BRITISH STANDARD

BS 6469 : Section 1.1 : 1992

Insulating and sheathing materials of electric cables

Part 1. Methods of test for general application

Section 1.1 Measurement of thickness and overall dimensions — Tests for determining the mechanical properties

(Implementation of HD 505.1.1 S3)

BSI STANDARDS

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cables and Insulation Standards Policy Committee (CIL/-) to Technical Committee CIL/20, upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
Association of Manufacturers of Domestic Electrical Appliances
British Approvals Service for Cables
British Cable Makers' Confederation
British Plastics Federation
British Steel Industry
British Telecommunications plc
Department of the Environment (Property Services Agency)
Department of Trade and Industry (Consumer Safety Unit, CA Division)
Electricity Association
Engineering Equipment and Materials Users' Association
Institution of Electrical Engineers
London Regional Transport

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Railways Board
British Rubber Manufacturers' Association Ltd.
ERA Technology Ltd.
GAMBICA (BEAMA Ltd.)
Institution of Incorporated Executive Engineers
London Underground Ltd.
Queen Mary and Westfield College
Telecommunications Cables Group of BCMC

This British Standard, having been prepared under the direction of the Cables and Insulation Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on
15 August 1992

The following BSI references relate to the work on this standard:
Committee reference CIL/20
Draft announced in *BSI News* December 1991

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Amendments issued since publication

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Contents

National foreword

This Section of BS 6469 has been prepared under the direction of the Cables and Insulation Standards Policy Committee. BS 6469 : Parts 1 to 5 and Part 99 supersede BS 6469 : 1990 which is withdrawn.

Parts 1 to 5 implement CENELEC HD 505 : Parts 1 to 5 which were derived from IEC 811 : Parts 1 to 5. Part 99 describes test methods having national applicability only.

The International Electrotechnical Commission has completed its comprehensive update of the test methods previously given in IEC 538, IEC 538A and IEC 540, which are now largely brought together in IEC 811. Electrical tests from IEC 540 have been incorporated into IEC 885. The technical changes introduced during this update, and endorsed by CENELEC in HD 505, are now included in BS 6469.

BS 6469 : Section 4.2 includes a number of test methods described in BS 6234. Other test methods from BS 6234, from BS 6746 and from BS 6899 have been incorporated in BS 6469 : Part 99. The status of these test methods in BS 6234, BS 6746 and BS 6899 will be reviewed separately.

BS 6469 describes methods of test, but does not specify requirements for products or materials. These will be specified in the relevant cable standards or cable material standards.

This Section of BS 6469 implements CENELEC Harmonization Document HD 505.1.1 S3 : 1991, which is identical with IEC 811-1-1 : 1985 plus Amendment No. 1 (1988) plus Amendment No. 2 (1989) plus Corrigendum 1986.

In order to describe more explicitly the method of measurement of the thickness of non-metallic sheath of national types of flat multi-core cables, amplification of the method given in HD 505.1.1 S3 is detailed in national annex NA.

Definitions of terms relating to electric cables are given in BS 4727 : Part 2 : Group 08.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

WARNING. The methods of test described in this British Standard do not necessarily detail all precautions necessary to meet the requirements of the Health and Safety at Work etc. Act 1974. Attention should be paid to any appropriate safety precautions and the tests should be carried out only by trained personnel.

The complete IEC standard (IEC 811) will eventually replace IEC Publications 538 and 540. To enable users to compare the relevant clauses in all three publications, a table of cross-references is given in appendix A.

Cross-references between the relevant clauses in BS 6469 : 1990 and those in BS 6469 : Parts 1 to 5 and Part 99 are given in table NC.1. Tests included in BS 6469 : Sections 1.3 and 5.1 which were not given in BS 6469 : 1990 are listed in table ND.1.

References to page numbers in the text relate to the IEC page numbers and should be ignored.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

HARMONIZATION DOCUMENT
DOCUMENT D'HARMONISATION
HARMONISIERUNGSDOKUMENT

HD 505.1.1 S3

January 1991

UDC 621.315.61 : 621.315.2/.3 : 620.1

Descriptors: Electric cable, insulated cable, electrical insulation, sheath, insulation, measurement of dimension, thickness, mechanical property

English version

Common test methods for insulating and sheathing materials of electric cables

Part 1. Methods for general application

Section one — Measurement of thickness and overall dimensions — Tests for determining the mechanical properties

(IEC 811-1-1 : 1985 + Amendment 1 : 1988 + Amendment 2 : 1989)

Méthodes d'essais communes pour les matériaux d'isolation et de gainage des câbles électriques
Première partie: Méthodes d'application générale
Section un: Mesure des épaisseurs et des dimensions extérieures — Détermination des propriétés mécaniques
(CEI 811-1-1 : 1985 + Modification 1 : 1988 + Modification 2 : 1989)

Allgemeine Prüfungen für Isolier- und Mantelwerkstoffe für Kabel und isolierte Leitungen
Teil 1: Allgemeine Prüfverfahren
Hauptabschnitt 1: Messung der Wanddicke und der Außenabmessungen — Prüfungen zur Bestimmung der mechanischen Eigenschaften
(IEC 811-1-1 : 1985 + Änderung 1 : 1988 + Änderung 2 : 1989)

This Harmonization Document was approved by CENELEC on 1990-12-10. 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 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

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

Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 811-1-1 : 1985 and its amendments 1 : 1988 and 2 : 1989 could be accepted without textual changes, has shown that no CENELEC common modifications were necessary for the acceptance as Harmonization Document.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as HD 505.1.1 S3 on 10 December 1990.

The following dates were fixed:

- latest date of announcement of the HD at national level (doa) 1991-06-01
- latest date of publication of a harmonized national standard (dop) 1991-12-01
- latest date of withdrawal of conflicting national standards (dow) 1991-12-01

CONTENTS

COMMON TEST METHODS FOR INSULATING AND SHEATHING MATERIALS OF ELECTRIC CABLES

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

1. Scope

This standard 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.

This Section 1 of Part 1 gives the methods for measuring the 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).

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 standard 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 standard 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.

Note. – For multicore cables and cords, not more than three cores (of different colours, if any) need be tested unless otherwise specified in the relevant cable standard.

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.

6. Test temperature

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

Note. – In the UK ambient temperature is defined as 20 ± 5 °C.

7. 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 × 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 as shown in Figure 1, page 24. For sector-shaped cores, six measurements shall be made as shown in Figure 2, page 24.

b) When the insulation is taken from a stranded conductor, six measurements shall be made as shown in Figures 3 and 4, page 25.

c) When the outer profile shows unevenness, the measurements shall be carried out as shown in Figure 5, page 26.

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, page 26 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 Sub-clause 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 Sub-clause 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 with a suitable device (sharp knife, razor blade, etc.) a thin slice along a plane perpendicular to the longitudinal axis of the cable.

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 as shown in Figure 1, page 24.

b) If the inner substantially circular 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, page 27.

c) When the inner profile exhibits deep grooves caused by the cores, measurements shall be taken at the bottom of each groove, as shown in Figure 8, page 27.

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

d) In order to eliminate the influence of any irregularities in 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, page 28.

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, page 28.

