

Insulating and sheathing materials of electric and optical cables — Common test methods —

Part 1-1: General application — Measurement of thickness and overall dimensions — Tests for determining the mechanical properties

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National foreword

This section of BS EN 60811 has been prepared by Technical Committee GEL/20 and is the English language version of EN 60811-1-1:1995 *Insulating and sheathing materials of electric and optical cables — Common test methods — Part 1-1: General application — Measurement of thickness and overall dimensions — Tests for determining the mechanical properties including* amendment A1:2001, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 60811-1-1:1993, Edition 2.1:2001, which comprises Edition 2:1993 consolidated by the incorporation of amendment 1:2001, published by the International Electrotechnical Commission (IEC).

This standard supersedes BS 6469-1:1992, which will be withdrawn on 1 December 1996.

Technical Committee GEL/20 will have made arrangements for the requirements for non-metallic sheathed flat multi-core cables contained in national annex NA of BS 6469-1:1992 to be specified elsewhere by the withdrawal date of the 1 December 1996.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standard Online. A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 23 and a back cover.

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Sideline in this document indicates the most recent changes by amendment.

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English version

Insulating and sheathing materials of electric and optical
cables — Common test methods —
Part 1-1: General application —
Measurement of thickness and overall dimensions —
Tests for determining the mechanical properties

(includes amendment A1:2001)
(IEC 60811-1-1:1993 + A1:2001)

Matériaux d'isolation et de gainage des câbles
électriques et des câbles optiques —
Méthodes d'essais communes —
Partie 1-1: Application générale — Mesure des
épaisseurs et des dimensions extérieures —
Détermination des propriétés mécaniques
(inclut l'amendement A1:2001)
(CEI 60811-1-1:1993 + A1:2001)

Isolier- und Mantelwerkstoffe für Kabel und
isolierte Leitungen — Allgemeine
Prüfverfahren —
Teil 1-1: Allgemeine Anwendung — Messung
der Wanddicke und der Außenmaße —
Verfahren zur Bestimmung der mechanischen
Eigenschaften
(enthält Änderung A1:2001)
(IEC 60811-1-1:1993 + A1:2001)

This European Standard was approved by CENELEC on 1995-03-06. Amendment A1:2001 was approved by CENELEC on 2001-05-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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CENELEC

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

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

The text of the International Standard IEC 811-1-1:1993, prepared by IEC TC 20, Electric cables, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 60811-1-1 on 1995-03-06 without any modification.

This European Standard supersedes HD 505.1.1 S3:1991.

Where reference is made to HD 505.1.1 S3:1991 in another standard, users should refer to this EN 60811-1-1 for the current information.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-03-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1996-12-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given for information only. In this standard, annex ZA is normative and annex A is informative. Annex ZA has been added by CENELEC.

Foreword to amendment A1

The text of document 20/455/FDIS, future amendment 1 to IEC 60811-1-1:1993, prepared by IEC TC 20, Electric cables, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60811-1-1:1995 on 2001-05-01.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2004-05-01

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COMMON TEST METHODS FOR INSULATING AND SHEATHING MATERIALS OF ELECTRIC CABLES AND OPTICAL CABLES –

Part 1-1: Methods for general application – Measurement of thickness and overall dimensions Tests for determining the mechanical properties

1 Scope

The International Standard IEC 60811-1 specifies the test methods to be used for testing polymeric insulating and sheathing materials of electric cables for power distribution and telecommunications including cables used on ships, and in offshore applications.

This section of IEC 60811-1 gives the methods for measuring thicknesses and overall dimensions, and for determining the mechanical properties, which apply to the most common types of insulating and sheathing compounds (elastomeric, PVC, PE, PP, etc.).

1.1 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60811-1. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60811-1 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*

IEC 60811-1-3:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Three: Methods for determining the density – Water absorption tests – Shrinkage test*

IEC 60811-2-1:1986, *Common test methods for insulating and sheathing materials of electric cables – Part 2: Methods specific to elastomeric compounds – Section 1: Ozone resistance test – Hot set test – Mineral oil immersion test*

2 Test values

Full test conditions (such as temperatures, durations, etc.) and full test requirements are not specified in this standard; it is intended that they should be specified by the standard dealing with the relevant type of cable.

Any test requirements which are given in this section may be modified by the relevant cable standard to suit the needs of a particular type of cable.

3 Applicability

Conditioning values and testing parameters are specified for the most common types of insulating and sheathing compounds and of cables, wires and cords.

4 Type tests and other tests

The test methods described in this section are intended, in the first instance, to be used for type tests. In certain tests, where there are essential differences between the conditions for type tests and those for more frequent tests such as routine tests, these differences are indicated.

5 Pre-conditioning

All the tests shall be carried out not less than 16 h after the extrusion or vulcanization (or cross-linking), if any, of the insulating or sheathing compounds.

Unless otherwise specified, before any test, all test pieces, aged and unaged, shall be kept for at least 3 h at a temperature of $(23 \pm 5) ^\circ\text{C}$.

6 Test temperature

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

7 Definitions

For the purposes of this section of IEC 60811-1, the following definitions apply:

7.1

maximum tensile force

highest value reached by the load during the test

7.2

tensile stress

tensile force per unit of the cross-sectional area of the unstretched test piece

7.3

tensile strength

maximum tensile stress recorded in extending the test piece to breaking point

7.4

elongation at break

increase of the reference length of the test piece, expressed as the percentage of the reference length of the unstretched test piece, at breaking point

7.5

median value

when several test results have been obtained and ordered in an increasing or decreasing succession, the median value is the middle value if the number of available values is odd, and is the mean of the two middle values if the number is even

8 Measurement of thicknesses and overall dimensions

8.1 Measurement of insulation thickness

8.1.1 General

Measurement of insulation thickness may be required as an individual test, or as a step in the procedure for carrying out other tests, such as the determination of mechanical properties.

In each case, the methods of selection of samples shall be in accordance with the relevant cable standard.

8.1.2 Measuring equipment

A measuring microscope or a profile projector of at least 10 x magnification. Both types of equipment shall allow a reading of 0,01 mm and an estimated reading to three decimal places when measuring insulation with a specified thickness less than 0,5 mm.

In case of doubt, the measuring microscope shall be taken as the reference method.

