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Specification for plastic films for electrical purposes - Part 2: Methods of test (IEC 60674-2:1998 + Corrigendum 1995)

Specification for plastic films for electrical purposes -- Part 2: Methods of test

Bestimmung für Isolierfolien für elektrotechnische Zwecke -- Teil 2: Prüfverfahren

Spécification pour les films en matière plastique à usages électriques -- Partie 2: Méthodes d'essai

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Specification for plastic films for electrical purposes — Part 2: Methods of test

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(IEC 60674-2:1988 + corrigendum 1995 + A1:2001)

Spécification pour les films en matière plastique à usages électriques —
Partie 2: Méthodes d'essai
(inclut l'amendement A1:2001)
(CEI 60674-2:1988 + corrigendum 1995 + A1:2001)

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Teil 2: Prüfverfahren
(enthält Änderung A1:2001)
(IEC 60674-2:1988 + corrigendum 1995 + A1:2001)

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of the International Standard IEC 60674-2:1988 and its corrigendum November 1995, prepared by SC 15C, Specifications, of IEC TC 15, Insulating materials, was submitted to the formal vote and was approved by CENELEC as EN 60674-2 on 1998-04-01 without any modification.

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) 1998-12-01

— latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1998-12-01

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.

Foreword to amendment A1

The text of document 15C/1263/FDIS, future amendment 1 to IEC 60674-2:1988, 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 amendment A1 to EN 60674-2:1998 on 2001-12-01.

The following dates were fixed:

— latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2002-09-01

— latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2004-12-01

Introduction

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

The series will consist of three parts:

— *Part 1: Definitions and general requirements* (IEC Publication 60674-1);
— *Part 2: Methods of test;*
— *Part 3: Specifications for individual materials* (IEC Publication 60674-3).

1 Scope

This standard is applicable to plastic films used for electrical purposes. This Part 2 gives methods of test.

2 General notes on tests

2.1 Discard at least the first three layers of film from the roll to be tested before removing test specimens.

2.2 Sample rolls shall be exposed for at least 24 h to the standard atmosphere 23 ± 2 °C and 50 ± 5 % r.h. before test specimens are removed for test. Unless otherwise specified, all individual test specimens shall be conditioned for 1 h and tested in the same standard atmosphere.

3 Thickness

Thickness shall be measured by any one or more of the methods given below as required by the future IEC Publication 60674-3.

3.1 Determination of thickness by mechanical scanning

3.1.1 *Principle*

The method is based on ISO Standard 4593 using a precision micrometer to measure the thickness of a single sheet test specimen.

3.1.2 *Test specimens and measuring points*

Cut three strips about 100 mm wide across the width of the sample. The test strips shall not contain creases or other defects.

Determine the thickness of the test strips in accordance with the requirements of ISO Standard 4593 using a micrometer having plane or radiused measuring surfaces.

Measurements shall be made at nine points at approximately equally spaced intervals along the length of the test strips. In the case of samples less than 300 mm wide make the measurements every 50 mm along the length of the test strips. In the case of untrimmed rolls, readings shall not be taken within 50 mm of the edges.

3.1.3 *Result*

The thickness is the central value of all the measurements, the highest and lowest values on each strip being reported.

3.2 Determination of gravimetric thickness of a sample

Principle: calculation of the thickness of a sample from measurements of mass, area and density in accordance with Section 1 of ISO Standard 4591.

3.3 Determination of average gravimetric thickness of a roll

Principle: calculation of the average thickness from measurements of the length, average width and net mass of the roll and the density of the film in accordance with Section 2 of ISO Standard 4591.

3.4 Crosswise thickness profile and lengthwise variation in thickness (Under consideration.)

4 Density

To be determined in accordance with ISO Recommendation 1183. The particular method will be specified in IEC Publication 60674-3.

5 Width

To be determined in accordance with ISO Standard 4592, except that a 5 m sample length is used. Determine the width five times along the length at equal intervals after the film has relaxed for one hour.

Record each width measured and report the central value as the width of the roll.

6 Windability (bias/camber and sag)

6.1 Principle

An assessment is made of the distortion of the film as supplied in the roll.

Two forms of distortion may be apparent in the film which can impair its subsequent winding characteristics. These distortions are:

1) the film may exhibit bias or camber and therefore its edges may not be straight (see Figure 1);

2) the film may sag below its general level in areas where it has been stretched (see Figure 2 and Figure 3).

