SLOVENSKI STANDARD
SIST HD 635 S1:2001

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Tests on external gas-pressure (gas compression) cables and accessories for alternating voltages up to and including 275 kV (Um = 300 kV)

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Prüfungen an Gasaußendruckkabeln und Garnituren für Wechselspannungen bis einschließlich 275 kV (Um = 300 kV)

Essais des câbles à pression de gaz externe (à compression de gaz) et de leurs dispositifs accessoires pour des tensions alternatives inférieures ou égales à 275 kV (Um = 300 kV)

Ta slovenski standard je istoveten z: **HD 635 S1:1997**

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This Harmonization Document was approved by CENELEC on 1997-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning such national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

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

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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FOREWORD

This Harmonisation Document was prepared by WG9 of CENELEC Technical Committee TC20, Electric Cables.

The document contains the following Parts:

Part 1 - General test methods
Part 2 - Additional test methods
Part 3 - List of test requirements for specific cable designs

Part 3 is further divided into particular sections and, by decision of the Technical Board (D68/047) National Committees need at present only implement in their national language those sections having national applicability. The obligation remains however to announce the full HD in public by titles and numbers, and also to withdraw any conflicting national standards.

Page numbering reflects the arrangement into Parts and particular sections, e.g. Page 3-B-5 is page 5 of particular section B of Part 3.

References to other HDs, ENs and international standards are given in the particular parts or sections.

The draft was submitted to the formal vote and was approved by CENELEC as HD 635 S1 on 1997-01-10. By decision of the Technical Board (D81/139) this HD exists only in English and French.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level	(doa)	1998-03-01
- latest date by which the HD has to be implemented at national level by publication of a harmonised national standard or by endorsement	(dop)	1998-09-01
- latest date by which the national standards conflicting with the HD have to be withdrawn	(dow)	1998-09-01

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HD 635 S1:1997

TESTS ON EXTERNAL GAS-PRESSURE (GAS COMPRESSION) CABLES AND ACCESSORIES FOR ALTERNATING VOLTAGES UP TO AND INCLUDING 275 kV (U_m = 300 kV)

PART 1

General test methods

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TESTS ON EXTERNAL GAS-PRESSURE (GAS-COMPRESSION) CABLES AND ACCESSORIES FOR ALTERNATING VOLTAGES UP TO AND INCLUDING 275 kV (U_m = 300 kV)

Part 1 - General test methods

1. General

1.1 Scope

HD 635 applies to tests on radial-field impregnated-paper insulated cables and accessories which, during normal operation, work under a gas pressure exceeding 1200 kPa (12 bar) applied outside a sheath or jacket, so that the gas is not in direct contact with the insulation. The tests are applicable to cables and accessories intended to be used in systems with a nominal voltage not exceeding 275 kV between phases.

This Part (Part 1) specifies the general test methods applicable to these cables, unless otherwise specified in the particular sections of Part 3 of this HD. However, the summary of tests as listed in one only of the particular sections in Part 3 of this HD is mandatory for the particular cables ordered.

Part 2 specifies additional test methods applicable only to certain particular sections of Part 3 of this HD.

Part 3 specifies the lists of tests applicable to the particular cable type.

1.2 Normative references

Part 1 of HD 635 incorporates by dated or undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated refences, subsequent amendments to, or revisions of any of these publications apply to Part 1 of HD 635 only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

IEC60071-1	Insulation co-ordination - Part 1: Definitions, principles and rules
IEC 60183	Guide to the selection of high-voltage cables
HD 383	Conductors of insulated cables

1.3 Definitions

The following definitions have been adopted for the purpose of this standard:

U_o = the rated power-frequency voltage between conductor and core screen for which the cable and its accessories are designed;

U = the rated power-frequency voltage between any two conductors for which the cable and its accessories are designed;

U_m = the maximum value of the highest permissible system voltage for which the equipment may be used;

U_p = the peak value of the impulse withstand voltage for which the cable and its accessories are designed.