8.1.3 Preparation of test pieces

Any covering shall be removed from the insulation, and the conductor(s), together with separator (if any) shall be withdrawn, care being taken to avoid damage to the insulation. Semi-conducting inner and/or outer layers, if bonded to the insulation, shall not be removed.

Each test piece shall consist of a thin slice of insulation. The slice shall be cut with a suitable device (sharp knife, razor blade, etc.) along a plane perpendicular to the longitudinal axis of the conductor.

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

If the insulation carries an indented marking, thus giving rise to a local reduction in thickness, the test piece shall be taken so as to include such marking.

8.1.4 Measuring procedure

The test piece shall be placed under the measuring equipment with the plane of the cut perpendicular to the optical axis.

- a) When the inner profile of the test piece is of circular form, six measurements shall be made radially as shown in figure 1. For sector-shaped cores, six measurements shall be made as shown in figure 2.
- b) When the insulation is taken from a stranded conductor, six measurements shall be made radially as shown in figures 3 and 4.
- c) When the outer profile shows unevenness, the measurement shall be carried out as shown in figure 5.
- d) When there are unremovable screening layers under and/or over the insulation, they shall be excluded from the measurements.

If unremovable screening layers are present under and/or over an opaque insulation, a measuring microscope shall be used.

- e) Flat non-sheathed cords shall be measured according to figure 6, the thickness of insulation in the direction of the other core being taken as half the distance between the conductors.

In all cases, the first measurement shall be taken where the insulation is thinnest.

If the insulation carries an indented marking, this shall not be included in the measurements made for the calculation of mean thickness. In any case, the thickness at the position of the indented marking shall comply with the minimum requirement specified in the relevant cable standard.

The readings shall be made in millimetres to two decimal places if the specified thickness is 0,5 mm or above and to three estimated decimal places if the specified thickness of the insulation is less than 0,5 mm.

8.1.5 Evaluation of the measurement results

The results shall be evaluated as specified in the test requirements of the relevant cable standard.

In the case of mechanical tests, the mean value of the thickness, δ , of each test piece (see item b1) of 9.1.4) shall be calculated from the six measurement results obtained on that test piece.

8.2 Measurement of thickness of non-metallic sheath

8.2.1 General

The measurement of sheath thickness may be required as an individual test, or as a step in the procedure for carrying out other tests, such as the measurement of mechanical properties. The test method applies to the measurement of all sheaths for which thickness limits are specified, for example separation sheaths, as well as external sheaths.

In each case, the method of selecting samples shall be in accordance with the relevant cable standard.

8.2.2 Measuring equipment

(See 8.1.2.)

8.2.3 Preparation of test pieces

After all materials, if any, inside and outside the sheath have been removed, each test piece shall be prepared by cutting a thin slice along a plane perpendicular to the longitudinal axis of the cable, using a suitable device (sharp knife, razor blade, etc.).

If the sheath carries an indented marking, thus giving rise to a local reduction in thickness, the test piece shall be taken so as to include such marking.

8.2.4 Measuring procedure

The test piece shall be placed under the measuring equipment with the plane of the cut perpendicular to the optical axis.

- a) When the inner profile of the test piece is of circular form, six measurements shall be made radially as shown in figure 1.
- b) If the substantially circular inner surface is not regular or smooth, six measurements shall be made radially at the positions where the sheath is thinnest, as shown in figure 7.

- c) When the inner profile exhibits deep grooves caused by the cores, radial measurements shall be taken at the bottom of each groove, as shown in figure 8.

When the number of grooves exceeds six, item b) applies.

- d) In order to eliminate the influence of any irregularities on the outer surface, which may be due to the presence of a proofed tape or a ribbed sheath finish, the measurements shall be made as shown in figure 9.
- e) In the case of sheathed flat cords, measurements shall be taken on lines approximately parallel to the minor axis and on the major axis of the cross-section, at the position of each core, one of the measurements being, however, made at the thinnest place, as shown in figure 10.
- f) For sheathed flat cables composed of up to and including six single cores, measurement shall be taken as shown in figure 11
- on both rounded off sides, along the major axis of the cross-section;
 - on both flat sides on the first and last core, and at the thinnest place (plus opposite sheath thickness) if this does not coincide with any of the other measurements.

For cables composed of more than six cores, the above applies but measurements shall also be taken on the middle core or on one of the two middle cores in case of an even number of cores.

In all cases, one of the measurements shall be taken where the sheath is thinnest.

If the sheath carries an indented marking, this shall not be included in the measurements made for the calculation of mean thickness. In any case, the thickness of the position of the indented marking shall comply with the minimum requirement specified in the relevant cable standard.

The readings shall be made in millimetres to two decimal places.

8.2.5 Evaluation of the measurement results

The results shall be evaluated as specified in the test requirements of the relevant cable standard.

In the case of mechanical tests, the mean value of the thickness, δ , of each test piece (see 9.2.4) shall be calculated from all measurement results obtained on that test piece.

8.3 Measurement of overall dimensions

8.3.1 General

The measurement of the dimensions over the insulation of cores or over the sheath may be required as individual tests or as steps in the procedure for carrying out other tests.

The methods in 8.3.2 below are for general use except where the procedure for a particular test specifies a different or alternative method.

In each case, the method of selecting samples shall be in accordance with the relevant cable standard.

8.3.2 Measuring procedure

- a) For cords and cables with overall dimensions not exceeding 25 mm, the measurements shall be made by means of a micrometer, a profile projector or similar apparatus, in two directions perpendicular to each other.

For measurements made in the course of routine tests, it is permissible to use a dial micrometer or a vernier calliper, care being taken to limit the pressure.

- b) If the overall diameter exceeds 25 mm, the circumference of the cord or cable shall be measured by means of a measuring tape, and the diameter shall be calculated. Alternatively, a direct reading diameter tape can be used.
- c) For flat cords and cables the measurements shall be made along the major and minor axes of the cross-section by means of a micrometer, a profile projector or similar apparatus.

Unless otherwise specified in the relevant cable standard, the readings shall be made to two decimal places of a millimetre for dimensions up to and including 25 mm, and to one estimated decimal place for dimensions exceeding 25 mm.

8.3.3 Evaluation of the measurement results

The results shall be evaluated as specified in the test requirements of the relevant standard.

