BRITISH STANDARD

BS EN 60811-2-1:1998
IEC 60811-2-1:1998
Incorporating Amendment No. 1

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

Part 2-1: Methods specific to elastomeric compounds — Ozone resistance, hot set and mineral oil immersion tests

The European Standard EN 60811-2-1:1998, with the incorporation of amendment A1:2001, has the status of a British Standard

ICS 29.035.20

BSI
British Standards

National foreword

This British Standard is the English language version of EN 60811-2-1:1998, including amendment A1:2001. It is identical with IEC 60811-2-1:1998, including amendment 1:2001. It supersedes BS EN 60811-2-1:1995 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags . Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by .

The UK participation in its preparation was entrusted by Technical Committee GEL/20, Electric cables, to Subcommittee GEL/20/3, Insulation and sheath, which has the responsibility to:

— aid enquirers to understand the text;
— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
— monitor related international and European developments and promulgate them in the UK.

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Summary of pages

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(includes amendment A1:2001)
(IEC 60811-2-1:1998 + A1:2001)

Matériaux d'isolation et de gainage des câbles électriques et optiques —
Méthodes d'essais communes —
Partie 2-1: Méthodes spécifiques pour les mélanges élastomères —
Essais relatifs à la résistance à l'ozone, à l'allongement à chaud et à la résistance à l'huile
(inclut l'amendement A1:2001)
(CEI 60811-2-1:1998 + A1:2001)

Isolier- und Mantelwerkstoffe für Kabel und isolierte Leitungen —
Allgemeine Prüfverfahren —
Teil 2-1: Besondere Verfahren für Elastomere — Ozonbeständigkeit, Wärmedehnung, Ölbeständigkeit
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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 20/328/FDIS, future amendment to IEC 60811-2-1, prepared by IEC TC 20, Electric cables, was submitted to the IEC-CENELEC parallel vote.

The text of this document, together with that of IEC 60811-2-1:1986 and its amendments 1:1992 and 2:1993, was approved by CENELEC as EN 60811-2-1 on 1998-08-01.

This European Standard supersedes EN 60811-2-1:1995.

The following dates were fixed:

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Annexes designated "normative" are part of the body of the standard.

In this standard, Annex ZA is normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60811-2-1:1998 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 20/469/FDIS, future amendment 1 to IEC 60811-2-1:1998, 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 60811-2-1:1998 on 2001-09-01.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2004-09-01

Annexes designated "normative" are part of the body of the standard. In this standard, Annex ZA is normative. Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:2001 to the International Standard IEC 60811-2-1:1998 was approved by CENELEC as an amendment to the European Standard without any modification.

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1 General

1.1 Scope

This standard specifies the test methods to be used for testing polymeric insulating and sheathing materials of electric and optical cables for power distribution and telecommunications, including cables used on ships and in offshore applications.

This standard gives the methods for the ozone resistance test, hot set test and mineral oil immersion test, which apply to elastomeric compounds.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60811. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60811 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60811-1-1:1993, *Common test methods for insulating and sheathing materials of electric cables — Part 1: Methods for general application — Section 1: Measurement of thickness and overall dimensions — Tests for determining the mechanical properties.*

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.*

ISO 1817:1999, *Rubber, vulcanized — Determination of the effect of liquids.*

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.

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.

If the test is carried out at ambient temperature, the test-pieces shall be kept for at least 3 h at a temperature of 23 C 5 C.

6 Test temperature

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

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.

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8 Ozone resistance test

WARNING: Attention is drawn to the toxicity of ozone. Precautions should be taken to minimize exposure of personnel to it at all times and the concentration in the workroom environment should not be allowed to exceed 0,1 ppm (parts ozone per million parts air by volume), or the value in the current industrial hygienic standard, whichever is the lower.

8.1 Test method

8.1.1 Test apparatus

a) A device for generating a controlled amount of ozone.

b) A means for circulating ozonized air under controlled conditions of humidity and temperature through a chamber containing the test pieces to be tested.

c) A means for determination of ozone concentration.

d) A suitable device for the clamping and elongation of test pieces.

e) Cylindrical mandrels consisting of wood or metal.

f) A desiccator filled with silica gel or equivalent material.

g) An accurate laboratory balance reading to 0,1 mg.

8.1.2 Sampling

8.1.2.1 Sampling of insulation

Whether the cable is single or multicore, only one core needs to be tested. Sufficient length of core shall be cut from a position not less than 1,5 m from the end of the length of cable to provide two test pieces, unless the core has an extruded semi-conductor layer on the outside, in which case sufficient length for four test pieces shall be taken.