* *f)* For sheathed flat cables composed of up to and including six single cores, measurement shall be taken as shown in Figure 11, page 29:

— on both rounded off sides, along the major axis of the cross-section,

— on both flat sides, on the first and nth 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 Sub-clause 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 Sub-clause 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.

* See national annex NA.

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 thermal ageing treatment(s), to be specified in the relevant cable specification.

The ageing procedures for the air oven, air bomb and oxygen bomb are given in Clause 8 of IEC Publication 811-1-2.

The test pieces for 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.

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, allowing 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 sign of mechanical damage shall not be used for the test.

9.1.3 *Preparation of 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 open 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 pieces, each about 100 mm long, and the pieces marked to identify the sample from which they are cut and their positions relative to each other in the original sample.

The pieces of insulation shall be ground or cut, so as to obtain two parallel surfaces between the marker lines mentioned below, care being taken to avoid undue heating. For PE insulation, cutting only, not grinding, shall be employed. After grinding or cutting, the thickness of the pieces shall be not less than 0.8 mm and not more than 2.0 mm.

A dumb-bell test piece in accordance with Figure 12, page 29, shall then be punched from each prepared piece of insulation, or if possible two dumb-bell test pieces shall be punched side by side.

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, page 30, shall be punched from each prepared piece of insulation.

The central 20 mm for the larger dumb-bells, or 10 mm for the smaller dumb-bells, shall be marked by two lines on each test piece, as shown in Figures 12 and 13, immediately before the tensile test.

b) Tubular test pieces

Tubular test pieces shall be used only when the core is of such small size 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.

The central 20 mm shall be marked by two lines, immediately before the tensile test.

9.1.4 *Determination of cross-sectional area*

a) Cross-sectional area of dumb-bell test piece

The cross-sectional area of each dumb-bell test piece shall be calculated from the width and the smallest thickness of three measurements of the piece between the marker lines.

If there is doubt about the uniformity of the width, this shall be measured at the same three positions as the thickness at both surfaces of the test piece, taking the mean of the two measurements as the width at each position.

The smallest of the three cross-sections thus found shall be used for the calculation of the tensile strength.

The measurements shall be taken by a micrometer or similar instrument giving a contact pressure not exceeding 7 N/cm^2. The measurements shall be made in millimetres to two decimal places. In case of dispute, the contact pressure for natural and synthetic rubbers shall not exceed 2 N/cm^2.

b) Cross-sectional area of 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 pieces 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 = mean value of the thickness of the insulation, in millimetres, determined as specified in Clause 8 and rounded off to two decimal places (see Sub-clause 8.1.4 last paragraph).

D = mean value of the outer diameter of the test piece, in millimetres, determined as specified in test method *b)* of Sub-clause 8.3.2 and rounded off to two decimal places

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

$$A = \frac{1\,000\,m}{d \times l}$$

where:

m = mass of the test piece, in grams, to three decimal places

l = length, in millimetres, to one decimal place

d = density, measured in accordance with Clause 8 of I E C Publication 811-1-3 * on an additional sample of the same insulation (without ageing) in grams per cubic centimetre, to three decimal places

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 Sub-clause 9.1.2) in accordance with Clause 8 of I E C Publication 811-1-2, under the conditions specified in the relevant cable standard.

9.1.6 *Conditioning of test pieces*

Before the tensile test, all test pieces, aged and unaged, shall be kept for at least 3 h at a temperature of 23 ± 5 °C, except for PVC insulation, which shall be kept at 23 ± 2 °C.

9.1.7 *Tensile testing procedure*

a) Test temperature

The test shall be carried out at ambient temperature and each test shall be completed within 5 min of the removal of the test piece from the conditioning chamber. In case of doubt for PVC insulation, the test shall be repeated 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.

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* Common Test Methods for Insulating and Sheathing Material of Electric Cables, Part 1: Methods for General Application, Section Three — Methods for Determining the Density. Water Absorption Tests. Shrinkage Test.

The rate of separation, except for PE and PP shall be 250 ± 50 mm/min.

For PE and PP, 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 breaking load and the distance between the two marker lines at rupture shall be measured simultaneously 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*

The breaking load shall be divided by the cross-sectional area of the unstretched test piece for calculation of tensile strength.

The elongation-at-break shall be calculated as the increase in the distance between the marker lines at rupture from the distance between the marker lines on the unstretched test piece as a percentage of the latter.

The values of tensile strength and elongation-at-break recorded shall be the median values of the results for each property.

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 Sub-clause 8.1.3 of I E C Publication 811-1-2 or with Clause 10 of I E C Publication 811-2-1 (in preparation): Common Test Methods for Insulating and Sheathing Material of Electric Cables, Part 2: Methods Specific to Elastomeric Compounds, Section One — Ozone Resistance Test. Hot Set Test. Mineral Oil Immersion Test), 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 made in immediate succession.

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, allowing 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 of test pieces*

Test pieces shall be prepared from the samples of sheath in the same way as specified for insulation in Sub-clause 9.1.3, except that the minimum thickness of the pieces shall be not less than 0.6 mm, dumb-bell test pieces being used whenever possible.

If the sheath has ridges caused by the cores on the inside, then, in the preparation of dumb-bell test pieces, the sheath shall be cut in the direction of the ridges for removal from the cable and the effect of the ridges shall be eliminated by grinding or cutting.

For PE sheaths, the thickness of the dumb-bells need not 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.

Bonded metal, if any, shall be removed in the preparation of both dumb-bell and tubular test pieces.

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 Sub-clause 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 Sub-clause 8.2.4 for thickness and Sub-clause 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)*;

— if the sheath has ridges, the method *b2)* only shall be used.

9.2.5 *Ageing treatment*

Each required ageing treatment shall be carried out on five test pieces (see Sub-clause 9.2.2) in accordance with Clause 8 of Publication 811-1-2, under the conditions specified in the standard for the type of cable.

9.2.6 *Conditioning of test pieces*

In accordance with Sub-clause 9.1.6.

9.2.7 *Tensile testing procedure*

In accordance with Sub-clause 9.1.7.

9.2.8 *Expression of results*

In accordance with Sub-clause 9.1.8.

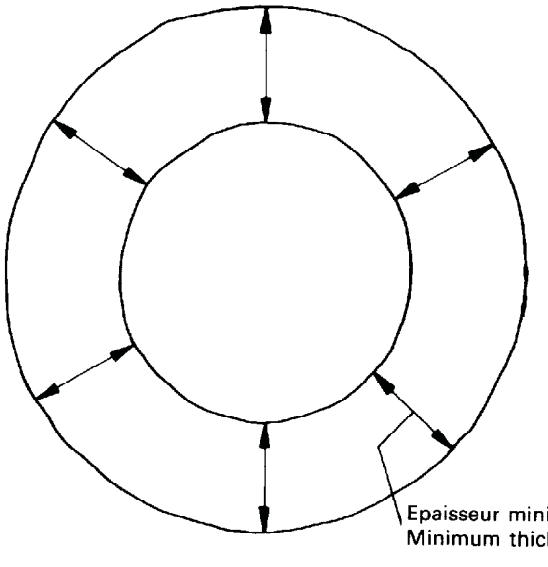


FIG. 1. — Mesure de l'épaisseur d'une enveloppe isolante et d'une gaine (profil intérieur circulaire).
Measurement of insulation or sheath thickness (circular inner profile).

