BS 7970:2012

BSI Standards Publication

Electric cables – Metal foil and longitudinally welded aluminium sheath constructions of power cables having XLPE insulation for rated voltages from 66 kV (U_m = 72.5 kV) to 132 kV (U_m = 145 kV)

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2012. It was prepared by Subcommittee GEL/20/16, *Medium/high voltage cables*, under the authority of Technical Committee GEL/20, *Electric cables*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7970:2005, which is withdrawn.

Relationship with other publications

This British Standard is intended to be read in conjunction with BS 7912 which, together with the additional tests in BS 7970, implements the nationally applicable parts (part 5, section H) of Harmonization Document HD 632 S2:2008 published by the European Committee for Electrotechnical Standardization (CENELEC) in accordance with the decision of the CENELEC Technical Board.

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- alignment with the parallel revision of BS 7912, and removal of unnecessary duplication;
- introduction of requirements for designs with longitudinally welded aluminium sheaths.

Product certification/inspection/testing
Users of this British Standard are advised to consider the desirability of third-party certification/inspection/testing of product conformity with this British Standard. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements for construction and performance, and gives methods of test, for metal wire and foil sheath, or metal wire and longitudinally welded aluminium, or longitudinally welded aluminium constructions of power cables having XLPE insulation for rated voltages from 66 kV (U_m = 72.5 kV) to 132 kV (U_m = 145 kV). The tests and requirements in this British Standard are additional to the tests and requirements for cables and their accessories specified in BS 7912.

NOTE 1 In exceptional cases, with very low fault currents, foil sheath designs without metal wires may also be used.

*NOTE 2 Tests described in BS 7912:2012, **15.2**, **15.3** and **15.4** are not required in this standard.*

This British Standard is applicable to single-core cables for usual conditions of installation and operation, but not to special cables, such as those designed for submarine applications.

NOTE 3 Annex A gives requirements for a die penetrant test for weld integrity. Annex B lists a test for peel strength of overlapped metal foil. Annex C lists test requirements for adhesion strength of metal foil. Annex D covers the test for impact and Annex E the test for sidewall loading. Annex F covers the test for corrosion.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7870-2:2011, *LV and MV polymeric insulated cables for use by distribution and generation utilities – Part 2: Methods of test*

BS 7912:2012, *Power cables with XLPE insulation and metal sheath, and their accessories, for rated voltages from 66 kV (U_m = 72.5 kV) to 132 kV (U_m = 145 kV) (Implementation of HD 632)*

BS EN 60228, *Conductors of insulated cables*

IEC 60050-461, *International Electrotechnical Vocabulary – Part 461 – Electric cables*

IEC 60840, *Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in IEC 60050-461 and BS 7912 apply.

4 Construction of metal wire and foil sheaths

4.1 Metal wires

For foil sheath constructions, and where required for longitudinally welded aluminium, a layer of metal wires shall be applied over the semi-conducting insulation screen in a single helical layer.

NOTE In exceptional cases, with very low fault currents, foil sheath designs without metal wires may also be used.

The wires shall be spaced with an average gap not greater than 4 mm and no gap shall exceed 8 mm. No wires shall cross other wires.

A metal tape or wires shall be applied helically over, and in contact with, the layer of metal wires in order to equalize the current flowing in the individual wires forming the layer of wires.

4.2 Water blocking

The requirements of BS 7912:2012, **4.6**, shall apply.

4.3 Metal sheath

4.3.1 General

The metal sheath shall conform to **4.3.2** or to **4.3.3**, as appropriate.

4.3.2 Metal foil sheath

A continuous metal foil sheath shall be longitudinally applied over the water blocking tapes with a minimum overlap of 7 mm. The foil shall either be a metal foil or a metal foil/polymer laminate. Joins in the foil shall have the same electrical performance as a continuous piece of foil. The metal foil overlap shall be sealed to prevent ingress of moisture.

