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colour inside

Electric and optical fibre cables – Test methods for non-metallic materials – Part 511: Mechanical tests – Measurement of the melt flow index of polyethylene and polypropylene compounds

Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 511: Essais mécaniques – Mesure de l'indice de fluidité à chaud des mélanges polyéthylène et polypropylène

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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FOREWORD

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IEC 60811-511 edition 1.1 contains the first edition (2012-03) [documents 20/1307/FDIS and 20/1356/RVD] and its amendment 1 (2017-07) [documents 20/1736/FDIS and 20/1741/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60811-511 has been prepared by IEC technical committee 20: Electric cables.

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

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 the base publication and its amendment 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- withdrawn,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.

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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 511: Mechanical tests – Measurement of the melt flow index of polyethylene and polypropylene compounds

1 Scope

This Part 511 of IEC 60811 describes the procedure for the measurement of the melt flow index for polyethylene and polypropylene 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 60811-606, *Electric and optical fibre cables – Test methods for non-metallic materials- Part 606: Physical tests – Methods for determining the density*

3 Terms and definitions

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

~~Additionally, for the purposes of this standard, a distinction is made between low-density, medium-density and high-density PE as shown in Table 1.~~

~~Table 1 – Definition of types of polyethylene~~

~~Type of polyethylene~~	~~Density at 23 °C [a] g/cm^3~~
~~Low-density polyethylene~~	~~≤ 0,925~~
~~Medium-density polyethylene~~	~~> 0,925 ≤ 0,940~~
~~High-density polyethylene~~	~~> 0,940~~
~~[a] These densities refer to unfilled resins as determined by the method specified in IEC 60811-606.~~	

4 Test method

4.1 General

This part of IEC 60811 shall be used in conjunction with ~~Part100: General~~ IEC 60811-100.

~~All the tests shall be carried out not less than 16 h after the extrusion of the insulating or sheathing compounds.~~

The melt flow index (MFI) of polyethylene and ~~polyethylene~~ polypropylene compounds is the quantity of material extruded in 1,5 min or 10 min at ~~190 °C~~ a given temperature through a specified die under the action of a load determined by the method used.

The temperature for polyethylene compounds is 190 °C and for polypropylene compounds it is 230 °C.

NOTE 1 The same method is also specified in ISO 1133 as melt mass-flow rate (MFR) procedure.

NOTE 2 The melt flow index is not applicable to flame retarding polyethylene. Flame retardant ~~PE~~ polyethylene is defined as ~~PE~~ polyethylene containing additives intended to reduce flame propagation.

4.2 Apparatus

The apparatus consists basically of an extrusion plastometer, the general design being as shown in Figure 1. The compound, which is contained in a vertical cylinder, is extruded through a die by a loaded piston under controlled temperature conditions. All surfaces of the apparatus in contact with the material under test shall have a high polish.

The apparatus consists of the following parts:

a) Steel cylinder

A steel cylinder fixed in a vertical position and thermally insulated for operation at 190 °C. The cylinder shall be at least 115 mm long with an internal diameter of between 9,5 mm and 10 mm and complying with the requirements in item b) below. The base of the cylinder shall be thermally insulated if the area of the exposed metal exceeds 4 cm^2 and it is recommended that the insulating material used be polytetrafluoroethylene (thickness about 3 mm) in order to avoid the extruded material from sticking.

b) Steel hollow piston

A steel hollow piston with a length at least the same as that of the cylinder. The axes of the cylinder and of the piston shall coincide and the effective length of the piston shall be a maximum of 135 mm. There is a head of length (6,35 ± 0,10) mm. The diameter of the head shall be less than the internal diameter of the cylinder at all points along the working length of the cylinder by (0,075 ± 0,015) mm. In addition, for calculating the load (see item c) this diameter should be known within ± 0,025 mm. The lower edge of the head shall have a radius of 0,4 mm and the upper edge has its sharp edge removed. Above the head, the piston has a diameter of about 9 mm. A stud may be added at the top of the piston to support the removable load, but the piston is thermally insulated from this load.

c) Removable load on top of the piston

The combined masses of the load and the piston shall be such that the force P applied is:

– P = 21,2 N in the case of method A (see 4.5);

– P = 49,1 N in the case of method C (see 4.7);

d) Heater

A heater to maintain the ~~polyethylene~~ compound in the cylinder at ~~a~~ the given temperature of (190 ± 0,5) °C for polyethylene and of (230 ± 0,5) °C for polypropylene. An automatic temperature control is strongly recommended.

e) Temperature measuring device

A temperature measuring device located as closely as possible to the die, but situated within the body of the cylinder. The measuring device shall be calibrated to permit temperature measurement to an accuracy of ± 0,1 °C.