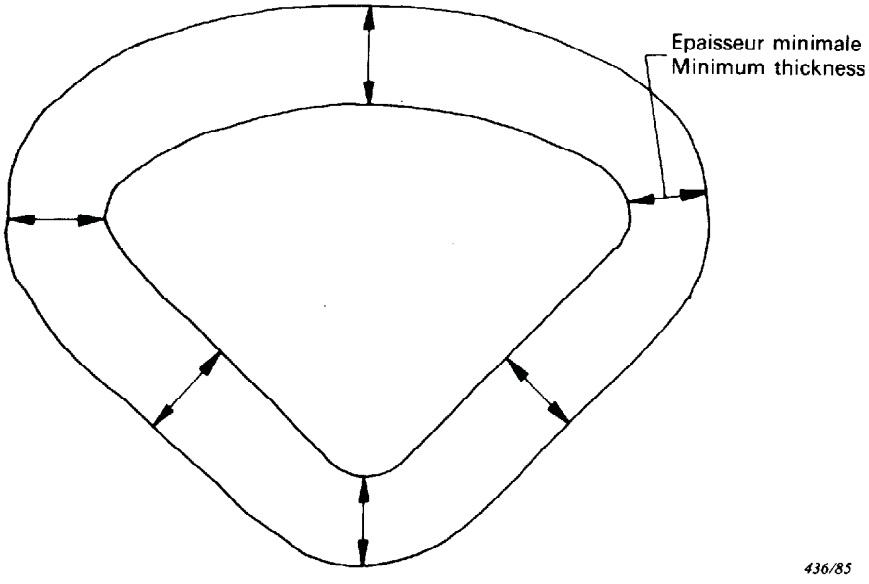


FIG. 2. — Mesure de l'épaisseur d'une enveloppe isolante (âme sectorale).
Measurement of insulation thickness (sector-shaped conductor).

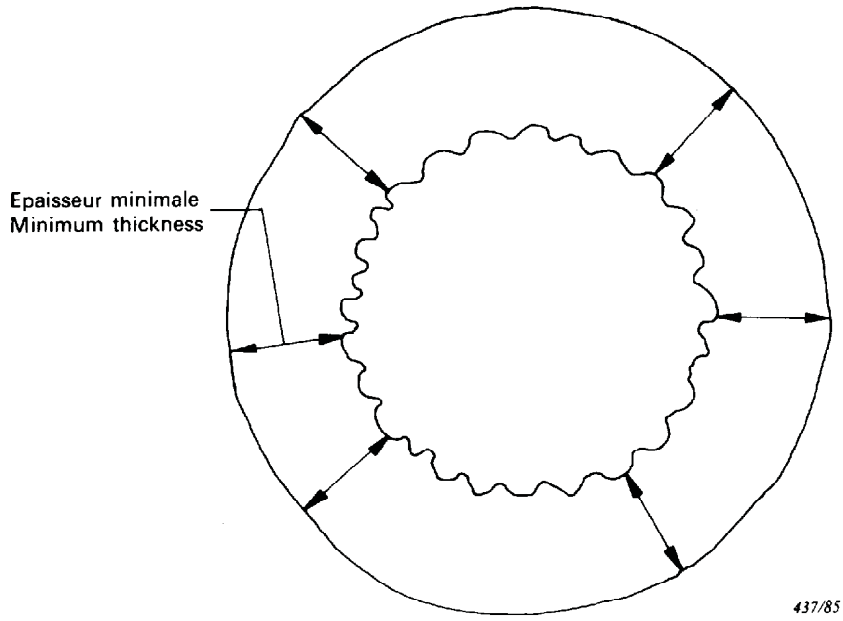


FIG. 3. — Mesure de l'épaisseur d'une enveloppe isolante (âme câblée).
Measurement of insulation thickness (stranded conductor).

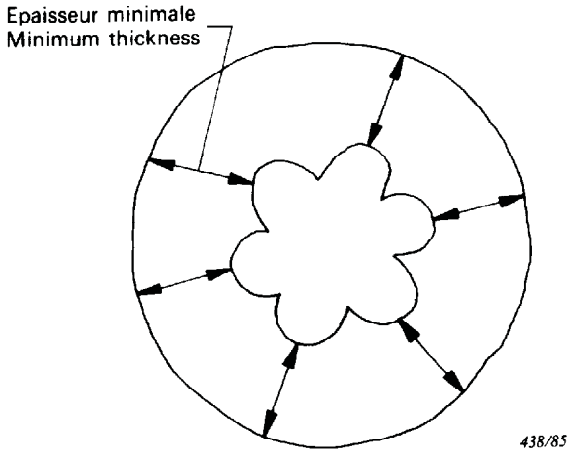


FIG. 4. — Mesure de l'épaisseur d'une enveloppe isolante (âme câblée).
Measurement of insulation thickness (stranded conductor).

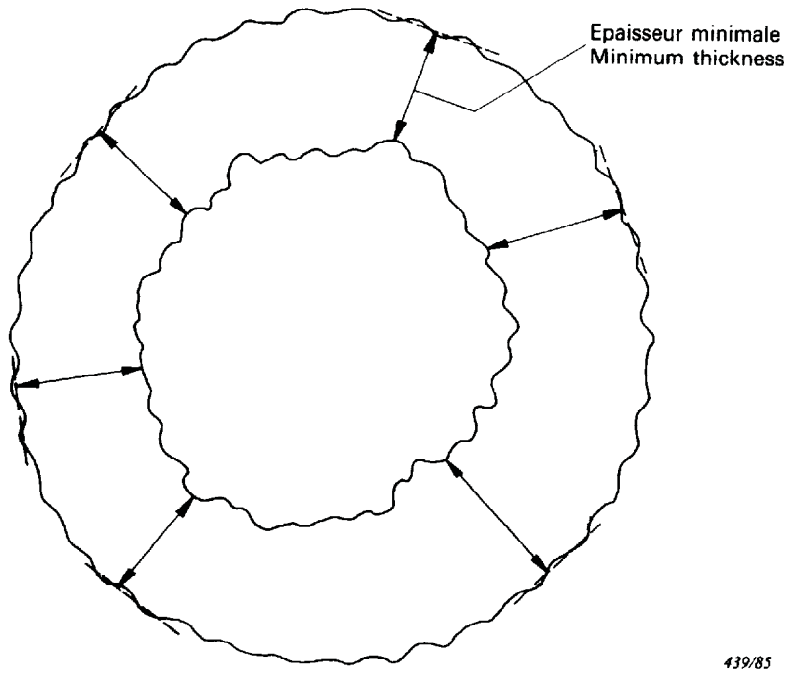


FIG. 5. — Mesure de l'épaisseur d'une enveloppe isolante (surface extérieure irrégulière).
Measurement of insulation thickness (uneven outer profile).