6.2 Introduction

Two methods are given. Method A is appropriate for narrow (i.e. less than 150 mm) films where distortion is apparent mainly as bias/camber and also for the measurement of sag for very thick films where the tension required for extension by Method B is excessive.

Method B is appropriate for wider (i.e. greater than 150 mm) films where distortion is apparent, mainly as sag.

6.3 Method A

6.3.1 *Principle*

To assess bias/camber, a length of film is unwound and laid on a flat surface and the deviation of each of its edges from a straight line is measured (see Figure 1).

To assess sag, a length of film is unwound and laid orthogonally over two parallel bars under defined conditions and the deviation from a uniform catenary is measured (see Figure 2). It may sometimes be convenient to make this measurement using the rollers of a winding machine, but in cases of dispute the dimensions and distances shall be as given below.

6.3.2 *Measurement of bias/camber*

6.3.2.1 *Apparatus*

A flat, horizontal table of any suitable material having a satin finish (not polished) of sufficient width to accommodate the maximum width of film to be tested and of length 1 500 ± 15 mm with ends parallel to within 0.1° (or 1.8 mm per 1 metre of table width). Alternatively, the table may be longer than the above length but must then have two reference lines clearly marked on its surface 1 500 ± 15 mm apart and parallel to the same accuracy.

— A soft brush suitable for smoothing the film specimen on the table surface.

— A long (in excess of 1 525 mm) steel straight-edge.

— A 150 mm steel rule with 1 mm graduations.

6.3.2.2 *Test specimens*

The first three layers of film from the roll are discarded. For each specimen a fresh length of approximately 2 m is taken, being drawn from the roll with the lightest tension necessary to unwind it slowly (at about 300 mm/s).

6.3.2.3 *Procedure*

The specimen length of film is placed lengthwise over the table as shown in Figure 1. Starting from one end, the soft brush is used to lightly press the film into intimate contact with the table surface, expelling any trapped air as far as possible.

The steel straight-edge is then placed along one edge of the film so that any deviation of the film edge from a straight line can be readily observed. The straight-edge is adjusted to coincide with the film edge at the two table ends (or at the reference marks if these are used) and the distance between these points shall be 1 500 ± 15 mm. The distance between the straight edge and the film edge is measured to the nearest 1 mm at approximately mid-span by means of the steel rule.

The deviation of the second film edge is then measured using the same procedure.

The sum of the distances in millimetres of the two edges of the film from the steel straight-edge at the mid-span is the bias/camber value for that test specimen.

The above procedure is repeated for two further test specimens.

6.3.2.4 *Results*

The bias/camber is the central value of the three determinations, the other two values being reported.

6.3.3 ***Measurement of sag***

6.3.3.1 *Apparatus*

A rigid framework supporting two parallel, freely rotatable metal rollers, each roller 100 ± 10 mm in diameter and of sufficient length to accommodate the maximum width of film to be tested. The axes of the rollers shall be in the same horizontal plane and set mutually parallel to within 0.1° (i.e. within 1.8 mm per 1 m length of roller) with a separation of 1 500 ± 15 mm. The roller surfaces shall be accurately cylindrical to within 0.1 mm with any suitable satin finish (not polished) (see Figure 2). The framework shall be fitted with a device for mounting the roll of film being tested immediately below one of the rollers. The mounting shall be such that the axis of the film roll is parallel to the superior roller to within 1° and the film may be drawn off the roll against an adjustable unwind tension. At the opposite end of the framework a weighted or sprung clamp is fixed to the film web hanging freely from the second roller. The weight or spring loading and its position on the film may be adjusted so as to give a substantially uniform tension across the web as specified in IEC Publication 60674-3.

A device for measuring along a line midway between the rollers the distance of the film below the plane of those rollers (see Figure 3). The device may comprise simply a long (in excess of 1,525 mm) steel straight-edge and a 150 mm steel rule with 1 mm graduations, or more complex devices may be employed whereby the film position is noted automatically or semi-automatically.

6.3.3.2 *Test specimens*

The first three layers of film from the roll are discarded. For each specimen a fresh length of approximately 2 m is drawn from the roll with the lightest tension necessary to unwind it slowly (at about 300 mm/s).

6.3.3.3 *Procedure*

The specimen length of film is placed over the apparatus rollers, the free end of the film is clamped in the tensioning device, the tension adjusted to the value given for the film in IEC Publication 60674-3 and the lateral position of the film as it passes over the second roller adjusted so that the film web lies approximately horizontal at mid-span.

