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Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 2: Test method

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HARMONIZATION DOCUMENT
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HD 21.2 S3

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Supersedes HD 21.2 S2:1990 and its amendments

Descriptors: Conductor, cable, flexible cable, rigid cable, single core cable, multicore cable, conductor material, flat cable, tinsel cord, compound, polyvinyl chloride, insulation compound, type test, sample test, routine test, rated voltage, mark, common marking, identification, colour scheme, construction, insulation, filler, sheath, covering, internal covering, extruded covering, thickness, mean value, specified value, electrical resistance, test, tensile strength, elongation at break, ageing, loss of mass, non contamination, heat shock, pressure, high temperature, low temperature, elongation at low temperature, complete cable, overall dimensions, bending, flexing, voltage test, insulation resistance, absence of short circuits, spark (test), snatch (test), separation of cores, test (under) fire (conditions), guide to use, test method, frequency of test

English version

Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
Part 2: Test methods

Conducteurs et câbles isolés au polychlorure de vinyle, de tension assignée au plus égale à 450/750 V
Partie 2: Méthodes d'essais

Polyvinylchlorid-isolierte Leitungen mit Nennspannungen bis 450/750 V
Teil 2: Prüfverfahren

This Harmonization Document was approved by CENELEC on 1997-07-01. 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 three official versions (English, French, German).

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

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FOREWORD

This edition 3 of HD 21.2 has been prepared by Technical Committee CLC/TC20, Electric cables.

HD 21 was originally adopted by CENELEC on 9th July 1975.

Edition 2 of HD 21 was implemented on 1st January 1984, and at that time contained five parts.

Since 1984, new parts have been published and original parts amended. This new edition provides a full updating, and amalgamation of amendments since 1984.

HD 21.2 S3 is related to IEC 60227-2 (1979), but is not directly equivalent.

HD 21 now has the following parts:

HD 21.1 S3	-	General requirements
HD 21.2 S3	-	Test methods
HD 21.3 S3	-	Non sheathed cables for fixed wiring
HD 21.4 S2	-	Sheathed cables for fixed wiring (Reprint)
HD 21.5 S3	-	Flexible cables (cords)
HD 21.6	-	(Spare)
HD 21.7 S2	-	Single core non-sheathed cables for internal wiring for a conductor temperature of 90°C
HD 21.8 S1	-	Single core non-sheathed cables for decorative chains (with A1 inclusive)
HD 21.9 S2	-	Single core non-sheathed cables for installation at low temperatures
HD 21.10 S1	-	Extensible leads
HD 21.11 S1	-	Cables for luminaires
HD 21.12 S1	-	Heat resistant flexible cables (cords)
HD 21.13 S1	-	Oil resistant PVC sheathed cables with two or more conductors

In order that this revision of Part 2 of HD 21 does not introduce unnecessary changes to long-established clause numbers, the Normative References (which would otherwise be inserted as clause 2) are given in Annex A.

The draft Harmonisation Document was submitted to the Unique Acceptance Procedure and approved by CENELEC as HD 21.2 S3 on 1997-07-01.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level	(doa)	1997-12-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement	(dop)	1998-06-01
- latest date by which the national standards conflicting with the HD have to be withdrawn	(dow)	1998-06-01

For products which have complied with HD 21.2 S2:1990 and its amendments A2:1990, A3:1993, A4:1993, A6:1995, A11:1995 and A13:1995 before 1998-06-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1999-06-01.

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POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750V

Part 2 : Test Methods

1. General

1.1 Scope

HD 21 applies to rigid and flexible cables with insulation and sheath, if any, based on polyvinyl chloride, of rated voltages U_o/U up to and including 450/750V used in power installations of nominal voltage not exceeding 450/750V a.c.

This Part 2 specifies the methods of carrying out the tests specified in HD 21 in conjunction with HD 405.1 and EN 60811. General Requirements are specified in Part 1 of HD 21. Particular types of cable are specified in Part 3 onwards of HD 21, and are hereafter referred to as "the particular specifications".

1.2 Applicable tests

The tests applicable to the types of cables are given in the particular specifications.

1.3 Classification of tests according to the frequency with which they are carried out

The tests specified are type tests (Symbol T) and/or sample tests (Symbol S) and/or routine tests (Symbol R) as defined in Part 1, sub-clause 2.2. The Symbols T, S and R are used in the relevant tables of the particular specifications.

1.4 Sampling

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

For multicore cables, except for the test specified in Part 2, sub-clause 1.9, not more than three cores (of different colours, if available) shall be tested unless otherwise specified.

1.5 Pre-conditioning

All the tests shall be carried out not less than 16 h after the extrusion of the insulation or sheathing compounds.

1.6 Test temperature

Unless otherwise specified, tests shall be made at ambient temperature.

1.7 Test voltage

Unless otherwise specified, the test voltages shall be a.c. 49 Hz to 61 Hz of approximately sine-wave form, the ratio peak value/r.m.s. value being equal to $\sqrt{2}$ with a tolerance of $\pm 7\%$.