1.4 Voltage designation

Cables and accessories shall be designated by the rated voltage between conductor and core screen U_o and by the rated voltage between conductors U, both in kilovolts, e.g. 63/110.

Note: See IEC 60183 "Guide to the selection of high-voltage cables".

1.5 Test conditions

1.5.1 Frequency and waveform of power-frequency test voltages

The frequency of alternating test voltages shall be not less than 49 Hz and not more than 61 Hz. The waveform of such voltages shall be substantially sinusoidal.

1.5.2 Waveform of impulse test voltages

The impulse wave shall be in accordance with HD 48.

1.5.3 Ambient temperature

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

1.6 Characteristics

1.6.1 For the purposes of carrying out and recording the tests described in this standard, the following characteristics must be known or declared:

1.6.1.1 a) The rated voltage U_o in kilovolts.

b) The lightning impulse withstand voltage U_p in kilovolts (see sub-clause 3.4.2) .

Note: The lightning impulse withstand voltage U_p specified above for each particular cable should be selected in accordance with IEC 60071-1.

1.6.1.2 The type of conductor, the material, the nominal cross-sectional area of the conductors, in square millimetres, and conductor resistance, in ohm per kilometer (for conductor resistances refer to 2.2).

1.6.1.3 The number of cores.

1.6.1.4 Brief description of type i.e. sheathed cable or cable in pipe.

Note: For this purpose a sheathed cable is a cable in which the pressure-retaining sheath is an integral part of the cable as supplied.

1.6.1.5 Details of pressure-retaining sheath or pipe.

1.6.1.6 Material of sheath or jacket over the insulation

1.6.1.7 The capacitance between each conductor and screen in microfarads per kilometre.

1.6.1.8 The maximum permissible conductor temperature in degrees Celsius for continuous operation under the specified ambient and installation conditions.

1.6.1.9 The normal gas pressure in kilopascals or bars as well as the lowest and highest values permissible for continuous operation.

1.6. 2 The following additional characteristics shall be stated by the manufacturer when requested by the purchaser:

1.6.2.1 Details of construction e.g. shaped or circular conductor, screened or unscreened conductor, types of joint and sealing end etc.

1.6.2.2 The insulation thickness of the cable in millimetres and the maximum voltage gradient in the cable insulation at U_o in volts per millimetre, neglecting any stranding effect.

1.6.2.3 The maximum current rating in amperes under the specified installation and operating conditions.

1.6.2.4 The estimated effective (a.c.) resistance in ohms per kilometre of the cable at the maximum operating temperature and under the specified installation conditions.

1.6.2.5 The estimated inductance in henries per kilometre per phase of the completed cable under the specified conditions.

1.7 Categories of tests on cables

In this standard, tests on cables are given under three main headings:

Routine tests;
Sample tests;
Tests after installation.

1.7.1 Routine tests (symbol R)

Tests made on all production cable lengths to demonstrate their integrity.

1.7.2 Sample tests (symbol S)

Tests made on samples of completed cable, or components taken from a completed cable adequate to verify that the finished product meets the design specifications.

The following tests are sample tests:

Tan δ/temperature test;
Dielectric security test;
Mechanical test and hot impulse-voltage test;
Mechanical test and physical examination;
Mechanical test on reinforcement of sheathed cables.

These sample tests shall be made on samples, as specified in sub-clause 3.1.

1.7.3 Type tests (symbol T)

Tests required to be made before supplying a type of cable covered by this HD on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated unless changes are made in the cable material, design or type of manufacturing process which might change the performance characteristics.

1.7.4 Test after installation

Tests intended to demonstrate the integrity of the cable and its accessories as installed.

2. Routine tests on cables

2.1 General

The tests specified in sub-clauses 2.2 to 2.5 inclusive shall be made on all cores of every length of cable forming part of a contract. For the tests specified in sub-clauses 2.3 to 2.5 the cables shall be suitably terminated and the tests shall be carried out at atmospheric pressure.