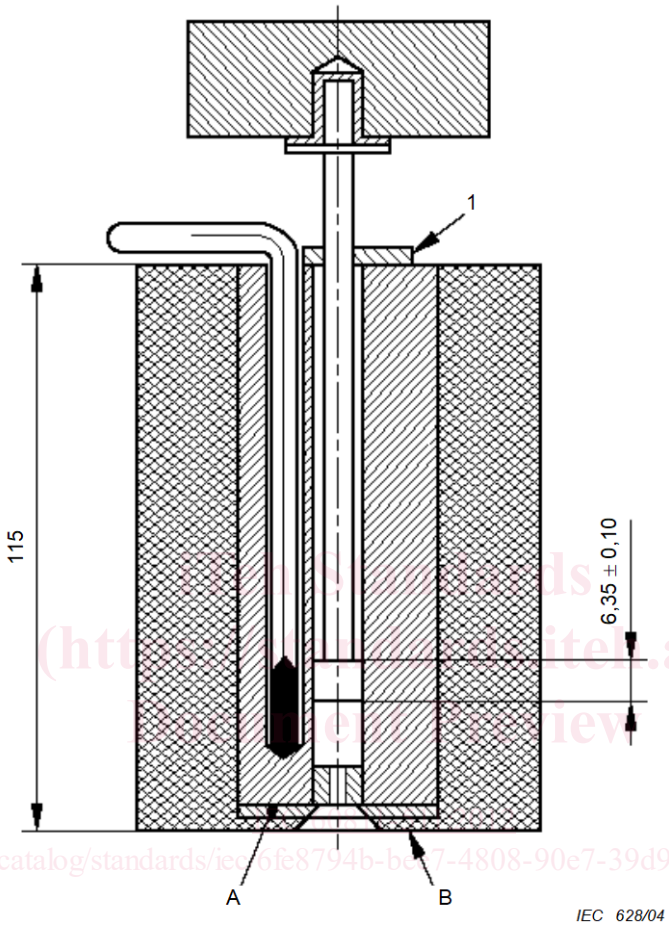
f) Die

A die of length (8,000 ± 0,025) mm made of hardened steel, the mean internal diameter being between 2,090 mm and 2,100 mm and uniform along its length to within ± 0,005 mm (see Figure 2). The die shall not project beyond the base of the cylinder.

g) Balance

A balance accurate to ± 0,000 5 g.

Dimensions in millimeters



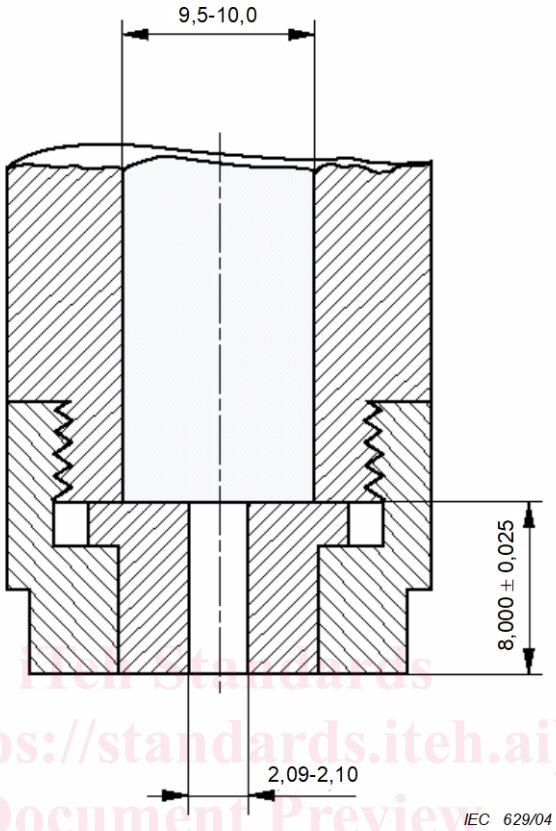
NOTE The figure shows the large external diameter cylinder, die-retaining plate A and insulating plate B.

