SLOVENSKI STANDARD
SIST HD 605 S3:2019

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Električni kabli - Dodatne preskusne metode

Electric cables - Additional test methods

Starkstromkabel - Ergänzende Prüfverfahren

Câbles électriques - Méthodes d'essais supplémentaires

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ICS:

29.060.20 Kabli Cables

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HARMONIZATION DOCUMENT

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HARMONISIERUNGSDOKUMENT

HD 605-S3

August 2019

ICS 29.060.20

Supersedes HD 605 S2:2008 and all of its amendments and corrigenda (if any)

English Version

Electric cables - Additional test methods

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This Harmonization Document exists in three official versions (English, French, German).

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European Committee for Electrotechnical Standardization
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European foreword

This document (HD 605 S3:2019) has been prepared by CLC/TC 20, “Electric cables”.

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2020-07-01
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2022-07-01

This document supersedes HD 605 S2:2008 and all of its amendments and corrigenda (if any).

In order to maintain the integrity of existing clause numbers, and hence avoid unnecessary amendments to over 100 particular sections of the product HDs, the normative references are given in Annex A.

The numbering of tables and figures in this standard is not conventional. It retains the scheme as used in HD 605 S1. This is to facilitate easier cross referencing in national sections of HD 603, HD 620 and other compendia HDs. It also allows for continuing work to rationalize and harmonize more of these test methods in the future, without the need for further re-numbering.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

1 General

1.1 Scope

This HD collates and specifies the test methods to be used for testing polymeric insulated and sheathed electric cables, of rated voltage up to and including 20,8/36 kV, intended for public distribution systems, and for use in power generating plants and sub-stations.

Test methods in this HD are additional to those already harmonized, e.g. EN 60332-1 series and EN 60811 series, and are used for testing cable types specified in HD 603, HD 604, HD 620, HD 622, HD 626 and HD 627. In each case, these HDs give complementary information needed for the practical application to each specific type. Therefore the present HD as such is not sufficient for carrying out and evaluating the tests on electric cables.

Full test conditions (e.g. temperatures, durations) and/or test requirements are not specified in this HD. Such data needed to carry out the tests is given in the particular sections.

NOTE The words 'particular section' refer throughout to the section of HD 603 or HD 604, or other HD to which HD 605 applies, in which a particular cable type is specified.

1.2 Applicable tests

Tests applicable to each type of cable are given in the particular section, which may also state the sequence, the frequency of test, and the possibility of repeating failed tests.

1.3 Classification of tests

The classification of tests is given in Parts 1 of HD 603, HD 604, HD 620, HD 622, HD 626 and HD 627.

1.4 Sampling

The size and number of samples are given either in this HD or in the particular HDs.

If a marking is indented in the insulation or sheath surface, the samples used for the tests shall be taken so as to include such markings.

For multicore cables, except for the test specified in 2.1.1, not more than three cores (of different colours, if available) shall be tested unless otherwise specified.

1.5 Test conditions

1.5.1 Ambient temperature

Unless otherwise specified in the details for the particular test, tests shall be made at an ambient temperature of (20 ± 15) °C.

1.5.2 Tolerance on temperature values

Unless otherwise specified in the particular specification, the tolerance on temperature values quoted in the test methods are the following:

Table 1.5.2 — Tolerance on temperature values

Specified temperature, *t* **°C**	Tolerance **K**
-40 ≤ t ≤ 0	**± 2**
0 < t ≤ 50	**according to relevant clause**
50 < t ≤ 150	**± 2**

t > 150	± 3

1.5.3 Frequency and waveform of power-frequency test voltages

Unless otherwise specified the test voltage shall be in the range 49 Hz to 61 Hz of approximately sine-wave form, the peak ratio value/r.m.s. value being equal to √2 with a tolerance of ± 7 %. The values given are r.m.s.

1.5.4 Pre-conditioning

Unless otherwise stated the tests shall be carried out not less than 16 h after the extrusion or cross-linking, if any, of the insulating or sheathing compounds.

