IEC 60674-3-2

Edition 2.0 2019-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Specification for plastic films for electrical purposes – Part 3: Specifications for individual materials Sheet 2: Requirements for balanced biaxially oriented polyethylene terephthalate (PET) films used for electrical insulation

Spécification pour les films en matière plastique à usages électriques – Partie 3: Spécifications pour matériaux particuliers Feuille 2: Exigences pour les films de polyéthylène-téréphtalate (PET), à orientation biaxe équilibrée, utilisés dans l'isolation électrique

IEC 60674-3-2:2019-01(en-fr)

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FOREWORD

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International Standard IEC 60674-3-2 has been prepared by IEC technical committee 15: Solid electrical insulating materials.

This second edition cancels and replaces the first edition published in 1992. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) this document has been completely revised editorially and technically and included in the IEC 60674 series of standards;
b) new types have been included;
c) the ranges of thickness have been expanded;
d) changes have been made to the requirements of some existing types.

The text of this International Standard is based on the following documents:

CDV	Report on voting
15/840/CDV	15/865/RVC

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

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

A list of all parts in the IEC 60674 series, published under the general title *Specification for plastic films for electrical purposes*, can be found on the IEC website.

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

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- withdrawn,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

INTRODUCTION

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

The series consist 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)

SPECIFICATION FOR PLASTIC FILMS FOR ELECTRICAL PURPOSES –

Part 3: Specifications for individual materials
Sheet 2: Requirements for balanced biaxially oriented polyethylene terephthalate (PET) films used for electrical insulation

1 Scope

This sheet of IEC 60674-3 gives the requirements for balanced biaxially oriented polyethylene terephthalate (PET) films used for electrical insulation.

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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

IEC 60674-2:2016, *Specification for plastic films for electrical purposes – Part 2: Methods of test*
IEC 60674-2/AMD1:–[1]

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Classification

The PET film shall be of the following types:

– Type 1: Standard
– Type 2: Ultra thin with high electric strength
– Type 3: High temperature resistance
– Type 4: High temperature and hydrolysis resistance
– Type 5: High temperature and hydrolysis resistance higher than type 4

Main applications of each type are as follows:

———————
[1] Under preparation. Stage at the time of publication: IEC/APUB 60674-2/AMD1:2018.

– Type 1: General
– Type 2: For use as the dielectric of capacitors
– Type 3: For use as the insulation of electrical windings
– Type 4 and 5: For use as the insulation of electrical windings, and back sheet of photovoltaic modules

5 Designation

The plastic film shall be identified by the following designation:

Designation of the film – IEC 60674-3-2 – PET – type – thickness in micrometres – width in millimetres – length in metres – colour.

Example:

Polyethylene terephthalate – IEC 60674-3-2 – PET – type 1 – 100 – 20 – 200 – nc (nc = natural colour; other colours according to IEC 60757).

6 General requirements

The material shall be made from polyethylene terephthalate; 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.

7 Dimensions

7.1 Thickness

The film thickness shall be measured by a gravimetric method according to 4.3.2 of IEC 60674-2:2016.

There are no requirements for thickness in this document but preferred thickness ranges are as follows:

– Type 1: 12 µm – 500 µm
– Type 2: 0,7 µm – 23 µm
– Type 3: 50 µm – 500 µm
– Type 4: 50 µm – 500 µm
– Type 5; 50 µm – 350 µm

The thickness tolerance shall comply with the requirements in 4.1 of IEC 60674-1:1980 unless otherwise specified in the purchase contract.

7.2 Width

The film width shall be measured according to Clause 6 of IEC 60674-2:2016.

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

The tolerance on the width shall comply with the requirements of 4.2 of IEC 60674-1:1980 except for slot closure applications where on a width of less than 25 mm, a tolerance of $^{0,0}_{-0,3}$ mm is specified as an alternative.

7.3 Roll diameter/film length

There are no requirements in this document for roll diameters or film lengths on a roll. These should be subject to contract.

