BRITISH STANDARD

BS EN 60674-3-1: 1998+A1:2011

Plastic films for electrical purposes —

Part 3: Specifications for individual materials —

Sheet 1: Biaxially oriented polypropylene (PP) films for capacitors

ICS 29.035.20

National foreword

This British Standard is the UK implementation of EN 60674-3-1:1998+A1:2011. It is identical to IEC 60674-3-1:1998, incorporating amendment 1:2011. It supersedes BS EN 60674-3-1:1998, which will be withdrawn on 18 October 2014.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1] ⟨A1⟩.

The UK participation in its preparation was entrusted to Technical Committee GEL/15 Solid electrical insulating materials.

A list of organizations represented on this committee can be obtained on request to its secretary.

This British Standard does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 June 1998

ISBN 978 0 580 72300 1

Amendments/corrigenda issued since publication

Date	Comments
30 September 2012	Implementation of IEC amendment 1:2011 with CENELEC endorsement A1:2011

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60674-3-1:
1998+A1

October 2011

ICS 29.035.20

Descriptors: Electrical insulating materials, solid electrical insulating materials, insulating films, plastic sheets, polypropylene, capacitors, designation, classifications, dimensions, physical properties, dielectric strength, winding tests, labelling

English version

Plastic films for electrical purposes
Part 3: Specifications for individual materials
Sheet 1: Biaxially oriented polypropylene (PP) film for capacitors

(IEC 60674-3-1:1998)

Films plastiques à usages électriques
Partie 3: Spécifications pour matériaux particuliers
Feuille 1: Films de polypropylène biorienté (PP) pour condensateurs
(CEI 60674-3-1:1998)

Isolierfolien für elektrotechnische Zwecke
Teil 3: Anforderungen für einzelne Werkstoffe
Blatt 1: Biaxial orientierte Polypropylen-(PP)-Folien für Kondensatoren
(IEC 60674-3-1:1998)

This European Standard was approved by CENELEC on 1998-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Ref. No. EN 60674-3-1:1998 E

Foreword

The text of document 15C/862/FDIS, future edition 1 of IEC 60674-3-1, prepared by SC 15C, Specifications, of IEC TC 15, Insulating materials, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60674-3-1 on 1998-04-01.

The following dates were fixed:

— latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-01-01

— latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2001-01-01

Annexes designated "normative" are part of the body of the standard.

In this standard, Annex ZA is normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60674-3-1:1998 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 15/596/CDV, future edition 1 of IEC 60674-3-1:1998/A1, prepared by IEC/TC 15, "Solid electrical insulating materials", was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60674-3-1:1998/A1:2011.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2012-07-18
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2014-10-18

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60674-3-1:1998/A1:2011 was approved by CENELEC as a European Standard without any modification.

Contents

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 1: Biaxially oriented (PP) polypropylene films for capacitors.

1 General

1.1 Scope

This sheet of IEC 60674-3 gives the requirements for biaxially oriented polypropylene film having a smooth or rough surface, corona treated when required for vacuum metallization. The films are for use as dielectric in capacitors.

〈A1〉 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. 〈A1〉

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this sheet of IEC 60674-3. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreement based on this sheet of IEC 60674-3 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below[1)]. Members of IEC and ISO maintain registers of currently valid International Standards.

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

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

IEC 61074:1991, *Determination of heats and temperatures of melting and crystallization of electrically insulating materials by differential scanning calorimetry.*

ISO 534:1988, *Paper and board — Determination of thickness and apparent bulk density or apparent sheet density.*

〈A1〉 ISO 11357-3, *Plastics – Differential scanning calorimetry (DSC) – Part 3:Determination of temperature and enthalpy of melting and crystallization* 〈A1〉

1.3 Classification

The polypropylene film shall be of the following types:

Type 1:	having smooth surfaces (space factor < 5 %, see **5.9**);
Type 1a:	not corona treated;
Type 1b:	one side pre-treated to facilitate the vacuum deposition of metal;
Type 1c:	both sides pre-treated;
Type 2:	having at least one rough surface (space factor ≥ 5 %, voir **5.9**);
Type 2a:	not corona treated;
Type 2b:	one side pre-treated to facilitate the vacuum deposition of metal;
Type 2c:	both sides pre-treated.