9 Tests for determining the mechanical properties of insulating and sheathing compounds

9.1 Insulating compounds

9.1.1 General

These tests are to determine the tensile strength and elongation at break of the insulating material (exclusive of any semi-conducting layers) of the cable in the condition as manufactured (i.e. without any ageing treatment) and, when required, after one or more accelerated ageing treatment(s), which are prescribed in the relevant cable standard.

The methods for carrying out ageing in an air oven, in an air bomb and in an oxygen bomb are specified in clause 8 of IEC 60811-1-2.

The test pieces selected for the ageing treatment shall be from positions adjacent to the test pieces used for the test without ageing and the tensile tests on the aged and unaged test pieces shall be made in immediate succession.

NOTE Where further increased test reliability is necessary, it is recommended that the tests on aged and unaged test pieces are performed by the same person using the same testing method and the same apparatus, in the same laboratory.

9.1.2 Sampling

One sample of each core to be tested (or of the insulation from each core to be treated) shall be taken of sufficient size to provide a minimum of five test pieces each for the tensile tests without ageing and the tensile tests after each of the required ageing treatments, bearing in mind that a 100 mm length is needed for the preparation of each test piece.

The cores of flat cords shall not be separated.

Any sample that shows signs of mechanical damage shall not be used for the test.

9.1.3 Preparation and conditioning of test pieces

NOTE It is advisable to read 9.1.3 c) "Conditioning of test pieces" before carrying out the preparation of the test pieces.

a) Dumb-bell test pieces

Dumb-bell test pieces shall be used whenever possible. They shall be prepared from samples of insulation removed from the conductor, cutting it only in the direction of the axis of the core.

Semi-conducting layers, if any, inside and/or outside the insulation, shall be removed mechanically, i.e. without using a solvent.

Each sample of insulation shall be cut into strips of an appropriate length. The strips shall be marked to identify the sample from which they are cut and their positions relative to each other in the original sample.

The strips of insulation shall be ground or cut, so as to obtain two parallel smooth surfaces between the reference marks mentioned below, care being taken to avoid undue heating. An example of a cutting machine is given in annex A. For polyethylene (PE) and polypropylene (PP) insulation, cutting only, not grinding, shall be employed. After cutting or grinding, including any removal of burrs, the thickness of the strips shall not be less than 0,8 mm and not more than 2,0 mm. If a thickness of 0,8 mm cannot be obtained from the original sample, a minimum thickness of 0,6 mm is permitted.

A dumb-bell test piece in accordance with figure 12, shall then be punched from each prepared strip of insulation, or if possible, two dumb-bell test pieces shall be punched side by side.

In order to improve the reliability of the results, the following is recommended:

- the punch shall be very sharp to minimize imperfections in the test piece;
- a cardboard or other suitable support shall be placed between the strip and the base plate. This support shall be marked during punching, but not completely cut through by the punch;
- burrs on the sides of the test piece shall be avoided.

For materials where punching results in burrs, the following method may be used:

- i) each end of the punch shall have a groove approximately 2,5 mm wide and 2,5 mm high (see figure 14);
- ii) the cut dumb-bell test pieces will remain attached at both ends with the strip previously prepared according to the requirements of 9.1.3 a) (see figure 15);
- iii) with the machine given in annex A, an additional 0,10 mm to 0,15 mm thickness can be cut away to remove possible burrs resulting from the dumb-bell punch. When this operation is completed, the dumb-bell test pieces shall be cut through at their ends in order to remove them from the strip.

When the diameter of the core is too small to allow the dumb-bell in accordance with figure 12, to be used, then a smaller test piece in accordance with figure 13, shall be punched from each prepared strip.

The central 20 mm for the larger dumb-bells or 10 mm for the smaller dumb-bells shall be marked on each test piece, immediately before the tensile test.

Dumb-bell test pieces with incomplete ends are permitted, provided that the breaking point occurs between the reference marks.

b) Tubular test pieces

Tubular test pieces shall be used only when the core is of such dimensions that it is not possible to prepare dumb-bell test pieces.

The samples of core shall be cut into pieces approximately 100 mm long and the conductor and any outer coverings removed, care being taken not to damage the insulation. The tubes shall be marked to identify the sample from which they were prepared and their relative positions in the sample.

Careful removal of the conductor can be facilitated by the use of one or more of the following operations:

- i) by elongation of the rigid conductors;
- ii) by careful rolling of the core under low mechanical force;
- iii) in the case of stranded or flexible conductors, by first removing one or more of the central strands or wires.

After removal of the conductor, the separators, if any, are removed. In case of difficulty, one of the following operations may be used:

- immersion in water, in the case of paper separators;
- immersion in ethyl alcohol, in the case of polyethylene terephthalate separators;
- rolling of the insulation on a smooth surface.

The central 20 mm shall be marked immediately before the tensile test.

The presence of pieces of separator, remaining inside the test piece, can be observed during the tensile tests by formation of irregularities in the test piece during elongation.

In such cases, the result shall be rejected.

c) Conditioning of test pieces shall be carried out as follows:

i) Elevated temperature conditioning

Where the relevant cable standard calls for conditioning at elevated temperature or where, in case of doubt, the test must be repeated, such conditioning shall be carried out as follows:

- for dumb-bells,
 - (A) after the removal of the insulation from the cable and removal of semi-conducting layers (if any) but before the cutting of strips;
 - (B) after grinding (or cutting) to obtain parallel surfaces.

Where grinding (or cutting) is not needed, the conditioning shall be performed at the point in the test protocol according to (A);
- for tubular test pieces, such conditioning shall be carried out after removal of the conductor, and any separator, but before applying the marks for measurement of the extension.

Where the relevant cable standard calls for conditioning at elevated temperature it shall be for the time and temperature given in that standard. Where, in case of doubt, the test must be repeated, the conditioning shall be 24 h at $(70 \pm 2) ^\circ\text{C}$, or a lower temperature corresponding to the maximum operating temperature of the conductor.

ii) Ambient temperature conditioning

Before determination of the cross-sectional area, all test pieces shall be protected from direct sunlight and maintained for at least 3 h at a temperature of $(23 \pm 5) ^\circ\text{C}$, except for thermoplastic insulating materials which shall be kept at $(23 \pm 2) ^\circ\text{C}$.