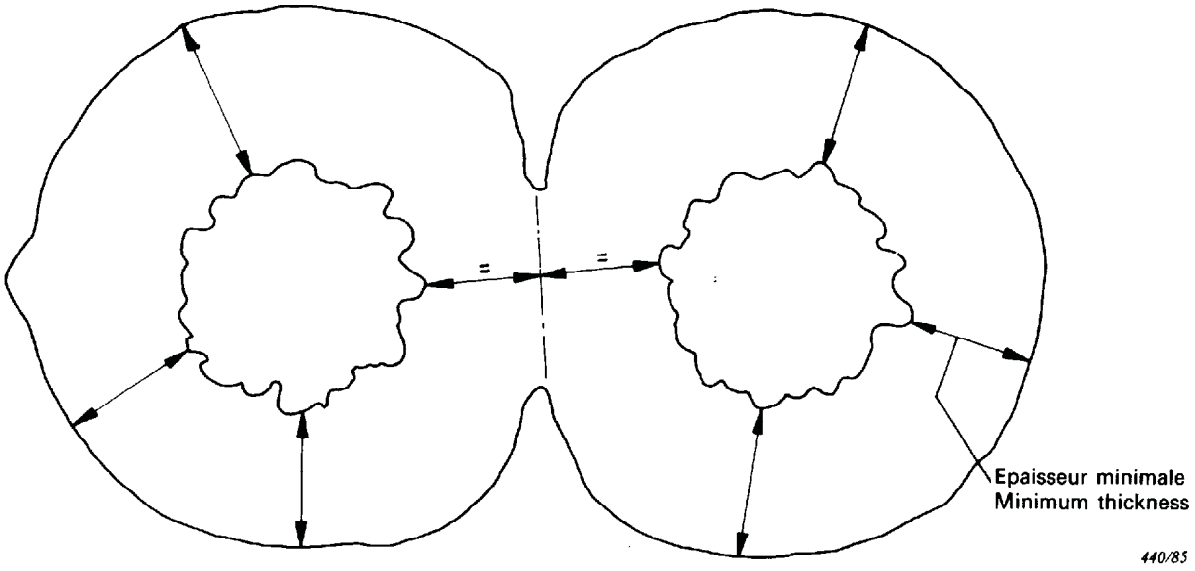


FIG. 6. — Mesure de l'épaisseur d'une gaine (câble méplat à deux conducteurs).
Measurement of sheath thickness (twin flat cord).

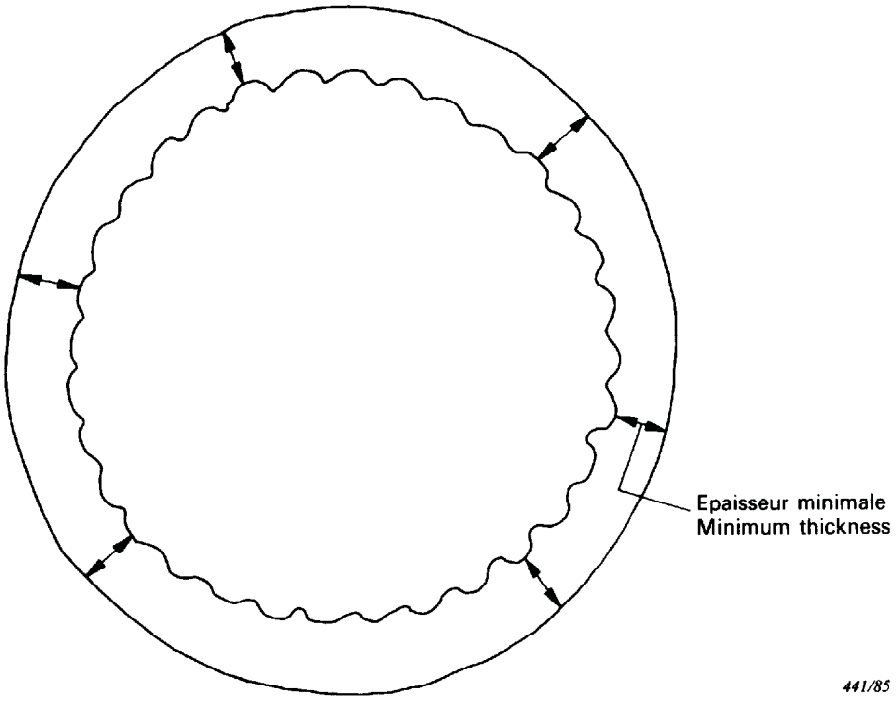


FIG. 7. — Mesure de l'épaisseur d'une gaine (profil intérieur irrégulier).
Measurement of sheath thickness (irregular circular inner profile).

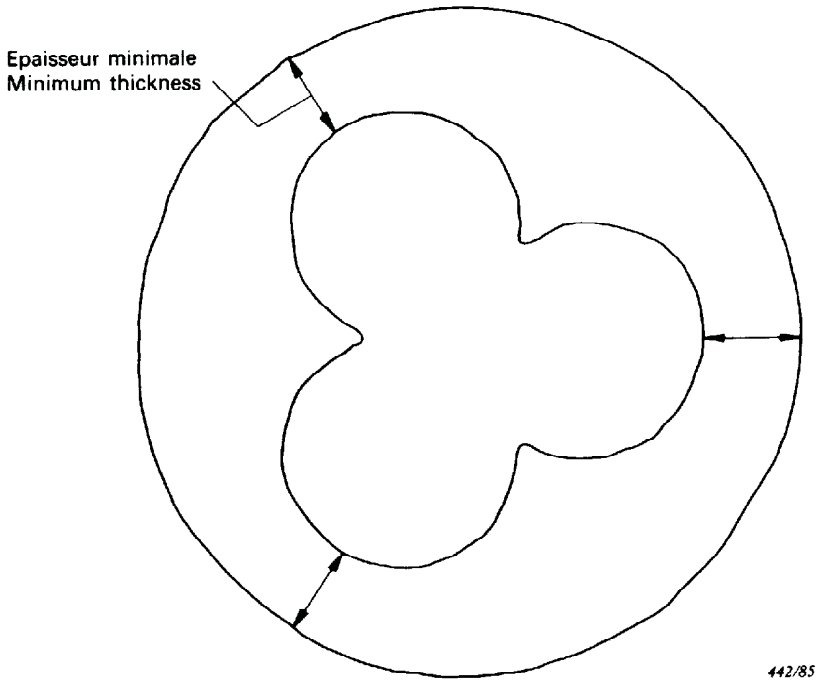


FIG. 8. — Mesure de l'épaisseur d'une gaine (profil intérieur non circulaire).
Measurement of sheath thickness (non-circular inner profile).