〈A1〉 Type 3: having high electric strength for thin film (film thickness ≤ 3,5 µm);

Type 3a: not corona treated;

Type 3b: one side pre-treated to facilitate the vacuum deposition of metal;

Type 3c: both sides pre-treated. 〈A1〉

2 Designation

The plastic film shall be identified by the following designation:

Designation of the film — IEC 60674-3-1 – PP – type — thickness in micrometres — width in millimetres — length in metres.

EXAMPLE

Polypropylene film — IEC 60674-3-1 – PP – 1a – 6 – 100 – 3000.

3 General requirements

The materials shall be made essentially from isotactic type polypropylene homopolymer and shall conform to the requirements laid down in IEC 60674-1.

4 Dimensions

4.1 Thickness

The film thickness shall be measured in accordance with the requirements of **3.3** of IEC 60674-2. This is in general the gravimetric thickness, but for type 2 distinction shall be made between thickness determined by weighing (t_g = gravimetric thickness) and thickness measured by micrometer method (t_b = bulking thickness).

[1)] In case of dispute, the referenced edition is applicable.

Gravimetric thickness shall be measured in accordance with the requirements of **3.3** of IEC 60674-2.

Bulking (micrometric) thickness shall be measured in accordance with ISO 534, except that the four test pieces are initially made up of 12 film layers, the layers being cut together using a suitable template (preferably 250 mm × 200 mm, the 200 mm dimension being in the machine direction) from a blanket of film about 0,5 mm thick taken from the outer surface of the roll being sampled. Discard the first and last layer of each pack or test piece just prior to imposing the pack between the open pressure faces of the micrometer.

There are no requirements for thickness in this standard but preferred gravimetric thicknesses are as follows:

Type 1: 4,0; 5,0; 6,0; 7,0; 8,0; 10,0; 12,0; 15,0; 18,0; 20,0 and 25 µm.

Type 2: 7,4; 9,0; 10,1; 11,0; 12,0; 12,7; 13,6; 14,4; 15,2; 16,2 and 17,8 µm.

〈A1〉 Type 3: 2,5; 2,8; 3,0 and 3,5 µm. 〈A1〉

The thickness tolerance shall comply with the requirements of IEC 60674-1 unless otherwise specified.

4.2 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 and different requirements throughout the capacitor industry.

The tolerance on the width shall comply with the requirements of **4.2** of IEC 60674-1.

4.3 Length/diameter

There are no requirements in this standard for length or diameters of rolls. These should be subject to purchase contract.

5 Properties

5.1 Physical properties

See Table 1.

Table 1 — Physical properties

Property	Test method	Unit	Requirement	Remarks
Density	IEC 60674-2, clause **4**, method D	Mg/m^3	0,91 ± 0,01	This method is only suitable for film thickness > 12 µm. The recommended mixture is methanol/ethylene glycol
Melting point 〈A1〉	IEC 61074 ISO 11357-3 〈A1〉	°C	165 to 175	DSC method
Tensile strength (either direction)	IEC 60674-2, clause **10**	MPa	Minimum Type 1: 120 Type 2: 90	Specimen width (15 ± 3) mm, rate of extension (100 ± 2) mm/min, reference lines with the initial grip separation (100 ± 2) mm apart
Elongation at break (either direction)		%	Minimum Type 1: 40 Type 2: 30 〈A1〉 Type 3: 30 〈A1〉	
Surface resistivity	IEC 60674-2, clause **14**[a]	Ω	$\geq 10^{14}$	
Volume resistivity	IEC 60674-2, clause **15**[a]	Ωm	$> 10^{15}$	The test voltages are (100 ± 10) V for thicknesses > 10 µm and (10 ± 1) V for thicknesses ≤ 10 µm
Dissipation factor at 23 °C and 48 Hz – 62 Hz: 1 kHz:	IEC 60674-2, subclause **16.1** or **16.2**		$\leq 3 \times 10^{-4}$ $\leq 3 \times 10^{-4}$	Use non-contacting electrodes or evaporated metal electrodes (subclause **16.1**)
Permittivity	IEC 60674-2, subclause **16.1**		2,2 ± 0,1	Use non-contacting electrodes or evaporated metal electrodes (subclause **16.1**)
Dimensional change for shrinkage: — Machine direction — Transverse direction	IEC 60674-2, clause **23**	% %		Shrinkage shall be agreed between buyer and seller

NOTE Although the potential effects of certain properties such as crystallinity, orientation and isotactic/atactic content on the performance of the film are recognized, no recommendations regarding the determination of these parameters have been made, particularly as no suitable test methods are available in IEC 60674-2.