2.2 Conductor resistance test

The measured d.c. resistance of each conductor in the completed cable, corrected to 20°C, shall not exceed by more than the following amounts the value of resistance calculated on the basis of a solid conductor of the same length as the cable, having a section equal to the specified sectional area and having a volume resistivity of X ohm.m:

up to 1000 mm² (*) : 4%
above 1000 mm² (*) : 5%
(*) Copper or aluminium conductors

In the above paragraph, the value of X shall be taken as follows:

Annealed copper: $1{,}7241 \times 10^{-8}$ ohm.m
Aluminium: $2{,}8264 \times 10^{-8}$ ohm.m

The temperature coefficients of electrical resistivity at 20°C are as follows:

Annealed copper: $3{,}93 \times 10^{-3}$ K^{-1}
Aluminium: $4{,}03 \times 10^{-3}$ K^{-1}

The cable shall be maintained at a reasonably constant temperature for at least 12 hours before the test. If it is doubtful whether the conductor temperature is the same as the ambient temperature, the period should be extended to 24 hours.

2.3 Capacitance test

The capacitance shall be measured at power frequency by means of an a.c. bridge; the capacitance of each core shall be not greater than 8% above the declared value (see sub-clause 1.6.1.7).

2.4 Tan δ measurement test

The tan δ measurement on the insulation shall be made at ambient temperature between each conductor and core screen, employing the power-frequency test voltages defined in sub-clause 1.5.1. If the measurements are made at a temperature below 20°C, the results shall be corrected to 20°C, either by subtracting from the measured value 2% of this value per °C of the difference between the test temperature and 20°C, or by the use of a correction curve appropriate to the insulant if agreement on such a curve has been reached between the purchaser and the manufacturer. No correction shall be made if the test temperature is 20°C or greater.

The test voltage shall be increased from 0,25 U_o to U_o in steps of about 0,25 U_o. The power-factor at 0,5 U_o shall not exceed 0,005 and the increase in tan δ between 0,25 U_o and U_o shall be not more than 0,001 per step of 0,25 U_o the total increase between 0,25 U_o and U_o being not greater than 0,002.

2.5 High voltage test

This test shall be made with a power-frequency test voltage applied for 15 minutes between each conductor and core screen. The value of the test voltage shall be U_o. The voltage shall be gradually increased to the specified value. No breakdown of the insulation shall occur.

A d.c. test may be applied as an alternative to the a.c. test specified above, the value of the test voltage being 5 U_o, and the duration of the test 15 minutes. No breakdown of the insulation shall occur.

Note: The a.c. test may be made in conjunction with the measurement of tan δ (see sub-clause 2.4).

2.6 Tests on corrosion resistant coverings

Under consideration.

3. Sample tests on cables

3.1 General

The tests specified in sub-clauses 3.2 to 3.6 inclusive shall be made on samples taken from cables manufactured for the contract, provided that the total length in the contract exceeds 2 km of three-core cable or 4 km of single-core cable on the following basis:

Cable length km				Number of samples
Three-core cable		Single-core cable		
above	up to and including	above	up to and including	
2	10	4	20	1
10	20	20	40	2
20	30	40	60	3
and so on				

In the case of three-core cables, the electrical tests described in sub-clauses 3.2, 3.3 and 3.4 shall be carried out on one core only.

For the electrical tests, the piece of cable shall be erected with suitable terminations and the gas pressure shall initially be adjusted to the minimum value declared under sub-clause 1.6.1.9.

The manufacturer may, if he wishes, carry out more than one of the sample tests specified in sub-clauses 3.2 to 3.6 inclusive on one and the same piece of cable, the order in which the tests are performed being left to his discretion. However, if on a subsequent test the requirements are not fulfilled, this test shall be repeated on a new piece of cable and the results of this latter test only shall be valid for the ultimate assessment of the results.