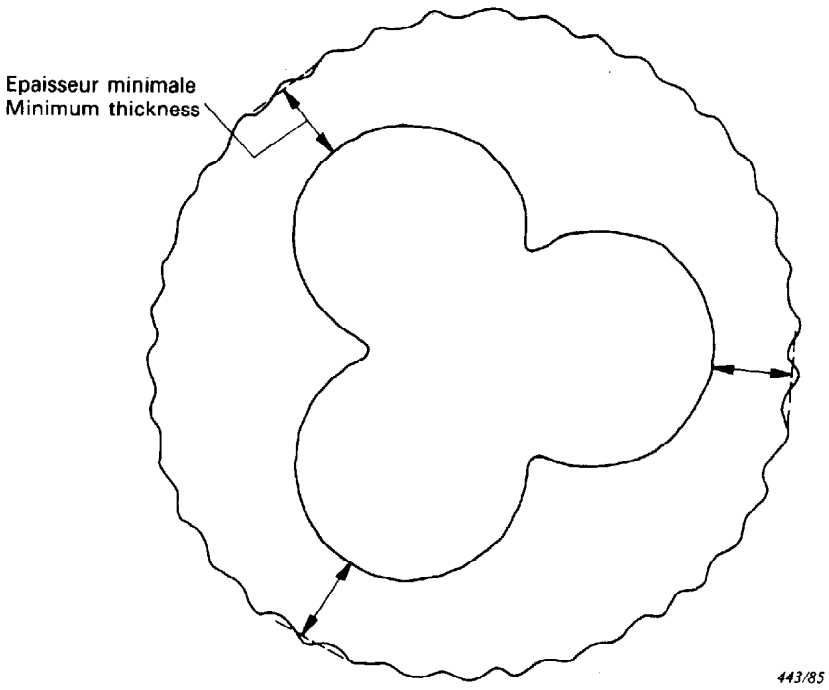


FIG. 9. — Mesure de l'épaisseur d'une gaine (surface extérieure irrégulière).
Measurement of sheath thickness (irregular outer surface).

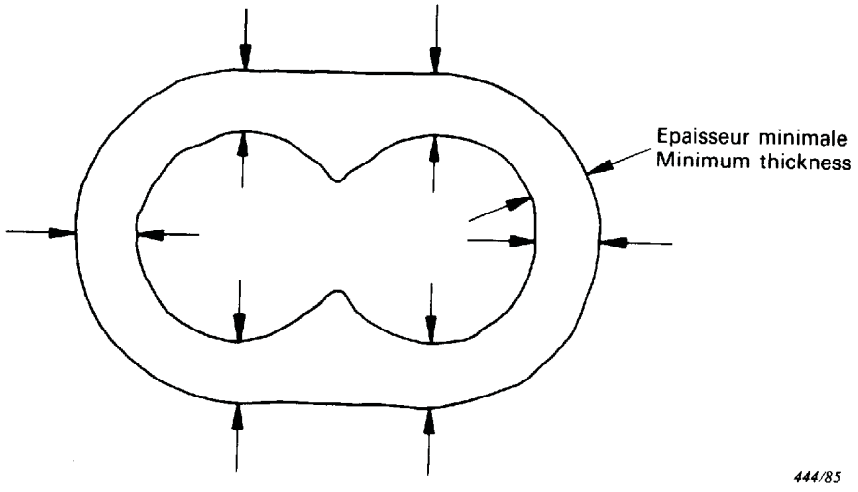


FIG. 10. — Mesure de l'épaisseur d'une gaine (câble méplat à deux conducteurs).
Measurement of sheath thickness (twin flat cord).

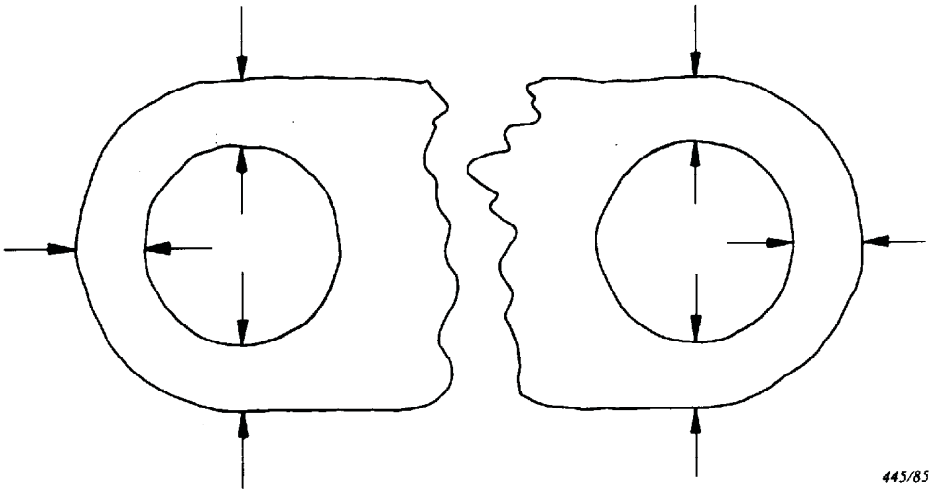
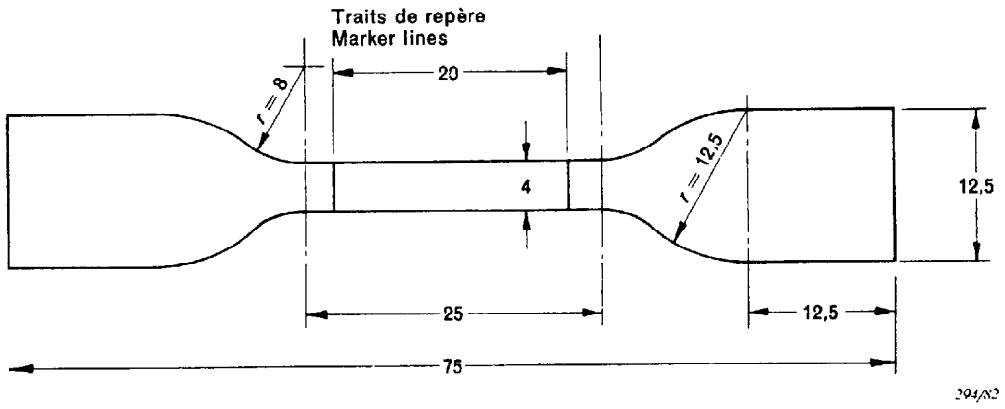
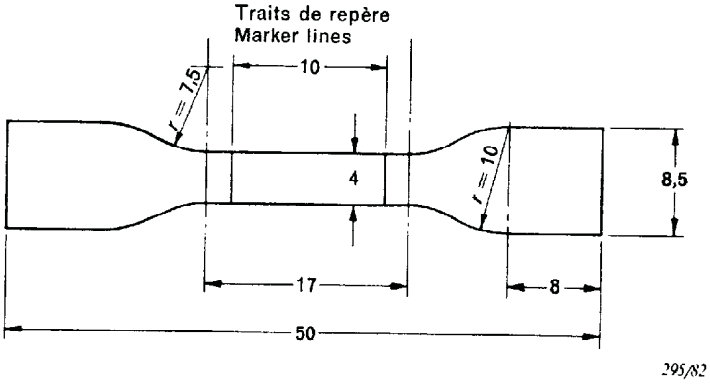


FIG. 11. — Mesure de l'épaisseur d'une gaine
(câble plat composé de conducteurs non préassemblés).
Measurement of sheath thickness
(flat cable with single cores).



Dimensions en millimètres *Dimensions in millimetres*

FIG. 12. — Eprouvette en forme d'haltère.
Dumb-bell test piece.



Dimensions en millimètres *Dimensions in millimetres*

FIG. 13. — Petite éprouvette en forme d'haltère.
Small dumb-bell test piece.