4.3.3 Longitudinally welded aluminium sheath

A continuous metal strip sheath shall be longitudinally applied over the water blocking tapes and the edges of the strip shall be welded to form a join with the same thickness as the strip material. If the strip material is joined to another strip then the join shall have the same electrical performance as the unjoined strip. The weld shall be continuous and without porosity. The integrity of the weld shall be monitored continuously during manufacture.

4.4 Earth fault capability

The earth fault capability in current (kA) and duration (seconds) shall be as specified by the purchaser. The cross-sectional area, approximate number and approximate diameter of the metal wires shall be as specified by the manufacturer.

4.5 Oversheath

The oversheath shall be an extruded layer of black medium density polyethylene (MDPE) conforming to the requirements specified for ST_3 or ST_7 as given in BS 7912:2012, Table 5 and Table 9, unless otherwise agreed.

NOTE Alternative materials to ST_3 and ST_7 may be provided by agreement between the manufacturer and the purchaser.

The thickness of the oversheath shall be as agreed between the manufacturer and the purchaser.

The oversheath shall be bonded to metal foil or longitudinally welded sheath.

An outer semi-conducting coating shall be applied to serve as an electrode for a voltage test on the oversheath.

5 Marking of cables

5.1 External marking

The external surface of all cables shall be legibly marked with the following elements.

	Element	Example of marking
a)	Electric cable	ELECTRIC CABLE
b)	Voltage designation	66 000 V or 110 000 V or 132 000 V
c)	British Standard number	BS 7970 [1)]
d)	Manufacturer's identification	XYZ
e)	Number of cores and nominal area and type (CU or AL) of conductor, e.g. single-core cable with 300 mm^2 copper conductor	1 × 300 CU

The marking of elements a) to d) shall be by embossing or indenting on the oversheath.

The marking of element e) shall be by embossing, indenting or printing on the oversheath.

Elements a), b) and c) shall appear on two or more primary lines along the axis of the cable, approximately equally spaced around the circumference of the cable.

Elements d) and e) shall appear on at least one line.

NOTE Elements d) and e) may be on one of the primary lines or a secondary line or lines and need not be on the same line.

The letters and figures shall consist of upright block characters. The characters shall have a height of not less than 3 mm.

The distance between the end of the one element of marking and the beginning of the next identical element of marking shall be not greater than 550 mm for elements a), b) and c), and not greater than 1 100 mm for elements d) and e).

5.2 Identification of year and month of manufacture

A means of identifying the year and month of manufacture of the cable shall be provided throughout the length of the cable by marking on the surface of the cable.

The marking shall be by embossing or indenting on the oversheath. The characters shall have a height of not less than 3 mm and the distance between the end of the one element of marking and the beginning of the next identical element of marking shall be not greater than 1 100 mm.

5.3 Mark of an approval organization

If the mark of an approval organization is used, it shall be provided throughout the length of the cable.

[1)] Marking BS 7970 or BS 7970:2012 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

6 Routine tests on cables

6.1 General

*COMMENTARY ON **6.1***

*"Routine test" is defined in BS 7912:2012, **3.4**.*

In addition to the requirements specified in BS 7912:2012, Clause **9**, the cable shall conform to the requirements specified in **6.2**, **6.3** and **6.4**.

6.2 Metal screen resistance

When measured in accordance with BS 7870-2:2011, **3.1.1**, and corrected to 20 °C in accordance with BS EN 60228, the d.c. resistance of the metal screen shall not exceed the value specified by the manufacturer.

6.3 Examination

6.3.1 Sampling

Two samples 0.5 m in length shall be taken, one from each end of the drum length.

6.3.2 Metal foil sheath overlap

When measured at each end of two samples, none of the metal foil sheath overlaps shall be less than 7 mm.

6.3.3 Metal foil sheath visual examination

When the metal foil sheath/oversheath assembly is cut longitudinally from the two 0.5 m samples and examined with normal or corrected vision, without magnification, the metal foil sheath shall show no evidence of cracking, splitting or annular wrinkling and there shall be no voids at the metal foil sheath/oversheath interface.

