

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Plastic films for electrical purposes –  
Part 3: Specifications for individual materials – Sheet 8: Balanced biaxially  
oriented polyethylene naphthalate (PEN) films used for electrical insulation**

**Films plastiques à usages électriques –  
Partie 3: Spécifications pour matériaux particuliers – Feuille 8: Films de  
polynaphtalate d'éthylène (PEN), à orientation bi-axiale équilibrée, utilisés dans  
l'isolation électrique**





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IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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IEC 60674-3-8

Edition 1.1 2016-11  
CONSOLIDATED VERSION

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INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 29.035.20

ISBN 978-2-8322-3633-8

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**PLASTIC FILMS FOR ELECTRICAL PURPOSES –**

**Part 3: Specifications for individual materials –  
Sheet 8: Balanced biaxially oriented polyethylene  
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**IEC 60674-3-8 edition 1.1 contains the first edition (2011-07) [documents 15/631/FDIS and 15/643/RVD] and its amendment 1 (2016-11) [documents 15/738/CDV and 15/761/RVC].**

**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 60674-3-8 has been prepared by IEC technical committee 15: Solid electrical insulating materials.

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

A list of all the parts in the IEC 60674 series, under the general title *Plastic films for electrical purposes*, 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

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## INTRODUCTION

This International Standard is one of a series which deals with plastic films for electrical purposes.

The series consists of three parts:

Part 1: Definitions and general requirements (IEC 60674-1).

Part 2: Methods of test (IEC 60674-2).

Part 3: Specifications for individual materials (IEC 60674-3).

This standard contains one of the sheets comprising part 3, as follows:

Sheet 8: Balanced biaxially oriented polyethylene naphthalate (PEN) films used for electrical insulation.

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## PLASTIC FILMS FOR ELECTRICAL PURPOSES –

### Part 3: Specifications for individual materials – Sheet 8: Balanced biaxially oriented polyethylene naphthalate (PEN) films used for electrical insulation

#### 1 Scope

This International Standard gives the requirements for balanced biaxially oriented polyethylene naphthalate (PEN) films for use as electrical insulation.

Materials which conform to this specification meet established levels of performance. However, the selection of a material by a user for a specific application should be based on the actual requirements necessary for adequate performance in that application and not based on this specification alone.

Safety warning: it is the responsibility of the user of the methods contained or referred to in this document to ensure that they are used in a safe manner.

#### 2 Normative references

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

IEC 60674-1:1980, *Specification for plastic films for electrical purposes – Part 1: Definitions and general requirements*

<https://standards.iteh.ai/catalog/standards/iec/9b5ce44c-3002-48ec-b4ec-4c21d8b6aebf/iec-60674-3-8-2011>

IEC 60674-2:1988, *Specification for plastic films for electrical purposes – Part 2: Methods of test*

IEC 60068-2-66:1994, *Environmental testing – Part 2: Test methods – Test Cx: Damp heat, steady state (unsaturated pressurized vapour)*

IEC 60216-5:2008, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

ISO 11357-3:1999, *Plastics – Differential scanning calorimetry (DSC) – Part 3: Determination of temperature and enthalpy of melting and crystallization*

#### 3 Classification

The PEN film shall be of the following types:

- Type 1a: General purpose, high hydrolytic stability grade.
- Type 1b: General purpose, standard grade.
- Type 2: Capacitor grade.

#### 4 Designation

The plastic film shall be identified by the following designation:

Designation of the film - IEC 60674-3-8 - PEN - type - thickness in micrometres - width in millimetres - length in metres - colour.

Example:

Polyethylene naphthalate - IEC 60674-3-8 - PEN - type 1b - 100 - 20 - 200 – nc  
(nc = natural colour; other colours according to IEC 60757).

## 5 General requirements

The material shall be made from polyethylene naphthalate; it shall be biaxially oriented with an approximately balanced orientation and shall conform to the requirements laid down in IEC 60674-1.

For certain applications additives to the base material may be present (e.g. pigments, dyes). Where such additives are included, they shall not affect the requirements for any of the properties listed for that type unless otherwise specified.

## 6 Dimensions

### 6.1 Thickness

The film thickness shall be measured by a gravimetric method in accordance with the requirements of Subclause 3.3 of IEC 60674-2.

NOTE There are no requirements for thickness in this standard but preferred thicknesses in  $\mu\text{m}$  are as follows:

1,2; 1,3; 1,5; 1,8; 1,9; 2; 2,1; 2,3; 3; 3,5; 4; 5; 6; 8; 9; 12; 16; 19; 20; 25; 38; 45; 50; 75; 89; 100; 125; 188; 200; 250.

The thickness tolerance shall comply with the requirements in Subclause 4.1 of IEC 60674-1 unless otherwise specified in the purchase contract.

### 6.2 Width

The film width shall be measured in accordance with the requirements of Clause 5 of IEC 60674-2.

Preferred widths cannot be given on account of the great variety of applications.

The tolerance on the width shall comply with the requirements of Subclause 4.2 of IEC 60674-1 except for slot closure applications where on a width of less than 25 mm a tolerance of  $x_{-0,3}^{0,0}$  mm is specified as an alternative.