APPENDIX A

CORRESPONDING CLAUSES AND SUB-CLAUSES IN I E C PUBLICATIONS 538 AND 540 AND I E C PUBLICATION 811

A1. Corresponding clauses and sub-clauses in I E C Publications 538 and 811

Heading of clause in Publication 538 *	538	811		
	Clause or sub-clause	Part	Section	Clause or sub-clause
General	1	All	All	1 to 7
Mechanical properties of insulation	2	1	1	9.1
Mechanical properties of sheath	3	1	1	9.2
Melt flow index (MFI)	4	4	1	10
Density	5	1	3	8
Ageing test for insulation and sheath	6.1	1	2	8
Shrinkage test for insulation	6.2	1	3	10
Bending test at low temperature				
insulation	6.3.1	1	4	8.1
sheath	6.3.2	1	4	8.2
Carbon black and/or mineral filler content	7	4	1	11
Measurement of thicknesses and diameters	Appendix A	1	1	8
Melt flow index	Appendix B	4	1	10

Heading of clause in Publication 538A **	538A	811		
	Clause or sub-clause	Part	Section	Clause or sub-clause
Wrapping test after thermal ageing in air	1	4	1	9
Resistance to environmental stress cracking	2	4	1	8

* Publication 538: Electric Cables, Wires and Cords: Methods of Test for Polyethylene Insulation and Sheath.

** Publication 538A: First supplement to Publication 538 (1976) — Additional Methods of Test for Polyethylene Insulation and Sheath of Electric Cables, Wires and Cords Used in Telecommunication Equipment and in Devices Employing Similar Techniques.

A2. Corresponding clauses in IEC Publications 540, 811 and 885*

Heading of clause in Publication 540 *	540	811			885
	Clause	Part	Section	Clause	Part
Partial discharge tests	3	–	–	–	2
Measurement of thicknesses and diameters **	4	1	1	8	–
Tests for determining the mechanical properties of insulating and sheathing compounds	5	1	1	9	–
Thermal ageing methods	6	1	2	8	–
Loss of mass test for PVC insulations and sheaths	7	3	2	8	–
Pressure test at high temperature for PVC insulations and sheaths	8	3	1	8	–
Tests at low temperature for PVC insulations and sheaths	9	1	4	8	–
Tests for resistance of PVC insulations and sheaths to cracking	10	3	1	9	–
Method for determining the density of elastomeric and thermoplastic compounds	11	1	3	8	–
Measurement of the melt flow index of thermoplastic polyethylene	12	4	1	10	–
Ozone resistance test	13	2	1	8	–
Hot set test	14	2	1	9	–
Mineral oil immersion test for elastomeric sheaths	15	2	1	10	–
Electrical tests for cables, cords and wires for voltages up to and including 450/750 V	16	–	–	–	1
Thermal stability of PVC insulations and sheaths	17	3	2	9	–
Carbon black and/or mineral filler content in PE	18	4	1	11	–
Water absorption tests	19	1	3	9	–
Shrinkage test	20	1	3	10	–

* Publication 540: Test Methods for Insulations and Sheaths of Electric Cables and Cords (Elastomeric and Thermoplastic Compounds).
Publication 885: Electrical Test Methods for Electric Cables.

** Technically not identical.

National annex NA (Normative)

In the method of measurement of the thickness of non-metallic sheath of national types of flat multi-core cables, the following methods shall be used instead of those specified in 8.2.4(f).

(1) In the case of flat twin sheathed cables and flat twin sheathed cables with protective conductor, make three measurements at the position of each core, two on lines approximately parallel to the minor axis and one on the major axis (as shown in figures NA.1 and NA.2).

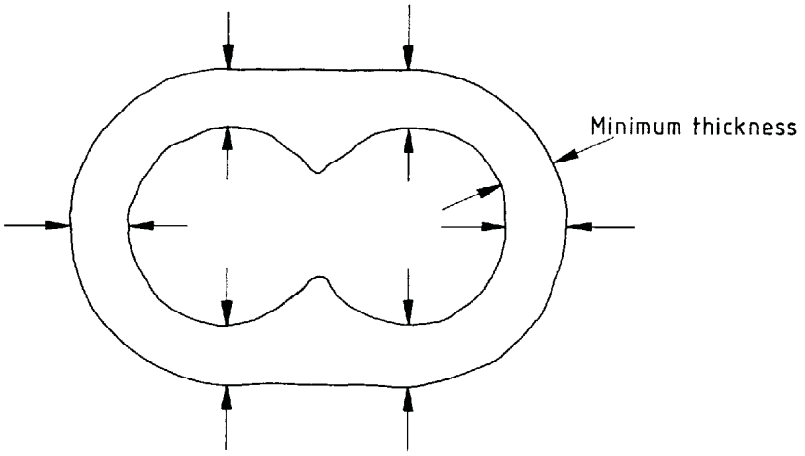


Figure NA.1. Positions for measurements of sheath thickness (flat twin sheathed cables)

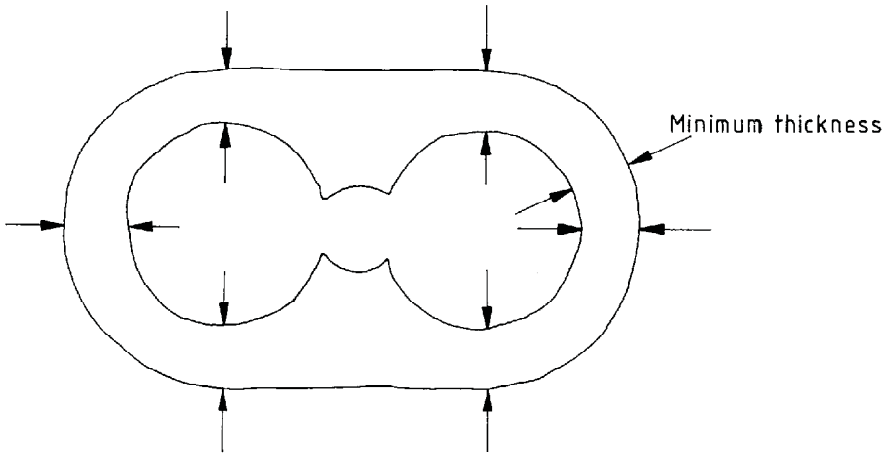


Figure NA.2. Positions for measurement of sheath thickness (flat twin sheathed cables with protective conductor)

(2) In the case of flat 3-core sheathed cables and flat 3-core sheathed cables with protective conductor, make measurements as shown in figures NA.3 and NA.4.