2 Non-electrical tests

2.1 Dimensional measurements

2.1.1 Measurement of insulation thickness

2.1.1.1 Procedure

The thickness of insulation shall be measured in accordance with EN 60811-201. Unless otherwise specified one sample of cable shall be taken and measurement made at three places.

Compliance shall be checked on each core of cables having up to five cores, and on the number of cores stated in the individual specification for cables with more than five cores.

If withdrawal of the conductor is difficult, it shall be stretched in a tensile machine or the piece of core shall be immersed in an appropriate liquid until the insulation becomes loose.

2.1.1.2 Evaluation of results

Unless otherwise specified the mean of the 18 values (expressed in millimetres) obtained from the three pieces of insulation from each core shall be calculated to two decimal places and rounded off as given below, and this shall be taken as the mean value of the thickness of insulation.

If in the calculation the second decimal figure is 5 or more, the first decimal figure shall be raised to the next number thus, for example, 1,74 shall be rounded off to 1,7 and 1,75 to 1,8.

The lowest of all values obtained shall be taken as the minimum thickness of insulation at any place.

2.1.2 Measurement of non-metallic sheath thickness

2.1.2.1 Procedure

The thickness of sheath shall be measured in accordance with EN 60811-202. Unless otherwise specified, one sample of cable shall be taken and measurement made at three places.

2.1.2.2 Evaluation of results

The mean of all the values (expressed in millimetres) obtained from the three pieces of sheath shall be calculated to two decimal places and rounded off as given below, and this shall be taken as the mean value of the thickness of the sheath.

If in the calculation the second decimal figure is 5 or more, the first decimal figure shall be raised to the next number, thus, for example, 1,74 shall be rounded off to 1,7 and 1,75 to 1,8.

The lowest of all values obtained shall be taken as the minimum thickness of sheath at any place.

2.1.3 Measurement of cable dimensions

2.1.3.1 Measurement of overall dimensions

Unless otherwise specified the three samples taken in accordance with this HD, 2.1.1 or 2.1.2 shall be used.

The measurement of the overall diameter of any circular cable and of the overall dimensions of flat cables with a major dimension not exceeding 15 mm shall be carried out in accordance with EN 60811-203.

For the measurement of flat cables with a major dimension exceeding 15 mm, a micrometer, a profile projector or similar equipment shall be used.

The mean of the values obtained shall be taken as the mean overall dimensions.

2.1.3.2 Measurement of ovality

For checking the ovality of circular sheathed cables, two measurements shall be made at the same cross-section of the cable, covering the maximum and minimum values.

2.1.4 Measurement of wires, strips and tapes

2.1.4.1 Conductor wires

Measurement of the diameter of conductor wires (class 5 conductors).

(a) Sampling

Take at random either 10 % of the total number of wires, rounded upwards, or 10 wires, whichever is the lowest, from one core of each length of cable selected for the test.

(b) Method

Determine the diameter of each wire with a micrometer by taking a measurement in three positions, approx. 300 mm far away from each other. The readings shall be made to two decimal places. Take the average of the three measurements to be the wire diameter.

2.1.4.2 Wires and tapes for concentric conductor or screen

(a) Sampling

A sample of about 500 mm length is taken from the test piece and straightened by means of a non-damaging tool. After that it is cleaned.

(b) Procedure

For wires and tapes the diameter or the thickness is measured with an screw type micrometer or a dial gauge with a measuring element with flat measurement planes with a diameter 4 mm to 8 mm. Measurements shall be made at three points which are uniformly spread along the sample.

(c) Expression of results

The diameter or the thickness is the mean value obtained from the three measurements. The test is considered to be fulfilled if the mean value does not fall below the minimum value prescribed in the particular specification.

2.1.4.3 Wires, strips and tapes for armour

(a) Round wires

Take at random 10 wires or 10 % of the total number of wires, whichever is the smaller, from a sample of the completed cable.

Determine the diameter of each wire of this sampling by taking two measurements at right angles to each other using a micrometer with flat noses to an accuracy of ± 0,01 mm.

Take the average value as the wire diameter.

(b) Flat wires or strips

Take at random 10 flat wires or strips or 10 % of the total number of flat wires or strips, whichever is the smaller, from a sample of the completed cable.

