-605
2.5	Contraction test	DIN VDE 0276-632-3	DIN EN 60811-503
2.6	Test on PE-copolymer coated aluminium sheath	DIN VDE 0276-632-3 Annex F Current TD, Section 9.7	DIN VDE 0276-632-3 Annex F
3.	Ageing test on whole cable to verify compatibility of materials	DIN VDE 0276-632-3	DIN EN 60811-401
4.	Tests on whole cable		
4.1	Ageing across whole cable	DIN VDE 0276-632-3	DIN EN 60811-401
4.2	Shore type-D hardness of the PE sheath	HD 620, Part 1 Table 4 B, DMP 2	HD 605 Section 2.2.1

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4.3	Water penetration test	DIN VDE 0276-632-3 Annex E **Along a cable length of 3 m rather than 6 m**	DIN VDE 0276-632-3 Annex E
5.	Review of cable assembly		
5.1	Conductor - Number of individual wires - Diameter	DIN EN 60228 Current TD, Section 9.1	DIN EN 60228 Visual checks DIN VDE 0276-605
5.2	Conductive layers - Wall thickness - Irregularities	 Current TD, Section 9.3 Current TD, Section 9.3	 DIN EN 60811-201 DIN VDE 0276-605 Section 2.1.10.2
5.3	Insulation - Wall thickness - Diameter across insulating cover - Minimum wall thickness - Consistency of wall thickness - Irregularities/silicone transparency test	 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 9.2 Current TD, Section 11.6	 DIN EN 60811-201 DIN EN 60811-203 DIN EN 60811-201 DIN EN 60811-201 Current TD, Section 11.6 DIN VDE 0276-605 Section 2.1.10.2
5.4	Shield - Measures and nominal cross section (geometric) - Shield wire intervals - Specific resistance of shield structure	 Current TD, Section 9.5 Current TD, Section 9.5 DIN VDE 0276-632-3	 DIN VDE 0276-605 DIN EN 60228
5.5	Oversheath - Wall thickness - Minimum wall thickness - External diameter	 Current TD, Section 9.7 Current TD, Section 9.7 DIN VDE 0276-632-3 Current TD, Section 9.7	 DIN EN 60811-202 DIN EN 60811-202 DIN EN 60811-203
5.6	Labelling	Current TD, Section 9.7	Visual checks

15.5 Routine inspection and testing of prefabricated fittings and pre-testable fittings parts

Table 15-5 Routine inspection and testing of prefabricated fittings and pre-testable fittings parts

	Tests	Requirements	Testing method
1.	Dimension checks and visual checks	No deviations from desired nominal state detected (e.g. dimensions, bumps, holes, loose parts, blemishes)	Measuring equipment Lamp Endoscope
2.	Voltage test - Test voltage 3.0 U_0 - Testing time 30 min. - Permissible interference level ≤1 pC	No disruptive breakdown	DIN VDE 0276-632-3
3.	Partial discharge test (to be performed immediately after test 3) - Strength of calibration pulse 2 pC - Test voltage 2.5 U_0 - Duration of testing 1 min. - Permissible interference level ≤1 pC	No partial discharges from test subject observed	DIN VDE 0276-632-3 DIN EN 60885-3
4.	Visual checks	- Test subject cleaned and degreased - No deviations from desired nominal state detected (e.g. bumps, holes, loose parts, blemishes)	Lamp Endoscope

Note:

If the test setup for fittings parts produces higher electrical field strengths in voltage testing (compared with readings which would have been obtained if the fittings had been fitted on a cable that conformed to the present provisions), the manufacturer and client's technical department should agree upon a test voltage.

15.6 Type approval for 110 kV XLPE-cable fittings (electrical properties)

Table 15-6 Type approval for 110 kV XLPE-cable fittings (electrical properties)

	Tests	Requirements	Testing method
1.	Order of tests	Sections 2 to 8 in this table	
2.	Rated power frequency withstand voltage test - Test AC voltage 230 kV - Duration of testing 1 min.	No disruptive break-down	
3.	Partial discharge test - Strength of calibration pulse 2 pC - Test voltage 2.5 U_0 - Duration of testing 1 min. - Permissible interference level $\leq$1 pC	No partial discharg-es from test subject observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
4. 4.1	Pressure cycling tests followed by partial dis-charge test Pressure cycling test - Heating the sample via conductor heating - Heating cycle: 24 hours Heat sample for eight hours at 5 to 10 K above the permitted conductor tempera-ture, maintaining this temperature for at least two hours before 16-hour cool-down - Test AC voltage 2.5 U_0 - Number of cycles in the air 20 Number of cycles in water 20		DIN VDE 0276-632-3 Part 4-D
4.2	Partial discharge test - Strength of calibration pulse 2 pC - Test voltage 2.5 U_0 - Duration of testing 1 min. - Permissible interference level $\leq$1 pC	No partial discharg-es from test subject observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
5.	Surge voltage test followed by AC voltage test		