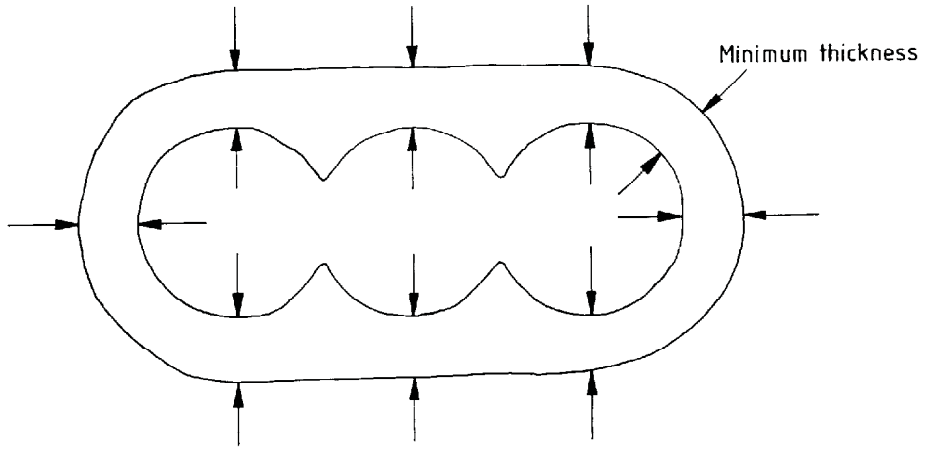


Figure NA.3. Positions for measurement of sheath thickness (flat 3-core sheathed cables)

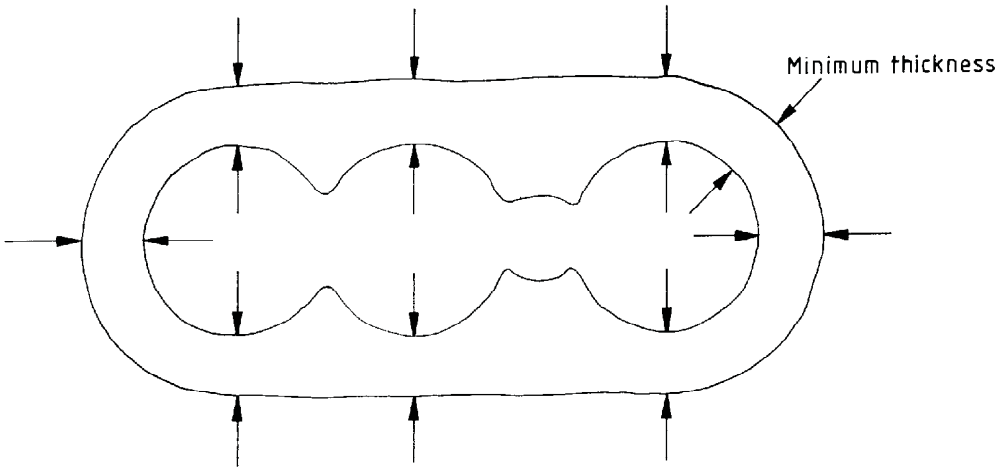


Figure NA.4. Positions for measurement of sheath thickness (flat 3-core sheathed cables with protective conductor)

(3) In the case of sheathed flat cables composed of n single cores, make measurements on the first and nth core. Measure the thickness of sheath approximately at right angles to the major axis and also the thickness approximately along the axis as shown in figure NA.5.

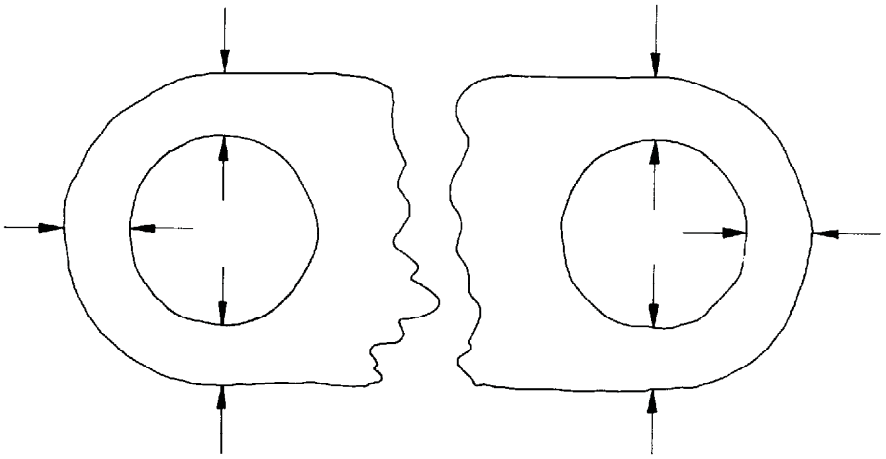


Figure NA.5. Positions for measurements of sheath thickness (sheathed flat cables with n cores)

(4) In the case of sheathed flat cables composed of n units and n multicore units, make measurements at points where the cores are nearest the periphery of the cable approximately along the axis as shown in figures NA.6 and NA.7 respectively.

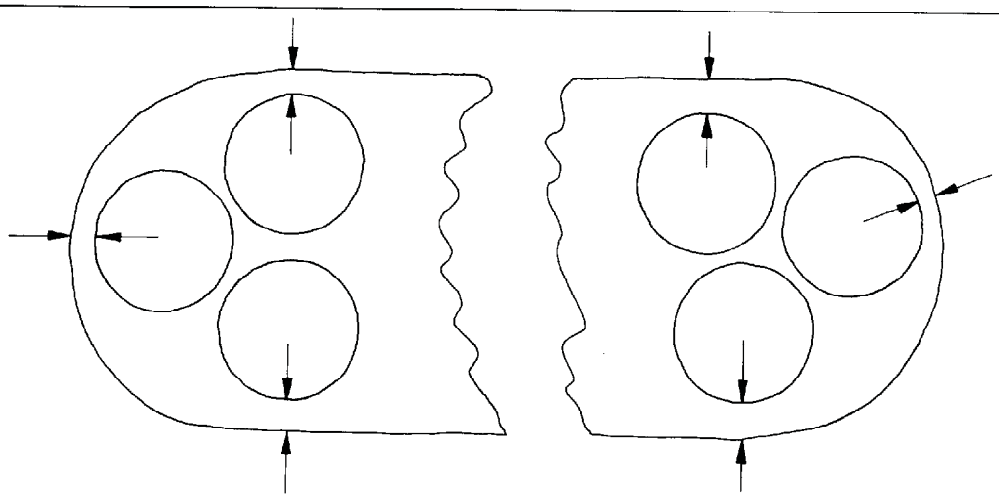


Figure NA.6. Positions for measurement of sheath thickness (sheathed flat cables with n units)

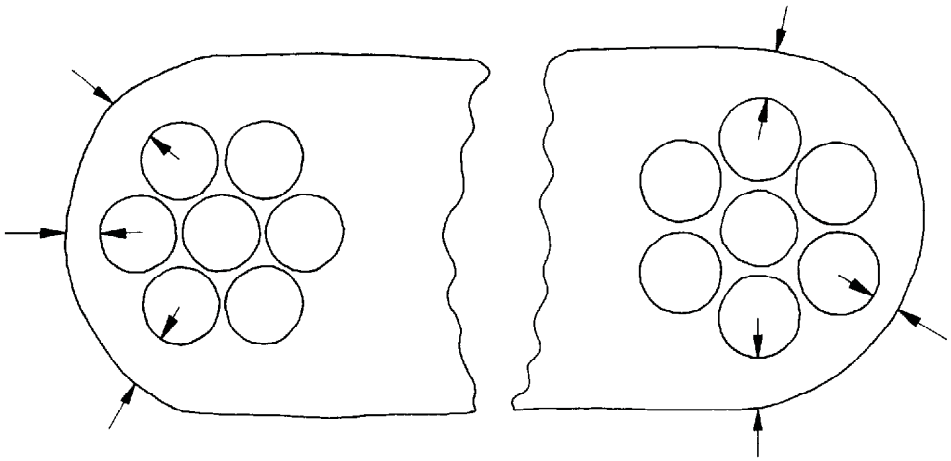


Figure NA.7. Positions for measurement of sheath thickness (sheathed flat cables with n multicore units)

(5) In the case of flat single sheathed cables with protective conductor, make a total of four measurements as follows:
- (i) two at the position of the core approximately parallel to the minor axis of the cable;
- (ii) one at the position of the protective conductor approximately parallel to the major axis of the cable;
- (iii) one at the thinnest point of the sheath, wherever it occurs.