Determine the thickness and width of each flat wire of this sampling by using either a micrometer with flat noses to an accuracy of ± 0,01 mm or a vernier calliper with flat noses to an accuracy of ± 0,02 mm.

Take the average value as the wire thickness and wire width.

(c) Metallic tapes thickness

Take and straighten a sample of each armour tape, remove the non-metallic coating if any, and determine the tape thickness at six different places.

The measurement shall be made with either a micrometer or a vernier calliper, both with two flat noses of approximately 5 mm in diameter, to a respective accuracy of ± 0,01 mm or ± 0,02 mm. For tapes up to 40 mm in width the thickness shall be measured at the centre of the width. For wider tapes the measurements shall be made 20 mm from each edge of the tape and the average of the results taken as the thickness.

Take the smallest value to be compared with the specified thickness with a tolerance given in the particular specification.

2.1.5 Measurement of thickness of metallic sheath

The thickness of lead sheaths shall be determined by one of the following methods, at the discretion of the manufacturer. (Methods of measuring thickness of other types of metallic sheath are under consideration.)

(a) Strip method

The measurement shall be made on a test piece of sheath about 50 mm in length removed from the finished cable length. The test piece shall be taken a sufficient distance from the cable end to allow a proper measurement to be made.

The piece shall be slit longitudinally and carefully flattened. After cleaning the test piece, a number of measurements shall be taken along the circumference of the sheath and not less than 10 mm away from the edge of the flattened piece to ensure that the minimum thickness is measured. The measurement shall be made with a micrometer with plane faces of 2 mm to 8 mm diameter and an accuracy of ± 0,01 mm.

(b) Ring method

The measurements shall be made on a ring of the sheath carefully cut from the sample. The thickness shall be determined at a sufficient number of points around the circumference of the ring to ensure that the minimum thickness is measured.

The measurements shall be made with a micrometer having either one flat nose and one ball nose, or one flat nose and a flat rectangular nose 0,8 mm wide and 2,4 mm long. The ball nose or the flat rectangular nose shall be applied to the inside of the ring. The accuracy of the micrometer shall be ± 0,01 mm.

2.1.6 Check of application of screen or armour tapes, or wires

2.1.6.1 Method 1

Take a cable sample 300 mm long, at not less than 150 mm from the end of a factory length. Measure the gap between adjacent edges of the tape(s), and also the tape width. Measurement is made at 4 positions along the sample, with an accuracy better than 0,5 mm.

2.1.6.2 Method 2

Remove two rings of the oversheath each 50 mm in length, cut at a distance of 5 D and 15 D, respectively, (where D is the overall diameter) from one end of the cable length, so as to expose the metallic tapes or wires.

Make a visual examination of the exposed components and measure the largest gap between adjacent wires or tapes. The measurement shall be made with an accuracy better than 0,5 mm and the result shall be given to one decimal place.

2.1.7 Percentage coverage of a braided metallic layer

The percentage coverage "*B*" of the braiding shall be calculated by the following formula:

$$B = \frac{100d}{q}\left(m_1 n_1 + m_2 n_2 - m_1 n_1 m_2 n_2 \frac{d}{q}\right)$$

where

$$q = \frac{\pi DS}{\sqrt{\pi^2 D^2 + S^2}}$$

D	= mean diameter of braiding (= diameter under metallic layer + 2 d, mm);
d	= nominal diameter of the wires of the braid, mm;
S	= lay of the wires of the braiding, mm;
m_1	= number of spindles in one direction;
m_2	= number of spindles in the other direction;
n_1; n_2	= number of wires per spindle according to the direction.

2.1.8 Measurement of the gap between non-metallic tapes of taped bedding

See 2.1.6.1

2.1.9 (Spare)

2.1.10 Irregularities of semi-conducting layers and insulation

2.1.10.1 Method 1 – Irregularities of semi-conducting conductor screen and insulation

(a) Procedure

See 2.1.10.2

(b) Requirements

(i) Irregularities of semi-conducting conductor screen (Figure 2.1.10.1 a))

The semi-conducting conductor screen shall be as far as possible free from irregularities; in any case, there shall be no pronounced irregularities.