Using the steel straight-edge and graduated steel ruler or other suitable device the film is checked across the film width at mid-span and any edge sag or sag lanes noted. The maximum depth of any sag lane below the general film surface surrounding it is measured to the nearest 1 mm (see Figure 3) and reported as the sag value for that test.

The above procedure is repeated for two further test specimens.

6.3.3.4 *Result*

The sag value is the central value of the three determinations, the other two values being reported.

6.4 Method B

6.4.1 *Principle*

The total amount of sag and bias/camber is assessed by one measurement. A length of film is unwound and laid orthogonally over two parallel bars under defined conditions. The film is strained until free of visible sag and bias/camber and the extension necessary to achieve this is measured. It may sometimes be convenient to make this measurement using the rollers of a winding machine but in cases of dispute the dimensions and distances shall be as given below.

6.4.2 *Apparatus*

A rigid framework supporting two parallel, freely-rotatable metal rollers, each roller 100 ± 10 mm in diameter and of sufficient length to accommodate the maximum width of film to be tested. The axes of the rollers shall be in the same horizontal plane and set mutually parallel to within 0.1° (i.e. within 1.8 mm per 1 m length of roller) with a separation of 1 500 ± 15 mm. The roller surfaces shall be accurately cylindrical to within ±0.1 mm with any suitable satin finish (not polished). The framework shall be fitted with a device for mounting the roll of film being tested immediately below one of the rollers. The mounting shall be such that:

a) the axis of the film roll is parallel to the superior roller to within 2°;

b) the lateral position of the film may be adjusted as desired; and

c) the film may be drawn off the roll against an adjustable unwind tension.

At the opposite end of the framework a weighted or sprung clamp is fixed to the film web hanging freely from the second roller. The weight or spring loading of the clamp and its position on the film may be varied to give an adjustable tension substantially uniform across the web.

— A steel straight-edge (in excess of 1 525 mm).

— A flexible steel rule 2 m or more in length with 1 mm graduations.

— Suitable self-adhesive labels.

6.4.3 *Test specimens*

The first three layers of film from the roll are discarded and a fresh length of approximately 2 m is drawn from the roll with the lightest tension necessary to unwind it slowly (at about 300 mm/s).

6.4.4 *Procedure*

The specimen length of film is placed over the apparatus rollers. With light hand tension applied to the web, the free end of the film is moved so that the film web between the rollers is as flat as possible and the free end is then clamped in the tensioning device. The tension is adjusted to 1.0 ± 0.2 mN/m^2 (based on the nominal thickness and width of the film).

Two reference marks (between 1.0 m and 1.1 m apart) are applied to the film on a line exhibiting minimal sag and which is approximately parallel to the edges of the film. These marks may conveniently be specific edges of two self-adhesive labels applied to the film surface.

The distance between the marks is measured to within ±0.5 mm using the flexible steel tape.

The tension applied to the film is increased until:

a) the film is visually smooth;

b) each film edge is straight to within 0.5 mm at mid-span when compared with the straight-edge; and

c) the sag at any point does not exceed 7.5 mm when compared with the straight-edge.

The distance between the reference marks at this tension is measured using the steel tape and the extension of the film is expressed as a percentage of the original mark separation.

The above procedure is repeated for two further test specimens.

6.4.5 *Result*

The total sag and bias/camber is the central value of the three determinations, the other two values being reported.

7 Surface roughness

Under consideration.

8 Coefficient of friction

To be determined in accordance with IEC Publication 60648.

Principle

This method covers determination of starting and sliding friction of plastic film and sheeting when sliding over itself or other substances under specified conditions. The procedure permits the use of a stationary sled with a moving plane or a moving sled with a stationary plane. Both procedures yield the surface coefficient of friction for a given test specimen.

9 Wetting tension (polyolefine films)

9.1 Test principle and introductory remarks

The determination of the wetting tension is based on the phenomenon that drops of a series of an organic liquid mixture with gradually increasing surface tension, when they have reached a specific concentration, have the ability to wet the film surface. Since the wetting tension of a film in contact with a drop of the respective liquid mixture in the presence of air is a function of the surface energies of both the air-film and the film-liquid interfaces, any trace of surface-active impurities in the liquid reagents or on the film may affect the results. It is, therefore, important that the film surface to be tested should not be touched or rubbed, that all equipment be clean and that reagent purity be carefully controlled.

9.2 Apparatus

— Cotton-tipped wooden applicators approximately 150 mm long.