Figure NA.8 shows these positions with an example in which the thinnest point is at the core position.

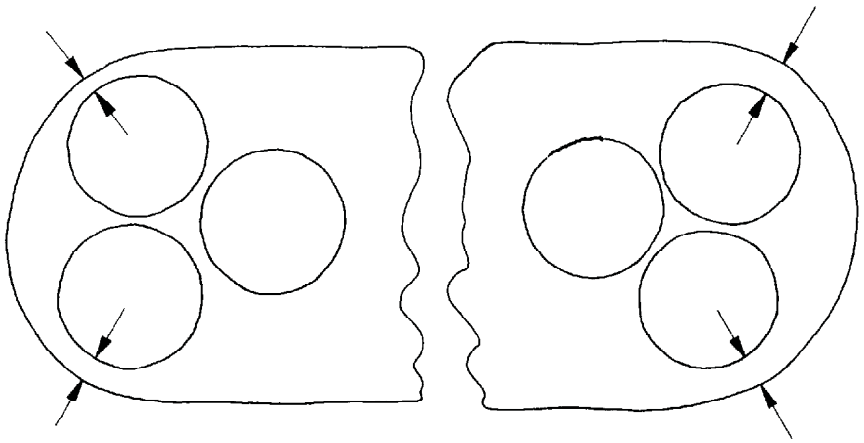


Figure NA.8. Positions for measurement of sheath thickness (sheathed flat cables, other cases)

For other cases make measurements as shown in figure NA.9.

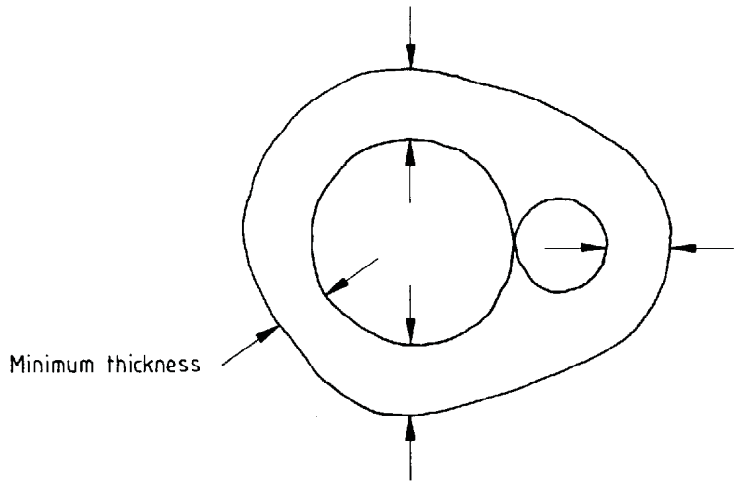


Figure NA.9. Positions for measurement of sheath thickness (flat single sheathed cables with protective conductor)

In all cases, for figures NA.1 to NA.9 measure the thinnest place on the sheath if this should not coincide with any of the previously described measurements.

Take the readings in millimetres to two decimal places.

National annex NB (informative)

Cross-references

Publication referred to	Corresponding British Standard
	BS 6469 Insulating and sheathing materials of electric cables
IEC 811-1-2 : 1985	Section 1.2 : 1992 Thermal ageing methods
IEC 811-1-3 : 1985	Section 1.3 : 1992 Methods for determining the density — Water absorption tests — Shrinkage test
IEC 811-2-1 : 1986	Section 2.1 : 1992 Ozone resistance test — Hot set test — Mineral oil immersion test

National annex NC (informative)

Table NC.1. Corresponding clauses or sub-clauses in BS 6469 : 1990 and BS 6469 : 1992

Clause in BS 6469 : 1990	BS 6469 : 1990	BS 6469 : 1992		
	Clause or sub-clause	Part	Section	Clause or sub-clause
General	1.1 to 1.3	1 to 4 and 99 5	All 5.1	1 to 7 1 to 3
Measurement of thickness and diameters	2.1	1	1.1	8
Determination of tensile strength and elongation at break	2.2	1	1.1	9
Thermal ageing methods	2.3	1	1.2	8
Methods for determining density	2.4	1	1.3	8
Shrinkage test	2.5	1	1.3	10
Gravimetric water absorption test	2.6	1	1.3	9.2
Green/yellow proportions	2.7	99	99.1	8
Mineral oil immersion test	3.1	2	2.1	10
Ozone resistance test	3.2	2	2.1	8
Hot set test	3.3	2	2.1	9
Tear resistance	3.4	99	99.1	9
Loss of mass tests	4.1	3	3.2	8
Pressure tests at high temperature	4.2	3	3.1	8
Tests at low temperature	4.3	1	1.4	8
Tests for resistance to cracking	4.4	3	3.1	9
Hot deformation test	4.5	99	99.1	10
Thermal stability test for insulations and sheaths	4.6	3	3.2	9
Determination of melt flow index (MFI)	5.1	4	4.1	10
Test for resistance to environmental stress cracking: Original granules	5.2.2	4	4.1	8
Test for resistance to environmental stress cracking: Complete cable	5.2.3	99	99.1	11
Carbon black content	5.3.2	4	4.1	11
Carbon black dispersion[1)]	5.3.3	-	-	-
Wrapping test after thermal ageing[2)]	5.4	4 4	4.1 4.2	9 10

[1)] Methods given in BS 2782 : Methods 823A or 823B.

[2)] It is intended that a formal proposal to IEC will result in the test in clause 9 of Section 4.1 being withdrawn.

National annex ND (informative)

Table ND.1. Tests included in BS 6469 : 1992 not previously covered

Test	Part	Section	Clause
Water absorption test: electrical	1	1.3	9.1
Tests specific to filling compounds:			
Drop-point	5	5.1	4
Separation of oil	5	5.1	5
Low temperature brittleness	5	5.1	6
Total acid number	5	5.1	7
Absence of corrosive components	5	5.1	8
Permittivity at 23 °C	5	5.1	9
D.C. resistivity at 23 °C and 100 °C	5	5.1	10
Determination of linear swell after ageing in oil	99	99.1	12
Alternative ozone resistance test method (low concentration)	99	99.1	13
Method of test for insulation resistance constant (K value)	99	99.2	8
Method of test for power factor and permittivity	99	99.2	9
Water absorption determined by the capacitance method	99	99.2	10

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