9.1.4 Determination of cross-sectional area

a) Dumb-bell test piece

The cross-sectional area of each test piece is the product of the common width and the measured individual minimum thickness which shall be determined as follows:

For the width:

- the common width is the minimum width of three, randomly selected test pieces;
- if there is doubt about the uniformity of the width, this shall be measured at three positions on the top and the bottom side of the three test pieces. The mean of the top and bottom side measurements shall be calculated for each position. The common width shall be the minimum of the nine mean values determined on the three test pieces;
- in the case of further doubt, the width is measured on each individual test piece.

For the thickness:

- the thickness of each test piece is the minimum of three thickness measurements carried out in the area to be stretched.

The measurements shall be carried out by an optical instrument or by a dial gauge giving a contact pressure not exceeding 0,07 N/mm².

The instrument shall be capable of measuring the thickness with an error of not more than 0,01 mm and the width with an error of not more than 0,04 mm.

In case of doubt, where technically possible, an optical instrument shall be used. Alternatively, a dial gauge with a maximum contact pressure of 0,02 N/mm² may be used.

NOTE An appropriate curved foot of the dial gauge may be used if the central part of the dumb-bell is still curved.

b) Tubular test piece

At the middle of the sample being used to prepare the test pieces, a piece shall be taken to determine the cross-sectional area A , in square millimetres, of the test piece by one of the following methods. In case of doubt, the second method b2) shall be used.

b1) From the dimensions, using the formula:

$$A = \pi (D - \delta) \delta$$

where

- δ is the mean value of the thickness of the insulation, in millimetres, determined as specified in clause 8 and rounded off to two decimal places (see 8.1.4, last paragraph);
- D is the mean value of the outer diameter of the test piece, in millimetres, determined as specified in test method b) of 8.3.2 and rounded off to two decimal places.

b2) From the density, the mass and the length, using the formula:

$$A = \frac{1000 m}{d \times l}$$

where

- m is the mass of the test piece, in grams, to three decimal places;
- l is the length, in millimetres, to one decimal place;
- d is the density, measured in accordance with clause 8 of IEC 60811-1-3 on an additional sample of the same insulation (without ageing) in grams per cubic centimetre, to three decimal places.

- b3) From the volume and the length, the volume being determined by means of immersion in ethyl alcohol using the formula:

$$A = \frac{V}{l}$$

where

V is the volume, in cubic millimetres, to two decimal places;

l is the length, in millimetres, to one decimal place.

Care shall be taken to avoid air bubbles in the test piece during immersion.

- c) For test pieces which are to be aged, the cross-sectional area shall be determined before ageing treatment, unless the insulation is to be aged in the presence of the conductor.

9.1.5 Ageing treatment

Each required ageing treatment shall be carried out on five test pieces (see 9.1.2) in accordance with clause 8 of IEC 60811-1-2, under the conditions specified in the relevant cable standard.

9.1.6 Spare.

9.1.7 Tensile testing procedure

a) Test temperature

The test shall be carried out at a temperature of (23 ± 5) °C. In case of doubt for thermoplastic insulation, the test shall be carried out at (23 ± 2) °C.

b) Distance between the grips and rate of separation

The grips of the tensile testing machine may be either of a self-tightening type or not.

The total length between the grips shall be about:

34 mm for dumb-bells as illustrated in figure 13;

50 mm for dumb-bells as illustrated in figure 12;

50 mm for tubes, if tested with self-tightening grips;

85 mm for tubes, if tested with non-self-tightening grips.

The rate of separation, except for PE and PP insulations, shall be (250 ± 50) mm/min and, in case of doubt, (25 ± 5) mm/min.

For PE and PP, or insulations containing these materials, the rate of separation shall be (25 ± 5) mm/min, but for routine tests, separation rates up to (250 ± 50) mm/min are permitted.

c) Measurements

The maximum tensile force during the test shall be measured and recorded, and the distance between the two reference marks at breaking point shall be measured on the same test piece.

An unsatisfactory result due to any test piece breaking due to damage in the grips shall be ignored. In this event, at least four valid results shall be obtained in order to calculate the tensile strength and elongation at break; otherwise the test shall be repeated.

9.1.8 Expression of results

Calculate the tensile strength and the elongation at break according to the definitions given in 7.3 and 7.4, respectively.

The median value of the results shall be determined.

9.2 Sheathing compounds

9.2.1 General

These tests are to determine the tensile strength and elongation at break of the sheathing material of the cable in the condition as manufactured and, when required, after one or more accelerated ageing treatment(s).

When the ageing treatment is to be carried out on prepared test pieces (in accordance with 8.1.3 of IEC 60811-1-2 or with clause 10 of IEC 60811-2-1), the test pieces for treatment shall be from positions adjacent to the test pieces used for the test without ageing, and the tensile tests on the treated and untreated test pieces shall be in immediate succession.

NOTE Where further increased reliability is necessary, it is recommended that the tests on aged and unaged test pieces are performed by the same person using the same testing method and the same apparatus, in the same laboratory.

9.2.2 Sampling

One sample of the cable or cord to be tested, or of the sheath removed from the cable, shall be taken of sufficient size to provide a minimum of five test pieces for the tensile tests without ageing and the required number of test pieces for each of the tensile tests after ageing specified for the sheathing material in the standard for the type of cable in question, bearing in mind that about 100 mm is needed for the preparation of each test piece.

Any sample that shows signs of mechanical damage shall not be used for the tests.

9.2.3 Preparation and conditioning of test pieces

Test pieces shall be prepared from the samples of sheath in the same way as specified for insulation in 9.1.3.

In the preparation of dumb-bell test pieces, a strip shall be cut from the sheath in the direction of the axis of the cables. All other cable components shall be removed from the strip. If the strip has ridges or imprints, these shall be removed by cutting or grinding. For PE and PP and related sheaths, only cutting is allowed.

NOTE For PE sheaths, the thickness of the dumb-bell does not need to be reduced to 2,0 mm, when the full sheath thickness is greater, provided that the test pieces are smooth on both surfaces.

In the preparation of tubular test pieces, all the components of the cable inside the sheath, including cores, fillers and inner covering, shall be removed.

For conditioning of the test pieces, see 9.1.3 c).

9.2.4 Determination of cross-sectional area

The cross-sectional area of each test piece shall be determined by the same method as for the insulation specified in 9.1.4, with the following modifications for tubular test pieces:

- the thickness and diameter of the sheath, measured in accordance with clause 8 with particular reference to 8.2.4 for thickness, and 8.3.2 for diameter, shall be used in the method b1);
- the density shall be measured on an additional piece of the same sheath in the method b2).