The values quoted are r.m.s. values.

1.8 Checking of the durability of colours and markings

Compliance with this requirement shall be checked by trying to remove the marking of the manufacturer's name or trademark and the colours of cores or numerals by rubbing lightly 10 times with a piece of cotton wool or cloth soaked in water.

1.9 Measurement of insulation thickness

1.9.1 Procedure

The thickness of insulation shall be measured in accordance with sub-clause 8.1 of EN 60811-1-1. Three samples shall be taken from the cable; each sample shall be separated from the next by a distance of at least 1m.

Compliance shall be checked on each core of cable.

If withdrawal of the conductor is difficult, it shall be stretched in a tensile machine or the piece of core shall be loosened by stretching or some other suitable means that does not damage the insulation.

The cores of flat non-sheathed cords shall not be separated.

1.9.2 Evaluation of results

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 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.

1.10 Measurement of sheath thickness

1.10.1 Procedure

The thickness of the sheath for circular cables shall be measured in accordance with sub-clause 8.2 of EN 60811-1-1.

For flat cords the measurements shall be carried out in accordance with Annex C of this Part 2.

One sample of cable shall be taken from each of three places, separated by at least 1m.

1.10.2 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 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 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.

1.11 Measurement of overall dimensions and ovality

The three samples taken in accordance with Part 2, sub-clause 1.9 or 1.10 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 15mm shall be carried out in accordance with sub-clause 8.3 of EN 60811-1-1.

For the measurement of flat cables with a major dimension exceeding 15mm, 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.

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. Electrical tests

2.1 Electrical resistance of conductors

In order to check the electrical resistance of conductors, the resistance of each conductor shall be measured from a sample of cable of at least 1m in length, and the length of each sample shall be measured.

If necessary a correction to 20°C and to a length of 1km shall be obtained by the formula:

$$R_{20} = R_t \times \frac{254,5}{234,5 + t} \times \frac{1\,000}{L}$$

where :

t	=	Temperature of the sample at the moment of measurement, in degrees Celsius
R_{20}	=	Resistance at 20°C, in ohm/kilometre
R_t	=	Resistance of L metres of cable at t°C in ohms
L	=	Length of the sample of cable, in metres (length of the complete sample and not of the individual cores or wires)

2.2 Voltage test on completed cable

- If the cable has no metallic layer, a sample of the cable as delivered shall be immersed in water. The length of the sample, the temperature of the water and the duration of immersion are given in Part 1, Table 3.

  A voltage shall be applied in turn between each conductor and all the others connected together and to the water.

- If the cable has a metallic layer, a sample of the cable shall be taken of the length defined in Part 1, Table 3.

  A voltage shall be applied in turn between each conductor and all the others connected together and to the metallic layer.

  If the cable has a metallic strain-bearing member, this shall be connected to the water or the metallic layer, as appropriate.

The voltage and the duration of its application are given for each case in Part 1, Table 3.

2.3 Voltage test on cores

The test applies to sheathed cables and to flat non-sheathed cords but not to flat tinsel cords.

The test shall be made on a sample of cable of 5m length. The sheath and any other covering or filling shall be removed without damaging the cores.

In the case of flat non-sheathed cord, a short cut shall be made in the insulation between the cores, and the cores shall be separated by hand for a length of 2m.

The cores shall be immersed in water as specified in Part 1, Table 3 and a voltage shall be applied between the conductors and the water.

The voltage and the duration of its application are given for each case in Part 1, Table 3.

2.4 Insulation resistance

NOTE: An explanation of the calculation of minimum insulation resistance is given in Annex D.

This test applies to all cables. It shall be made on the core samples, 5m long, previously submitted to the test described in Part 2, sub-clause 2.3 or, if this is not applicable, to the test described in Part 2, sub-clause 2.2.

The sample shall be immersed in water previously heated to the specified temperature, a length of about 0,25m at each end of the sample being kept above the water.

The length of the samples, the temperature of the water and the duration of immersion are given in Part 1, Table 3.

A d.c. voltage of between 80V and 500V shall be then applied between the conductor and the water.

The insulation resistance shall be measured 1 min after application of the voltage and this value shall be related to 1km.

None of the resulting values shall be below the minimum insulation resistance value prescribed in the particular specifications.

2.5 Long term resistance of insulation to direct current

This test applies to all the cables and cords. It shall be made on samples of core 5m long, after removal of any covering. The cores of flat non-sheathed cords shall not be separated. The samples shall be immersed in an aqueous solution of sodium chloride at about 10 g/litre, brought to the specified temperature. A length of about 0,25m at each end of the sample shall be kept above the solution. A voltage of 220V d.c. shall be applied between the conductor(s) of each sample, connected to the negative pole, and copper electrode immersed in the solution, connected to the positive pole. The temperature of the solution and the duration of the applied voltage shall be as specified in Part 1, Table 3.

After the test, the exterior of the insulation shall show no damage.

Note: Discolouration of the insulation should be ignored.