[a] Measurement conditions: (23 ± 2) °C and (50 ± 5) % relative humidity after at least 24 h exposure.

5.2 Electric strength (d.c. test)

Electric strength shall be measured according to **18.2** of IEC 60674-2. The central value shall be not less than the value given in Table 2. The winding tension shall 2,5 N/mm^2 ± 0,5 N/mm^2.

A1 Table 2 – Electric strength (d.c. test) for types 1, 2 and 3

Nominal film thickness µm	Type	Electric strength (central value) V/µm		Not more than 1 of 21 results shall be below V/µm	
		23 °C	105 °C	23 °C	105 °C
2,5	3	250	125	150	75
2,8		250	125	150	75
3,0		250	125	150	75
3,5		250	125	150	75
4	1 and 2	120	–	40	–
5		150	–	60	–
6		190	–	80	–
7 and 7,4		230	–	100	–
8		250	–	120	–
9		270	–	145	–
10 and 10,1		290	–	165	–
11		300	–	175	–
12		310	–	185	–
12,7		315	–	195	–
>12,7 to 25		320	–	200	–

A1

5.3 Electrical weak spots

A1 Electrical weak spots shall be measured according to **19.3** of IEC 60674-2 with a test voltage of 150 V/µm for types 1 and 2, and 250 V/µm for type 3, based on the nominal thickness of the film. A1

The number of faults counted shall not exceed the numbers given in Table 3. A minimum surface area of 5 m^2 is to be tested.

5.4 Thermal endurance

There is no requirement in this standard for thermal endurance.

A1 5.5 Wetting tension (types 1b + 1c, 2b + 2c, and 3b + 3c only) A1

When tested in accordance with clause **9** of IEC 60674-2, the wetting tension of the tested surface shall not be less than 35 mN m^{-1}.

A1 Table 3 – Electric weak spots for types 1, 2 and 3

Nominal thickness µm	Type	Fault count/m^2
2,5	3	2,6
2,8		2,6
3,0		2,6
3,5		2,6
4	1 and 2	2,6
5		2,3
6		1,8
7 and 7,4		1,7
8		1,5
9		1,3
10 and 10,1		1,2
11		1,1
≥12		1,0

A1

5.6 Liquid absorption

For satisfactory construction of impregnated capacitors the absorption of the impregnant by the film may need to be controlled within certain limits. If required, the method of measurement, the time and the temperature used and the absorption limits shall be agreed between supplier and purchaser[2)].

The preferred method shall conform with clause **31** of IEC 60674-2.

5.7 Compatibility with impregnants

The compatibility of the film with selected dielectric fluids shall be determined using a method agreed upon between the supplier and the purchaser. This method may, for example, be based on swelling or solubility of the film in the fluid, or on contamination of the fluid or the film[2)].

5.8 Dissipation factor under impregnated conditions

The impregnants and the methods of testing used throughout the capacitor industry vary widely and many of the materials and procedures are proprietary. Where the dissipation factor of the film under impregnated conditions must be to an agreed standard, the limiting values and the method of measurement should be agreed between supplier and purchaser[2)].

5.9 Space factor

Space factor: Caused by surface *roughness*, space factor is the percentage increase in bulking (micrometric) thickness over gravimetric thickness.

There are no requirements for space factor in this standard but the preferred space factor value is SF = (10 ± 3) %.

[2)] In view of the wide variety of impregnants available today and under development for capacitor application, no specific tests and/or limits can be given in this standard for liquid absorption (**5.6**), compatibility with dielectric fluids (**5.7**) and dissipation factor under impregnated conditions (**5.8**).

Space factor is calculated using the following formula:

$$SF = \frac{t_b - t_g}{t_g} \times 100\ (\%)$$

where

t_b is the bulking thickness in micrometres;

t_g is the gravimetric thickness in micrometres.

6 Roll characteristics

6.1 Windability

The windability shall be measured in accordance with the requirements of clause **6** of IEC 60674-2.