NOTE The b2) method should not be used for multi-layer materials.

9.2.5 Ageing treatment

Each required ageing treatment shall be carried out on five test pieces (see 9.2.2) in accordance with clause 8 of IEC 60811-1-2, under the conditions specified in the standard for the particular type of cable.

9.2.6 Spare.

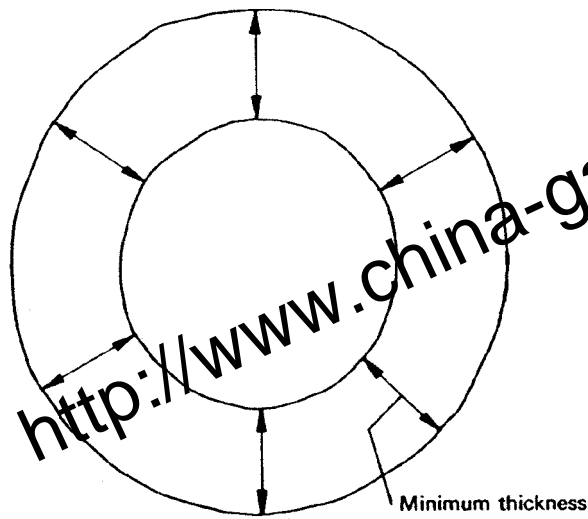
9.2.7 Tensile testing procedure

In accordance with 9.1.7.

9.2.8 Expression of results

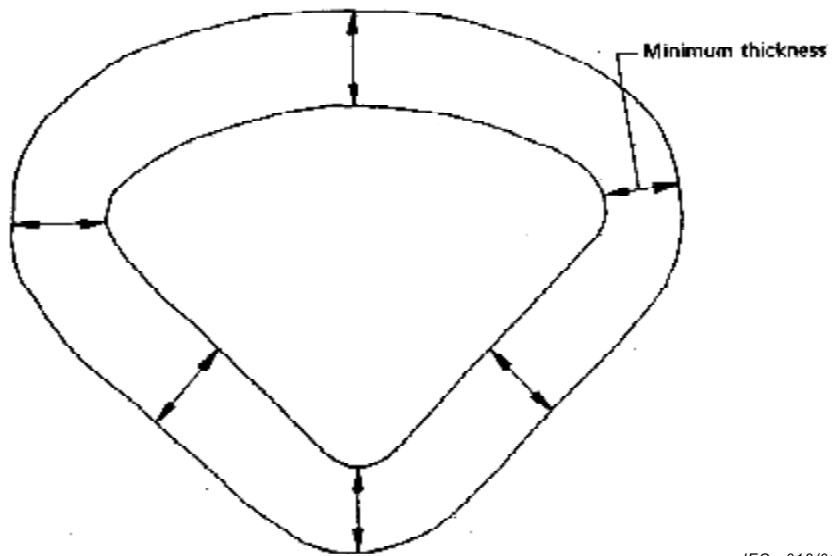
In accordance with 9.1.8.

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IEC 911/01

Figure 1 – Measurement of insulation or sheath thickness
(circular inner profile)



IEC 912/01

Figure 2 – Measurement of insulation thickness (sectoral-shaped conductor)

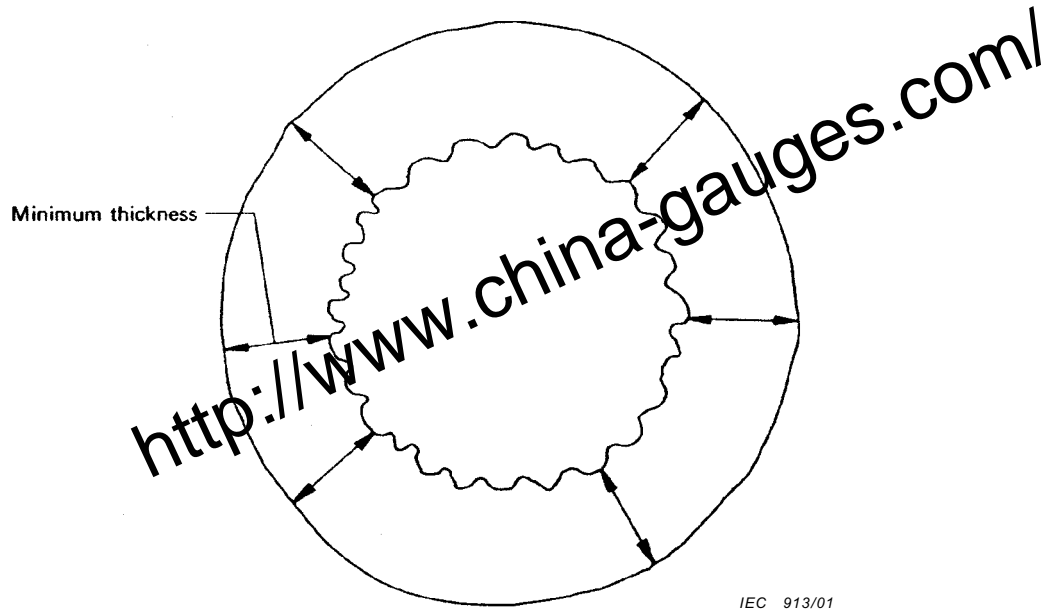


Figure 3 – Measurement of insulation thickness (stranded conductor)

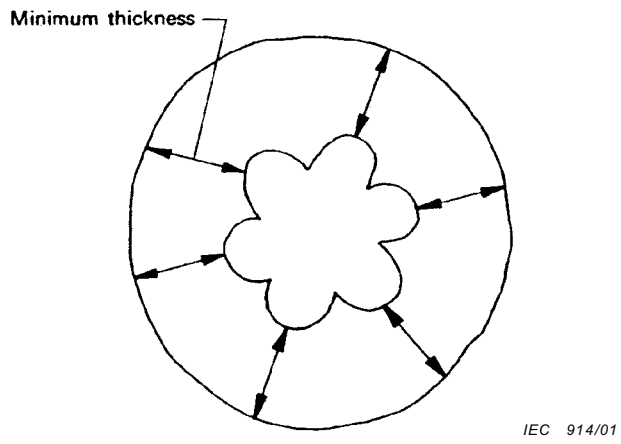


Figure 4 – Measurement of insulation thickness (stranded conductor)