Sporadic irregularities may be allowed if the following requirements are complied with:

— irregularities of the semi-conducting conductor screen may not penetrate by more than 0,080 mm into the insulation;

— when the height *H* of the irregularities is not less than 0,040 mm, the ratio (*B*)/(*H*) shall be greater than or equal to 3;

— irregularities where (*H*) is less than 0,040 mm are not taken into consideration.

(ii) Irregularities of the insulation into semi-conducting conductor screen (Figure 2.1.10.1 b))

Irregularities of the insulation shall not penetrate into the semi-conducting conductor screen by more than 0,20 mm.

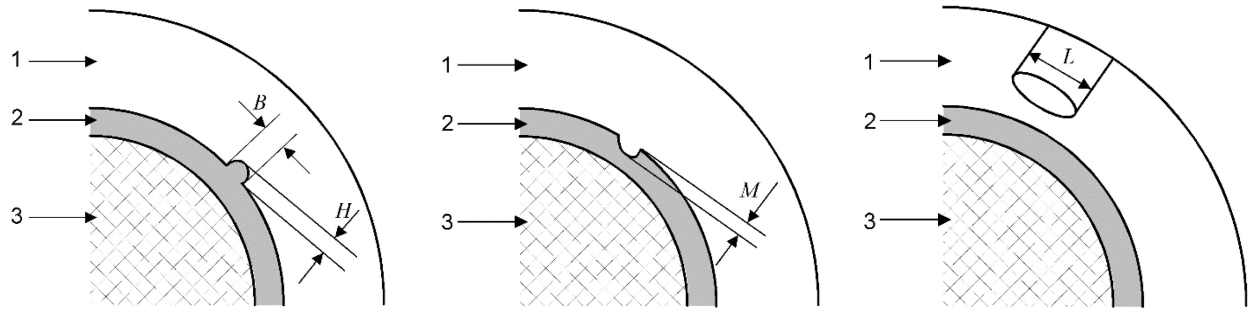
(iii) Irregularities inside the insulation (Figure 2.1.10.1 c))

Sporadic irregularities are allowed taking into account the following conditions:

— Irregularities for which the maximum dimension (*L*) is less than 0,05 mm are not considered;

— Irregularities for which the maximum dimension (*L*) is greater than 0,20 mm are not authorized;

— If irregularities are observed for which the maximum dimension (*L*) is greater than 0,05 mm but less than or equal to 0,20 mm a second sample, taken close to the first one, shall be examined and shall not be permitted to show irregularities.



a) Irregularities of semi-conducting conductor screen | **b) Irregularities of the insulation into the semi-conducting conductor screen** | **c) Irregularities inside the insulation**

Key

1	Insulation	*B*	Base of the irregularity
2	Semiconducting screen	*H*	Height of the irregularity
3	Conductor	*M*	Penetration depth of the irregularity
		L	Dimension of the irregularity

Figure 2.1.10.1 — Method 1 – Irregularities of semi-conducting conductor screen and insulation

2.1.10.2 Method 2 – Irregularities of semi-conducting conductor screen and insulation

(a) Scope

This standard specifies the tests of irregularities of the surface of extruded inner semi-conducting layers and in insulation of XLPE insulated power cables with rated voltages U_o/U 6/10 kV to 20,8/36 kV.

(b) Measuring equipment

(i) electrical air oven with natural air flow

(ii) beaker

(iii) silicone oil

(iv) measuring microscope or profile projector of at least 10x magnification, with rotating holding device for the test piece, which shall allow for a reading of 0,01 mm

(v) illumination

(c) Preparation of test pieces

From one end of the cable a test piece of 300 mm in length shall be taken. The outer semi-conducting layer of the test piece will be removed. The test piece may be stored for one to two hours in the air oven ((b) (i)) at approximately 80 °C. The beaker ((b) (ii)) shall be filled with silicone oil ((b) (iii)) and heated to approximately 130 °C.

(d) Measuring procedure

The test piece shall be inserted into the heated silicone oil until the XLPE insulation reaches its full transparency. The test piece shall then be visually inspected with the assistance of the lamp ((b) (v)) and, if necessary, any irregularities on the surface of the test piece shall be marked. The test piece shall then cool down to room temperature.