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

8.1.2.2 Sampling of sheath

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 two test pieces.

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

8.1.3 Preparation of test pieces

8.1.3.1 Test pieces of insulation

Any protective coverings present on the core shall be removed without damaging the insulation, unless they were applied directly to the insulation prior to vulcanization and are adherent to it.

If the core has a semi-conducting layer in the form of tape on the outside, this shall be removed.

If the core has an extruded semi-conducting screen on the outside, this shall be removed from two test pieces and left in position on the other two.

8.1.3.2 Test pieces of sheath

Two dumb-bell test pieces shall be prepared in accordance with **9.1.3** and **9.2.3** of IEC 60811-1-1. The minimum test piece thickness shall be 0,6 mm.

In the case of cables of such small size that it is not possible to prepare dumb-bell test pieces, the test method used shall be that specified for insulation.

8.1.4 Conditioning and deformation procedure of test pieces

8.1.4.1 Test pieces of insulation

If the core does not have an extruded semi-conducting screen, one test piece shall be bent in the direction and plane of its existing curvature, without twisting, for one complete turn around a mandrel, and bound with twine or tape where the ends cross, and a second test piece of the same core shall be bent similarly in the plane of its existing curvature but in the opposite direction.

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If the core as manufactured has an extruded core screen on the outside, two test pieces, one with the semi-conducting layer removed and one with the semi-conducting layer left in position, shall be bent, as above, in each direction.

The bending shall be carried out at room temperature or 20 C, whichever is higher, using a brass, aluminium or suitably treated wooden mandrel with the following diameter:

Outside diameter of insulated core *d* mm	Mandrel diameter (as a multiple of the outside diameter of insulated core)
d 12,5	4 0,1
12,5 < *d* 20	5 0,1
20 < *d* 30	6 0,1
30 < *d* 45	8 0,1
45 < *d*	10 0,1

If the test piece is too rigid to permit the ends to be crossed, it shall be bent and tied so that at least 180 bend round a mandrel of the specified diameter is obtained.

The surface of each test piece shall be wiped with a clean cloth to remove dirt or moisture. The bent test pieces on their mandrels shall be kept in air at ambient temperature without any further treatment for 30 min to 45 min before being tested.

8.1.4.2 Test pieces of sheath

The surface of each test piece shall be wiped with a clean cloth to remove dirt or moisture. The test piece shall then be stored in the desiccator for at least 16 h at 23 C 5 C.

Clamp both ends of the test piece in the clamping device, and elongate it by 33 % 2 % and keep the test piece elongated in the clamping device.

NOTE To avoid possible ozone cracks near the clamps, the test pieces may be covered locally by a suitable ozone resistance lacquer.

8.1.5 Exposure to ozone

The conditioned test pieces prepared as in **8.1.4** shall be placed in the middle of the test chamber fitted with a test cock, the test pieces shall be at least 20 mm from each other.

The test pieces shall be maintained at a temperature of 25 C 2 C, unless otherwise specified in the cable standard, and exposed to a circulating current of dry air with the required ozone concentration.

The ozone concentration and the exposure time shall be as specified in the relevant cable standard.

The ozone concentration shall be measured inside of the test chamber in accordance with **8.2**.

The air with the required ozone concentration shall have a flow rate of between 280 l/h and 560 l/h, and the air pressure shall be maintained slightly above atmospheric pressure.

8.1.6 Evaluation of results

After the specified test duration, the test pieces shall be removed from the test chamber and examined with normal or corrected vision without magnification.

The insulation in the 180 section of the bent portion furthest from the tie shall be free from cracks.

The surfaces of the central narrow portions of the dumb-bell test pieces shall be free from cracks.

Any cracks near the clamps shall be disregarded.

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8.2 Determination of ozone concentration

8.2.1 Chemical analysis

8.2.1.1 Reagents

The reagents shall be of a recognized analytical reagent quality.

Distilled water shall be used throughout the test.

a) Starch indicator solution: 1 g of soluble starch shall be stirred into 40 ml of cold water and heated to boiling point with constant stirring until the starch is completely dissolved. This dissolution shall be diluted with cold water to about 200 ml and 2 g of crystallized zinc chloride added. The solution shall be allowed to settle and the supernatant liquid poured off for use. In keeping for periodic use, the solution shall be renewed every two or three days.

Alternatively, a fresh solution of 1 g of soluble starch in 100 ml of boiling water may be prepared.