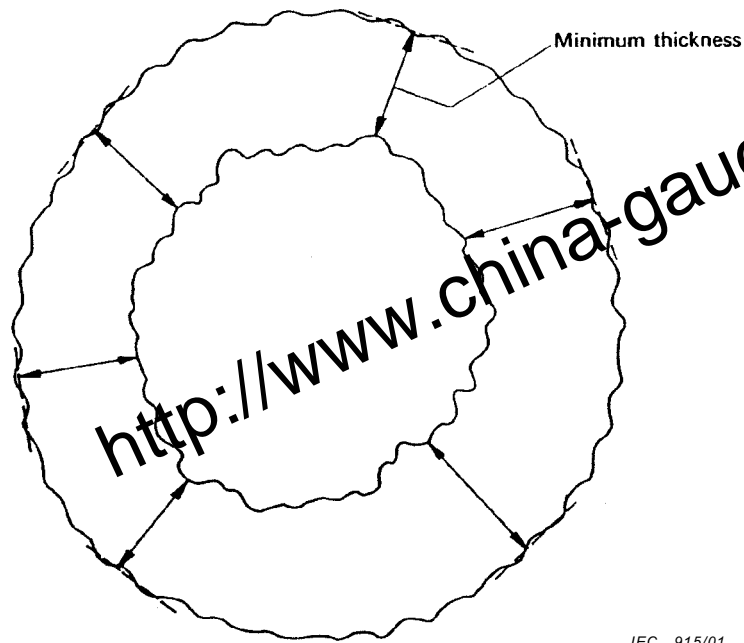


Figure 5 – Measurement of insulation thickness
(uneven outer profile)

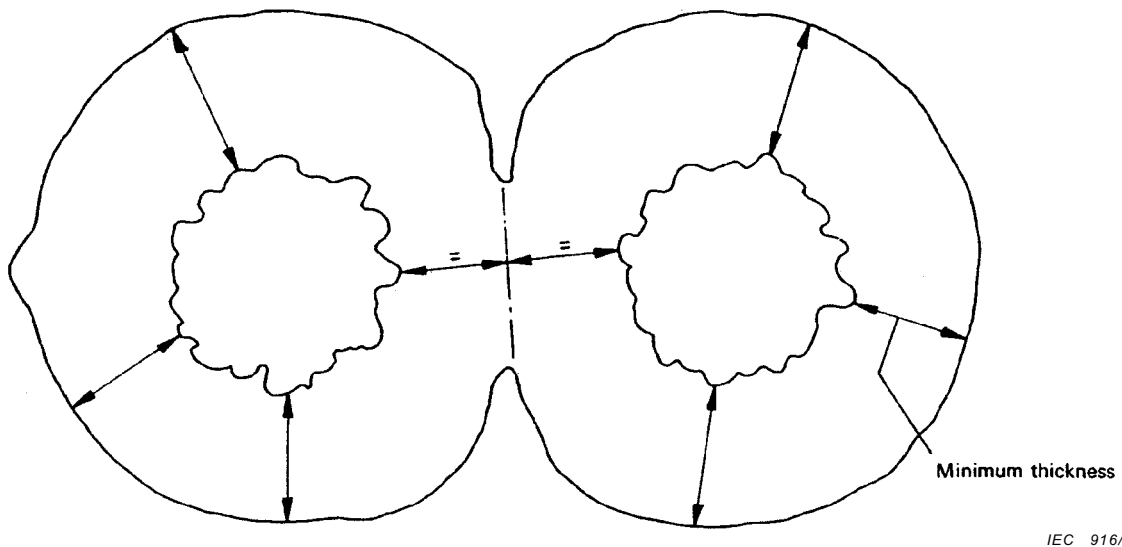


Figure 6 – Measurement of insulation thickness
(twin flat non-sheathed cord)

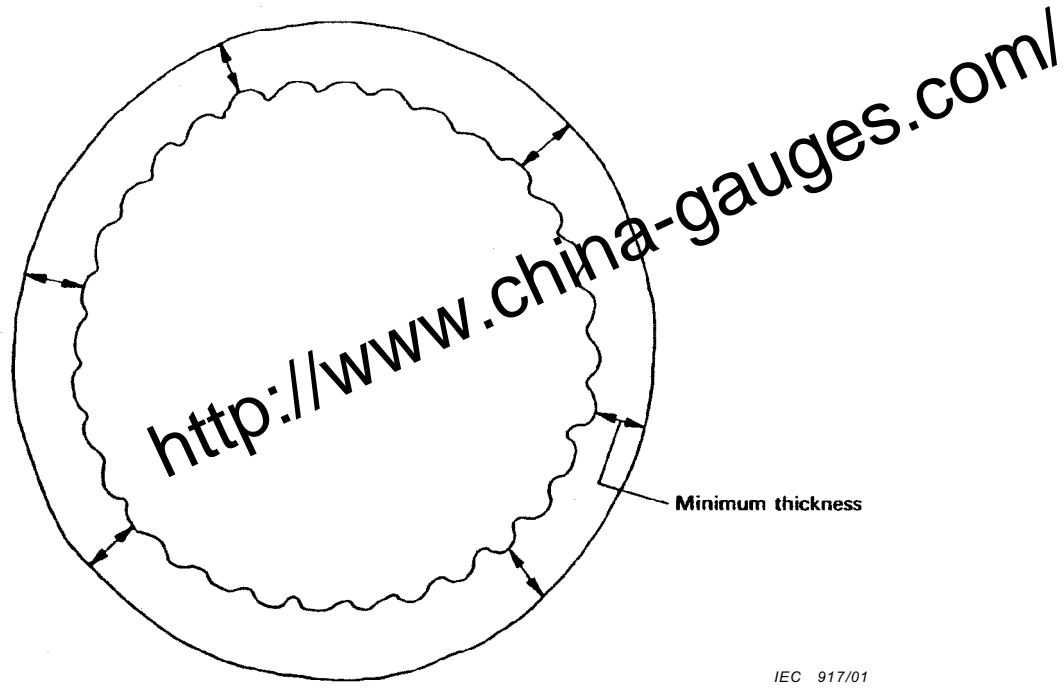


Figure 7 – Measurement of sheath thickness (irregular circular inner profile)