In order to measure the irregularities the test piece shall be cut into discs or spirals at the points marked. The measurement of the irregularities shall be carried out by means of the measuring equipment ((b) (iv)) in such a manner that,

— the largest extension (*b*) of an irregularity in the insulation (Figure 2.1.10.2 a));

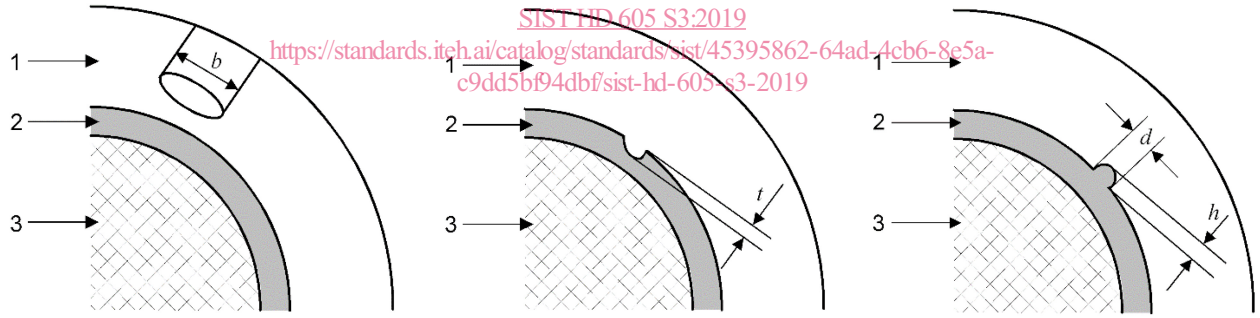
— the largest extension (*t*) of an irregularity in the inner semi-conducting layer (Figure 2.1.10.2 b));

— the largest extension (*h*) of an irregularity in the inter-facial area semi-conducting layer/insulation into the insulation and its basis diameter (*d*) (Figure 2.1.10.2 c));

shall be ascertained.

(e) Evaluation of test results

The results are acceptable if the measured values are with the limits given in the particular specifications.



a) Irregularities in the insulation **b) Irregularities extended into the conductor screen** **c) Irregularities of the conductor screen extended into the insulation**

Key

1	Insulation	*b*	Dimension of the irregularity
2	Semiconducting screen	*t*	Penetration depth of the irregularity
3	Conductor	*d*	Base of the irregularity
		h	Height of the irregularity

Figure 2.1.10.2 — Method 2 – Irregularities of semi-conducting conductor screen and insulation

2.1.10.3 Method 3 – Imperfection in cross-linked polyethylene insulation and semi-conducting layers

(a) Cross-linked Polyethylene Insulation

The insulation material shall be inspected for contaminants using a continuous sampling plan. The plan shall sample a minimum of 2 % of the insulation material volume. The material analysis shall be reported for engineering information only and at a minimum, list the size and a number of contaminants found per weight of insulation inspected. Material that is not inspected by the producer, shall be inspected at the 2 % rate by the cable supplier.

The insulation of the completed cable shall be free from:

(i) Any void larger than 0,075 mm. The number of voids larger than 0,05 mm shall not exceed two per cubic cm of insulation for all voltages.

(ii) Any contaminant (opaque material or material that is not homogeneous cross-linked polyethylene) larger than 0,125 mm in its greatest dimension. The number of contaminants of sizes between 0,05 mm and 0,125 mm shall not exceed one per cubic cm of insulation for all voltages.

(iii) Any translucent material that is larger than 1,25 mm in its greatest dimension.

(b) Semi-conducting conductor and insulation screen voids and protrusions

1. Semi-conducting extrusion for conductor shielding shall be free of any voids larger than 0,075 mm at the insulation interface.

2. Semi-conducting extrusion for insulation shielding shall be free of any voids larger than 0,125 mm at the insulation interface.