— Two burets, 50 ml.

— Bottles, 100 ml with caps and labels { cleaned with chrome sulphuric acid and rinsed with distilled water.

9.3 Reagents

Prepare mixtures of reagent-grade formamide ($HCONH_2$) and reagent-grade ethylene-glycol-monoethyl-ether ($CH_3\ CH_2 — O — CH_2\ CH_2 — OH$) in the proportions shown in the following Table I for the integral values of wetting tension in the range over which measurements are to be made.

If desired, add to each of the mixtures mentioned in Table I a very small amount of dye of high tinctorial value. The dye used should be of such colour as to make drops clearly visible on the surface of the polyolefin film. Furthermore, the dye must be of such chemical composition that it will not measurably affect the wetting tension of the liquid mixtures.

NOTE 1 It is recommended that the surface tension of the liquid mixtures be checked weekly. Any wetting tension method usually applied in the laboratory is suitable.

NOTE 2 Although the shown liquid mixtures are relatively stable, exposure to temperatures above 30 °C and humidity above 70 % r.h. should be avoided.

NOTE 3 Both ethylene-glycol-monoethyl-ether and formamide are toxic and should be handled with due precaution. Since formamide is particularly dangerous when in direct contact with the eyes, safety goggles should be worn when making up the liquid mixtures. National safety regulations should be observed.

Table I

Concentrations of ethylene-glycol-monoethyl-ether, formamide mixtures used in measuring wetting tension of polyethylene and polypropylene films

Formamide volume per cent	Ethylene-glycol-monoethyl-ether per cent	Wetting tension mN/m
0	100.0	30
2.5	97.5	31
10.5	89.5	32
19.0	81.0	33
26.5	73.5	34
35.0	65.0	35
42.5	57.5	36
48.5	51.5	37
54.0	46.0	38
59.0	41.0	39
63.5	36.5	40
67.5	32.5	41
71.5	28.5	42
74.7	25.3	43
78.0	22.0	44
80.3	19.7	45
83.0	17.0	46
87.0	13.0	48
90.7	9.3	50
93.7	6.3	52
96.3	3.7	54
99.0	1.0	56

9.4 Test specimens

The first three layers of film from the roll are discarded. One sample across the entire width of a roll should be tested in such a way that one determination at each location ¼, ½, ¾ of the way across the width of the film is made. If the range of these three determinations exceeds 2.0 mN/m, indicating that the polyolefin film has been unevenly treated, measurements, as described above, shall be made at three points spaced along the length of the roll (a total of nine measurements).

Extreme care must be taken to prevent the surface of the film sample from being touched or handled in the areas upon which the test is to be made.

9.5 Conditioning

Standard atmosphere B according to IEC Publication 60212 during testing (23 °C/50 % r.h.).

9.6 Procedure

Wet the extreme tip of a cotton applicator with one of the mixtures. Use only a minimum amount of liquid as an excess of reagent may affect the result.

Spread the liquid lightly over an area of approximately 6.5 cm² (~25 mm in diameter) of the test specimen at the selected location. Do not try to cover a larger area lest there be insufficient liquid to give complete coverage. Note the time required for the continuous liquid coverage formed on the film to break up into droplets. If the continuous liquid coverage holds for more than 2 s proceed to the next highest wetting tension mixture, but if the continuous liquid coverage breaks into droplets in less than 2 s proceed to the next lowest wetting tension mixture. A clean, new cotton applicator must be used each time to avoid contamination of the solution.

Proceed in the direction indicated above continuously repeating the prescribed steps until it is possible to select the right mixture according to Sub-clause **9.7**.

Experience with the test has shown that occasionally erroneous results can be obtained by working progressively to lower surface tension mixtures. Therefore, it is recommended that the tester should check the wetting tension of the film by working progressively to higher surface tension mixtures.

9.7 Evaluation

The mixture is considered as wetting the test specimen when it remains intact as a continuous coverage of the liquid for 2 s as close as possible. Shrinkage of the periphery of the continuous liquid coverage does not indicate lack of wetting; only breaking into droplets within 2 s indicates lack of wetting. Severe peripheral shrinking may be caused by too much liquid being placed upon the film surface. The surface tension of the applied mixture in millinewtons per metre which remains intact for 2 s is called the wetting tension of the polyolefin film test specimen.

9.8 Report

If one specimen has been tested and the range of results is less than 2.0 mN/m, report the central value of the three wetting tension test results.