6.1.1 For reels of width less than 150 mm, method A shall be used.

Bias/camber	< 10 mm
Sag (tension 5 MN/m^2)	< 2 mm

6.1.2 For reels of width 150 mm and above, method B shall be used.

Bias/camber	< 10 mm
Sag (tension 5 MN/m^2)	< 2 mm

The extension required to achieve bias/camber and sag limit shall be not more than 0,1 %.

6.2 Joins

Where joins (splices) are permitted, their construction shall conform to the requirements given in **3.3** of IEC 60674-1. Breaks (unjoined pieces) shall also be indicated so as to be clearly visible when viewed from the end faces of the roll. The offset of either edge at a join shall not exceed 0,5 mm.

The number of joins (splices) or breaks in each roll shall not exceed the values given in Table 4.

6.3 Roll width (overall width)

The overall width is the distance between roll end faces measured between the outermost points of each end face (see **3.2** of IEC 60674-1). The difference between the film width measured according to clause **5** of IEC 60674-2 and the roll width excluding the core shall be not greater than:

— 0,5 mm for film width ≤ 150 mm;

— 1,0 mm for film width > 150 mm and < 300 mm;

— 2,0 mm for film width ≥ 300 mm.

6.4 Core

The preferred inner diameters of cores are 76 mm and 150 mm.

6.5 Labelling

Films pre-treated on one side shall have the pre-treated side indicated on the label.

〈A1〉 Table 4 – Maximum number of joints within a roll (types 1, 2 and 3)

Nominal film thickness µm	Number of joints within a roll of width >350 mm, core diameter = 150 mm and outer diameter			Number of joints within a roll of width ≤350 mm, core diameter = 76 mm and outer diameter <250 mm
	≤300 mm	>300 mm ≤400 mm	>400 mm ≤500 mm	
≤3,5	1	1	1	1
4	3	4	–	3
5	2	3	4	3
6	2	3	4	2
7 and 7,4	2	2	3	2
8	2	2	3	2
≥9	2	2	2	1

〈A1〉

Annex ZA (normative)
Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60674-1	1980	Specification for plastic films for electrical purposes Part 1: Definitions and general requirements	EN 60674-1	1998
IEC 60674-2 + corr. November	1988 1995	Part 2: Methods of test	EN 60674-2	1998
IEC 61074	1991	Determination of heats and temperatures of melting and crystallization of electrical insulating materials by differential scanning calorimetry	EN 61074	1993
ISO 534	1988	Paper and board — Determination of thickness and apparent bulk density or apparent sheet density	—	—
ISO 11357-3	–	Plastics – Differential scanning calorimetry (DSC) – Part 3: Determination of temperature and enthalpy of melting and crystallization	—	—

British Standards Institution (BSI)

BSI is the independent national body responsible for preparing British Standards and other standards-related publications, information and services. It presents the UK view on standards in Europe and at the international level.

BSI is incorporated by Royal Charter . British Standards and other standardization products are published by BSI Standards Limited.

Revisions

British Standards and PASs are periodically updated by amendment or revision. Users of British Standards and PASs should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using British Standards would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Similary for PASs, please notify BSI Customer Services.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001

BSI offers BSI Subscribing Members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of British Standards and PASs.

Tel: +44 (0)20 8996 7669 Fax: +44 (0)20 8996 7001
Email: plus@bsigroup.com

Buying standards

You may buy PDF and hard copy versions of standards directly using a credit card from the BSI Shop on the website **www.bsigroup.com/shop.** In addition all orders for BSI, international and foreign standards publications can be addressed to BSI Customer Services.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001
Email: orders@bsigroup.com

In response to orders for international standards, BSI will supply the British Standard implementation of the relevant international standard, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Knowledge Centre.

Tel: +44 (0)20 8996 7004 Fax: +44 (0)20 8996 7005
Email: knowledgecentre@bsigroup.com

BSI Subscribing Members are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration.

Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001
Email: membership@bsigroup.com

Information regarding online access to British Standards and PASs via British Standards Online can be found at **www.bsigroup.com/BSOL**

Further information about British Standards is available on the BSI website at **www.bsigroup.com/standards**

Copyright

BSI

389 Chiswick High Road London W4 4AL UK

Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards

raising standards worldwide™