8 Physical properties

8.1 Physical properties not dependent on thickness

See Table 1.

Table 1 – Physical properties not dependent on thickness

Property	Requirements	Units	IEC 60674-2:2016 Test method Clause/Subclause	Type
Density - normal	1 390 ± 10	kg/m^3	5, Method D [a]	All
Density – for opaque pigmented film	1 420 ± 70			
Melting- point	260 ± 7	°C	24	1 and 3
	255 ± 5			2
	260 + 7, − 10			4 and 5
Permittivity	3,3 ± 0,2	–	18.2 (23 °C, 1 kHz) [b]	All
Dissipation factor	≤ 3 × 10^{-3}	–	18.2 (23 °C, 48 Hz – 62 Hz) [b]	All
	≤ 6 × 10^{-3}	–	18.2 (23 °C, 1 kHz) [2]	All
Volume resistivity	≥ 10^{14}	Ω × m	17 [c]	1, 3, 4 and 5
	≥ 10^{15}			2
Surface resistivity	≥ 10^{13}	Ω	16 [c]	1, 3, 4 and 5
	≥ 10^{14}			2

[a] This method is only suitable for film thicknesses above 12 µm.

[b] Use non-contacting electrodes or evaporated metal electrodes.

[c] Measurement conditions shall be (23 ± 2) °C and (50 ± 5) % RH after 24 h exposure. The test voltages are 100 V for thicknesses > 10 µm and 10 V for thicknesses ≤ 10 µm.

8.2 Physical properties dependent on thickness

See Tables 2 and 3.

Table 2 – Physical properties dependent on thickness for types 1, 3, 4 and 5

Property	Requirements					Units	IEC 60674-2:2016 Test method Clause
	≥ 12 µm ≤ 15 µm	> 15 µm ≤ 100 µm	> 100 µm ≤ 250 µm	> 250 µm ≤ 350 µm	> 350 µm		
Tensile strength (either direction)	≥ 170	≥ 150	≥ 140	≥ 110	≥ 90	MPa	12 [a]
Elongation at break (either direction)	≥ 50	≥ 80	≥ 80	≥ 80	≥ 100	%	12 [a]
Dimensional change for shrinkage (either direction)	≤ 3,5	≤ 3,0	≤ 3,0	≤ 2,0	≤ 2,0	%	25 (150 °C, 15 min)

[a] Rate of extension 100 mm/min, reference lines 100 mm apart.

Table 3 – Physical properties dependent on thickness for type 2

Property	Requirements					Units	IEC 60674- 2:2016 Test method Subclause
	≥ 0,7 µm ≤ 1,5 µm	> 1,5 µm ≤ 2,0 µm	> 2,0 µm ≤ 4,0 µm	> 4 µm ≤ 15 µm	> 15 µm ≤ 23 µm		
Tensile strength (either direction)	≥ 135	≥ 155	≥ 170	≥ 170	≥ 150	MPa	12 [a)]
Elongation at break (either direction)	≥ 20	≥ 30	≥ 40	≥ 50	≥ 80	%	12 [a)]
Dimensional change for shrinkage						%	25 (150 °C, 15 min)
Machine direction	≤ 3,5	≤ 3,5	≤ 3,5	≤ 3,5	≤ 3,5		
Transverse direction	≤ 2,0	≤ 2,0	≤ 2,0	≤ 2,0	≤ 2,0		

[a)] Rate of extension 100 mm/min, reference lines 100 mm apart.

8.3 Electric strength (AC test)

Electric strength under AC voltage given in Table 4 shall be measured according to 20.1 of IEC 60674-2:2016. The electrode shall be selected from the following configurations:

– unequal electrodes;
– sphere and plate electrodes;
– 6 mm diameter rod and rod electrodes.