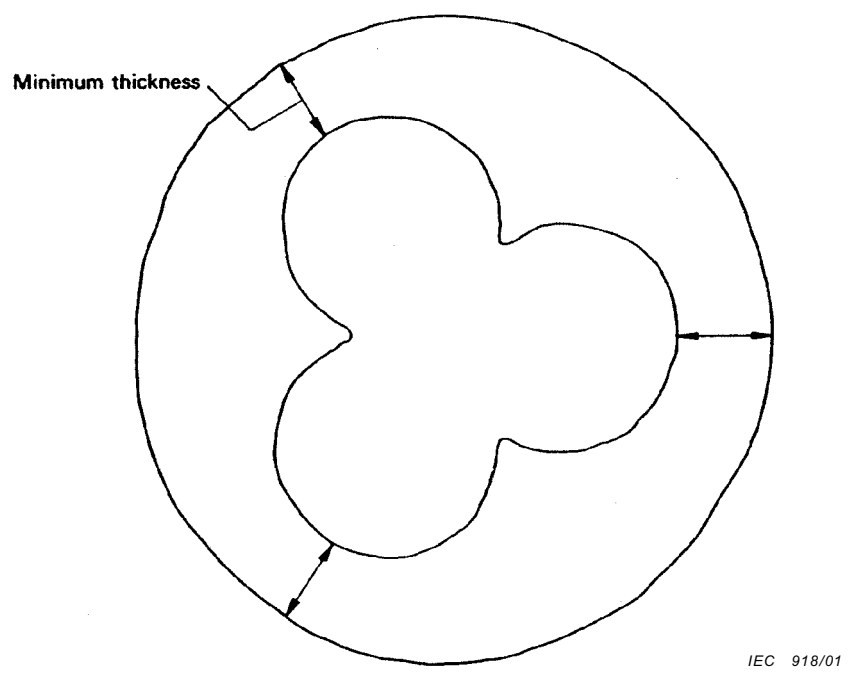


Figure 8 – Measurement of sheath thickness (non-circular inner profile)

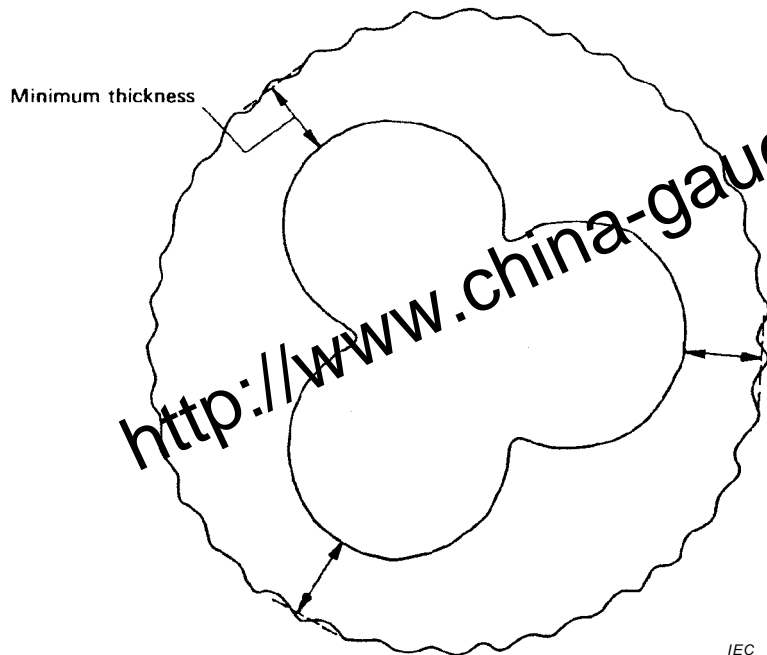


Figure 9 – Measurement of sheath thickness (irregular outer surface)

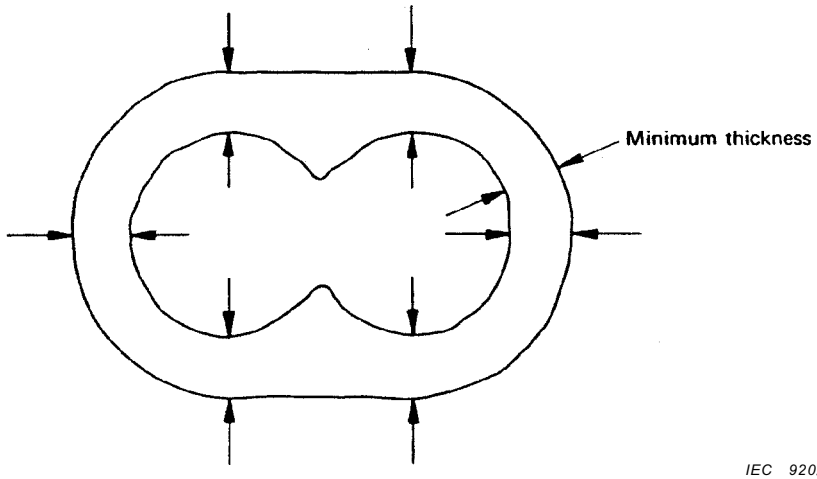


Figure 10 – Measurement of sheath thickness (twin sheathed flat cord)