By agreement between the purchaser and the manufacturer, any or all of the tests prescribed in sub-clauses 3.2, 3.3 and 3.4 may be omitted, provided that the test or tests has or have previously been made on pieces of cable taken from samples having similar construction to the cable included in the contract and the manufacturer produces a certificate to this effect. Similar construction means that the cable included in the contract and the cable covered by the test certificate have identical characteristics in respect of Sub-clauses 1.6.1.1(a), 1.6.1.1(b), 1.6.1.4, 1.6.1.8, 1.6.1.9, 1.6.2.1 and 1.6.2.2.

3.2 Tan δ/temperature test

This test shall be made on a piece of cable at least 10 m long.

The tan δ measurement of the insulation shall be made at voltages of $0,5U_o$, U_o, $1,5U_o$ and $2U_o$

a) at ambient temperature;

b) after the cable has been slowly heated to a maximum temperature 5 °C above the maximum permissible operating temperature of the conductor, as stated under sub-clause 1.6.1.8;

c) immediately after cooling to ambient temperature.

The tan δ measurement shall, in addition, be made at U_o at temperatures of about 60 °C and 40 °C during cooling.

The cable shall be maintained at each temperature until a stable temperature distribution is achieved. The test temperature shall be the temperature at the hottest point in the cable as determined from thermocouples placed at intervals along it and from the increase in resistance of the conductor, making due allowance for the temperature difference between the thermocouples and the conductor.

Throughout the tests, the tan δ at U_o shall not exceed 0,005. For cables having a capacitance of 0,2 μF/km or less, the increase in tan δ between 0,5 U_o and 2 U_o shall be not more than 0,0004 per step of 0,5 U_o, and the total increase in power-factor between 0,5 U_o and 2 U_o shall not exceed 0,0010. For other cables, the figures 0,0004 and 0,0010 shall be multiplied by the ratio:

$$\frac{\text{Cable capacitance } (\mu\text{F/km})}{0,2\ \mu\text{F/km}}$$

3.3 Dielectric security test

A piece of cable at least 10 m in length excluding the terminals shall be subjected at ambient temperature to a power-frequency test voltage applied between conductor and core screen. The value of the test voltage shall be $2,5U_0$ and it shall be applied for 24 hours without the occurrence of a breakdown of the insulation.

Note: Other forms of dielectric security test are under consideration.

3.4 Mechanical test and hot impulse-voltage test

The test shall consist of a bending test, followed by an impulse-voltage test of the behaviour of the insulation and followed (for sheathed cables) by a physical examination of the coverings.

3.4.1 Bending test

The bending test shall be made at a temperature between 10°C and 15°C, unless otherwise agreed between the purchaser and the manufacturer, on a piece of cable of sufficient length to provide one complete turn round the test cylinder.

The diameter of the test cylinder shall be (tolerance on cylinder diameter -0%, +5%):

a) for single-core cables with lead, lead-alloy or corrugated aluminium sheaths 25 (D + d);

b) for three-core cables with lead, lead-alloy or corrugated aluminium sheaths 20 (D + d);

c) for all cables with non-corrugated aluminium sheaths 30 (D + d);

where: D, for sheathed cables, is the external diameter of the pressure-retaining sheath or, for pipe type cables, is the external diameter of the completed cable as it will be drawn into the pipe;

and d is the diameter of the conductor or, if a non-circular conductor is concerned, the diameter of the equivalent circular conductor.

The piece of cable shall be bent round the test cylinder at least one complete turn. It shall then be unwound and the process repeated in the opposite direction. This cycle of operations shall be carried out three times if the sheath is of lead, lead alloy or corrugated aluminium, but twice only if the sheath is of non-corrugated aluminium.

3.4.2 Impulse-voltage test

The piece of cable shall be heated slowly to a maximum conductor temperature not less than the maximum permissible operating temperature declared under sub-clause 1.6.1.8 and not greater than the maximum permissible operating temperature plus 5°C. The maximum conductor temperature is understood to be the temperature at the hottest point in the cable and it shall be determined from the increase in resistance of the conductor and from the thermocouples placed at intervals along the cable, making due allowance for the temperature difference between the thermocouples and the conductor. The cable shall be maintained at this test temperature for at least two hours.