6.3.4 Longitudinally welded aluminium – visual examination

The longitudinally welded aluminium sheath/oversheath assembly shall be cut longitudinally from the two 0.5m samples such that the weld is at the centre of one of the samples. The weld shall be examined with normal or corrected vision, without magnification. There shall no evidence of voids or fractures, and the thickness of the weld shall be at least equal to that of the adjacent aluminium strip.

The insulation screen of the two 0.5 m samples shall be examined to confirm that there is no damage due to the aluminium sheath welding process.

6.4 Longitudinally welded aluminium – die penetrant test

When tested in accordance with Annex A, there shall be no indication of defect in the weld.

7 Sample tests on cables

7.1 General

*COMMENTARY ON **7.1***

*"Sample test" is defined in BS 7912:2012, **3.5**.*

In addition to the requirements specified in BS 7912: 2012, Clause **10**, the cable shall conform to the requirements specified in **7.2** and **7.3**.

7.2 Peel strength

7.2.1 Peel strength of metal foil sheath overlap

When tested in accordance with Annex B, the minimum value of the peel strength shall be not less than 0.5 N/mm.

NOTE When the peel strength is greater than the tensile strength of the metal foil so that the latter breaks before peeling, the test should be terminated and the break point should be recorded.

7.2.2 Peel strength of metal sheath to oversheath

The metal foil sheath shall be tested in accordance with Annex C.

The adhesion strength shall be calculated by dividing the peel force, in Newtons, by the width of the specimen, in millimetres. At least five specimens shall be submitted to the test and the minimum value of the adhesion strength shall be not less than 0.5 N/mm.

NOTE When the adhesion strength is greater than the tensile strength of the metal foil so that the latter breaks before peeling, the test should be terminated and the break point should be recorded.

For the longitudinally welded aluminium sheath, it shall not be possible readily to separate the welded aluminium from the polyethylene.

7.3 Bend test

The test shall be carried out only at the request of the purchaser and then at a frequency no greater than once per manufacturing batch, the batch being that related to the sheathing process only.

A sample of cable, 10 m to 15 m long, shall be subjected to a bending test in accordance with BS 7912:2012, **12.5**. The weld or foil overlap shall be located on the axis normal to the bend (i.e. at the position of maximum strain change during bending). After completion of the bend test, samples shall be taken from the middle of the length and shall conform to the requirements specified in **6.3.3** and **6.3.4**, **7.2.1** and **7.2.2**.

8 Type tests on cables and components

8.1 Range of approval

*NOTE 1 "Type test" is defined in BS 7912:2012, **3.7**.*

NOTE 2 Type tests which have been successfully performed in accordance with the previous edition (BS 7970:2005) of this British Standard are valid.

The range of approval shall be generally in accordance with BS 7912:2012, except that tests described in BS 7912:2012, **15.2**, **15.3** and **15.4** are not required.

For cables to this British Standard, when the type tests specified in **8.3** have been successfully performed on the smallest and largest diameter of cable in the range of approval, the type approval shall be deemed to be valid for cables in the same product range from the smallest diameter less 20% to the largest diameter +20%, provided that cables of these sizes conforming to BS 7912 or IEC 60840 have been type tested.

8.2 Tests on cable components

The cable shall conform to the requirements specified in BS 7912:2012, Clause **13**.

8.3 Tests on complete cable

8.3.1 General

In addition to the requirements specified in BS 7912:2012, Clause **12**, the cable shall conform to the requirements specified in **8.3.2** to **8.3.6**.

8.3.2 Bending test

The weld or foil overlap shall be located on the axis normal to the bend (i.e. at the position of maximum strain change during bending). The test shall be carried out to BS 7912:2012, **12.5**.