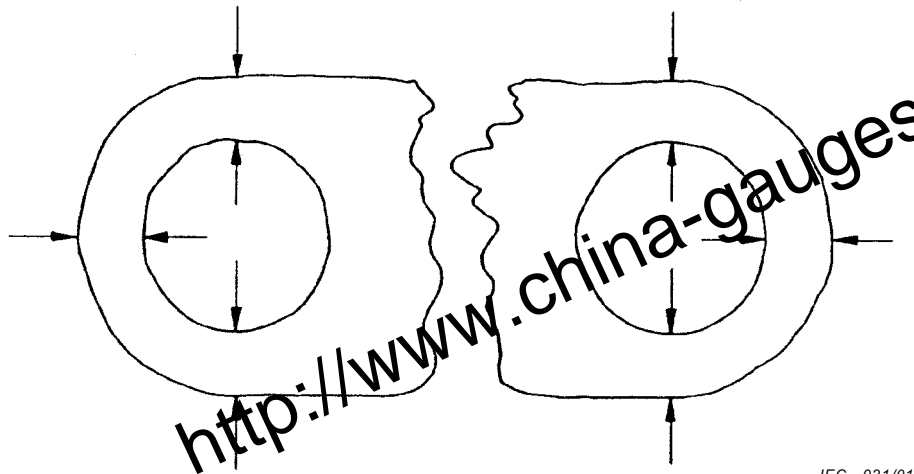
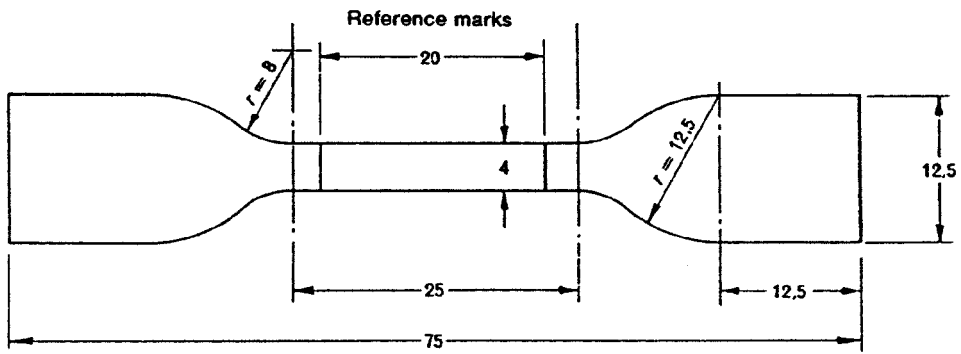


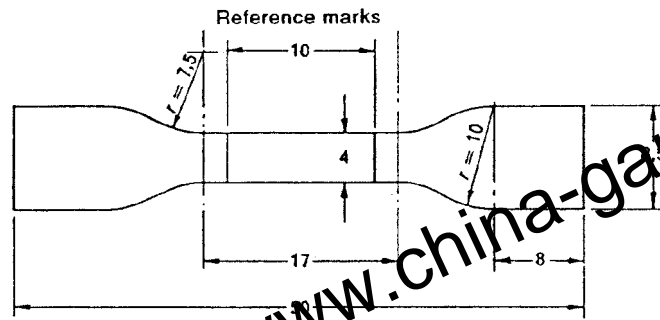
Figure 11 – Measurement of sheath thickness (flat cable with single cores)



IEC 922/01

Dimension in millimetres

Figure 12 – Dumb-bell test piece

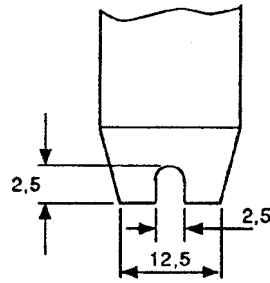


IEC 923/01

Dimensions in millimetres

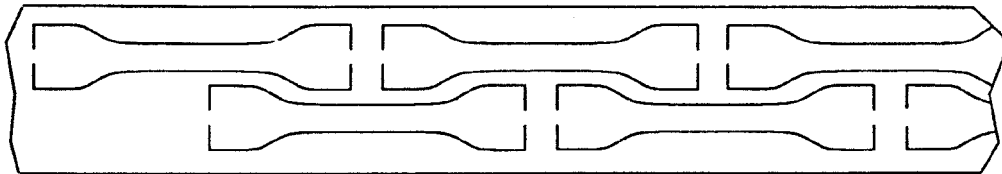
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Figure 13 – Small dumb-bell test piece



IEC 924/01

Figure 14 – Punch end showing groove

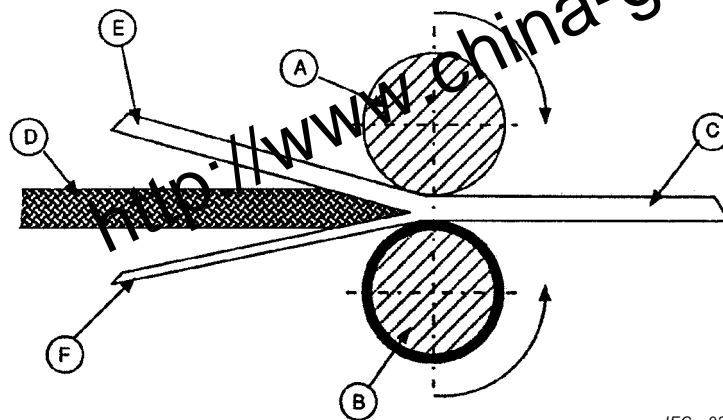


IEC 925/01

Figure 15 – Test pieces cut by grooved punch

Annex A
(informative)

**Principle of operation of a typical machine for
preparing test pieces**



IEC 926/01

Two rolls, one made of steel and partly grooved (A), and the other, in rubber-tyred steel (B), drive the strip (C) against a highly sharpened fixed, or moving blade (D) (surgical scalpel quality).

The strip is longitudinally cut into two parts: part (E) from which the test piece is cut, and part (F) which is rejected.

NOTE The thickness of part (E) can be limited to 0,1 mm if necessary. (For this purpose, consideration should be given to the behaviour of the material prepared and the preservation of the blade sharpness.)

When the strip (C) has marks of tearing or scratching, which may induce a premature break, it is recommended that part (E) be cut and rejected from both sides.

Annex ZA (normative)**Normative references to international publications with their corresponding European publications**

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments and revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN/HD applies.

IEC publication	Date	Title ¹⁾	EN/HD	Date
IEC 811-1-2	1985	<i>Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application Section 2: Thermal ageing methods</i>	EN 60811-1-2 ²⁾	1995
IEC 811-1-3	1985	<i>Section 3: Methods for determining the density Water absorption tests — Shrinkage test</i>	HD 505.1.1 S3 ³⁾	1991
IEC 811-2-1	1986	<i>Part 2: Methods specific to elastomeric compounds Section 1: Ozone resistance test — Hot set test Mineral oil immersion test</i>	EN 60811-2-1 ⁴⁾	1995

¹⁾ IEC 538, IEC 538A and IEC 540 are superseded by IEC 811 and IEC 885 — *Electrical test methods for electric cables*.

²⁾ The main title and title of Part 1 have been adapted to the new title decided by IEC/TC 20.

³⁾ HD 505.1.1 S3:1991 is superseded by EN 60811-1-1:1995, which is based on IEC 811-1-1:1993.

⁴⁾ EN 60811-2-1 includes A1:1992 and A2:1993 to IEC 811-2-1:1986.

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