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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electric and optical fibre cables – Test methods for non-metallic materials – Part 606: Physical tests – Methods for determining the density

Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 606: Essais physiques – Méthodes de détermination de la masse volumique

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

Part 606: Physical tests – Methods for determining the density

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60811-606 has been prepared by IEC technical committee 20: Electric cables.

This Part 606 of IEC 60811 cancels and replaces Clause 8 of IEC 60811-1-3:1993, which is withdrawn.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
20/1315/FDIS	20/1364/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 606: Physical tests – Methods for determining the density

1 Scope

This Part 606 of IEC 60811 descries the methods for determining the density for the most common types of insulating and sheathing compounds (cross-linked, PVC, PE, PP, etc.).

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*

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.

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

4.2 Suspension method (general method)

4.2.1 Testing materials and equipment

These shall comprise:

a) ethanol (ethyl-alcohol) of analytical grade or another suitable liquid for densities below 1 g/ml;

b) zinc chloride solution for densities equal to or greater than 1 g/ml;

c) distilled or deionized water;

d) mixing cylinder;

e) thermostat;

f) hydrometer calibrated at (23,0 ± 0,1) °C;

g) thermometer graduated in tenths of a degree Celsius.

4.2.2 Procedure

From the insulation or the sheath to be tested, a sample shall be taken perpendicularly to the conductor axis and cut into small pieces of 1 mm to 2 mm edge length. The density shall be determined by putting the sample in suspension in a liquid which does not react with the material to be tested.

The following liquids are suitable:

– for a density expected to be lower than 1 g/ml, a mixture of ethanol and water;
– for a density of 1 g/ml and higher, a mixture of zinc chloride and water.

Three pieces of the sample shall be placed in the liquid at a temperature of (23,0 ± 0,5) °C, avoiding any formation of air bubbles. Distilled water shall be added to the liquid until the pieces are freely suspended within the liquid in the mixing cylinder. The liquid mixture shall be homogeneous and maintained at the indicated temperature.

The density of the liquid mixture shall be determined by means of the hydrometer and indicated to three decimal places; the determined density is the same as that of the samples under test.

NOTE The gradient method specified in ISO 1183 may also be used.

4.3 Pycnometer method (reference method)

4.3.1 Testing equipment

The testing equipment for this method consists of

– a balance with a precision of 0,1 mg,
– a pycnometer of 50 ml capacity,
– a liquid bath provided with a thermostatic control,
– immersion liquid (ethyl alcohol, 96 %).

4.3.2 Sample and test piece preparation

The test piece shall be taken from the bare insulation or sheath. The mass of the test piece shall be not less than 1 g and not greater than 5 g. The test piece shall be made by cutting the sample of insulation or sheath into a number of small pieces; small tubes of insulation and sheath shall be cut longitudinally into two or more parts to prevent the enclosure of air bubbles.

4.3.3 Conditioning

The test pieces shall be conditioned at a temperature of (23 ± 2) °C.

4.3.4 Procedure

After weighing the pycnometer empty and dry, a suitable quantity of the test piece shall be weighed in the pycnometer. The test piece shall be covered with the immersion liquid (alcohol, 96 %) and all air removed from the test piece by, for example, applying a vacuum to the pycnometer standing in a desiccator. Any vacuum applied shall be broken and the pycnometer filled with immersion liquid which shall be brought to a temperature of (23 ± 0,5) °C in a liquid bath, the pycnometer being filled to the limits of its capacity. The pycnometer shall be wiped dry and weighed with its contents, after which it shall be emptied and filled with immersion liquid. Air shall be removed and the weight of the pycnometer and its contents determined at a temperature of (23 ± 0,5) °C.

4.3.5 Calculation

The density of the insulation and sheath shall be calculated as follows:

$$\text{density at 23 °C} = \frac{m}{m_1 - m_2} \times d$$

where

m is the mass of test piece, in grams;

m_1 is the mass of liquid required to fill the pycnometer, in grams;

m_2 is the mass of liquid required to fill the pycnometer, when containing the test piece, in grams;

d is the density of ethyl alcohol, 96 %, at 23 °C and is equal to 0,798 8 g/ml.

4.4 Apparent mass method

4.4.1 Testing equipment

The testing equipment for this method consists of

– an analytical balance with a precision of 0,1 mg suitable to weigh a suspended sample,

– a liquid bath,

– immersion liquid: deionized (or distilled) water or ethyl alcohol (96 %).

4.4.2 Sampling and preparation of test pieces

The test piece shall be taken from the bare insulation or sheath. The mass of the test piece shall be not less than 1 g and not greater than 5 g. The test piece shall be made by cutting the sample of insulation or sheath into one or more small pieces; small tubes of insulation and sheath shall be cut longitudinally into two or more parts to prevent the enclosure of air bubbles.

4.4.3 Conditioning

The test pieces shall be conditioned at a temperature of (23 ± 2) °C.

4.4.4 Procedure

The test piece shall first be weighed in air. The test piece shall then be fixed to a suitable hook and the hook with the test piece hung up in the balance. Subsequently, the test piece shall be immersed in distilled or deionized water (or ethyl alcohol, 96 %, if the density is expected to be lower than 1 g/ml) at (23 ± 5) °C and its apparent mass determined. Care shall be taken that the test piece is fully covered by the liquid and that the surface is free of bubbles before the apparent mass is recorded. It may be necessary to add a small quantity of a surface active agent to ensure elimination of all bubbles.

The recorded mass shall be corrected for the apparent mass of the empty hook in the immersion liquid.

4.4.5 Calculation

The density, in grams per millilitre of the insulation and sheath, may be calculated as follows:

$$\text{density at 23 °C} = \frac{m}{m - m_a}$$

where

m is the mass of the test piece in air (in grams);

m_a is the apparent mass of the test piece in water (in grams).

NOTE Where the immersion liquid is water, the density is assumed to be 1,0 g/ml. If ethyl alcohol, 96 %, is used, the value of m_a should be corrected for the density of the alcohol (0,798 8 g/ml at 23 °C).

4.5 Correction for filled polyethylene (PE)

Antioxidants and organic coloured pigments which are normally used in negligible quantities may be neglected. However, where other additives such as mineral fillers are used in considerable quantities, an appropriate correction shall be made. This shall be done by determining the nature and quantity of the additive by reputable chemical means using the formula:

$$\delta = \frac{m \times \delta_C \times \delta_F}{m_C \times \delta_F - m_F \times \delta_C}$$

where

δ is the density of the PE (corrected value), in g/cm^3;

δ_C is the measured density of PE compound, in g/cm^3;

δ_F is the density of additive or filler (measured value), in g/cm^3;

m is the mass of PE polymer (difference of m_C and m_F), in grams;

m_C is the mass of PE compound (measured value), in grams;

m_F is the mass of filler (measured value), in grams.

For compounds containing carbon black, the correction is made by means of the following simplified formula:

$$\delta = \delta_C - 0{,}004\ 5 \times c_B$$

where

c_B is the numerical value of the percentage of carbon black.

5 Test report

The test report shall be in accordance with that given in IEC 60811-100.