8.3.3 Cable examination after electrical type tests

After completion of the electrical type tests of BS 7912:2012, Clause **12**, samples shall be taken from the middle of the bend and shall conform to the requirements specified in **6.3.3**, **6.3.4**, **7.2.1** and **7.2.2**.

8.3.4 Impact test

NOTE This test need not be carried out if the manufacturer has evidence of satisfactory performance with cables of similar design.

When tested in accordance with Annex D, the cable shall conform to the requirements specified in **6.3.3**, **6.3.4**, **7.2.1** and **7.2.2**.

8.3.5 Sidewall loading test

NOTE 1 This test need not be carried out if the manufacturer has evidence of satisfactory performance with cables of similar design.

When tested in accordance with Annex E, the cable shall conform to the requirements specified in **6.3.3**, **6.3.4**, **7.2.1** and **7.2.2.**

*NOTE 2 Additionally, 2 × 1 m test pieces are required for the subsequent test to **8.3.6** (see Annex F).*

8.3.6 Corrosion test

NOTE This test need not be carried out if the manufacturer has evidence of satisfactory performance with cables of similar design. If ST_7 material is used, the test is not required.

When tested in accordance with Annex F, there shall be no signs of corrosion on the internal surface of the metal sheath and no holes or punctures of the sheath. No liquid shall be present on the internal surface of the metal sheath or on the cable core.

Annex A (normative) Die penetrant test for weld integrity

A 0.5 m long sample of metal sheath complete with oversheath shall be cut in two longitudinally so that the weld is at the centre of one of the pieces. The oversheath shall be removed from the sheath in the region of the weld, and the surfaces thoroughly cleaned to remove all traces of oversheath material or bonding adhesive which might be present at the weld.

NOTE 1 A proprietary aerosol die penetrant kit should be used for the following procedure; specific manufacturer's instructions should be followed.

Die penetrant shall be sprayed over the full length of the weld on both inside and outside surfaces of the metal sheath so that the weld surface is covered with die penetrant. If the die penetrant forms droplets or does not wet the surfaces fully then the surfaces shall be re-cleaned with solvent. The die penetrant shall be allowed to remain on the weld for 30 min.

The surface shall be wipe-cleaned with a clean cloth, using solvent on the cloth as necessary to remove all the surface die penetrant. Solvent shall not be applied directly to the weld as this can make the test ineffective.

The developer shall be mixed thoroughly by shaking the can. The weld surfaces shall be sprayed with developer just enough to wet the surface thinly and evenly.

NOTE 2 When correctly applied, the developer dries to an even white layer.

The developer shall then be allowed to dry.

The surfaces of the weld shall be examined with normal or corrected vision, without magnification.

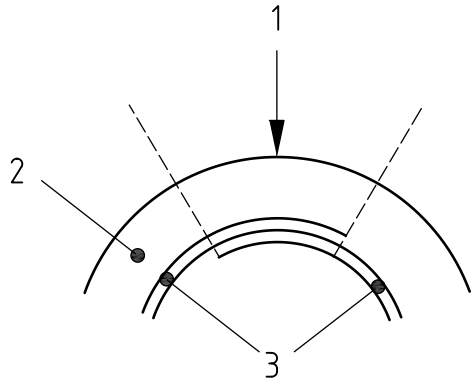
NOTE 3 Defects are marked by a deep-coloured (normally red) indication. A line or dotted line marks a crack, lap, forging burst or cold shut. If wide and deep, the indication is likely to grow and spread. Porosity, shrinkage, lack of bond and leaks appear as dots or local areas of colour; these, too, are likely to grow and spread if the defect is large or extensive.

Annex B (normative) Test for peel strength of overlapped metal foil

A sample specimen 200 mm in length shall be taken from the cable including the overlapped portion of the metal foil. The test specimen shall be prepared by cutting only the overlapped portion from this sample as shown in Figure B.1.