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5.1	Lightning surge voltage test - Heat the sample at 5 to 10 K above the permitted conductor temperature, maintaining this temperature for at least two hours - Surge voltage amount 550 kV - Number of surges 10 surges of positive polarity 10 surges of negative polarity	No disruptive breakdown	DIN VDE 0276-632-3 Part 4-D DIN EN 60230 DIN EN 60060
5.2	Voltage test - Test AC voltage 2.5 U_0 - Duration of testing 4 hours	No disruptive breakdown	DIN VDE 0276-632-3 Part 4-D
6.	Partial discharge test - Strength of calibration pulse 2 pC - Permissible interference level $\leq$ 1 pC - Test AC voltage 2.5 U_0	No partial discharges from test subject observed	DIN VDE 0276-632-3 Part 4-D DIN EN 60885-3
7.	Test on sleeve outer protective jacket Authorisation for sleeves without separated shields can be officially accepted once the tests on a cross bonding sleeve have been successfully completed. This test must be performed on a sleeve which has already successfully passed the previous tests from Sections 2 to 6.		DIN VDE 0276-632-3 Annex G
7.1	Storage in water and heating cycles - Water column 1 m - Heating/cooling cycles: minimum 24 hours Heat sample for 12 hours at 15 to 20 K below the permitted conductor temperature, followed by cooling in water at 30 °C - Number of water heating/cooling cycles 20		DIN VDE 0276-632-3 Annex G
7.2	Underwater test on **sleeves without separated shields** - Test DC voltage 25 kV - Duration of testing 1 min.	No disruptive breakdown	DIN VDE 0276-632-3 Annex G

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7.3 7.3.1	Underwater tests on **cross bonding sleeves** Voltage test 1. Test between the shield/metal sheaths at both ends of sleeve 2. Test between the shield/metal sheaths and the earthed surface of sleeve outer protective casing - Test DC voltage 25 kV - Duration of testing 1 min.	No disruptive breakdown	DIN VDE 0276-632-3 Annex G
7.3.2	Surge voltage test between conductive layers - Surge voltage amount 75 kV - Number of surges: - 10 surges of positive polarity - 10 surges of negative polarity	No disruptive breakdown	DIN VDE 0276-632-3 Annex G DIN EN 60230
7.3.3	Surge voltage tests on the conductive layers and the surface of the outer sleeve casing - Surge voltage amount 37.5 kV - Number of surges: - 10 surges of positive polarity - 10 surges of negative polarity	No disruptive breakdown	DIN VDE 0276-632-3 Annex G DIN EN 60230
8.	Analysis of testing procedure	No visible signs of water or corrosion detected	DIN VDE 0276-632-3 Annex G

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Appendix

I. Abbreviations and definitions

TD	technical description
XLPE	cross-linked polyethylene
CB sleeve	cross-bonding connection sleeve

II. List of illustrations

Illustration 14-1 Geometry of the insulation connector

III. List of tables

Table 1-01 Overview of amendments

Table 15-1 Routine inspection and testing of 110 kV XLPE cables

Table 15-2 Screening of 110 kV XLPE cables

Table 15-3 Type approval for 110 kV XLPE cables (electrical properties)

Table 15-4 Type approval for 110 kV XLPE cables (non-electrical properties)

Table 15-5 Routine inspection and testing of prefabricated fittings and pre-testable fittings parts

Table 15-6 Type approval for 110 kV XLPE-cable fittings (electrical properties)

Table IV-01 Revision index

Table IV-02 Overview of document creation, document owners, checking and approval

IV. Revision index

Table IV-01 *Revision index*

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Section	Topic
Version n-1	
Section	Topic

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Table IV-02 *Overview of document creation, document owners, checking and approval*

	Created:	Owned by:	Checked:	Approved:
Date:	8 April 2014			
By:	Volkmar Ulewski	Mr Wunderlich		