## 7 Properties

### 7.1 Properties not dependent on thickness

**Table 1 – Properties not dependent on thickness**

Property	Requirements	Units	IEC 60674- 2 Test method Subclause	Type
Density - normal	1 350 ± 20	kg/m <sup>3</sup>	4, Method D	1a,1b and 2
Melting- point	270 ± 5 <sup>a</sup>	°C	–	1a,1b and 2
Permittivity	2,6 ± 0,5	–	16.1 (23 °C, 1 kHz) <sup>b</sup>	1a,1b and 2
Dissipation factor	<5 × 10 <sup>-3</sup>	–	16.1 (23 °C, 48 Hz – 62 Hz) <sup>b</sup>	1a,1b and 2
	<9 × 10 <sup>-3</sup>	–	16.1 (23 °C, 1 kHz) <sup>b</sup>	1a and 1b
Volume resistivity	>10 <sup>16</sup>	Ω × m	15 <sup>c</sup>	1a and 1b
	>10 <sup>16</sup>			2
Surface resistivity	>10 <sup>14</sup>	Ω	14 <sup>c</sup>	1a and 1b
	>10 <sup>15</sup>			2
<sup>a</sup> DSC method according to ISO 11357-3. <sup>b</sup> Use non-contacting electrodes or evaporated metal electrodes. <sup>c</sup> Measurement conditions shall be 23 °C and 50 % r.h. after 24 h exposure. The test voltages are 100 V ± 10 V for thicknesses > 10 μm and 10 V for thicknesses < 10 μm.				

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## 7.2 Properties dependent on thickness

**Table 2 – Properties dependent on thickness**

Property	Requirements			Units	IEC 60674- 2 Test method Subclause	Type	
	≤15 μm	>15 μm up to 100 μm	>100 μm up to 250 μm				
Tensile strength (either direction) Minimum value  - Initial value	180 <sup>a</sup>	120	95	MPa	10 <sup>b</sup>	1a, 1b and 2	
	- After exposure to unsaturated damp heat for 96 h <sup>c</sup>	130 <sup>a</sup>	100			90	1a
		110 <sup>a</sup>	90			85	1b and 2
Elongation at break (either direction) Minimum value  - Initial value	35 <sup>a</sup>	40	40	%	10 <sup>b</sup>	1a, 1b and 2	
	- After exposure to unsaturated damp heat for 96 h <sup>c</sup>	20 <sup>a</sup>	20			20	1a
		10 <sup>a</sup>	10			10	1b and 2
Dimensional change (shrinkage either direction)	1,3	1,0	0,8	%	23 (150 °C, 15 min)	1a, 1b and 2	
	6,5	3,5	1,6		23 (200 °C, 10 min)	1a, 1b and 2	
Electric strength	See Tables 3 and 4				18.1, a.c. <sup>d</sup>	1a, 1b and 2	
					18.2, d.c.	2	
<p><sup>a</sup> No requirement for film thicknesses below 5 μm.</p> <p><sup>b</sup> Rate of extension 100 mm/min, reference lines 100 mm apart.</p> <p><sup>c</sup> Exposure to unsaturated damp heat (unsaturated pressurized vapour), 120 °C, 85 % r.h. according to Clauses 3 to 9 in IEC 60068-2-66.</p> <p><sup>d</sup> Method to use 6 mm diameter electrodes. For materials of thicknesses 100 μm or less, tests shall be made in air using a rate of rise of voltage of 500 V/s. For materials thicker than 100 μm, tests shall be made in transformer oil in accordance with IEC60243-1.</p>							

**Table 3 – Electric strength (a.c. test) for all types**

Nominal thickness $\mu\text{m}$	Minimum electric strength $\text{V}/\mu\text{m}$		IEC 60674- 2 Test method Subclause
	23 °C	150 °C	
6	-	-	18.1 Using 6 mm diameter electrodes
9	-	-	
12	-	-	
16	<del>405</del> 290 <sup>a</sup>	230 <sup>c</sup>	
20	<del>360</del> 260 <sup>a</sup>	190 <sup>c</sup>	
25	<del>305</del> 235 <sup>a</sup>	170 <sup>c</sup>	
38	<del>235</del> 190 <sup>a</sup>	140 <sup>c</sup>	
50	<del>190</del> 160 <sup>a</sup>	120 <sup>c</sup>	
75	<del>150</del> 125 <sup>a</sup>	100 <sup>c</sup>	
100	<del>120</del> 100 <sup>a</sup>	80 <sup>c</sup>	
125	<del>95</del> 80 <sup>b</sup>	70 <sup>c</sup>	
188	<del>80</del> 65 <sup>b</sup>	50 <sup>c</sup>	
250	<del>70</del> 60 <sup>b</sup>	40 <sup>c</sup>	

<sup>a</sup> in air.  
<sup>b</sup> in mineral transformer oil.  
<sup>c</sup> in silicone transformer oil.

**Table 4 – Electric strength (d.c. test) type 2 only**

Nominal thickness $\mu\text{m}$	Minimum breakdown voltage Central value V	Not more than two of the 21 results shall be below V	Not more than one of the 21 results shall be below V
4	1200	500	100 <sup>a</sup>
5	1200	500	200 <sup>a</sup>
6	1800	1200	1000 <sup>a</sup>
12	5900	3600	3000

<sup>a</sup> This value is only for information. The actual value shall be agreed between purchaser and manufacturer.

### 7.3 Other properties

#### 7.3.1 Thermal endurance

Thermal endurance for types 1a and 1b films ( $\geq 25 \mu\text{m}$ ) shall be measured according to IEC 60216-5.

RTE  $\geq 160^*$

\* End point criterion: 50 % retention of tensile strength.

Reference material: PPS (Polyphenylene Sulfide) film having approximately the same thickness as the subject material and an ATE in accordance with IEC 60216-5, Subclause 3.1.4.

Ageing temperatures of 180 °C, 200 °C and 220 °C are recommended.