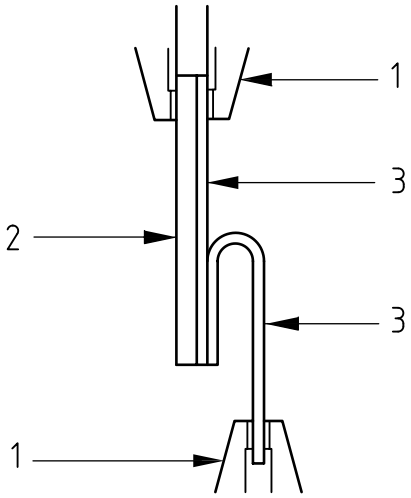
The test shall be conducted in the same manner as described in Annex C. The arrangement of the test specimen shall be as shown in Figure B.2.

Figure B.1 **Peel strength of metal foil sheath overlap – Preparation of test sample**



Key
1 Test sample
2 Oversheath
3 Metal foil

Figure B.2 **Peel strength of metal foil sheath overlap – Test arrangement**



Key
1 Grip
2 Oversheath
3 Metal foil

Annex C (normative)

Test for adhesion strength of metal foil

The test specimen shall be taken from the cable covering where the metal foil is adhered to the oversheath.

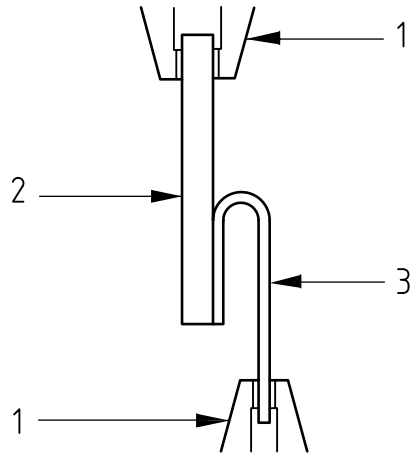
The length and width of the test specimen shall be 200 mm and 10 mm respectively.

One end of the test specimen shall be peeled between 50 mm and 120 mm and inserted in a tensile testing machine by clamping the free end of the oversheath or the insulation screen in one grip. The free end of the metal foil shall be turned back and clamped in the other grip as shown in Figure C.1.

The specimen shall be maintained approximately vertical in the plane of the grips during the test by holding the specimen.

After adjusting the continuous recording device, the metal foil shall be stripped from the specimen at an angle of approximately 180° and the separation continued for a sufficient distance to indicate the adhesion strength value. At least one half of the remaining bonded area shall be peeled with a speed of approximately 50 mm/min.

Figure C.1 **Peel strength of metal foil sheath to the oversheath**



Key

1 Grip
2 Oversheath
3 Metal foil

Annex D (normative)

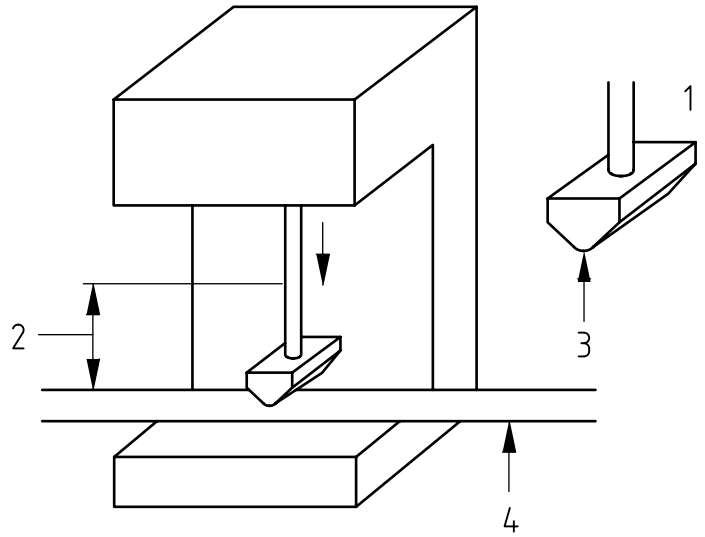
Test for impact

The test shall be carried out at (20 ±15) °C and performed by dropping a weight of 5 kg from a height of 1 m on a cable sample 1 m in length. At the impact point, the weight shall have a 90° corner angle with a 2 mm radius of curvature.