Key

1 guide collar

Figure 1 – Apparatus for determining melt flow index

Dimensions in millimetres



NOTE The figure shows the small external diameter cylinder with an example method of retaining the die.

Figure 2 – Die

4.3 Test samples

The test shall be carried out on granules or a ~~sample~~ section of insulation or sheath of sufficient mass shall be taken from one end of the cable or wire. In the latter case, the sample shall be cut into pieces, the dimension of which shall not exceed 3 mm in any direction.

It is permitted to take material from different cores of the same cable.

4.4 Cleaning and maintenance of the apparatus

The apparatus shall be cleaned after each test.

On no account should abrasives or materials likely to damage the surfaces of the piston, cylinder or die be used in removing superficial ~~polyethylene~~ compound or in manipulating any part of the apparatus.

Suitable solvents for cleaning the apparatus are xylene, tetrahydronaphthalene or odourless kerosene. The piston shall be cleaned while still hot with a cloth dipped in the solvent; likewise, the cylinder shall also be cleaned while still hot, with a swab dipped in the solvent. The die shall be cleaned with a closely-fitting brass reamer or wooden peg and then immersed in boiling solvent.

It is recommended that, at fairly frequent intervals, for example once a week for apparatus in constant use, the insulating plate and the die-retaining plate, if fitted (see Figure 1), be removed and the cylinder cleaned thoroughly.

4.5 Method A

4.5.1 General

Method A is suitable for determining the melt flow index (MFI) of a sample of compound whose MFI is unknown.

The MFI of a compound may be affected by previous thermal and mechanical treatments, and in particular oxidation will tend to reduce the MFI. Oxidation occurring during the test will usually cause a systematic reduction in the masses of successive cut-offs. This phenomenon is not exhibited by compounds containing an anti-oxidant.

4.5.2 Test procedure

The apparatus shall be cleaned (see 4.4). Before beginning a series of tests, the temperature of the cylinder and piston shall be at (190 ± 0,5) °C for polyethylene or (230 ± 0,5) °C for polypropylene for 15 min and this temperature maintained during the extrusion of the ~~polyethylene~~ compound.

It is recommended that the temperature measuring device (see item e) of 4.2 be a mercury-in-glass thermometer located permanently within the mass of the cylinder (see note below). A low melting-point alloy, such as Wood's metal, improves the thermal contact and its use is recommended.

~~NOTE~~ If any other temperature measuring device is used, it should be calibrated at (190 ± 0,5) °C for polyethylene or (230 ± 0,5) ºC for polypropylene before the beginning of each series of tests in comparison with a mercury-in-glass thermometer, conforming to item e) of 4.2), placed within the cylinder and immersed in ~~polyethylene~~ the compound to its appropriate depth of immersion.

The cylinder shall then be charged with a portion of the sample (see Table 2) and the unloaded piston reinserted into the top of the cylinder.

Four minutes after introducing the sample, during which time the temperature of the cylinder shall have returned to (190 ± 0,5) °C for polyethylene or (230 ± 0,5) °C for polypropylene, the load is placed on the piston to extrude the ~~polyethylene~~ compound through the die. The rate of extrusion shall be measured by cutting the extruded material at regular intervals of time at the die with a suitable sharp-edged instrument to give short lengths of extruded material referred to as "cut-offs". The time intervals at which each cut-off is taken are given in Table 2.

Several cut-offs shall be taken within 20 min of the introduction of the sample into the cylinder. The first cut-off and any containing air bubbles shall be ignored. The remaining successive cut-offs, of which there shall be at least three, shall be weighed individually to the nearest milligram and the average mass determined. If the difference between the maximum and the minimum values of the individual weightings exceeds 10 % of the average, the test results shall be discarded and the test repeated on a fresh portion of the sample.

4.5.3 Expression of results

The melt flow index (MFI) shall be reported to two significant figures and expressed in g/600 s as ~~MFI.190.20.A~~ MFI.T.20.A (see NOTE):

$$\text{~~MFI.190.20.A~~ MFI.T.20.A} = \frac{600 \times m}{t}$$

where