3. The contact surface between semi-conducting extrusion shields and the insulation shall be cylindrical and free from protrusion and irregularities which, at the conductor shield, extend by more than 0,125 mm into the insulation and 0,25 mm into the conductor shield. Protrusions at the surface between insulation and insulation shield shall be limited to 0,25 mm into the insulation and 0,25 mm into the insulation shield.

The conductor shielding shall be extruded and shall consist of black, semi-conducting material compatible with the insulation and the conductor and shall have allowable operating temperatures equal to or higher than those of the insulation. The outer surface of the conductor shield shall be cylindrical and shall be firmly bonded to the overlying insulation. The extruded shield shall be easily removable from the conductor. The average minimum thickness shall be 0,40 mm.

A semi-conducting tape may be used between the conductor and the extruded semi-conducting material. The insulation shielding shall be extruded and shall consist of black, semi-conducting thermoplastic or cross-linked material applied directly over the insulation.

(c) Method for determination of voids, contaminants, translucents and protrusions

(i) Samples shall be prepared as follows: 50 mm of the sample shall be cut helically or in some other convenient manner to produce thin samples of the conductor shield, insulation and insulation shield. Wafers (or the turns of the helix) shall be approximately 0,6 mm thick (producing approximately 80 wafers). The cutting blade shall be sharp and shall produce a sample with uniform thickness and with very smooth cut surfaces. The sample shall be kept clean and shall be handled carefully to prevent scratching the cut surfaces.

(ii) The entire specimen shall be viewed by transmitted light for general determination of freedom from voids, contaminants, and translucent materials in the insulation and between the insulation and conductor and insulation shield. For mineral-filled cross-linked polyethylene insulated cables, and conductor shields, the reflected light method shall be used.

1. A contaminant is any solid or liquid material which is opaque or not homogeneous thermoplastic of cross-linked polyethylene insulation, including discoloured, translucent material of more than 1,25 mm in its greatest dimension.

2. The entire area of 20 consecutive wafers (or equivalent turns of the helical sample) shall be examined with a minimum of 15-power magnification, including any areas which appear suspect during the above examination by transmitted light.

3. A tabulation of numbers and sizes shall be made with a minimum of 15-power magnification of:

   (a) all voids, 0,05 mm in greatest dimension and larger; and

   (b) all contaminants, 0,05 mm in greatest dimension and larger in cross-linked polyethylene; and

   (c) discoloured, translucent material of more than 0,05 mm in its greatest dimension.

This tabulation shall be recorded and reported.

4. The largest void, the largest contaminant and the largest translucent material shall be marked by encircling and shall be subsequently measured on a micrometer microscope.

5. The number of voids, contaminants and translucents expressed per cubic cm of insulation shall be calculated from the tabulation. (The volume of the 20 wafers, or equivalent turns, may be determined by any convenient method.) If the 20 wafers constitute less than 16,4 cm^3 and if the void or contaminant count exceeds the allowable number specified in the relevant cable specification then a sufficient number of wafers from the sample shall be examined to a total of 16,4 cm^3 of insulation (16,4 cm^3 = 1 cubic inch).

(iii) The largest void, contaminant and translucent material marked on the sample shall be measured with a micrometer microscope using a minimum of 40 power magnification. The largest dimension shall be measured only. If voids, contaminants or translucents exceed the limits listed in the relevant cable specification the sample shall be considered to have failed to meet the test requirements.

(iv) The contact area between the insulation and the shield extrusions (both the conductor shield and the insulation shield) on the 20 wafers or equivalent turns shall also be examined, using a minimum of 15-power magnification. The sample shall be considered to have failed to meet the test requirements if the contact surface between these extrusions and the insulation has protrusions or irregularities which exceed the limits specified in the relevant cable specifications.

2.1.10.4 Method 4 – Counting of voids and contaminants in insulation

Take a sample of insulation 5 cm long.

Cut the insulation into thin slices and check against light. Some 20 slices, specially if offering doubts shall be observed with an amplification of 15x.

For counting voids and contaminants use always an amplification of 15x.

(a) Count:

— Every void with a diameter ≥ 50 µm

— Every contaminant with the larger dimension ≥ 50 µm

(b) Measure:

— Dimension of largest void and largest contaminant with an amplification ≥ 40x.