The shape of the weight and the test configuration shall be in accordance with Figure D.1. One impact shall successively be made at five different points along the cable, rotating the cable through 90° between impacts, starting and finishing on the metal foil overlap or longitudinal weld. The distance between two adjacent impacts shall be greater than 100 mm.

The sample shall then be examined with normal or corrected vision, without magnification.

Figure D.1 **Impact test**



Key

1 Mass 5 kg
2 Drop height 1 m
3 Radius of curvature 2 mm
4 Cable

Annex E (normative)

Test for sidewall loading

The test shall be carried out at (20 ±15) °C on a suitable length of unconditioned cable such that the required 3 × 1 m test pieces can be cut from the centre of a 5 m length that has been subjected to the test at a specified load.

NOTE 1 Where applicable, 2 × 1 m test pieces are required for the test in Annex F.

The sidewall loading shall be applied by pulling the cable around a fixed wheel the circumference of which shall contain a number of rollers 50 mm to 100 mm in diameter. The cable shall be in contact with the wheel for at least 90° during the test. The foil overlap or longitudinal weld shall be in contact with the fixed wheel for first pass forwards and backwards around the wheel. The diameter of the fixed wheel shall be not greater than the diameter for the bend test defined in BS 7912:2012, **12.5**.

If the two end portions of the cable (marked as "X" in Figure E.1 and Figure E.2) do not pass fully around the rollers, they do not constitute part of the cable under test. In this case, they shall not be part of the examination at the end of the test.

If desired, a number of samples can be tested in series as one length, changing the tension between samples, or successively, as one length. In this case, any cable within the fixed wheel when the tension is changed shall not be used for subsequent tests.

NOTE 2 Examples of two possible test arrangements are shown in Figure E.1 and Figure E.2.

Tension shall be set at the beginning of the test, and necessary variations while the cable is moving can be discounted. The tension shall be measured at the end of the test. If it has reduced by more than 10%, then this reduced value of tension shall be used to calculate the sidewall loading, otherwise the initial tension shall be used.

The cable shall be passed forwards and backwards round the fixed wheel under a sidewall loading of T/R, where T is the tension in the steel wire, in Newtons, applied by the apparatus and R is the fixed wheel radius in metres. The cable sample shall then be rotated through 180° and the operation repeated.

The value of tension used for the test shall be determined either:

a) from the maximum permitted sidewall loading for the cable, in Newtons per metre (N/m) given by the manufacturer; or

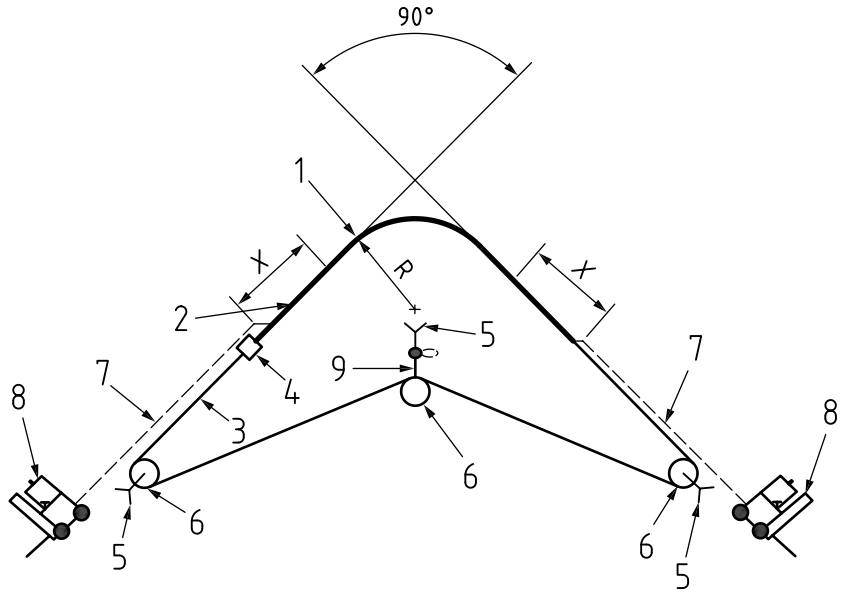
b) using the maximum pulling force for the cable recommended by the manufacturer, in which case the sidewall loading shall be calculated in Newtons per metre (N/m).