Table 4 – Electric strength (AC test) for all types

Nominal thickness µm	Electric strength (median) V/µm	IEC 60674-2:2016 Test method Subclause
12	≥ 208	20.1 in air
15	≥ 200	
19	≥ 190	
23	≥ 174	
36	≥ 150	
50	≥ 130	
75	≥ 105	
100	≥ 90	
125	≥ 80	20.1 in transformer oil or in air
190	≥ 65	
250	≥ 60	
350	≥ 50	
500	≥ 35	

8.4 Electric strength (DC test) for type 2

Electric strength under DC voltage given in Table 5 shall be tested by one of the following methods:

– wound capacitor method according to 20.2 of IEC 60674-2:2016;
– 6 mm diameter electrodes method according to 20.1 of IEC 60674-2:2016;
– Aluminium foils sandwich method according to 20.3 of IEC 60674-2/AMD1:–.

Table 5 – Electric strength (DC test) type 2 only

Nominal thickness	Wound capacitor method 20.2 of IEC 60674-2:2016			6 mm diameter electrodes method 20.1 of IEC 60674-2:2016	Aluminium foils sandwich method 20.3 of IEC 60674-2/AMD1:–
	Breakdown voltage (Median)	Not more than two of the 21 results shall be below	Not more than one of the 21 results shall be below	Electric strength (Median)	Electric strength (Median)
µm	V (V/µm)	V	V	V/µm	V/µm
≥ 0,7 < 1,4	–	–	–	≥ 200	≥ 100
≥ 1,4 < 2,0	–	–	–	≥ 250	≥ 120
≥ 2,0 < 3,0	–	–	–	≥ 290	≥ 130
≥ 3,0 < 4,0	–	–	–	≥ 330	≥ 170
≥ 4,0 < 5,0	–	–	–	≥ 370	≥ 200
≥ 5,0 < 6,0	–	–	–	≥ 370	≥ 225
6	≥ 1 500 (250)	600	400	≥ 370	≥ 250
8	≥ 2 000 (250)	1 100	550	≥ 370	–
10	≥ 2 400 (240)	1 500	800	≥ 370	–
12	≥ 2 800 (233)	1 800	1 000	≥ 370	–
15	≥ 3 200 (213)	2 000	1 600	≥ 370	–
19	≥ 3 400 (179)	2 200	1 900	–	–
23	≥ 4 000 (174)	2 500	2 200	–	–

It should be confirmed before every event of the measurement that electrode surfaces of 6 mm diameter are mirror surface having free from damage, and the centres of the two electrode rods are set in a straight line.

8.5 Electrical weak spots (type 2 only)

When measured according to 21.4 of IEC 60674-2:2016, the number of faults counted shall not exceed the numbers given in Table 6. A minimum surface area of 5 m^2 is to be tested.

Compliance with any one of three method criteria shall constitute compliance with this document.

Table 6 – Number of faults counted (type 2 only)

Nominal thickness	Method C1 (Aluminium foil electrodes) 21.4.2.2 of IEC 60674-2:2016		Method C2 (Metalized film electrode) 21.4.2.3 of IEC 60674-2:2016		Method C3 (Metal electrode with air gap) 21.4.2.4 of IEC 60674-2:2016	
	Fault	Test voltage	Fault	Test voltage	Fault	Test voltage
µm	count/m^2	V/µm	count/m^2	V/µm	count/m^2	V/µm
≥ 0,9 < 2,5	–	–	≤ 6	100	–	–
2,5	–	–	≤ 3	150	–	–
3	≤ 6	200	≤ 3	150	≤ 5	250
3,5	≤ 4	200	≤ 3	150	≤ 3	250
5	≤ 2	200	≤ 2	150	≤ 1	250
6	≤ 1	200	≤ 1,5	150	≤ 0,5	250
8	≤ 0,8	200	≤ 1,5	150	≤ 0,4	250
10	≤ 0,4	200	≤ 1,2	150	≤ 0,2	250
≥ 12	≤ 0,2	200	≤ 1,0	150	≤ 0,1	250