When either of these starch solutions is used as indicator, a few drops of 10 % acetic acid shall be added to the solution being titrated.

b) Standard iodine solution: 2 g of potassium iodide (KI) and 10 ml of water shall be placed in a weighing tube, which shall then be weighed. Iodine shall be added directly to the solution in the tube on the balance pan until the total iodine in solution is about 0,1 g. The solution with the added iodine shall be accurately weighed and the amount of added iodine determined. The solution shall then be poured into a beaker, the weighing tube, held over the beaker, shall be washed with water. The solution shall be poured from the beaker into a flask calibrated at 1 000 ml, the beaker rinsed with water into a flask and the solution in the flask diluted to 1 000 ml.

NOTE This solution is fairly stable if kept in a cool dark place in a well-stoppered brown bottle.

c) Sodium thiosulphate solution: Sodium thiosulphate ($Na_2S_2O_3$) solution of approximately the same strength as the standard iodine solution shall be prepared by placing about 0,24 g of $Na_2S_2O_3 \cdot 5\ H_2O$ in a 1 000 ml flask and diluting to 1 000 ml. Since it gradually loses its strength, the solution shall be standardized against the iodine solution on the day of the ozone test.

The strength E of the $Na_2S_2O_3$ solution, calculated as iodine equivalence and expressed as milligrams of iodine per millilitre of the solution is:

$$\frac{F \cdot C}{S}$$

where

F is the volume of the iodine solution in millilitres;

C is the concentration of iodine in milligrams per millilitre;

S is the volume of the $Na_2S_2O_3$ solution used to titrate the solution.

d) Potassium iodide solution: about 20 g of pure KI shall be dissolved in 2 000 ml of water.

e) Acetic acid: a 10 % solution (by volume) shall be prepared.

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8.2.1.2 Procedure

A measured volume of the air containing ozone shall be bubbled from the test chamber through the KI solution, or a measured volume of the air containing ozone shall be collected and mixed with the KI solution by a suitable means.

Two alternative methods which may be employed are:

a) A sampling bottle containing 100 ml of KI solution is connected to the sampling cock of the test chamber on one side and to a 500 ml gas burette on the other. The glass tube connecting the sampling bottle to the sampling cock of the gas chamber reaches well below the level of the KI solution in the sampling bottle. The two-way stop-cock on the burette is opened to the atmosphere and the burette filled to its full mark with water by lifting the aspirator connected to the bottom of the burette. The stop-cock on the burette is then closed to the atmosphere and opened to the sampling bottle and the sampling cock on the test chamber is opened to the bottle. The aspirator is then lowered until the water is emptied from the burette. When this point is reached, 500 ml of the gas from the test chamber will have bubbled through the KI solution. The stop-cocks are then closed and the bottle withdrawn for titration.

b) A separating funnel of 400 ml capacity is filled with the KI solution and the filling hole is connected to the test cock of the test chamber. The test cock and the stop-cock on the bottom of the separating funnel are opened simultaneously until about 200 ml of the KI solution have drained into a graduated cylinder placed below it. The test cock and stop-cock are quickly closed and the separating funnel, which then contains a volume of gas equal to the volume of KI solution in the measuring cylinder, is removed and stoppered. The separating funnel shall be shaken to produce complete reaction with the KI solution. The solution in the graduated cylinder shall be tested with a starch indicator for the presence of free iodine and if any is detected, the gas sample shall be rejected and another collected.

The KI solution which has reacted with a known volume of gas from the test chamber, by whatever method adopted, shall be titrated with the standardized $Na_2S_2O_3$ solutions using the starch indicator.

8.2.1.3 Calculation

Since 1 mg of iodine is equivalent to 0,1 ml of ozone at room temperature and pressure (within the accuracy of this method of analysis at average room temperature and pressure), the ozone concentration can be calculated as follows:

$$\text{ozone \% by volume} = \frac{10\ S\ E}{V}$$

where

S is the volume of the $Na_2S_2O_3$ solution used to titrate the solution in millimetres;

E is the iodine equivalent of the $Na_2S_2O_3$ solution in milligrams of iodine per millilitre of $Na_2S_2O_3$;

V is the volume of the gas sample collected in millilitres.

8.2.2 Direct measurement with an ozonemeter

As an alternative to the chemical analysis, the ozone concentration may be measured directly with an ozonemeter, which has been calibrated by comparison with results obtained by the chemical method.