A 1 m section shall be taken from the cable tested at each value of tension and sidewall loading, other than from the ends, and shall be examined and conform to **6.3.2** or **6.3.3**.

If tests have been carried out at different levels of sidewall loading, the maximum sidewall loading for the cable shall correspond to the highest value applied to a sample conforming to **6.3.2** or **6.3.3**.

The result shall be declared as the maximum sidewall loading for the cable in Newtons per metre (N/m).

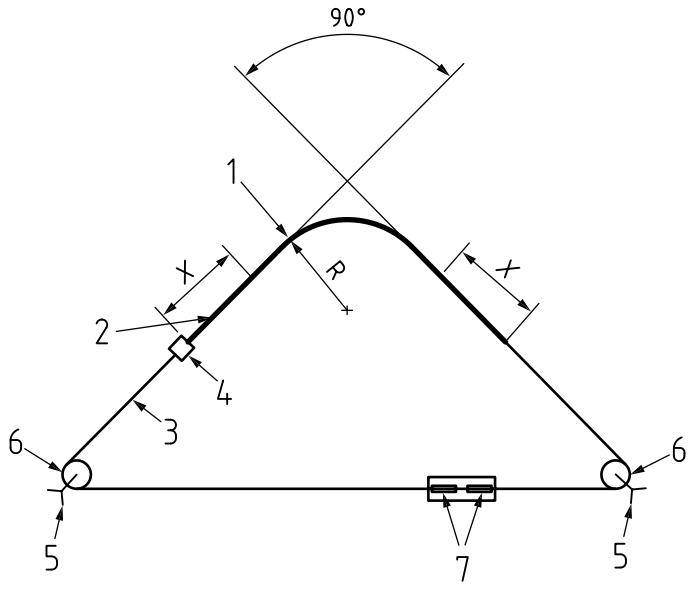
Figure E.1 **Example (Arrangement A) for the sidewall loading test**



Key

1	Fixed wheel (radius R)	6	Sheave block
2	Cable sample	7	Tow rope
3	Steel wire	8	Towing device
4	Load cell	9	Chain block
5	Anchoring	X	Cable not for examination (see text)

Figure E.2 **Example (Arrangement B) for the sidewall loading test**



Key

1	Fixed wheel (radius *R*)	6	Sheave block
2	Cable sample	7	Motorized winches
3	Steel wire	X	Cable not for examination (see text)
4	Load cell		
5	Anchoring		

Annex F (normative)

Test for corrosion

The test shall be carried out on two 1 m samples of cable (not taken from the ends) previously subjected to the sidewall loading test (Annex E).

All the samples, the ends of which shall be sealed, shall be immersed to a depth of 0.5 m in a solution of 1% NaCl, 1% Na_2SO_4 with NaOH added to adjust the pH to 8.5 ±0.5. The temperature of the solution shall be maintained at (70 ±3) °C during the test.

The samples shall be removed from the solution after 3 000 h immersion.

The combined oversheath and metal sheath shall be removed from the samples and examined with normal or corrected vision, without magnification.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

HD 632 S2:2008, *Power cables with extruded insulation and their accessories for rated voltages above 36 kV (U_m = 42 kV) up to 150 kV (U_m = 170 kV)*

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