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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds

Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques –
Partie 403: Essais divers – Essai de résistance à l'ozone sur les mélanges réticulés

IEC 60811-403:2012

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 60811-403 has been prepared by IEC technical committee 20: Electric cables.

This Part 403 of IEC 60811 cancels and replaces Clause 8 of IEC 60811-2-1:1998, which is withdrawn. Full details of the replacements are shown in Annex A of IEC 60811-100:2012.

There are no specific technical changes with respect to the previous edition, but see the Foreword to IEC 60811-100:2012.

The text of this standard is based on the following documents:

FDIS	Report on voting
20/1287/FDIS	20/1336/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This part of IEC 60811 shall be used in conjunction with IEC 60811-100.

A list of all the parts in the IEC 60811 series, published under the general title *Electric and optical fibre cables – Test methods for non-metallic materials*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The IEC 60811 series specifies the test methods to be used for testing non-metallic materials of all types of cables. These test methods are intended to be referenced in standards for cable construction and for cable materials.

NOTE 1 Non-metallic materials are typically used for insulating, sheathing, bedding, filling or taping within cables.

NOTE 2 These test methods are accepted as basic and fundamental and have been developed and used over many years principally for the materials in all energy cables. They have also been widely accepted and used for other cables, in particular optical fibre cables, communication and control cables and cables for ships and offshore applications.

ELECTRIC AND OPTICAL FIBRE CABLES – TEST METHODS FOR NON-METALLIC MATERIALS –

Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds

1 Scope

This Part 403 of IEC 60811 specifies the method for the ozone resistance test, which typically applies to cross-linked compounds.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60811-100:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 100: General*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulation and sheathing compounds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60811-100 apply.

4 Test method

4.1 General

This part of IEC 60811 shall be used in conjunction with IEC 60811-100.

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 1×10^{-5} % by volume, or the value in the current industrial hygienic standard, whichever is the lower.

Unless otherwise specified, tests shall be carried out at room temperature.

4.2 Apparatus

The following apparatus shall be used:

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.

4.3 Pre-conditioning of the samples

All the tests shall be carried out not less than 16 h after the extrusion 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 ± 5) °C.

4.4 Sampling and preparation of test pieces

4.4.1 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.

4.4.2 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.

4.4.3 Preparation of test pieces from 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.

4.4.4 Preparation of test pieces from sheath

Two dumb-bell test pieces shall be prepared in accordance with IEC 60811-501. 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.

4.5 Conditioning and deformation procedure of test pieces

4.5.1 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.

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 temperature 20 °C to 28 °C using a brass, aluminium or suitably treated wooden mandrel with a diameter according to Table 1.

Table 1 – Mandrel diameters

Outside diameter of insulated core *d* mm	Mandrel diameter (as a multiple of the outside diameter of insulated core)
$d \leq 12,5$	4 ±0,1
$12,5 < d \leq 20$	5 ±0,1
$20 < d \leq 30$	6 ±0,1
$30 < d \leq 45$	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.

4.5.2 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 ± 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.

4.6 Exposure to ozone

The conditioned test pieces prepared as in 4.4 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 ± 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 4.8.

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.

4.7 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.

4.8 Determination of ozone concentration

4.8.1 Chemical analysis

4.8.1.1 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. If being used repeatedly, 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:

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

where

F is the volume of the iodine solution in millilitres;

C is the concentration of iodine in milligrams per millilitre;