9 Hot set test

9.1 Sampling and preparation of test pieces and determination of their cross-sectional area

Two test pieces of sheath and of insulation from each core, after they have been prepared and their cross-sectional areas measured, as specified in the test method in clause **9** of IEC 60811-1-1. Dumb-bell test-pieces shall be prepared from the inner part of the sheath and of the insulation after any ridges and/or semi-conducting layers have been removed.

The thickness shall be not less than 0,8 mm and not more than 2,0 mm. If 0,8 mm cannot be obtained from the original sample, a minimum of 0,6 mm is permitted. The central 20 mm for the larger dumb-bells, or 10 mm for the smaller dumb-bells, shall be marked on each test piece.

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9.2 Test apparatus

a) The test shall be carried out in an oven, as specified in **8.1** of IEC 60811-1-2.

b) Grips shall be provided, such that each test piece can be suspended from an upper grip in the oven and weights attached to a lower grip attached to the test piece.

NOTE Testing tubular test pieces, fixing of the grips should not cause an air-tight sealing of both ends. This can be achieved by any appropriate means, for instance by inserting at least on one end a short piece of metal pin, having slightly smaller dimensions than those of the innerside of the test piece.

9.3 Procedure

a) The test pieces shall be suspended in the oven and the weights attached to the lower grip to exert a force of the value specified for the material in the standard for the type of cable. This process shall be carried out as quickly as possible, so that the oven door is open for the minimum time.

b) After the oven has regained temperature (preferably within 5 min), the test pieces shall be held in the oven for a further 10 min. The distance between the marker lines shall then be measured so that the elongation can be calculated. If the oven does not have a window and the oven door has to be opened to make the measurement, the measurement shall be made not more than 30 s after opening the door.

In case of dispute the test shall be carried out in an oven with a window and the measurement made without opening the door.

c) The tensile force shall then be removed from the test pieces (by cutting the test pieces at the lower grip), and the test pieces left to recover in the oven. The test pieces shall be held in the oven for 5 min or until the specified temperature is required, whichever is the longer.

The test pieces shall then be removed from the oven and allowed to cool slowly to ambient temperature, after which the distance between the marker lines shall be measured again.

NOTE Adequate precautions should be taken to avoid physical danger from the handling of the heated grips, weights and test pieces.

9.4 Evaluation of results

a) The median value of the elongation, after 10 min at the specified temperature, with the weight attached, shall not exceed the value specified in the standard for the type of cable.

b) The median value of the distance between the marker lines after removing the test piece from the oven and allowing it to cool shall not have increased from the value before inserting the test piece in the oven by more than the percentage specified in the standard for the type of cable.

10 Mineral oil immersion test for sheaths

10.1 Sampling and preparation of the test pieces

Five test pieces shall be prepared in accordance with the procedures described in **9.2.2** and **9.2.3** of IEC 60811-1-1.

10.2 Determination of the cross-sectional area of the test piece

See test method in **9.2.4** of IEC 60811-1-1.

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10.3 Oil to be used

Unless otherwise agreed, the mineral oil to be used shall be oil No. 2 (IRM902) as described in ISO 1817.

10.4 Procedure

The test pieces shall be immersed in the oil bath, previously heated to the specified test temperature, and shall be maintained in the oil at that temperature for the specified time (see standard for the type of cable).

At the end of the specific duration, the test pieces shall be removed from the oil, blotted lightly to remove excess oil and suspended in air at ambient temperature for at least 16 h but not more than 24 h, unless otherwise specified in the relevant cable standard. At the end of this period, any further excess oil shall be removed by lightly blotting the test pieces.

10.5 Determination of mechanical properties

See test method in **9.1.6** and **9.1.7** of IEC 60811-1-1.

10.6 Expression of results

The calculation of tensile strength shall be based on the area of the test piece measured before immersion (see **10.2**).

The difference between the median value obtained of the five test pieces immersed in oil and the median value of the values obtained for the untreated test pieces (see **9.1.2** of IEC 60811-1-1), expressed as a percentage of the latter, shall not exceed the percentage specified in the standard for the type of cable.

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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 to or 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 an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60811-1-1	1993	*Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 1: Measurement of thickness and overall dimensions — Tests for determining the mechanical properties*	EN 60811-1-1	1995
IEC 60811-1-2	1985	*Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 2: Thermal ageing methods*	EN 60811-1-2[1)]	1995
ISO 1817	1999	*Rubber, vulcanized — Determination of the effect of liquids*	—	—

[1)] EN 60811-1-2 includes corrigendum May 1986 + A1:1989.

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