In case of an unevenly treated polyolefin film, for which nine determinations have been made, report the central value and the individual values.

10 Tensile properties

To be determined in accordance with ISO Standard 1184.

Tensile properties generally to be specified are tensile stress and percentage elongation at break but sometimes 1 % secant modulus may be specified.

10.1 Test specimens

Test specimens shall be in accordance with Sub-clause **6.1** of ISO Standard 1184, i.e. strips 10 mm to 25 mm wide, not less than 150 mm long, with gauge marks at least 50 mm apart.

Five specimens shall be tested in each of the directions specified in IEC Publication 60674-3.

10.2 Speed of testing

The speed of testing is the rate of separation of the grips of the testing machine during a test and shall be the speed specified in IEC Publication 60674-3.

10.3 Result

For each property and for each direction of test, the result is the central value of the five determinations, the highest and lowest values being reported.

11 Edge tearing resistance

To be determined in accordance with Clause 8 of IEC Publication 60394-2.

11.1 Principle

The test specimen is inserted into an inclined slot of a fixture which is clamped to a tensile testing machine. The force needed to initiate tearing of the edge is determined.

12 Tear resistance

The tear resistance shall be determined in accordance with either Draft International Standard ISO/DIS 6824 or ISO Standard 6383/1. The method to be used will be specified in IEC Publication 60674-3.

13 Stiffness of film

Principle

This test method describes a means for determining the flexibility of a material by means of a fixed angle flexometer in which the test specimen bends under its own weight. A rectangular strip of material is supported on a horizontal platform in a direction perpendicular to one edge of the platform. The strip is placed on the platform with a specified length overhanging the platform and the time taken for this overhang to fall to an angle of 41° 30′ below the horizontal is recorded.

14 Surface resistivity

To be determined according to IEC Publication 60093.

15 Volume resistivity

15.1 Method 1: Electrode method

To be determined according to IEC Publication 60093, using a guarded electrode of 25 mm diameter and an unguarded one of at least 40 mm diameter.

Determinations to be made under the conditions specified in IEC Publication 60674-3 from the following:

— standard dry conditions of IEC Publication 60212 (18 °C – 28 °C/<1.5 % r.h.);

— standard atmosphere B of Table I of IEC Publication 60212 (23 °C/50 % r.h.);

— dry hot conditions selected from Table I of IEC Publication 60212.

15.2 Method 2: Method for wound capacitor dielectric films or films too thin for Method 1

15.2.1 *Principle*

This method uses the fact that the volume resistivity ρ of a capacitor dielectric may be calculated from the time constant ($t = CR$) by the relation:

$$\rho = CR/\varepsilon \times \varepsilon_0$$

where

C is in farads;

R is in ohms;

ρ is in ohms metres;

ε is the permittivity;

ε_0 is equal to 8.85×10^{-12} F · m^{-1}.

15.2.2 *Test specimens*

Each test specimen is a wound capacitor on a rigid insulating core, of extended foil construction, with an active electrode width of 40 mm to 70 mm and an edge margin of 3 mm. The dielectric is a single layer of the film under test and the capacitance (measured at 1 kHz) is 0.5 ± 0.1 µF. If preliminary heat or vacuum treatment is required, this will be indicated in IEC Publication 60674-3.

15.2.3 *Procedure*

Three test specimens are wound as above and subjected to any necessary treatment. After further conditioning for 6 h in standard dry conditions (18 - 28 °C and < 1.5 % r.h.) the two-minute resistance (100 ± 10 V or 25 ± 4 V/µm for films of thickness 4 µm or less) is measured and then the capacitance at a frequency below 1.6 kHz.

The permittivity is measured as indicated in Clause **16**. Alternatively the theoretical value may be sufficiently accurate.

The values of ρ are calculated from the equation:

$$\rho = CR/\varepsilon \times \varepsilon_0$$

15.2.4 *Result*

The volume resistivity is the central value of the three measurements. The report should state the temperature of measurement and whether the permittivity was measured or assumed.

NOTE In order to reduce the error caused by the charging current of the capacitor to acceptable proportions, it is necessary for the time constant of the capacitance C of the test specimen and the input resistance r of the current measuring device to be small compared to both the time of application of voltage and the time constant of decay of the apparent leakage current. Where the application time is 2 min the Cr value should be less than 2 s for most films. Where the test specimen is 0.5 µF, the value of r should be less than 4 MΩ.

Some direct reading megohmmeters may not be satisfactory in this respect.