2.6 Test to check the absence of faults on insulation

This test shall be carried out as a routine test in the final stage of manufacture either on delivery lengths or on manufacturing lengths before cutting them into delivery lengths.

The test shall be either, for single core cables, a spark test in accordance with Part 2, sub-clause 2.6.1, or, for multicore cables, a voltage test in accordance with Part 2, sub-clause 2.6.2.

Unsheathed two-core cables shall be tested in accordance with Part 2, sub-clause 2.6.1 and sub-clause 2.6.2.

2.6.1 Spark test

Test requirements : The cable shall withstand the test voltage specified below without failure of the insulation. The spark test equipment shall detect a puncture in the insulation having a diameter equal to or greater than half of the specified insulation thickness. The recovery time of the spark tester shall be not greater than one second.

Test voltage : The voltage applied by the spark tester may be power frequency a.c, d.c., high frequency or of other form.

The magnitude and the presence of the voltage shall be such that with the electrode system employed and at the speed employed for the passage of the cable through the spark tester the test requirements are effectively met.

The reference method to be used to establish the efficacy of the spark testing equipment is given in Part 2, Annex B.

2.6.2 Voltage test

Test requirements : The cable in the dry state and at ambient temperature shall withstand the test voltage applied as specified below without failure of the insulation.

Test voltage : The voltage shall be either derived from an a.c. source complying with Part 2, clause 1.7, or from a d.c. source.

The magnitude of the applied voltages shall be as follows:

Rated voltage U_0/U of the cable, V	Test Voltage, V	
	a.c. (rms)	d.c. Not less than
300/300	2 000	5 000
300/500	2 000	5 000
450/750	2 500	5 000

The voltage shall be applied between conductor and groups of conductors in such a way that the insulation on each core is tested against all adjacent cores and screen if any. The voltage shall be increased gradually and thereafter be maintained at the full value for 5 min.

2.7 Screening efficiency

2.7.1 General

The screening efficiency of a cable depends both on the screening against currents and the screening against voltages.

The screening efficiency against currents is specified in terms of the transfer impedance due to resistive and magnetic coupling per unit length, against voltages in terms of the transfer admittance due to electric coupling (see Note below) per unit length. Transfer impedance is defined in an elementary length of cable as the ratio of the voltage measured along the screen in the disturbed system to the current flowing in the interfering system. This may be of interest at any frequency up to 10 000 MHz. In general, there is no problem where homogeneous cylindrical shields are used since the screening effect in such cases can be readily calculated, but where a braided or taped construction is employed it becomes necessary to measure the screening efficiency. The present state of experience shows that the surface transfer impedance remains constant at frequencies from 0 Hz to 0,1 MHz or 1 MHz, depending on the type of cable and is equal to the direct current resistance of the screen. At frequencies over 0,1 MHz or 1 MHz the transfer impedance increases. Depending on the construction of the screen, this increase starts directly or after having passed through a minimum.

Over 10 MHz to 15 MHz, the increase is proportional to the frequency.

Transfer admittance is defined in an elementary length of cable as the ratio of the current flowing into the disturbed system to the voltage originating it in the specified interfering system. Measurements show that the transfer admittance may be represented by a capacitance which is independent of frequency from audio frequencies up to 1 000 MHz at least.

Note: Attention is drawn to the fact that in some countries the term 'transfer admittance' is taken to be the reciprocal of 'transfer impedance' which is not the case in this standard.

2.7.2 Transfer impedance due to resistive and magnetic coupling

2.7.2.1 Test apparatus

The apparatus is of the 'triple coaxial' form (see Figure 1). A short length of the cylindrical screen under investigation forms both the inner conductor of an energised coaxial system and, at the same time, the outer conductor of another coaxial line. The signal in the inner coaxial system is caused by the surface transfer impedance of the screen.

The cable with the screen to be measured is terminated at one end by a resistance the value of which is numerically equal to the characteristic impedance of the screen. The terminal resistance is shielded by a metal sleeve whose edge at the open end is soldered to the screen. Terminal resistance and cable are coaxially mounted inside a metal tube. This tube is terminated at the side opposite the resistance by a short-circuiting disk, which is soldered to the screen (see Figure 1).

The length of the cable in the metal tube is not to exceed 0,1λ to 0,35λ according to the measuring equipment used, where λ is the wavelength corresponding to the frequency of the test apparatus. The length of the projecting cable is of no consequence.

2.7.2.2 Test procedure

The outer coaxial system, formed by the screen under investigation and the metal tube, is fed from a generator through an interconnected resistance (Method 1) or by way of a direct connection (Method 2).

The measurement shall be carried out at 30MHz.

Note: For both methods a cable length of 1m is mostly adequate. The correction factor at 30 MHz is approximately 1.

Method 1 : Feeding through a resistance

The generator feeds the outer system through a pure resistance (R) which, to best advantage, should be equal to about 1,4 times the value of the characteristic impedance of the outer system. The input voltage to the resistance is measured by means of a suitable voltmeter. The output voltage of the inner system, which is formed by the cable proper, is measured by means of a matched voltmeter.